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G.I.-30 SEPT. 1976

GEOCRES No. 40P9-35

DIST. 3 REGION

W.P. No. 604-90-01/02

CONT. No. 96-37

W. O. No.

STR. SITE No. 35-404

HWY. No. 6

LOCATION Hwy 6 & Speed River
(NBL & SBL)

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

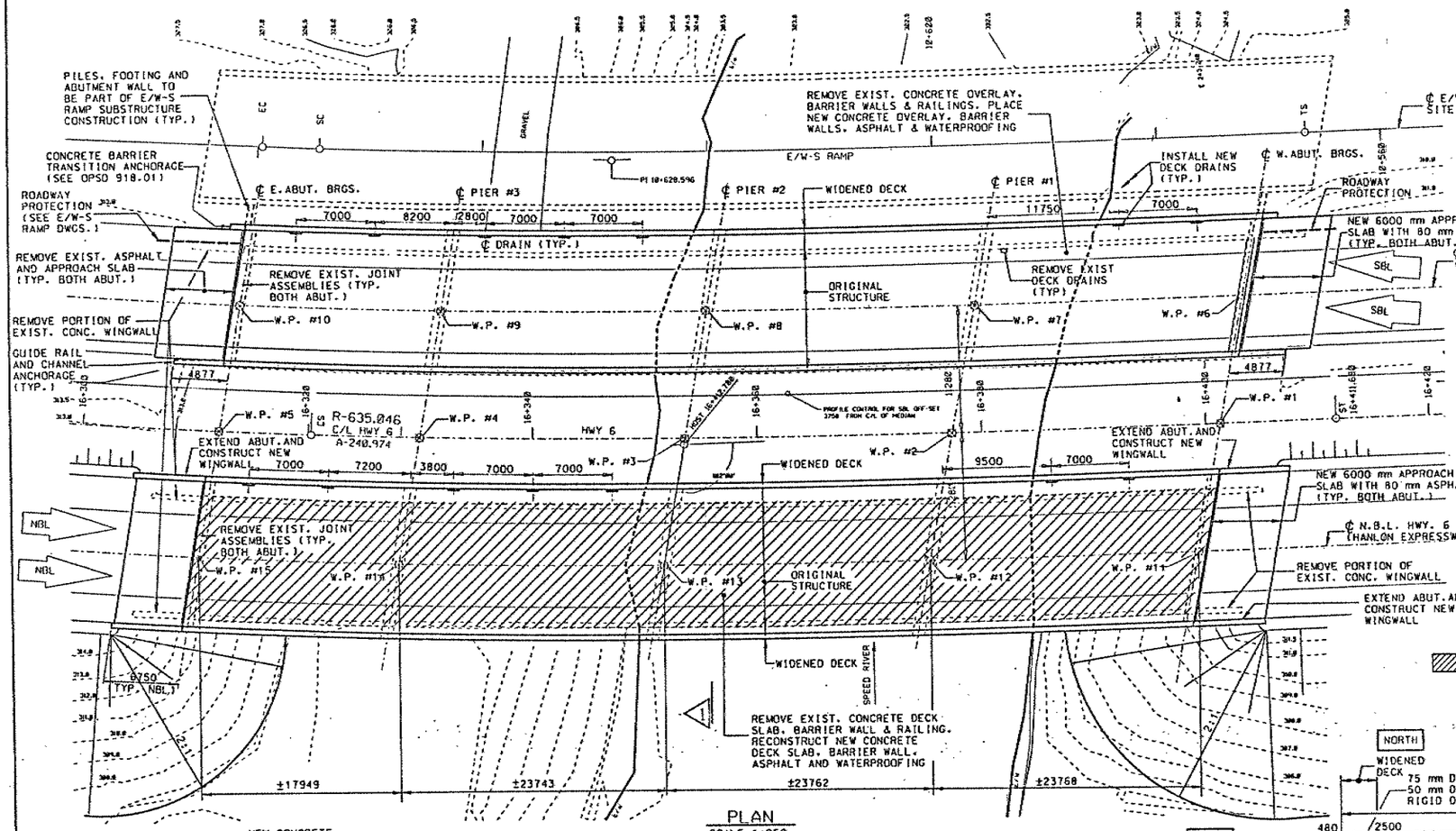
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST. No. 3
CONT No 96-37
WP No 604-90-01/02

SPEED RIVER BRIDGE
HWY. 6 (HANLON EXPRESSWAY)
REHABILITATION
GENERAL ARRANGEMENT (NBL & SBL)

SHEET 160

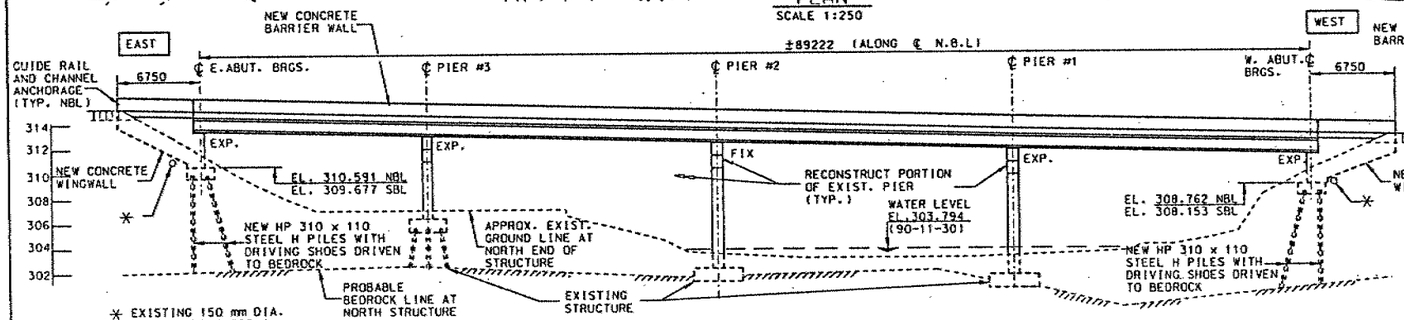


PLAN
SCALE 1:250

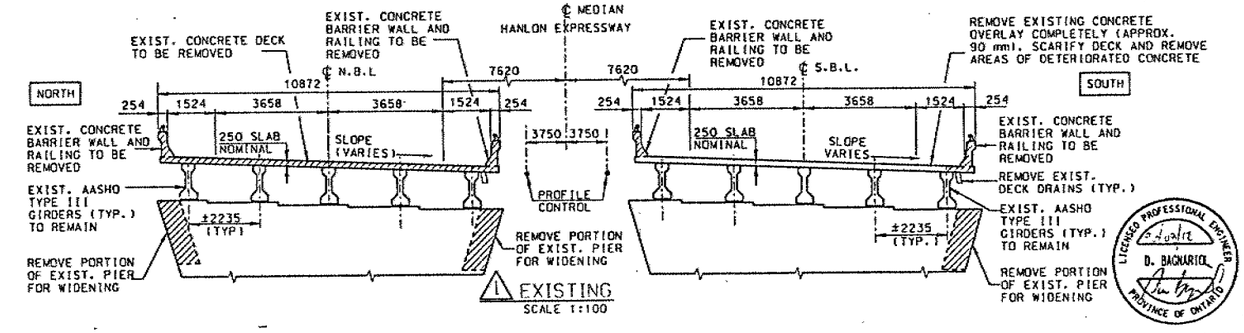
WP. #	STATION	ELEVATION T/P
WP. #1	16+401.347	
WP. #2	16+377.571	
WP. #3	16+353.800	
WP. #4	16+330.030	
WP. #5	16+312.052	
WP. #6	16+403.737	311.971
WP. #7	16+379.866	312.324
WP. #8	16+355.884	312.762
WP. #9	16+331.875	313.260
WP. #10	16+313.488	313.712
WP. #11	16+398.985	312.549
WP. #12	16+375.310	313.013
WP. #13	16+351.766	313.594
WP. #14	16+328.328	314.265
WP. #15	16+310.662	314.798

T/P = TOP OF PAVEMENT

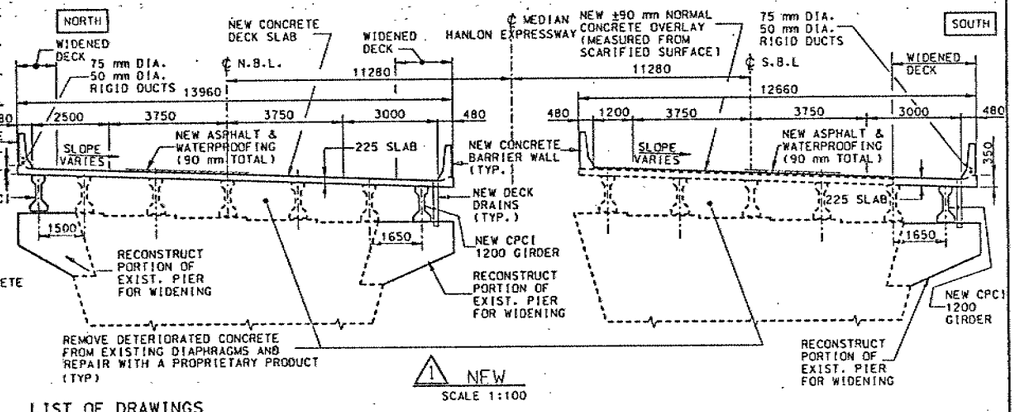
▨ DENOTES REMOVAL OF EXIST. CONCRETE



ELEVATION
(NORTH FACE OF N. STRUCTURE)
SCALE 1:250



1 EXISTING
SCALE 1:100



1 NEW
SCALE 1:100

GENERAL NOTES

CLASS OF CONCRETE .....30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS.....100 ± 25
DECK:.....TOP.....70 ± 20
BOTTOM.....40 ± 10
REMAINDER, UNLESS OTHERWISE NOTED.....70 ± 20

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.

BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

CONSTRUCTION NOTES

1. THE CONTRACTOR SHALL FIELD CHECK AND VERIFY ALL CONDITIONS AND MEASUREMENTS AT THE SITE AND REPORT ALL DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE PROCEEDING WITH THE WORK.
2. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESS FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESS ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
3. SAWCUTS IN CONCRETE, WHERE DESIGNATED, SHALL BE 25 mm DEEP OR TO THE FIRST LAYER OF REINFORCING STEEL, WHICHEVER IS LESS.
4. FOR SCOPE OF REPAIR WORK, SEE STAGING DIAGRAMS AND CONSTRUCTION SEQUENCE NOTES ON DRAWING 2.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWING

OPSD 918.01-CONCRETE BARRIER TRANSITION TO STRUCTURES.
OPSD 4010.00 GUIDE RAIL AND CHANNEL ANCHORAGE

LICENSED PROFESSIONAL ENGINEER — D. BAGNARIOL — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — S.S.T. WONG — PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS					
			DESCRIPTION		
DESIGN DB	CHK SW	CODE DNBDC-91	LOAD	DATE MAY. 94	
DRAWN WP	CHK DB	SITE 35-404	STRUCT	SCHEME	DWG 1

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 96-37

Ontario **Ministry of Transportation**

INDEX

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

EXPLANATION OF TERMS USED IN REPORT

N VALUE THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O D SPLIT BARREL SAMPLER TO PENETRATE 0 3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63 5kg, FALLING FREELY A DISTANCE OF 0 76m FOR PENETRATIONS OF LESS THAN 0 3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED AVERAGE N VALUE IS DENOTED THUS $\bar{N}$

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0 3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

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

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

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY S.P.T. N VALUES AS FOLLOWS

N (BLOWS/0 3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

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

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

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0 3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening

of

Hwy. 6 (NB & SB)/Speed River Crossing

W.P. 604-90-01/02, Site 35-404

District 3, Stratford

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted in conjunction with the proposed widening of the two existing Hwy. 6-Speed River Crossing structures.

SITE DESCRIPTION AND GEOLOGY

The site is located at the existing Hwy. 6-Speed River Crossing structures situated approximately 0.5 km south of the existing Hwy. 24 in the City of Guelph, County of Wellington. The existing structures constructed in 1971 are four(4) span concrete beam structures that carry traffic on Hwy. 6 over the Speed River. Longitudinal and transverse

slopes are evidence of approach embankment fill material placed at the structure locations. The slopes appear to be stable at the constructed 2H:1V gradient. An unpaved gravel roadway has been benched into the slope at the south approach embankment location. This roadway appears to have been an access route to the Guelph Dolime Quarry which is located just west of the site location. A chain link fence and guardrail installed has presently blockaded an easterly access to the Quarry.

Variable land use is evident in the site area. Earth and rock excavation and stockpiles of processed dolostone reflects the operation and activity at the Guelph Dolime Quarry. Northwest of the site and north of the Speed River, a woodlot containing tall deciduous trees is present. Northeast of the site, the land which is primarily flat, is occupied by an abandoned landfill area. Southeast of the site, a residential development exists.

The terrain at the site consists of sloping surfaces indicative of the fill placed in what was previously probably low lying flat to gently rolling land. Concrete rubble has been placed on the surface of the north approach embankment beneath the existing SBL structure.

The Speed River, flowing in a westerly direction is a dominant feature at the site. The river is approximately thirty-five metres in width and at the time of the investigation the water depth was shallow and approximately one metre in depth. A concrete weir exists downstream of the Hwy. 6 SB structure.

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this

area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximately 12,000 years ago), the ice which moulded this drumlin field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

As a result of the glacial activity, the general landform pattern in the area consists of drumlins or groups of drumlins fringed by gravel terraces. The dominant soil materials are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways. Overburden in the site area is underlain by dolostones of the Amabel and Guelph Formations. Native overburden thicknesses are shallow at the site and usually less than three(3) metres.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

A desk study that entailed the review of the foundation report produced for the existing

Hwy. 6/ Speed River Crossing structures (see W.P. 109-68-02/03) and also the examination of the structure foundations (type, elevation, etc.) preceded the fieldwork and laboratory testing program. This information was used to define the extent of the fieldwork and also in providing recommendations for the foundation design and construction of the proposed widening. Reference can be made to the foundation report and the contract drawings for the existing structures in conjunction with this report.

Field Investigation

The recent fieldwork for this project was conducted between 93 02 16 and 93 02 17 and consisted of a total of three(3) boreholes. However, subsurface information was also obtained from a previous investigation conducted between 69 10 08 and 69 10 23 executed for the existing Hwy. 6/ Speed River Crossing structures as discussed above. The three(3) boreholes advanced during the recent investigation ranged in depth from 5.9 m to 12.1 m. Boreholes originally advanced ranged in depth from 3.8 m to 7.8 m.

The three(3) boreholes that were recently advanced were done so using conventional track and truck mounted drilling units. Hollow stem augering techniques were used to penetrate the overburden at the site. Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). The samples were generally retrieved at 1.5 m intervals. Automatic hydraulic tripping hammers were used to impart the standard driving energy.

Bedrock underlying the overburden was cored 1.5 metres in depth using conventional rock coring techniques. A NX core barrel within NW casing was used in the coring process.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes and the river level was also monitored throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Southwestern Region Surveys and Plans.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil

Classification Manual. Physical property tests included natural moisture contents, grain size distributions and Atterberg Limit Tests. Particle size distributions were determined by mechanical sieve and hydrometer analysis. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The rock core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

GENERAL

The subsurface conditions at the site reflect the previous placement of fill material and hence consists primarily of an irregular mixture of silt, sand and gravel at the proposed abutment locations and also at the east pier location. The thickness of the fill material varies up to 9.1 metres. At the locations beyond the fill placement, the native surficial deposit consists of a heterogeneous mixture of gravel, sand and silt. This deposit underlies the fill material where the fill material exists and underlies the waters of the Speed River at the proposed west and centre piers. The deposit also contains boulders and cobbles

which were explored and also visible at the river bottom. The thickness of this deposit varies from 0.8 to 5.3 m.

Across the entire site, the native heterogeneous mixture of gravel, sand and silt is underlain by dolostone bedrock. The bedrock was encountered at Elevations ranging from 298.9 to 302.6 indicating an irregular bedrock surface.

A plan of the site illustrating the locations and elevations of the boreholes and proposed structure foundations is shown on Dwg. No. 6049001/02-A.* The plan also includes boreholes advanced as part of the original investigation conducted in 1968. A subsoil stratigraphical profile section has also been included on the drawing.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical section and also on the individual Record of Borehole sheets in the Appendix.

SOIL/ROCK DESCRIPTIONS

Water

Approximately 0.5 to 1 metre of standing water was present in the Speed River at the time of the investigation. Flow was generally laminar but turbulent flow was apparent at overflow weir location.

* Dwg. No 3, Sheet 162, of the Contract Drawings.

Irregular Mixture of Silt, Sand and Gravel (Fill Material)

The composition of the fill material located adjacent to the abutments of the existing Hwy. 6/ Speed River Crossing structures and within the median of the highway and also between the east piers of the existing structures is predominantly an irregular mixture of brown silt, sand and gravel. Random zones of an irregular mixture of clayey silt, sand and gravel are also present within the fill material. The thickness of the fill material varies from 3.0 m to 9.1 m and contains traces of black organics at random depths. A grain size distribution envelope as determined by hydrometer and mechanical sieve analysis is shown on Figure 1 in the Appendix. The figure illustrates the broad gradation of the fill material.

The 'N' values as determined by the Standard Pentration Test ranged from 1 blow/ 0.3 m to 61 blows/ 0.3 m indicating a denseness ranging from very loose to very dense. The larger 'N' values however are suspected to be attributable to the larger gravel sizes in the fill. In general, 'N' values range from 14 blows/ 0.3 m to 36 blows/ 0.3 m indicating a compact to dense state of denseness.

Heterogeneous Mixture of Gravel, Sand Silt (Glacial Till)

The fill material and waters of the Speed River are underlain by a heterogeneous mixture of gravel, sand and silt. This deposit, which is predominantly brown in colour also contains traces of black organics. Boulders and cobbles are also present in this deposit as determined by actual sampling, visual observation in the Speed River and inference from frequent auger grinding that was encountered. The thickness of this deposit ranges from 0.8

Grain size distribution curves produced by mechanical sieve and hydrometer analysis are given in Figure 2 in the Appendix. The results reveal a broad range of particle sizes ranging primarily from silt to gravel. The envelope does not include particle sizes larger than gravel. The broad range of particle sizes is typical of deposits of glacial till origin.

An Atterberg Limit test on one representative sample of the material containing organic percentages revealed a liquid limit (W_L) of 43% and a plasticity index (I_P) of 13%. The fine grained portion of the material can be described as a plastic silt of intermediate plasticity (MI). In general, however, the fine grained portion of the deposit is cohesionless and non-plastic.

The 'N' values as determined by the Standard Penetration Test range from 6 blows/0.3 m to 200 blows/0.3 m. The larger 'N' values are the result of the larger boulder and cobble sizes and hence may not necessarily accurately represent the denseness of the deposit. In general, the 'N' values range between 10 blows/0.3 m and 80 blows/0.3 m indicating a compact to very dense state of denseness.

Bedrock

The bedrock that underlies the heterogeneous mixture of gravel, sand and silt at the site is primarily a light brown coloured dolostone of the Guelph Formation. Bedrock surface elevations varied across the site and are summarized in Table 1 below.

elevations varied across the site and are summarized in Table 1 below.

TABLE 1 - BEDROCK SURFACE ELEVATIONS	
Area	Elevation (m)
West Abutment	298.9 - 302.2
West Pier	299.4 - 302.1
Centre Pier	301.3 - 301.7
East Pier	300.3 - 302.6
East Abutment	301.9 - 302.5

The results tabulated in Table 1 reveal that the bedrock surface elevation is variable across the site indicating a reef type structure to the bedrock.

The dolostone bedrock is a chemical sedimentary rock that is very pale orange to yellowish brown in colour and medium grained. The rock which is of the Guelph Formation is unweathered to slightly weathered and characterized by a porous "vug" texture and stylolites. The rock contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Rock Core Description".

An assessment of the quality and strength of the rock was carried out by measuring core

and RQD's ranged from 0% to 53%. Rock quality can be categorized as very poor to fair.

Rock strengths can be described as weak as determined by physical index property tests. Rock core penetration rates were generally rapid which confirms the weaker nature of the sedimentary rock.

GROUNDWATER CONDITIONS

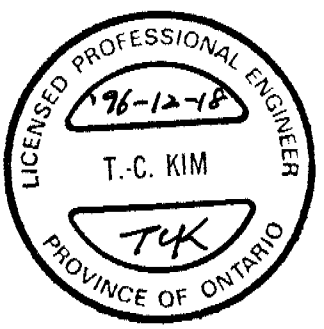
Observation of the groundwater level was carried out by measuring the water levels in the open boreholes and monitoring the lake level throughout the duration of the field investigation. The river level was approximately 303.7 m at the time of the recent investigation and remained constant throughout the duration of the investigation.

On shore, the water level measured at the time of the recent investigation ranged from elevation 302.8 m to 305.7 m which is approximately equal to the elevation of the water level.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

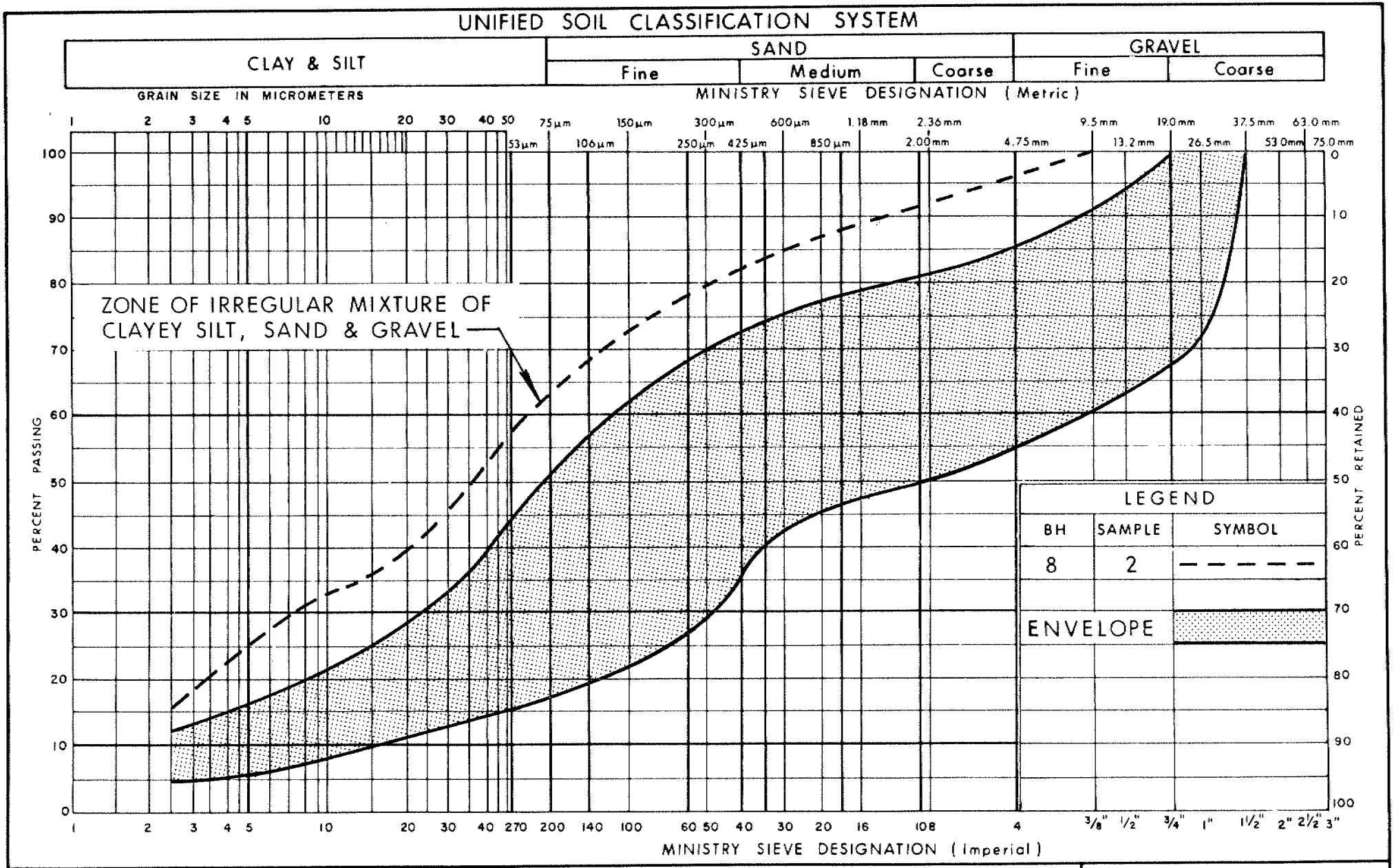
MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Malone's Soil Samples. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer. The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

IRREGULAR MIXTURE OF

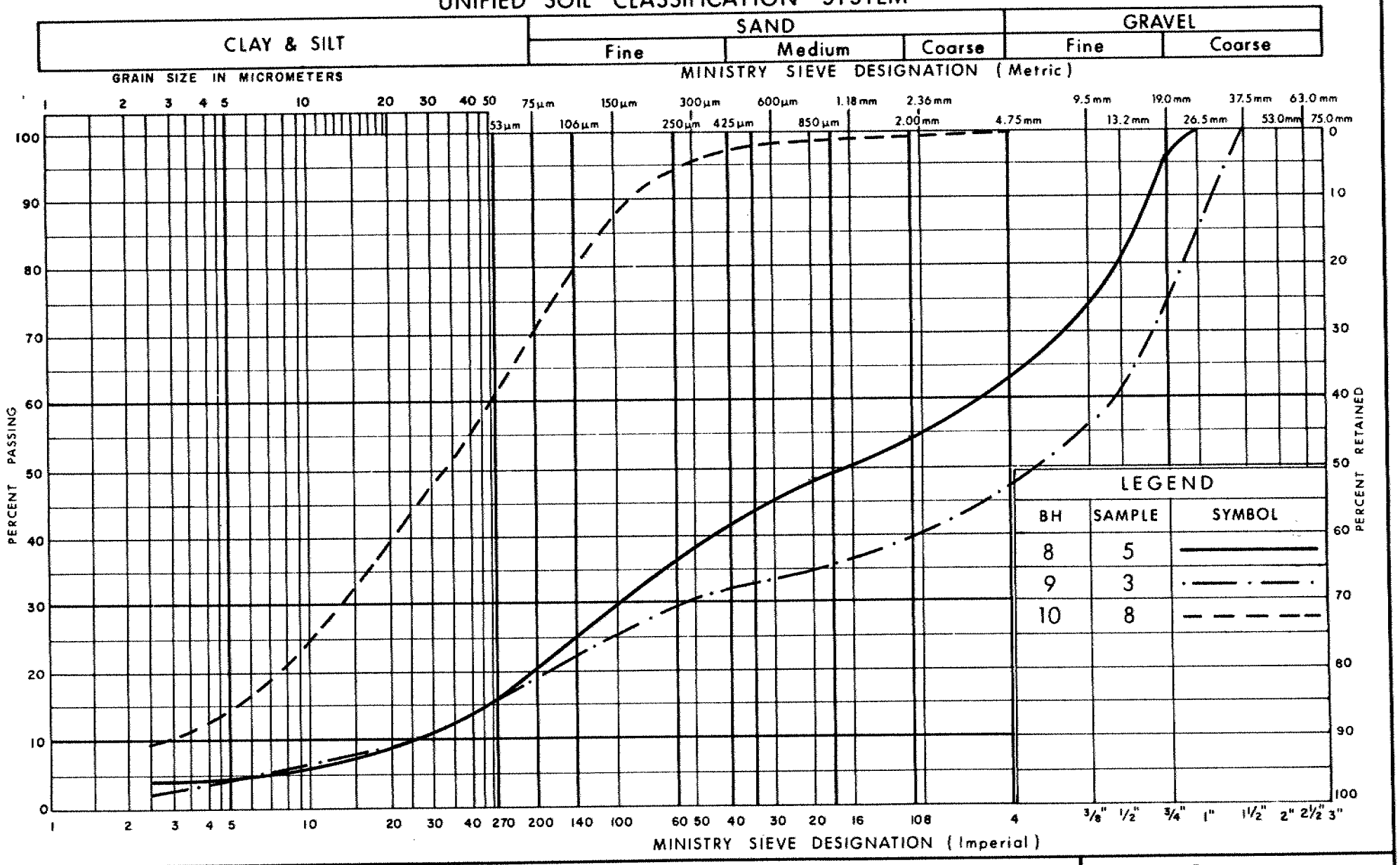
SILT, SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 604-90-01/02

16

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

GRAVEL, SAND & SILT (Glacial Till)

FIG No 2

W P 604-90-01/02

17

RECORD OF BOREHOLE No 1A 1 OF 1 METRIC

(Formerly BH 1A, WP 109-68-02) *

W.P. 604-90-01/02 LOCATION Co-Ords: N 4 820 827.4; E 243 248.6 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 09 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.3	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Dense to Very Dense					▼	304				
			1	SS	34				○		36 45 (19)
			2	SS	42		302		○		
			3	SS	69				○		
			4	SS	110 /15cm				○		
299.7							300				
4.6	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		5	RC	REC 95%						
			6	RC	REC 95%						
297.8							298				
6.5	End of Borehole * Embankment Fill presently exists at Borehole location										

+^{3}, ×^{5}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 1B

1 OF 1 METRIC

(Formerly BH 1B, WP 109-68-02) *

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 805.3; E 243 242.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 08 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.2	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Loose / Dense to Very Dense Brown		1	SS	6	▼	304		o		
			2	SS	30				o		
			3	SS	87		302		o		
			4	SS	70				o		56 34 (10)
			5	SS	59		300		o		
298.9			6	RC	REC 98%						
5.3	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		7	RC	REC 98%		298				
296.4			8	RC	REC 95%						
7.8	End of Borehole * Embankment Fill presently exists at Borehole location										

+³, ×⁵: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2A

1 OF 1 METRIC

(Formerly BH 2A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords;N 4 820 825.5; E 243 265.3 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 16-17 CHECKED BY HR

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa: o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 20 40 60 80 100	WATER CONTENT (%) 10 20 30	γ kN/m^3	GR SA SI CL
304.0 / 0.0	Roft Deck										
302.8 / 1.2	Water										
	Compact Very Dense Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand & Silt (Glacial Till)		1	SS	24		302		o		
			2	SS	69				o		
			3	SS	106		300		o		
299.4			4	SS	152 /17cm				o		
4.6	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		5	RC	REC 97%		298				
298.0 / 6.0	End of Borehole										

+^{3}, x^5 : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2B

1 OF 1 METRIC

(Formerly BH 2B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 803.7; E 243 257.9 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 14 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.1	Raft Deck										
0.0											
302.9	Water										
1.2	Heterogeneous Mixture of Boulders, Cobbles, Gravel Sand and Silt (Glacial Till) Brown, Dense		1	SS	31		302				
			2	SS	**						
			3	RC	REC 94%						
300.2			4	RC	REC 33%						
3.9	Weathered / Unweathered Dolostone Bedrock Weak		5	RC	REC 75%		300				
			6	RC	REC 100%						
298.4											
5.7	End of Borehole ** Sampler Bouncing										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3A 1 OF 1 METRIC

(Formerly Bh 3A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 824.2; E 243 277.4 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 17 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.1	Raft Deck										
0.0											
	Water										
302.9											
1.2	Heterogenous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Compact		1	SS	22				○		
302.1											
2.0	Weathered / Unweathered		2	RC	REC 95%		302				
	Dolostone Bedrock Weak										
			3	RC	–		300				
299.0											
5.1	End of Borehole										

+^{3}, ×^{5} : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3B

1 OF 1 METRIC

(Formerly BH 3B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 802.4; E 243 270.1 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
304.0	Raft Deck										
0.0											
302.8	Water										
1.2	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		1	SS	113 /20cm		302		o		
301.7											
2.3	Dolostone Bedrock Weak, Unweathered		2	RC	REC 95%						
300.2											
3.8	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4A 1 OF 1 METRIC

(Formerly BH 4A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 822.0; E 243 295.4 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 20-21 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.2	Raft Deck										
0.0							304				
303.2	Water										
1.0	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Brown, Compact to Very Dense		1	SS	50/5cm						
			2	SS	27		302				
301.3			3	SS	65/5cm				o		
2.9	Dolostone Bedrock Weak, Unweathered		4	RC	REC 98%						
299.9							300				
4.3	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4B

1 OF 1 METRIC

(Formerly BH 4B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 800.9; E 243 286.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE * QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.1	Raft Deck										
0.0											
303.1	Water										
1.0	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Very Dense		1	SS	140				o		
			2	RC	REC 98%		302				
301.7											
2.4	Dolostone Bedrock Weak, Unweathered		3	RC	REC 97%						
300.2											
3.9	End of Borehole										

+^{3}, x^5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5A 1 OF 1 METRIC

(Formerly BH 5A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 820.3; E 243 307.8 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 20 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.8	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown Compact, Trace Organics					▼					
	Dense		1	SS	24						
			2	SS	43		302				
301.1											
2.7	Dolostone Bedrock Weak, Unweathered		3	RC	REC 100%						
			4	RC	REC 100%		300				
299.6											
4.2	End of Borehole										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 20 40 60 80 100

WATER CONTENT (%): PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) 303.8 GR SA SI CL

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5B

1 OF 1 METRIC

(Formerly BH 5B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords:N 4 820 798.4; E 243 299.2 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 16-17 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.9 0.0	Ground Surface										
	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)					▼					
			1	SS	34						
	Dense, Trace Organics										
	Very Dense		2	SS	101	/20cm	302		o		58 30 (12)
300.3			3	SS	200				o		
3.6	Dolostone Bedrock Weak, Unweathered		4	RC	REC 98%		300				
			5	RC	REC 98%						
297.4			6	RC	REC 99%		298				
6.5	End of Borehole										

+^{3}, ×^{5} : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 6A 1 OF 1 METRIC

(Formerly BH 6A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 817.5; E 243 313.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring COMPILED BY GA

DATUM Geodetic DATE 69 10 22-23 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.2	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)		1	SS	14		306		o		
	Loose to Compact		2	SS	7				o		
303.9							304				
2.3	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		3	SS	21	▼					
	Compact to Very Dense		4	SS	58						
	trace Organics						302				
			5	SS	84	/23cm			o		
300.1			6	SS	100	** /18cm			o		
6.1	End of Borehole										

** Sampler Bouncing

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6B

1 OF 1 METRIC

(Formerly BH 68, WP 109-68-02) *

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 798.0; E 243 305.9 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.2	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Compact		1	SS	11	▼	304		o		0 51 (49)
			2	SS	**						
302.3											
1.9	Dolostone Bedrock Weak, Unweathered		3	RC	REC 100%		302				
			4	RC	REC 98%						
299.9							300				
4.3	End of Borehole										

* Fill Material presently exists at Borehole location

** Sampler Bouncing

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7A

1 OF 1 METRIC

(Formerly BH 7A, WP 109-68-02)*

W.P. 604-90-01/02 LOCATION Co-ords:N 4 820 815.5; E 243 337.0 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 10 & 14 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
306.8	Ground Surface										
0.0	Irregular Mixture of Gravel, Sand and Silt (Fill Material) Compact		1	SS	22		306				
			2	SS	12				o		51 27 20 2
303.3			3	SS	21		304		o		
3.5	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Dense		4	SS	36	▼					
301.9			5	SS			302				
4.9	Dolostone Bedrock Weak, Unweathered		6	RC	REC 75%						
			7	RC	REC 100%						
299.9							300				
6.9	End of Borehole										

* Embankment Fill presently exists at Borehole location

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \overset{20}{\diamond} 5$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7B

1 OF 1 METRIC

(Formerly BH 7B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 792.4; E 243 327.3 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 14-15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
307.5	Ground Surface										
0.0	Irregular Mixture of Silt to Clayey Silt, Sand and Gravel (Fill Material) Loose to Compact/Stiff		1	SS	9		307				
			2	SS	10						
			3	SS	14		305		o		
303.6			4	SS	13				o		
3.9	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)					▼					
302.4	Compact		5	SS	127/25cm		303		o		
5.1	Dolostone Bedrock Weak, Unweathered		6	RC	REC 95%						
301.0											
6.5	End of Borehole										

* Embankment Fill presently exists at Borehole location

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 815.7 E 243 235.7 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 16 CHECKED BY PP

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.3	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)		1	SS	1		310				
	Brown, Very Loose										
	Brown with Black, trace Organics		2	SS	19		308		○		39 44 11 6
	Compact to Very Dense										
			3	SS	51		306				
	Grey		4	SS	23				○		46 29 21 4
303.7						▼*	304				
7.6	Heterogeneous Mixture of Gravel, Sand and Silt Trace Organics (Glacial Till), Compact Brown with Black		5	SS	23				○		37 42 18 3
302.2											
9.1	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		6	SS	60 /5cm		302				
			7	RC	REC 100%						RQD = 53%
300.4											
10.9	End of Borehole										

* 93 02 17

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 807.1 E 243 312.9 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 16 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
307.0	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Compact to Dense		1	SS	32		306		o		37 32 24 7
			2	SS	17				o		15 35 40 10
304.0							304				
3.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till), Loose Trace Organics Grey with Black Inclusions		3	SS	7	▼			o		53 27 18 2
			4	SS	60	/5cm					
302.6											
4.4	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		5	RC	REC 100%		302				RQD = 36%
301.1											
5.9	End of Borehole										
	* 93 02 17										

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 803.1 E 243 340.7 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 17 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.1	Ground Surface										
0.0	Loose Compact to Dense Irregular Mixture of Silt, Sand and Gravel with Random Zones of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	2		312				
			2	SS	36		310		o		4 34 45 17
			3	SS	61						
			4	SS	29		308				
	Trace Organics		5	SS	17						
	Brown		6	SS	38		306		o		32 43 20 5
			7	SS	14	▼*					
304.0											
9.1	Black, Trace Organics Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		8	SS	15		304			43	0 29 63 8
302.5	Brown, Compact										
10.6	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		9	RC	REC 100%		302				RQD = 0%
301.0											
12.1	End of Borehole										

• 93 02 18

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 604-90-01/02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	7	9.35-10.87	100	53	9.35-10.87	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
9	5	4.42-5.94	100	36	4.42-5.94	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 3 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
10	9	10.62-12.14	100	0	10.62-12.14	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 2 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

FOUNDATION INVESTIGATION REPORT

For

Proposed Hwy. 6 N-E/W Ramp Structure

(CNR Subway)

W.P. 533-91-02, Site 35-576

Hwy. 6 & 24, District 3, Stratford

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with the proposed Hwy. 6 N-E/W ramp structure that will carry traffic beneath the existing CNR line (known as the Fergus subdivision) to Wellington Street (Hwy. 24). A rigid frame, single span subway structure will support the railroad tracks.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately fifty(50) metres west of the existing four(4) span Hwy. 6/CNR subway structure in the City of Guelph, Wellington County. The existing structure is a four span concrete beam structure that is located approximately two hundred(200) metres north of the existing Wellington Street (Hwy. 24) and Hanlon Expressway (Hwy. 6)

intersection. The Manor Motel is located on the northeast quadrant of the intersection and a gas station and a hardware store are located west of the intersection in close proximity of the proposed ramp roadway.

The site is characterized by a rolling terrain incised by excavation cuts. Prominent excavations exist at the existing Hwy. 6/CNR subway structure south approach and also north of the proposed ramp where apparently a sand and gravel pit once existed. Excavation slopes at the CNR tracks at the site are approximately three(3) to five(5) metres high and stable at approximately 3H:1V. The land is covered by grassland and small clusters of trees are located within the site area.

An existing 3.4 m diameter tunnel within the rock at the site underlies the proposed ramp structure. The tunnel which has an invert elevation of 303.1 m serves as a storm relief sewer. An open channel collects stormwater north of the site and water is then pumped within the tunnel beneath the tracks and south of Wellington Street, where the stormwater exits through a 3.4 m x 7.6 m multi-plate super span structure into an open channel. The stormwater eventually flows into the Speed River located further south at the site. A concrete block pumphouse and inlet shaft are present at the toe of the existing north railroad slope situated just west of the proposed S-E/W ramp alignment.

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this

area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximately 12,000 years ago), the ice which moulded this field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

As a product of the glacial activity the general landform pattern consists of drumlins or groups of drumlins fringed by gravel terraces. The dominant soil materials associated with these features are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways. Overburden in the site area is underlain by dolostones of the Amabel and Guelph Formations. Native overburden thicknesses are relatively shallow at the site and usually less than eleven(11) metres.

INVESTIGATION PROCEDURES

GENERAL

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analysis. Details of the field investigation and laboratory testing

program are discussed below.

The fieldwork for this project was conducted between 93 02 12 and 93 03 03 and consisted of a total of eleven(11) boreholes. The boreholes were advanced to depths ranging from 6.9 metres to 13.6 metres below the ground surface. All boreholes were advanced using conventional track mounted Central Mining Equipment (CME) 55 drilling units. Hollow stem augering techniques were used to penetrate the overburden at the site.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). An automatic hydraulic tripping hammer mechanism was used to impart the standard driving energy. Samples were generally retrieved at 0.76 m intervals within a 5 metre significant depth of a potential shallow foundation elevation and at 1.5 m intervals beyond this depth.

Bedrock underlying the overburden was cored up to 3.2 metres in depth using conventional rock coring techniques. A NX core barrel within NW casing was used in the coring process.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. Natural moisture contents and soil gradations were determined by conducting the appropriate laboratory tests on representative samples. Sample preparation and testing was conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The rock core logging includes descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and

figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

General

The subsurface conditions at the site consists of an extensive surficial native deposit comprised of a heterogeneous mixture of gravel, sand and silt underlain by dolostone bedrock. The heterogeneous mixture of gravel, sand and silt has a thickness ranging from 5.5 to 10.6 metres and has a denseness ranging from very loose to very dense. In general, however, its denseness ranges from compact to very dense. The dolostone bedrock is of the Guelph Formation and the bedrock surface elevation varies from 309.5 m to 312.4 m.

A plan of the site illustrating the locations and elevations of the boreholes and proposed structure foundation locations is shown on Dwg. No. 5339102-A*. The proposed profile grade of the N-E/W ramp roadway and a stratigraphical section profile is also shown. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical profile section and also on the individual Record of Borehole sheets in the Appendix.

Detailed soil/rock descriptions are given below.

* Dwg. No AA956-29.31-1.2, Sheet 220, of the Contract Drawings.

SOIL/ROCK DESCRIPTIONS

Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)

The native surficial deposit at the site consists of a heterogeneous mixture of gravel, sand and silt that extends to depths ranging from 5.5 metres to 10.6 metres. This deposit is an unsorted, unstratified material of glacial till origin and as characteristic of these deposits, also contains boulders and cobbles. The deposit is predominantly brown, although traces of organics present within the surficial one to two metres gives the deposit a blackish hue at some locations.

A grain size distribution envelope produced by mechanical sieve and hydrometer analysis is given in Figure 1 in the Appendix. The results reveal a broad range of particle sizes ranging primarily from silt to gravel. The envelope does not include particle sizes larger than gravel. The broad range of particle sizes is typical of deposits of glacial till origin.

The 'N' values as determined by the Standard Penetration Test range from 4 blows/0.3 m to 60 blows/0.3 m indicating a denseness ranging from very loose to very dense. The larger 'N' values may be a reflection of the presence of the larger particle sizes in the deposit. In general, 'N' values exceed 10 blows/0.3 m and hence can be categorized as having a compact to very dense state of denseness. It appears that the material south of the CNR slope is of a "looser" denseness than the material elsewhere on the site.

Bedrock

The bedrock that underlies the heterogeneous mixture of gravel, sand and silt at the site consists of a light coloured dolostone of the Guelph Formation. Bedrock surface elevations ranged from 309.5 m to 312.4 m with surface elevations gradually increasing in a northward direction.

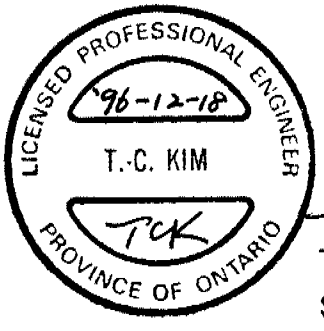
The dolostone bedrock is a chemical sedimentary rock that is medium grained. The rock is unweathered to slightly weathered and is featured by a porous "vug" texture and stylolites. The rock is very pale orange to yellowish brown and contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality and strength of the rock was carried out by measuring core recoveries and Rock Quality Desginations (RQD's) in the field and physical index property testing. Recoveries were all at 100% and RQD's ranged from 10% to 100%. In general, however recoveries ranged from 50% to 90% indicating that the rock is of fair to good quality.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, utilizing equipment owned and operated by Malone's Soil Samples. Logging of the rock core in the laboratory was carried out by D. Williams, Petrographer.

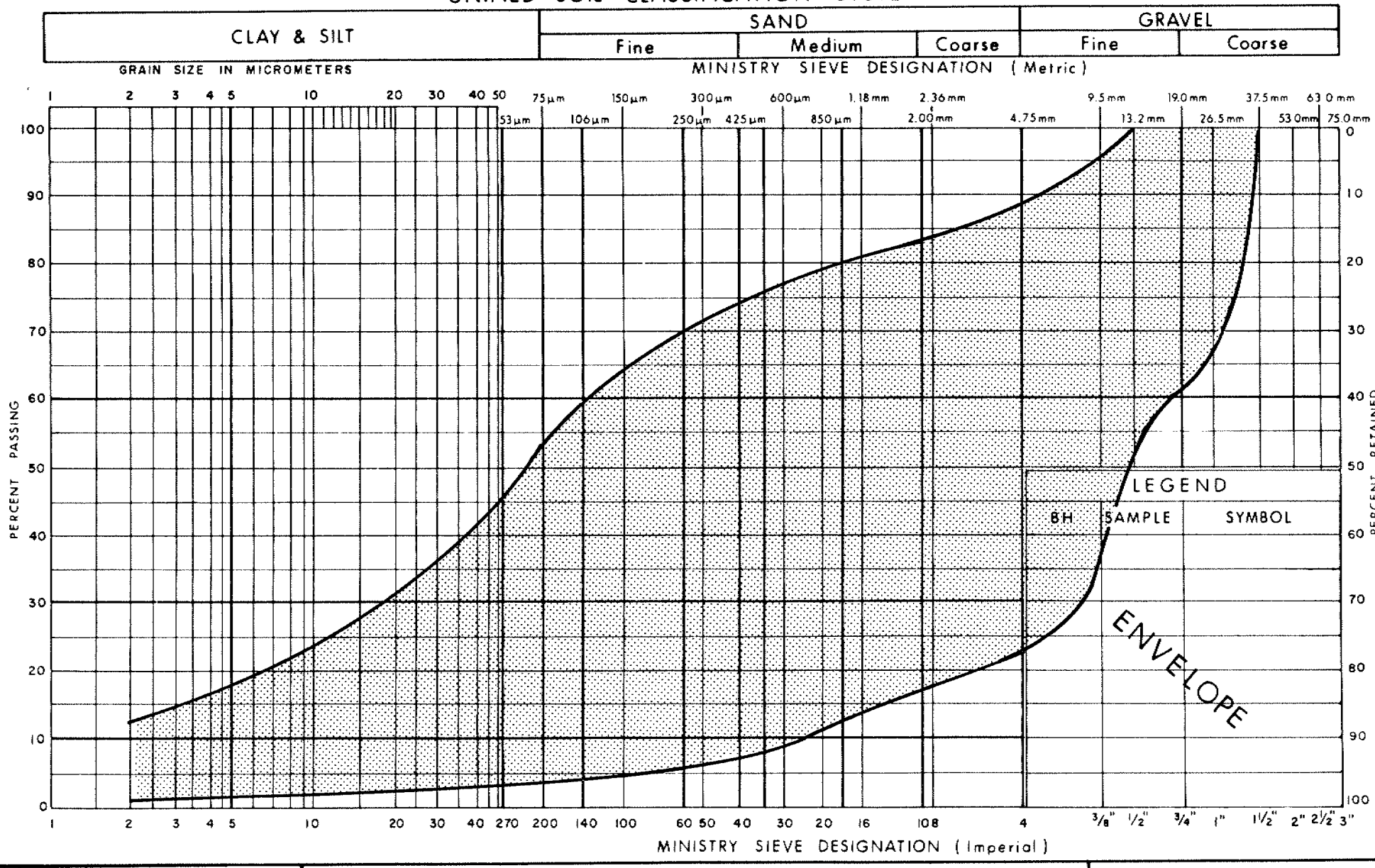
The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

GRAVEL, SAND & SILT, (Glacial Till)

FIG No 1

W P 533 - 91 - 02

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 895.0; E 242 779.5 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 03 01 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.1	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown		1	SS	37		320				
			2	SS	20						
			3	SS	19		318		o		51 43 5 1
	Compact to Dense										
	Very Dense		4	SS	100		316				
			5	SS	51						
			6	SS	66				o		15 48 28 9
			7	SS	106	/25cm	314				
			8	SS	120				o		10 46 36 8
			9	SS	60	/3cm					
311.5	trace Dolostone fragments		10	SS	**	▼*	312				
10.6	Dolostone Bedrock Weak, Unweathered		11	RC	REC 100%						RQD = 10%
310.0							310				
12.1	End of Borehole										

* 93 03 02

** Sampler Bouncing

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 860.0; E 242 790.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 03 02 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
321.7	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Very Dense		1	SS	62		320				
	Compact		2	SS	17		318				
			3	SS	26				o		55 38 6 1
			4	SS	60		316				
			5	SS	52				o		30 31 30 9
			6	SS	60	/15cm	314				
			7	SS	60	/13cm					
			8	SS	80		312				
311.5			9	SS	60	/3cm					
10.2	Dolostone Bedrock Weak, Unweathered		10	RC	REC 100%						RQD = 69%
			11	RC	REC 100%		310				RQD = 100%
308.4											
13.3	End of Borehole * 93 03 03										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 881.5; E 242 770.5 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 03 01-02 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
321.8	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown		1	SS	23		320				
			2	SS	17		318				
	Compact — Dense to Very Dense		3	SS	46		316				
			4	SS	30						
			5	SS	52		314				
			6	SS	47						
			7	SS	100		312				
			8	SS	60	/13cm					
311.2			9	SS	60	/10cm ▼*					
10.6	Dolostone Bedrock Weak, Unweathered		10	RC	REC 100%		310				RQD = 71%
308.2			11	RC	REC 100%						RQD = 88%
13.6	End of Borehole * 93 03 03										

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 851.0; E 242 779.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 03 03 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
322.0	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown		1	SS	30		320		○		60 32 6 2
			2	SS	18		318				
			3	SS	10		316				
			4	SS	14						
	Compact to Dense		5	SS	19						
	Dense to Very Dense		6	SS	37		314		○		29 59 10 2
			7	SS	86						
			8	SS	60	/15cm					
			9	SS	72		312				
311.4						▼*					
10.6	Dolostone Bedrock Weak, Unweathered		10	RC	REC 100%						RQD = 63%
309.9							310				
12.1	End of Borehole										
	* 93 03 04										

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 837.5; E 242 795.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 12 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
318.2	Ground Surface				
0.0	Heterogenous Mixture of Gravel, Sand and Silt (Glacial Till)	1	SS	43	
	Brown, Compact to Dense	2	SS	27	
		3	SS	15	55 38 6 1
		4	SS	14	
		5	SS	15	
		6	SS	16	78 18 (4)
		7	SS	24	
310.6		*	SS	**	
7.6	Dolostone Bedrock Weak, Unweathered to Slightly Weathered	9	RC	REC 100%	RQD = 83%
309.1					
9.1	End of Borehole				

* 92 02 15
** Sampler Bouncing

ELEVATION SCALE: 318, 316, 314, 312, 310

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m^3

GROUND WATER CONDITIONS

STRAT PLOT

SAMPLES

+^{3}, ×^{5} : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 820.0; E 242 788.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 12 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
318.6	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown with Black, trace Organics		1	SS	20		318				
	Brown, Very Loose to Compact		2	SS	15						
			3	SS	4		316				
			4	SS	6						
			5	SS	11		314		o		47 46 (7)
			6	SS	20						
			7	SS	24				o		54 40 (6)
	Dense		8	SS	45		312				
309.5			9	SS	**	▼*	310				
9.1	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		10	RC	REC 100%						RQD = 86%
			11	RC	REC 100%		308				RQD = 92%
306.3											
12.3	End of Borehole										

* 93 02 15

** Sampler Bouncing

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 803.5; E 242 803.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 12 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, * QUICK TRIAXIAL, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
318.2	Ground Surface										
0.0	Brown with Black, trace Organics					*	318				
	Brown		1	SS	29						
	Heterogeneous Mixture of Gravel, Sand and Silt		2	SS	27		316		o		38 35 23 4
	(Glacial Till)		3	SS	22						
	Compact										
	Dense to Very Dense		4	SS	47				o		32 51 (17)
			5	SS	35		314				
			6	SS	35						
			7	SS	110 /23cm		312				
			8	SS	81						
310.0							310				
8.2	Dolostone Bedrock Weak, Unweathered		9	RC	REC 100%						RQD = 66%
308.4											
9.8	End of Borehole										

* GWL not established

+^{3}, x^5: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 907.0; E 242 765.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 03 03 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
318.1	Ground Surface										
0.0	Heterogenous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Very Dense		1	SS	40		316				
	Compact		2	SS	19						
			3	SS	95						
			4	SS	30		314				
			5	SS	120						
312.2			6	SS	60	/10cm					
5.9	Dolostone Bedrock Weak, Unweathered		7	RC	REC 100%		312				RQD = 67%
310.6											
7.5	End of Borehole * 93 03 04										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 917.0; E 242 770.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 15 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
318.0 Ground Surface											
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown		1	SS	19						
			2	SS	29		316		o		33 39 22 6
	Compact										
	Dense to Very Dense		3	SS	43						
			4	SS	67		314				
	Cobbles and Boulders		5	SS	60	/3cm ▼					
312.4			6	SS	60	/8cm					
5.6	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		7	RC	REC 100%		312				RQD = 78%
310.9											
7.1	End of Borehole										
	• 93 02 16										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 13 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 932.0; E 242 762.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 15 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
317.8	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown Compact / Very Dense		1	SS	11	DRY	316				
			2	SS	61						
			3	SS	66		314				
			4	SS	60	/15cm					
			5	SS	60	/15cm					
312.0	Boulders and Cobbles		6	SS	85	/28cm	312				
5.8	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		7	RC	REC 100%						RQD = 57%
310.8											
7.0	End of Borehole • 93 02 16										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 14 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 950.5; E 242 740.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 15 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
318.0	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)					DRY					
	Loose		1	SS	7		316				
	Dense to Very Dense		2	SS	30				o		13 43 35 9
			3	SS	76						
			4	SS	60	/13cm	314		o		12 37 40 11
			5	SS	60	/13cm					
			6	SS	54						
			7	SS	60	/8cm	312				
311.4											
6.6	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		8	RC	REC 100%						RQD = 60%
309.9							310				
8.1	End of Borehole										
	• 93 02 16										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 15 1 OF 1 METRIC

W.P. 533-91-02 LOCATION Co-ords: N 4 820 986.0; E 242 723.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 15 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
316.3	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown					DRY *	316				
			1	SS	33						
			2	SS	31		314		o		41 39 (20)
	Dense										
	Very Dense		3	SS	83						
			4	SS	71						
			5	SS	60 /10cm		312				
310.8	Boulders and Cobbles		6	SS	100 /5cm						
5.5	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		7	RC	REC 100%		310				RQD = 75%
309.4											
6.9	End of Borehole										

* 93 02 16

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

ROCK CORE DESCRIPTION
WP 533-91-02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	11	10.59-12.12	100	10	10.59-12.12	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 2 cm in diameter, commonly containing calcite crystals; corals common), very pale orange to moderate brown; medium grained; weak; unweathered to slightly weathered (moderately weathered, 10.59-11.71 m); fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
2	10 11	10.21-11.73 11.73-13.26	100 100	69 100	10.21-13.26	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 3 cm in diameter; corals common), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
3	10 11	10.59-12.12 12.12-13.64	100 100	71 88	10.59-13.64	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 2 cm in diameter; stromatoporoids common), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
4	10	10.59-12.12	100	63	10.59-12.12	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 3 cm in diameter; stromatoporoids and corals common), very pale orange to medium grey; medium grained; weak; unweathered to slightly weathered (moderately weathered, 10.59-10.80 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
6	9	7.62-9.14	100	83	7.62-9.14	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to at least 5 cm in diameter; corals common), white to very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to close spaced, flat to near vertical, undulating to planar, smooth to rough.
7	10 11	9.24-10.77 10.77-12.29	100 100	86 92	9.24-12.29	**DOLOSTONE** (with abundant small vugs and some larger vugs up to at least 3 cm in diameter, commonly containing calcite crystals; corals and stromatoporoids common), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures wide to close spaced, flat to near vertical, undulating to planar, smooth to rough.
8	9	8.23-9.75	100	66	8.23-9.75	**DOLOSTONE** (with abundant small vugs and some larger vugs up to at least 5 cm in diameter), very pale orange to medium grey; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
10	7	5.94-7.47	100	67	5.94-7.47	**DOLOSTONE** (with abundant small vugs and some larger vugs up to at least 5 cm in diameter, commonly containing calcite crystals; corals common), white to very pale orange; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
11	7	5.56-7.09	100	78	5.56-7.09	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 3 cm in diameter; corals common), white to very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures wide to very close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)
Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
13	7	5.77-7.29	100	57	5.77-7.29	**DOLOSTONE** (with abundant small vugs and some larger vugs up to at least 4 cm in diameter; corals common), white to very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
14	8	6.61-8.13	100	60	6.61-8.13	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 4 cm in diameter, commonly containing calcite crystals), white to very pale orange to medium grey; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to dipping, undulating to planar, smooth to rough.
15	7	5.39-6.91	100	75	5.39-5.49 5.49-6.91	**OVERBURDEN** (till). **DOLOSTONE** (with abundant small vugs and some larger vugs up to at least 5 cm in diameter, commonly containing calcite crystals; corals common), very pale orange to medium grey; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

FOUNDATION INVESTIGATION REPORT

FOR

PROPOSED CROSSING AT

E/W-S RAMP AND SPEED RIVER

WP 533-91-03, SITE 35-578

HWY 6 & HWY 24 - DISTRICT 3, STRATFORD

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted at the proposed Hwy 24 E/W - Hwy 6 south ramp structure in the City of Guelph, District 3 (Stratford), within the Southwestern Region. The structure is proposed to cross the Speed River and is one of many structures planned in conjunction with the revamped Hanlon Expressway (Hwy 6) and Wellington Street (Hwy 24) interchange. The scope of this report is limited to the structure itself and immediate approaches.

SITE DESCRIPTION AND GEOLOGY

The site is located at the Speed River immediately adjacent and downstream of the existing Hwy 6 Southbound River Crossing. The site location is situated approximately 0.5 km south of the existing Hwy 24 in the City of Guelph, County of Wellington. The forward and transverse embankment fill slopes of the existing Hwy 6 Southbound structure bound the northern limits of the site. The

structure and the adjacent existing northbound structure are reinforced concrete four (4) span structures constructed in 1971. The Guelph Dolime rock quarry is located southeast of the site. Significant earth and rock excavation is evident at the quarry and stockpiles of processed dolostone is indicative of the operation. A woodlot containing tall deciduous trees is located immediately northwest of the site.

The Speed River flowing in a southerly direction is naturally the dominant feature at the site. At the site location, the river is approximately thirty-five metres in width. Embankment slopes exist on either side of the Speed River downstream of the proposed structure. The embankment slopes which are approximately three (3) metres in height are approximately 1.5H:1V to 2H:1V and covered with trees and low lying shrubs. At the crest of the eastern embankment, a gravel roadway exists. This roadway and a bridge located downstream permit access to the site south of the River. A concrete weir is presently located in the water at the proposed structure location.

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximately 12,000 years ago), the ice which moulded this field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the

drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

Therefore, the general landform pattern consists of drumlins or groups of drumlins fringed by gravel terraces. As a result, the dominant soil materials are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways.

Overburden in the site area is underlain by dolostones of the Amabel and Guelph Formations. Native overburden thickness are shallow at the site and usually less than four (4) metres.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

Field Investigation

The fieldwork for this project was conducted between 93 02 05 and 93 02 16 and consisted of a total of twelve (12) boreholes. The boreholes were advanced to depths ranging from 3.8 to 12.3m. Nine (9) of the twelve (12) boreholes were advanced in conjunction with structure foundation locations whereas three (3) of the boreholes were advanced at the proposed embankment fill locations.

Nine of the boreholes were advanced on land using conventional truck and track mounted Central Mining Equipment (CME) 55 drilling units. Hollow stem augering techniques were used to penetrate the overburden at the site. Traffic protection provided by the nearest Patrol (#13) was required on the Hwy 6 Southbound lane to advance four of these boreholes.

Two boreholes were advanced offshore and within the Speed River utilizing a raft and a more portable diamond drill unit. The diamond drill used was a skid mounted Boyles Bros. No. 1 unit that had a weight of approximately 700 kg. Conventional diamond drilling techniques that included washboring within rotary drilled casing was used to advance the boreholes.

Disturbed subsoil samples were retrieved in the overburden using a 50mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). The samples were generally retrieved at 0.76 intervals for the surficial 4.5 metres and at 1.5m intervals thereafter at the structure foundation locations. At the approach embankment locations, samples were retrieved at 1.5m intervals. The track/truck mounted units employed an automatic hydraulic tripping hammer mechanism to impart the standard driving energy. Bedrock underlying the overburden was cored up to 3.1 metres in depth using conventional rock coring techniques. A NXL core barrel within NW casing was used in the coring process.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual

classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes and the lake level was also monitored throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Southwestern Region Surveys and Plans. A boat was required to determine the lake bottom and lake level elevation at the boreholes located offshore.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation, and natural moisture contents were determined by conducting the appropriate laboratory tests on representative samples.

Sample preparation and testing were conducted in accordance with the MTO

Laboratory Testing Manual

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

General

The subsurface conditions at the site reflect the previous placement of fill material and hence consists of an irregular mixture of silt to clayey silt, sand and gravel at the proposed abutment locations and also at the east pier location. The thickness of this fill material varies up to 10.7 metres. At the locations beyond the fill placement, the native surficial deposit consists of a heterogeneous mixture of gravel, sand and silt. This deposit underlies the fill material where the latter exists and underlies the waters of the Speed River at the proposed west and centre piers. The deposit also contains boulders and cobbles which were explored and also visible at the river bottom. The thickness of this deposit varies from 0.6m to 4.6m.

The native heterogeneous mixture of gravel, sand and silt is underlain by dolostone bedrock. The bedrock was encountered at Elevations ranging from 299.8m

to 303.9 indicating an irregular bedrock surface.

A plan of the site illustrating the locations and elevations of the boreholes and proposed structure foundation locations is shown on Dwg. No. 5339103-A*.

A profile of the E/W-S ramp and a number of stratigraphical sections at the proposed structure foundation locations are also provided. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical sections and also on the individual Record of Boreholes sheets in the Appendix. A detailed description of the subsurface conditions are given below.

SOIL/ROCK DESCRIPTIONS

Water

Approximately 0.4m to 0.9m of standing water was present in the Speed River at the time of the investigation. The greater depths of water existed upstream of the concrete weir and water velocities produced turbulent flow immediately downstream of the concrete weir.

Irregular Mixture of Silt to Clayey Silt, Sand and Gravel (Fill Material)

The composition of the fill material present at the site is predominately an irregular mixture of brown silt, sand and gravel. However, at various locations, random zones of an irregular mixture of clayey silt, sand and gravel were also encountered. The thickness of the fill material varies up to 10.7 metres with the greatest thickness encountered at the crest of the approach embankment slope. Boulders and cobbles as inferred by auger grinding are also randomly present

* Dwg. No 2, Sheet 184, of the Contract Drawings.

within the fill material. A grain size distribution envelope as determined by hydrometer and mechanical sieve analysis and shown on Figure 1 in the Appendix illustrates the broad gradation of the fill material.

Figure 2 in the Appendix shows the results of Atterberg limit tests conducted on the fine grained portion of the fill material (less than 425 micrometres). The results reveal that liquid limits (w_l%) range from 17% to 24% and the plasticity index (Ip%) ranges from 4% to 8%. Based on these results, it can be concluded that at some random locations, the fine grained portion of the fill material contains sufficient clay fractions to exhibit a low plasticity and hence can be categorized as a plastic silt (ML) to a clayey silt (CL). However, as Figure 1 illustrates, silt, sand and gravel percentages predominant and hence the fill material exhibits generally a cohesionless non-plastic behaviour.

The "N" values as determined by the Standard Penetration Test ranged from 2 blows/0.3m to 70 blows/0.28m indicating a denseness ranging from very loose to very dense. In general, however, "N" values ranged between 5 blows/0.3m to 30 blows/0.3m representing a loose to compact state of denseness. The cohesive fill material can be described as soft to firm as indicated by the "N" values.

Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)

Underlying the fill material and water, and also occurring surficially at some locations across the site, a heterogeneous mixture of gravel, sand and silt exits. This deposit, which is predominantly brown in colour also contains a surficial black crust up to 1.5 metres in thickness at some locations. Boulders and cobbles are also present in this deposit as determined by actual sampling,

visual observation in the Speed River and frequent auger grinding that was encountered. The thickness of this deposit ranges from 0.6 metres to 4.6 metres.

A grain size distribution envelope produced by mechanical sieve and hydrometer analysis is given in Figure 3 in the Appendix. The results reveal a broad range of particle sizes ranging primarily from silt to gravel. (Note: the envelope does not include particle sizes larger than gravel). The broad range of particle sizes is typical of deposits of glacial till origin.

An Atterberg Limit test was conducted on a representative sample of the black soil which occurs at random locations (See BH 8, SS5) across the site. The test results reveals a liquid limit (w_l) of 53% and plasticity index of approximately 10%. Based on this result, the material can be categorized as an organic silt (MH).

The "N" values as determined by the Standard Penetration Test range from 8 blows/0.3m to 60 blows/0.3m. The larger "N" values may be the result of the larger boulder and cobble sizes and hence may not necessarily accurately represent the denseness of the deposit. The "N" values tend to generally range between 10 blows/0.3 and 50 blows/0.3m indicating a compact to dense state of denseness.

Bedrock

The bedrock that underlies the heterogeneous mixture of gravel, sand and silt at the site is primarily a light coloured dolostone of the Guelph formation. However, some darker coloured dolostone of the Amabel Formation was also

encountered underlying the Guelph Formation at the proposed east pier location. Bedrock surface elevations varied across the site and are summarized in Table 1 below.

TABLE 1 - BEDROCK SURFACE ELEVATIONS	
AREA	ELEVATION (m)
West Abutment/Approach	299.8 - 301.5
Particle Size Analysis	302.6 - 302.9
Natural Moisture Contents	303.1 - 303.9
Bulk Unit Weights	301.8 - 302.2

The dolostone bedrock is a chemical sedimentary rock that is medium grained. The rock is unweathered to slightly weathered and featured by a porous "vug" texture and stylolites. The rock is very pale orange to yellowish brown (Guelph Formation) and is light-grey to dark yellowish brown (Amabel Formation) in colour and contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality and strength of the rock was carried out by measuring core recoveries and Rock Quality Designations (RQD's) in the field and conducting physical index property tests. Recoveries ranged from 67% to 100% and RQD's ranged from 0% to 88%. In general, however, recoveries exceeded 90% and RQD's ranged from approximately 25% to 60% indicating that the rock is of poor

to fair quality.

Rock strengths can be described as weak for the Guelph formation and medium strong for the Amabel Formation. Rock core penetration were generally rapid which is indicative of the weaker nature of the sedimentary rock.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes and monitoring the lake level throughout the duration of the field investigation. The river level was approximately at elevation 303.7m at the time of the investigation and remained constant throughout the duration of this investigation.

On shore, the water level ranged from elevation 301.9m to 304.2m which is approximately equal to the elevation of the water level.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in the this report.

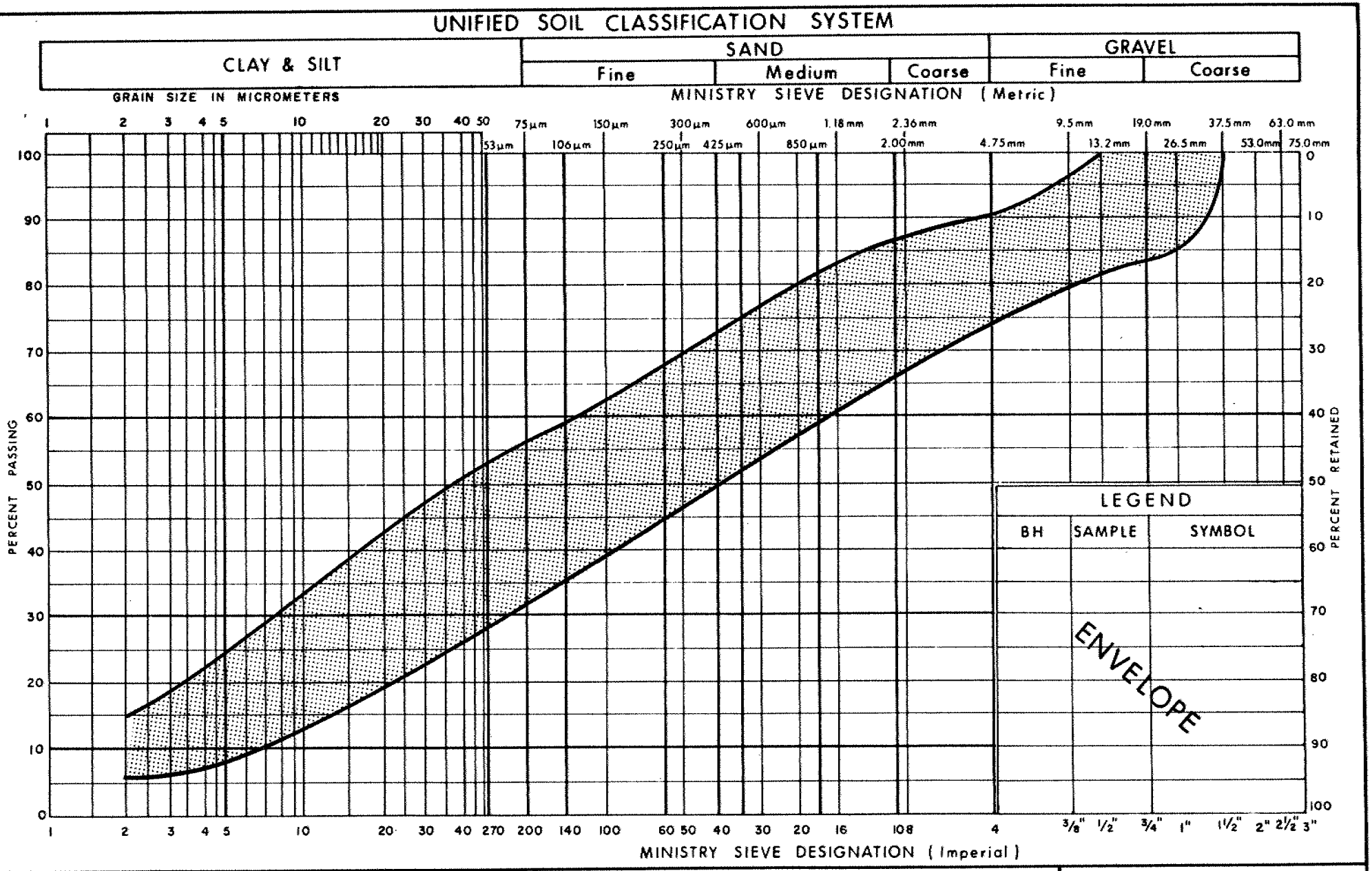
MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer utilizing equipment owned and operated by Malone's Soil Samples and Master Soils Investigation. Logging of the rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.

Taechul Kim
T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX



Ministry of Transportation
Ontario

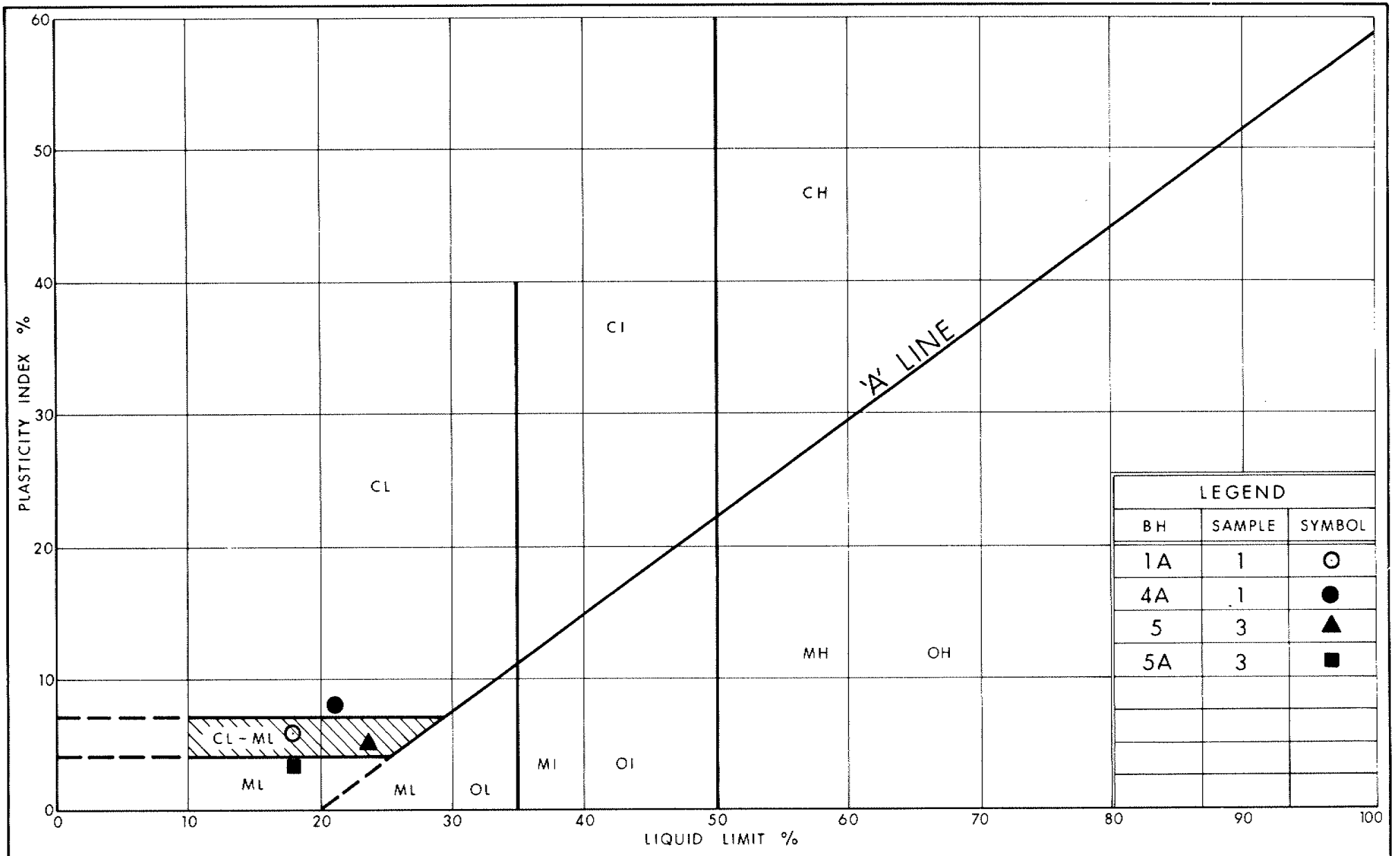
GRAIN SIZE DISTRIBUTION

IRREGULAR MIXTURE OF SILT TO CLAYEY SILT, SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 533 - 91 - 03

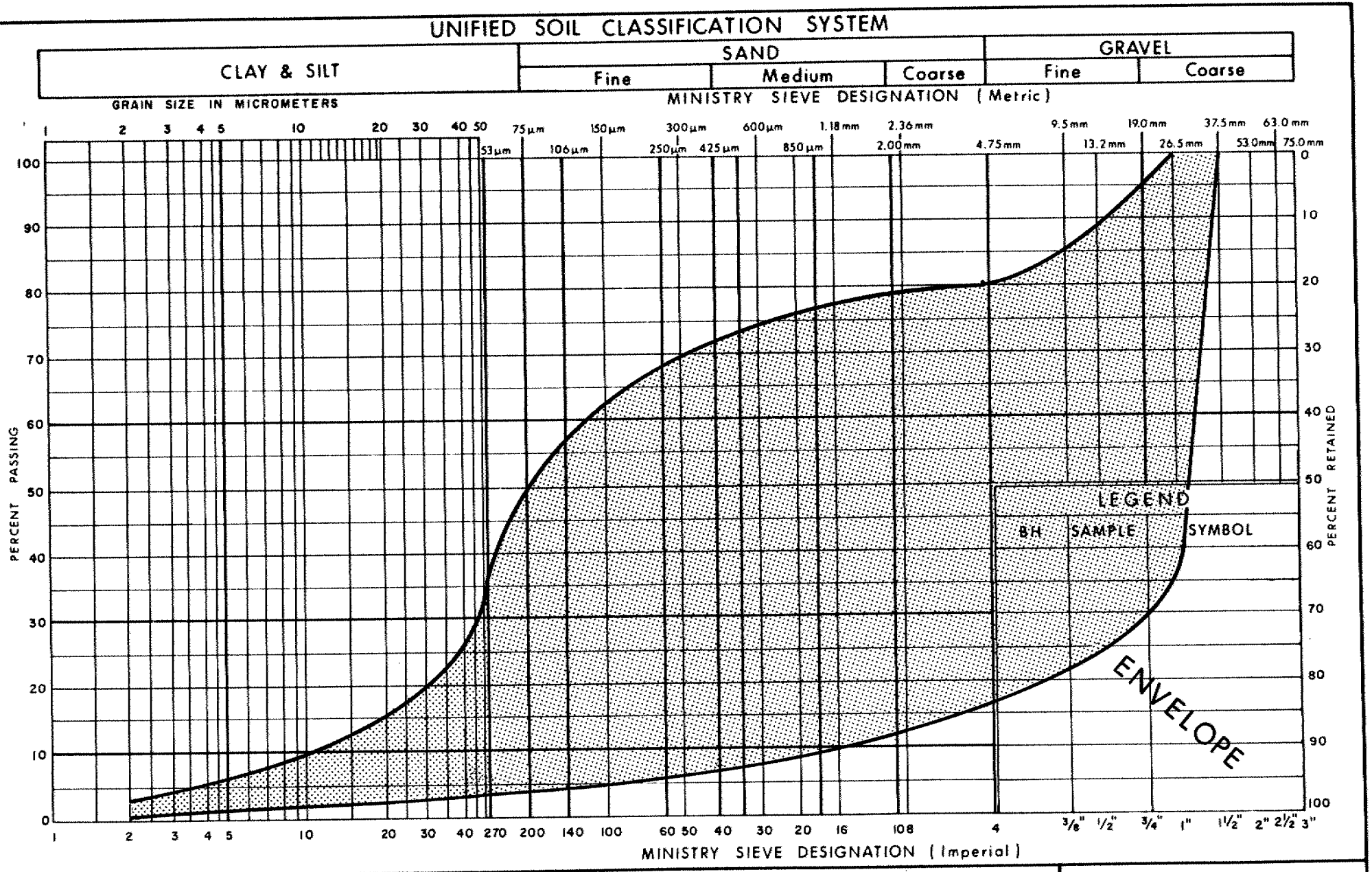
75



Ministry of Transportation
Ontario

PLASTICITY CHART
IRREGULAR MIXTURE OF SILT TO CLAYEY SILT, SAND & GRAVEL (FILL MATERIAL)

FIG No 2
W P 533-91-03



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Ontario

GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF
GRAVEL, SAND & SILT (Glacial Till)

FIG No 3

W P 533-91-03

77

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 780.6; E 243 231.8 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 05-08 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.0	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown Compact Dense to Very Dense		1	SS	18	▼*					
			2	SS	29		302				
			3	SS	46				o		53 37 (10)
			4	SS	60	/13cm					
300.2			5	SS	60	/8cm					
3.8	Dolostone Bedrock Weak, Slightly Weathered to Unweathered						300				
			6	RC	REC 100%						RQD = 88%
							298				
296.5			7	RC	REC 100%						RQD = 85%
7.5	End of Borehole										

• 93 02 09

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 1A 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 801.5; E 243 233.4 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 09 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.6	Roadway Surface										
0.0 / 311.2	Asphalt					*					
0.4	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Loose to Dense		1	SS	10		310		o	22.7	9 45 36 10
			2	SS	5		308		o		19 49 22 10
			3	SS	45						
			4	SS	45		306				
304.0											
7.6	Black, trace Organics		5	SS	8		304				
	Heterogenous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Loose to Compact		6	SS	22		302				
301.5			7	SS	60/3cm						
10.1	Dolostone Bedrock Weak, Unweathered		8	RC	REC 100%		300				RQD = 33%
299.7											
11.9	End of Borehole										

* GWL not established

+³, x⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 793.5; E 243 260.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 15-16 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
303.7	Water Surface										
0.0 302.8	Water										
0.9 302.2	Het. Mixt. of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Grey, Very Dense		1	SS	80 /13cm						
			2	SS	90 /8cm						
1.5	Dolostone Bedrock Weak, Unweathered		3	RC	REC 92%		302				RQD = 38%
			4	RC	REC 100%		300				RQD = 60%
299.4 4.3	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 780.0; E 243 280.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 16 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.6	Water Surface										
303.2 0.4	Water										
301.9	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Grey, Very Dense		1	RC	REC 40%		302				RQD = 0%
298.7 1.7	Dolostone Bedrock Weak, Unweathered		2	RC	REC 100%		300				RQD = 18%
			3	RC	REC 100%						RQD = 0%
4.9	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3A 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 791.0; E 243 284.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 16 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.7 Water Surface											
0.0 303.0	Water										
0.7	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		1	SS	8						
301.8	Trace Organics Grey, Loose to Very Dense		2	SS	95 /23cm		302				
1.9	Dolostone Bedrock Weak, Unweathered		3	RC	REC 92%						RQD = 33%
299.9			4	RC	REC 100%		300				RQD = 54%
3.8	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 787.0; E 243 307.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 08 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.9	Ground Surface										
0.0	Irregular Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Fill Material) Brown, Compact		1	SS	70	/28cm	306				
			2	SS	18						
303.9			3	SS	60	/3cm	304				
3.0	Dolostone Bedrock Slightly Weathered to Unweathered		4	SS	60	/3cm					
			5	RC	REC 67%						RQD = 67%
			6	RC	REC 87%		302				RQD = 8%
	Weak										
	Medium Strong		7	RC	REC 100%		300				RQD = 0%
299.1											
7.8	End of Borehole										
	* 93 02 10										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4A 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 776.5; E 243 304.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 08-09 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.8	Ground Surface										
0.0	Irregular Mixture of Silt to Clayey Silt, Sand and Gravel (Fill Material) Brown, Loose to Compact / Soft to Firm		1	SS	10		306				
			2	SS	5						
			3	SS	8		304				
303.1			4	SS	60/3cm	▼*					
3.7	Dolostone Bedrock Slightly Weathered to Unweathered		5	RC	REC 100%		302				RQD = 34%
	Weak		6	RC	REC 100%						RQD = 10%
299.9	Medium Strong						300				
6.9	End of Borehole										

* 93 02 10

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 773.5; E 243 322.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 05 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
307.6	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Loose to Compact		1	SS	9		306				
			2	SS	14						
303.8			3	SS	13		304		o		27 40 27 6
3.8	Black, trace Organics		4	SS	9						
302.9	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Loose to Compact		5	SS	60 /13cm	▼*					
4.7			6	SS	50 /3cm		302				
	Dolostone Bedrock Weak, Unweathered		7	RC	REC 88%						RQD = 36%
299.2			8	RC	REC 100%		300				RQD = 38%
8.4	End of Borehole										
	* 93 02 08										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5A 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 787.5; E 243 331.3 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 10 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.3	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Loose to Dense		1	SS	6		312		o		10 41 38 11
			2	SS	2		310				
			3	SS	15				o H		26 35 28 11
			4	SS	34		308				
305.7											
7.6	Black, trace Organics / Brown Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Compact		5	SS	10	▼*	306				
			6	SS	23		304				
302.6			7	SS	60 /13cm						
10.7	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		8	RC	REC 100%		302				RQD = 28%
301.0											
12.3	End of Borehole • 93 02 11										

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 780.5; E 243 350.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 02 11 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.6	Roadway Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Loose to Compact		1	SS	6	DRY •	312				
			2	SS	8		310		o		26 30 35 9
			3	SS	23		308				
			4	SS	16		306				
			5	SS	26		304				
302.9			6	SS	14						
10.7	Dolostone Bedrock		7	SS	56						
302.3	Weak, Slightly Weathered										
11.3	End of Borehole										

• 93 02 12

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 783.5; E 243 206.9 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 93 02 08 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.4	Ground Surface										
0.0	Black, trace Organics		1	SS	9	▼*	304				
	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		2	SS	13						
			3	SS	48		302		o		84 13 3 0
	Brown, Loose to Dense		4	SS	60 /3cm						
299.8			5	SS	60 /3cm		300				
4.6	Dolostone Bedrock Weak, Slightly Weathered to Unweathered										
298.2			6	SS	60 /10cm						
6.2	End of Borehole										

* 93 02 09

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 533-91-03 LOCATION Co-ords: N 4 820 801.0; E 243 216.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 02 11 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.3	Roadway Surface										
0.0	Irregular Mixture of Silt to Clayey Silt, Sand and Gravel (Fill Material) Brown, Compact to Dense/ Soft to Firm		1	SS	7	*	310		o		24 38 30 8
			2	SS	3		308				
			3	SS	44				o		48 41 9 2
			4	SS	23		306				
303.7							304				
7.6	Black, Organic		5	SS	20				o	53	20 28 49 3
	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Grey, Compact to Dense		6	SS	44		302		o		20 57 21 2
300.6			7	SS	60	/13cm					
10.7	Dolostone Bedrock Weak, Slightly Weathered										
300.1											
11.2	End of Borehole										

* G.W.L. not established

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

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

ROCK CORE DESCRIPTION
WP 533-91-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1B	6 7	4.42-5.94 5.94-7.47	100 100	88 85	4.42-7.47	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to 6 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (4.42-7.32 m) and dark yellowish brown to pale yellowish brown (7.32-7.47 m); medium grained; weak (4.42-7.32 m) to medium strong (7.32-7.47 m); unweathered to slightly weathered; fractures wide to very close spaced, flat to dipping, undulating to planar, smooth to rough.
1C	8	10.36-11.89	100	33	10.36-10.46 10.46-11.89	**OVERBURDEN** (till). **DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to dipping, undulating to planar, smooth to rough.
2	3 4	1.54-2.84 2.84-4.29	92 100	38 60	1.54-4.29	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 3 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
3	1	0.36-1.88	40	0	0.36-1.73	**OVERBURDEN** (till).
	2	1.88-3.40	100	18	1.73-4.93	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to at least 5 cm in diameter, commonly containing calcite and sphalerite crystals), very pale orange to pale yellowish brown (1.73-3.71 m) and dark yellowish brown to pale yellowish brown (3.71-4.93 m); medium grained; weak (1.73-3.71 m) to medium strong (3.71-4.93 m); unweathered to slightly weathered; fractures close to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
	3	3.40-4.93	100	0		
3A	3	1.88-2.80	92	33	1.88-3.81	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 1 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures close to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
	4	2.80-3.81	100	54		
4	5	3.81-4.72	67	67	3.81-7.77	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to at least 7 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (3.81-6.27 m) and dark yellowish brown to pale yellowish brown (6.27-7.77 m); medium grained; weak (3.81-6.27 m) to medium strong (6.27-7.77 m); unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	6	4.72-6.25	87	8		
	7	6.25-7.77	100	0		

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
4A	5 6	3.83-5.36 5.36-6.88	100 100	34 10	3.83-6.88	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to 5 cm in diameter, commonly containing calcite and sphalerite crystals), very pale orange to pale yellowish brown (3.83-6.43 m) and dark yellowish brown to pale yellowish brown (6.43-6.88 m); medium grained; weak (3.83-6.43 m) to medium strong (6.43-6.88 m); unweathered to slightly weathered; fractures close to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
5	7 8	5.36-6.88 6.88-8.41	88 100	36 38	5.36-8.41	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to 5 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (5.36-8.23 m) and dark yellowish brown to pale yellowish brown (8.23-8.41 m); medium grained; weak (5.36-8.23 m) to medium strong (8.23-8.41 m); unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
5C	8	10.80-12.32	100	28	10.80-12.32	**DOLOSTONE** (with stylolites and abundant small vugs), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

FOUNDATION INVESTIGATION REPORT

For

Proposed S-E/W Ramp Structure Crossing

Over Speed River

and

Adjacent Retaining Wall

W.P. 533-91-04, Site 35-579

Hwy. 6 & Hwy. 24 District 3, Stratford

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the proposed Hwy. 6 South - Hwy. 24 E/W Ramp structure and adjacent retaining wall in the City of Guelph, District 3 (Stratford) within the Southwestern Region. The ramp structure is proposed to cross the Speed River and the retaining wall is proposed immediately south of the structure extending beyond the ramp structure abutment and the existing Hydro transmission tower which is located approximately 30 metres south of the abutment. The structures are planned in conjunction with the new Hanlon Expressway (Hwy. 6) and Wellington Street (Hwy. 24) interchange. The new interchange will replace the existing level intersection that is now present. The scope of the report is limited to the structures and immediate approaches.

SITE DESCRIPTION AND GEOLOGY

General

The site is located approximately 75 to 100 metres east of the existing Hwy. 6 Northbound/Speed River Crossing structure in the City of Guelph, Wellington County. Wellington Street (Hwy. 24) is located approximately 0.5 km north of the proposed structure

location. The existing northbound structure is located adjacent to a twin southbound structure. The structures are reinforced concrete four (4) span structures constructed in 1971.

The Speed River flowing in a westerly direction is naturally the dominant feature at the site. At the site location, the river is approximately thirty-five metres in width. Embankment slopes, approximately 1H:1V and five (5) metres in height are present on the south river bank whereas on the north river bank the land is flat adjacent to the river. The south embankment appears to be the result of fill placed for the construction of an access roadway in the area. The river level at the time of the investigation was approximately 1 metre in depth.

Beyond the river on the south side, the slope of the ground rises gradually. A hydro corridor exists within the southern limits of the site. On the north side, the ground surface rises gradually as well but approximately 100 metres north of the site, the ground level is flat. An abandoned landfill site is situated at this location. It appears that this area was the location of a former gravel pit.

Land Use and Terrain

The site is mainly grassland, which was snow covered for the duration of the investigation. Some wooded areas are also located along the Speed River.

There are several storm water outfalls in the general site area. The storm sewers discharge storm waters into the Speed River.

Land use surrounding the site is primarily residential and industrial. A new residential subdivision was partially completed in the area south of the site at the time of the investigation. The Guelph Dolome Quarry is situated just west of the site and the Bryden Apartments and Manor Motel are located north of the site.

Geology

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximately 12,000 years ago), the ice which moulded this drumlin field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

As a result of the glacial activity, the general landform pattern consists of drumlins or groups of drumlins fringed by gravel terraces. The dominant soil materials are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways. Overburden in the site

area is underlain by dolostones of the Amabel and Guelph Formations. Overburden thicknesses are shallow in the site and usually less than five (5) metres.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analysis. Details of the field investigation and laboratory testing program are discussed below.

Field Investigation

The fieldwork for this project was conducted between 93 02 01 and 93 03 11 and consisted of a total of thirteen(13) boreholes. The boreholes were advanced to depths ranging from 2.1 m to 11.9 m. Two dynamic cone penetration tests advanced to depths of 4.9 m and 6.7 m were also conducted. Six (6) of the boreholes were advanced in conjunction with the proposed S-E/W Ramp structure foundation locations and two (2) of the boreholes were advanced at the proposed embankment fill locations in advance of this structure. A total of five(5) boreholes were advanced in conjunction with the proposed retaining wall.

Eleven of the boreholes were advanced on land using a conventional track mounted Central Mining Equipment (CME) 55 drilling unit. Hollow stem augering techniques were used to penetrate the overburden at these borehole locations.

Two boreholes were advanced offshore and within the Speed River utilizing a raft and a more portable, diamond drill unit. The diamond drill used was a skid mounted Boyles Bros. No. 1 unit that had a weight of approximately 700 kg. Conventional diamond drilling techniques that included washboring within rotary driven casing was used to advance the boreholes.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). The samples were generally retrieved at 0.76 m intervals for the surficial 4.5 metres and at 1.5 m intervals thereafter. The track mounted unit employed an automatic hydraulic tripping hammer mechanism to impart the standard driving energy. Bedrock underlying the overburden was cored up to 3.1 metres in depth using conventional rock coring techniques. A NX core barrel within NW Casing was used in the coring process.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes and the lake level was also monitored throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Southwestern Region Surveys and Plans. A boat was required to determined the lake bottom and lake level elevations at the borehole locations off-shore.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation and natural moisture contents of the soil were determined by conducting the appropriate laboratory tests on representative samples.

Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The rock core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and

figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

General

The subsurface conditions across the site consist of a shallow native deposit comprised of a heterogeneous mixture of gravel, sand and silt underlain by dolostone bedrock. The heterogeneous mixture of gravel, sand and silt has a thickness ranging from 0.7 m to 4.4 m and is considered a glacial till deposit. Boulders and cobbles, which are characteristic of these types of deposits, were also encountered. The dolostone bedrock encountered were from two formations, the Guelph and the Amabel. The bedrock surface elevation varies from 299.3 m to 308.2 m.

As mentioned earlier, an embankment exists on the south river bank attributable to the placement of fill material placed and supposedly compacted over the native heterogeneous mixture of gravel, sand and silt. The fill material was placed up to a thickness of 5.0 metres and consists primarily of an irregular mixture of silt, sand and gravel. Traces of black organic inclusions are also present randomly within the fill material. The fill material overlies the native soil at the ramp structure location but the native soil thickness diminishes in a southerly direction and hence the fill material is directly underlain by bedrock at the southern limits of the proposed retaining wall.

Fill material also exists at the proposed north approach embankment location. The fill material, comprised of an irregular mixture of silt, sand and gravel with traces of organics and incinerated refuse is suspected to be part of the abandoned landfill. The thickness of this fill material is approximately 1.8 metres.

A plan of the site illustrating the locations and elevations of the boreholes is shown on Dwg. No. 5339104-A*. A subsoil stratigraphical profile is also provided. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical profile and also on the individual Record of Borehole sheets in the Appendix.

SOIL/ROCK DESCRIPTIONS

Water

Approximately 0.8 to 0.9 m of standing water was present in the Speed River at the time of the investigation. The water had frozen, although not completely, at the time of the investigation. Some flow was evident within the middle of the river.

Irregular Mixture of Silt, Sand and Gravel (Fill Material)

Fill material comprised of an irregular mixture of silt, sand and gravel exists at the proposed south abutment, south pier, retaining wall and also at the proposed north approach embankment location. The thickness of the fill material ranges from 1.5 m to 5.0 m south

*Dwg. No 2, Sheet 202, of the Contract Drawings.

of the river and has a thickness of approximately 1.8 metres at the north approach location. Traces of black organic material was evident within the predominantly brown material. Incinerated refuse material was also encountered at the north approach location.

A grain size distribution envelope as determined by hydrometer and mechanical sieve analysis that illustrates the gradation of the fill material is shown on Figure 1 in the Appendix. The envelope depicts a broad range of particle sizes ranging primarily from silt to gravel.

Atterberg Limit tests conducted on the fine grained portion (less than 425 micrometres) of some representative samples indicate that the fine grained portion ranges from a non-plastic silt to a plastic silt (ML). In general, however, it can be concluded that the material is cohesionless.

The 'N' values as determined by the Standard Penetration Test ranged from 3 blows/0.3 m to 60 blows/0.08 m. In general however, 'N'values were less than 30 blows/0.3 m indicating a state of denseness ranging from very loose to compact. The higher 'N' values are perhaps attributable to the larger gravel particle sizes within the fill material.

Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)

Underlying the fill material on land and the water offshore, a native heterogeneous mixture of gravel, sand and silt is present across the site. This deposit of glacial till origin is unsorted and unstratified and as observed by samples retrieved in the water and by

observation of the lake bottom and auger grinding inference, the deposit also contains boulders and cobbles. The deposit which varies in colour from brown to grey has a thickness ranging from 0.7 to 4.4 m. At some locations across the site, the surficial 1 to 1.5 metres of the deposit also contains traces of organics and hence is black in colour.

A grain size distribution envelope produced by mechanical sieve and hydrometer analysis is given on Figure 2 in the Appendix. The results reveal a broad range of particle sizes ranging primarily from silt to gravel. The envelope does not include particle sizes larger than gravel. The broad range of particle sizes is typical of deposits of glacial till origin.

The 'N'values as determined by the Standard Penetration Test range from as low as 2 blows/0.3 m to as high as 60 blows/0.03 m indicating a very loose to very dense state of denseness. The low 'N' values are the result of the organics in most cases and the larger 'N' values are the result of perhaps the natural denseness of the deposit and the larger gravel, cobble and boulder particle sizes.

Bedrock

The bedrock at the site underlies the heterogeneous mixture of gravel, sand and silt and consists of a "vuggy" fossiliferous dolostone of the Guelph and the underlying Eramosa Member of the Amabel Formation. The Guelph dolostone, the younger formation, was encountered at the boreholes within the water at an elevation ranging from 300.7 m to 302 m. Offshore and south of the river the Amabel dolostone was encountered at elevations ranging from 299.3 m to 299.8 m at the S-E/W ramp structure and along the proposed

retaining wall, the bedrock surface elevation rises from Elevation 302.7 m to Elevation 308.2 m in a southerly direction. The bedrock surface varies from 301.4 m to 301.8 m north of the river. Up to 3 metres of NX rock core was retrieved at each of the individual boreholes advanced at the proposed structure foundation locations.

The dolostone bedrock is a chemical sedimentary rock that is medium grained. The rock is unweathered to slightly weathered and is featured by a porous "vug" texture and stylolites. The rock is very pale orange to yellowish brown (Guelph Formation) to dark yellowish brown (Amabel Formation) in colour and contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality of strength of the rock was carried out by measuring core recoveries and Rock Quality Designations (RQD's) in the field and conducting physical index property tests. Recoveries were in the order of 95 to 100% and RQD's ranged from 0% to 66% indicating that the rock is of very poor to fair quality. Rock strengths can be described as medium strong for the Amabel Formation and weak for the Guelph Formation. Rock Core penetration rates were generally rapid which is indicative of the weaker nature of this sedimentary rock.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes and monitoring the lake level throughout the duration of the field

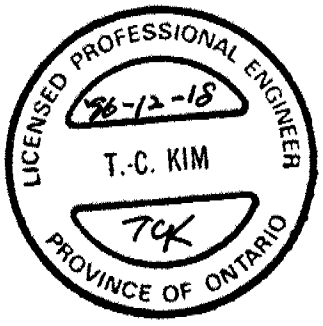
investigation. The river level was approximately 303.7 m at the time of the investigation and remained constant throughout the investigation. On shore and adjacent to the Speed River the water level appeared to reflect the river level and ranged from elevation 303.2 m to 303.9 m. Most of the boreholes advanced in conjunction with the proposed retaining wall further beyond the Speed River were dry upon completion.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer utilizing equipment owned and operated by Malone's Soil Samples and Master Soils Investigation Ltd. Logging of the rock core in the laboratory was carried out by D. Williams, Petrographer.

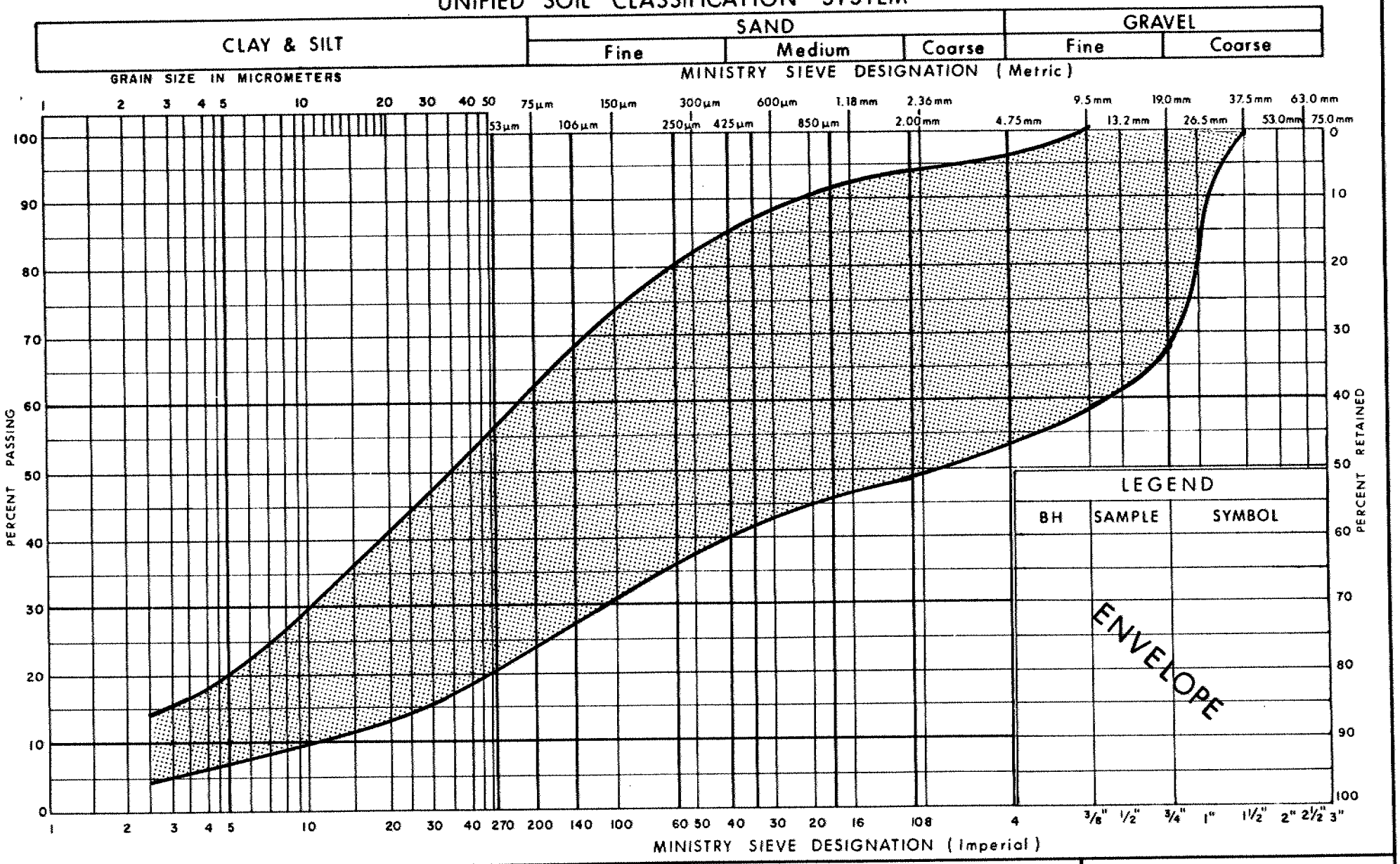
The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



T.C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

IRREGULAR MIXTURE OF

SILT, SAND & GRAVEL (FILL MATERIAL)

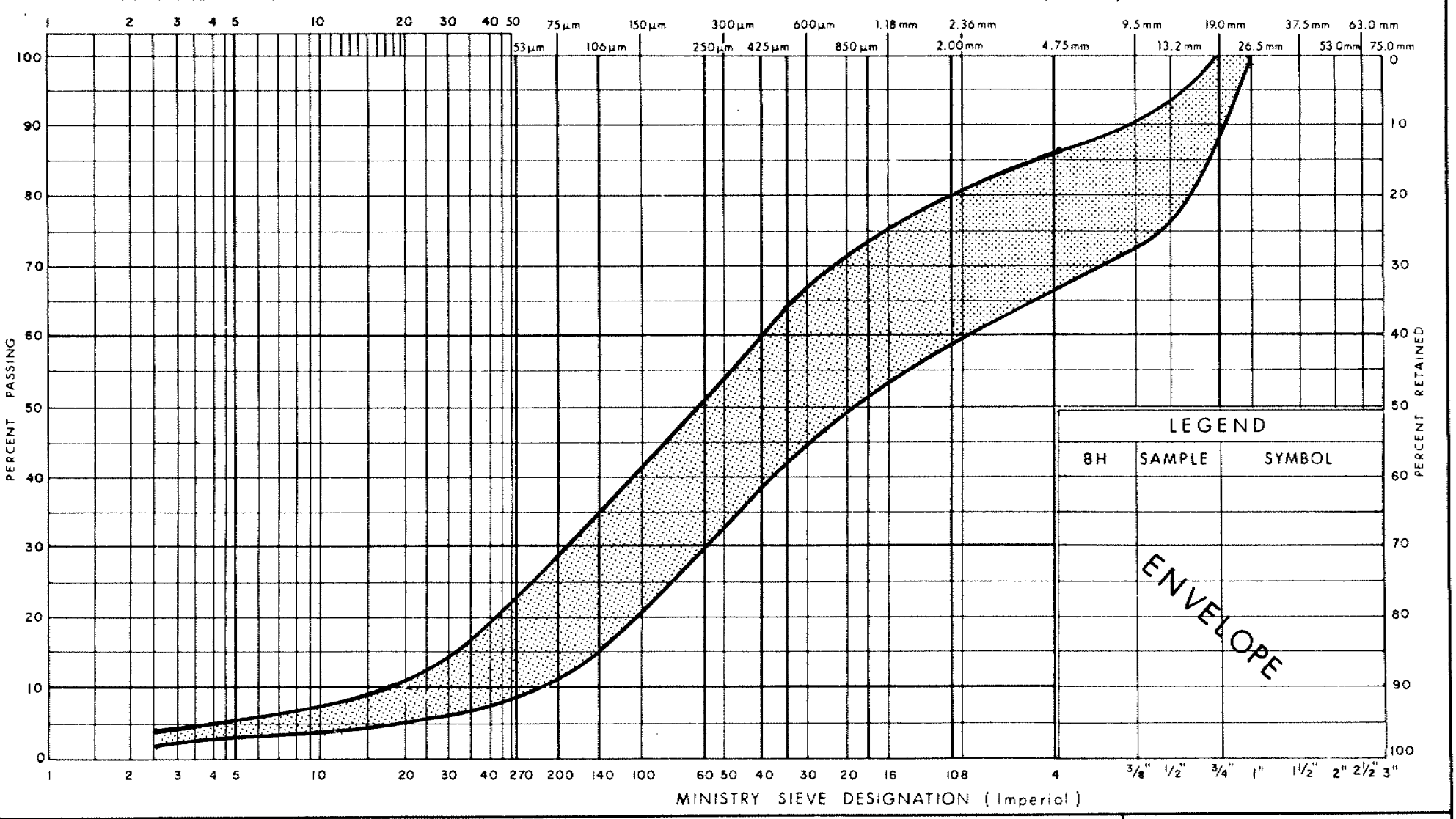
FIG No 1

W P 533-91-04

107

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

GRAVEL, SAND & SILT (Glacial Till)

FIG No 2

W P 533-91-04

1108

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 867.0; E 243 352.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core and Cone Test COMPILED BY TS

DATUM Geodetic DATE 93 02 01-02 CHECKED BY PP

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.9	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown with traces of Black Organics Very Loose to Compact		1	SS	4		306				
			2	SS	4				o		
			3	SS	16		304				
303.7											
3.2	Compact V. Dense Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown		4	SS	78	▼*					
			5	SS	17						
			6	SS	74		302	50/3cm	o		22 50 25 3
			7	SS	60 /8cm		300				
299.3											
7.6	Dolostone Bedrock Weak to Medium Strong, Slightly Weathered to Unweathered		8	RC	REC 100%		298				RQD = 33%
			9	RC	REC 100%						RQD = 66%
296.2											
10.7	End of Borehole										

* 93 02 03

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 866.5; E 243 330.0 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core and Cone Test COMPILED BY TS
DATUM Geodetic DATE 93 02 02-03 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS
307.4	Ground Surface					
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Compact to Very Dense		1	SS	35	
			2	SS	15	
			3	SS	35	
	Brown					
	Brown with Black, trace Organics		4	SS	10	
			5	SS	60	*8cm
302.8						
4.6	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Grey, Compact		6	SS	15	
			7	SS	23	
			8	SS	60	/3cm
299.8						
7.6	Dolostone Bedrock Medium Strong, Slightly Weathered to Unweathered		9	RC	REC 95%	
			10	RC	REC 100%	
295.5						
11.9	End of Borehole					

* 93 02 04

ELEVATION SCALE: 306, 304, 302, 300, 298, 296

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
110/25cm

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
• QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	22	31	35	12
	14	66	18	2
RQD = 20%				
RQD = 40%				

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 887.5; E 243 322.5 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 10 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
303.7	Water Surface							20 40 60 80 100	10 20 30		
0.0 / 302.8	Water										
0.9 / 302.0	Heterogeneous Mixture of Cobbles, Gravel, Sand and Silt (Glacial Till) Brown, Very Dense		1	SS	75 /13cm		302				
1.7	Dolostone Bedrock Weak to Medium Strong, Slightly Weathered to Unweathered		2	RC	REC 100%						RQD = 19%
			3	RC	REC 100%		300				RQD = 27%
299.0											
4.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 907.0; E 243 301.5 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 02 11 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.7 Water Surface											
0.0 / 302.9	Water										
0.8	trace Organics Compact Very Dense Heterogeneous Mixture of Cobbles, Gravel, Sand and Silt (Glacial Till) Brown		1	SS	21						
			2	SS	85	/15cm	302		o		98 0 (2)
			3	SS	100						
300.7			4	SS	75	/10cm					
3.0	Dolostone Bedrock Weak to Medium Strong, Slightly Weathered to Unweathered		5	RC	REC 100%		300				RQD = 30%
299.0											
4.7	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4A 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 898.0; E 243 289.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
304.1	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Black, trace Organics, Very Loose		1	SS	2	▼*					
	Grey, Very Dense		2	SS	60 /15cm				o		28 60 10 2
301.8			3	SS	**		302				
2.3	Dolostone Bedrock Weak to Medium Strong, Slightly Weathered to Unweathered		4	RC	REC 100%						RQD = 0%
			5	RC	REC 100%		300				RQD = 0%
298.8											
5.3	End of Borehole										

* 93 02 05

** Sampler Bouncing

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 923.5, E 243 286.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 05 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.4	Ground Surface										
0.0	Black, trace Organics, Very Loose		1	SS	2	▼*	304				
	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Compact to Very Dense		2	SS	21						
301.4			3	SS	60	/15cm	302		o		33 53 12 2
3.0	Dolostone Bedrock Weak to Medium Strong, Slightly Weathered to Unweathered		4	RC	REC 100%		300				RQD = 0%
298.3			5	RC	REC 100%						RQD = 16%
6.1	End of Borehole										

▲ 93 02 08

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 939.5; E 243 273.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 93 02 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.8	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel with traces of Organics and Incinerated Refuse (Fill Material)		1	SS	3	▼	304				
303.0	Black, Very Loose to Compact		2	SS	12						
1.8	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)										
302.3	Grey, Very Dense										
2.5	End of Borehole Auger Refusal (Probable Bedrock) • 93 02 08										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 849.0; E 243 370.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 93 02 03 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.0	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)										
	Brown to Black, trace Organics		1	SS	11		306				
	Loose to Compact		2	SS	25				o		47 30 19 4
303.0			3	SS	8	▼*	304				
5.0	Heterogenous Mixture of Gravel, Sand and Silt (Glacial Till)		4	SS	50/4cm		302				
	Brown, Very Dense										
300.4											
7.6	End of Borehole Auger Refusal (Probable Bedrock)										
	* 93 02 03										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 865.9; E 243 369.6 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 93 03 04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE * QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
306.9 Ground Surface											
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown and Black, trace Organics Loose to Compact		1	SS	5		306				4 34 49 13
			2	SS	6		304				
			3	SS	14						
302.7			4	SS	36						
4.2	Slightly Weathered Unweathered		5	SS	60/10cm	*	302				
	Dolostone Bedrock Weak		6	SS	60/3cm						
			7	RC	REC 100%						RQD = 8%
300.0											
6.9	End of Borehole										
	* 93 03 05										

+3, x5 : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8A 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 851.5; E 243 384.3 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 93 03 04 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.2	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel with random Zones of Clayey Silt (Fill Material)		1	SS	4	DRY *	308				
			2	SS	5						
	Dolostone fragments		3	SS	61		306				
	Brown with Black, trace Organics Very Loose to Compact		4	SS	12						
			5	SS	21		304				
303.2			6	SS	66 **						
5.0	End of Borehole (Auger Refusal – Probable Bedrock)										

* 93 03 05

** Sampler Bouncing (Probable Bedrock)

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 834.2; E 243 415.9 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 03 04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
309.7	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown with Black, trace Organics Loose					DRY *					
308.2			1	SS	65	/15cm	308				
1.5	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		2	SS	50	/5cm					
			3	RC	REC 100%		306				RQD = 53%
305.6											
4.1	End of Borehole										

* 93 03 05

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9A 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 840.3; E 243 397.3 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 03 04 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.5	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown with Black trace Organics Loose to Compact					DRY *	308				
			1	SS	10						
			2	SS	10						
			3	SS	18		306		o H		37 29 25 9
305.1			4	SS	65						
305.0	**										
3.5	End of Borehole (Auger Refusal)										

* 93 03 05

** Dolostone Bedrock

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 533-91-04 LOCATION Co-ords: N 4 820 843.3;E 243 405.2 ORIGINATED BY TS
DIST 3 HWY 6 BOREHOLE TYPE SS Auger COMPILED BY TS
DATUM Geodetic DATE 93 03 04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
308.7 Ground Surface											
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown with Black, Trace Organics					DRY	308				
306.6											
2.1	End of Borehole (Auger Refusal – Probable Bedrock) • 93 03 04										

+³, x⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 533-91-04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	8 9	7.62-9.14 9.14-10.67	100 100	33 66	7.62-10.67	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to 5 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (7.62-8.59 m) and dark yellowish brown to pale yellowish brown (8.59-10.67 m); medium grained; weak (7.62-8.59 m) to medium strong (8.59-10.67 m); unweathered to slightly weathered; fractures moderate to very close spaced, flat to dipping, undulating to planar, smooth to rough.
2	9 10	8.84-10.36 10.36-11.89	95 100	20 40	8.84-11.89	**DOLOSTONE** (with abundant small vugs and larger vugs up to 5 cm in diameter, commonly containing calcite crystals), dark yellowish brown to pale yellowish brown; medium grained; medium strong; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
3	2 3	1.96-3.18 3.18-4.70	100 100	19 27	1.96-4.70	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to 3 cm in diameter), very pale orange to pale yellowish brown (1.96-4.44 m) and dark yellowish brown to pale yellowish brown (4.44-4.70 m); medium grained; weak (1.96-4.44 m) to medium strong (4.44-4.70 m); unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
4	5	2.44-3.96	100	30	2.44-3.96	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to at least 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (2.44-3.51 m) and dark yellowish brown to pale yellowish brown (3.51-3.96 m); medium grained; weak (2.44-3.51 m) to medium strong (3.51-3.96 m); unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
4A	4	2.29-3.81	100	0	2.29-5.33	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to at least 7 cm in diameter, commonly containing calcite and sphalerite crystals), very pale orange to pale yellowish brown (2.29-3.10 m) and dark yellowish brown to pale yellowish brown (3.10-5.33 m); medium grained; weak (2.29-3.10 m) to medium strong (3.10-5.33 m); unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	5	3.81-5.33	100	0		
5	4	3.05-4.57	100	0	3.05-6.10	**DOLOSTONE** (with stylolites, abundant small vugs, and larger vugs up to at least 7 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown (3.05-4.27 m) and dark yellowish brown to pale yellowish brown (4.27-6.10 m); medium grained; weak (3.05-4.27 m) to medium strong (4.27-6.10 m); unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	5	4.57-6.10	100	16		

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 533-91-04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	7	5.36-6.88	100	8	5.36-6.88	**DOLOSTONE** (with stylolites and abundant small vugs), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered (moderately weathered, 5.36-5.56 m); fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
9	3	2.59-4.11	100	53	2.59-4.11	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

Note: Depths are approximated where core recovery is less than 100%
Logged by: DAW, Soils and Aggregates Section

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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 96-37

WP 604-90-01/02 DIST 3

HWY 6 (NB & SB) STR SITE 35-404

Proposed Widening
Hwy. 6 (NB & SB)/Speed River Crossing

DISTRIBUTION

A. Ho (2)
C.M. Bond
A.E. Irving
E.J. Zavitski (2)
B. Farago
G.E. Greene
E.A. Joseph
G. Laithwaite (Cover Only)
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GEOCRES 40P9-35

DATE SEP 09 1993

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening

of

Hwy. 6 (NB & SB)/ Speed River Crossing

W.P. 604-90-01/ 02, Site 35-404

District 3, Stratford

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted in conjunction with the proposed widening of the two existing Hwy. 6-Speed River Crossing structures. Widening is to take place at the outer ends of the existing structures and also between the existing structures. The proposed widenings will increase the number of traffic lanes on the Hwy. 6 and is one of many projects planned in association with the revamped Hanlon Expressway (Hwy. 6) and Wellington Street (Hwy. 24) interchange.

SITE DESCRIPTION AND GEOLOGY

The site is located at the existing Hwy. 6-Speed River Crossing structures situated approximately 0.5 km south of the existing Hwy. 24 in the City of Guelph, County of Wellington. The existing structures constructed in 1971 are four(4) span concrete beam structures that carry traffic on Hwy. 6 over the Speed River. Longitudinal and transverse

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 604-90-01/02 DIST 3

HWY 6 (NB & SB) STR SITE -

Proposed Widening
Hwy. 6 (NB & SB)/Speed River Crossing

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GEOCRES 40P9-35 DATE SEP 07 1993

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening

of

Hwy. 6 (NB & SB)/Speed River Crossing

W.P. 604-90-01/02, Hwy. 6

District 3, Stratford

INTRODUCTION

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slopes are evidence of approach embankment fill material placed at the structure locations. The slopes appear to be stable at the constructed 2H:1V gradient. An unpaved gravel roadway has been benched into the slope at the south approach embankment location. This roadway appears to have been an access route to the Guelph Dolime Quarry which is located just west of the site location. A chain link fence and guardrail installed has presently blockaded an easterly access to the Quarry.

Variable land use is evident in the site area. Earth and rock excavation and stockpiles of processed dolostone reflects the operation and activity at the Guelph Dolime Quarry. Northwest of the site and north of the Speed River, a woodlot containing tall deciduous trees is present. Northeast of the site, the land which is primarily flat, is occupied by an abandoned landfill area. Southeast of the site, a residential development exists.

The terrain at the site consists of sloping surfaces indicative of the fill placed in what was previously probably low lying flat to gently rolling land. Concrete rubble has been placed on the surface of the north approach embankment beneath the existing SBL structure.

The Speed River, flowing in a westerly direction is a dominant feature at the site. The river is approximately thirty-five metres in width and at the time of the investigation the water depth was shallow and approximately one metre in depth. A concrete weir exists downstream of the Hwy. 6 SB structure.

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this

area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximately 12,000 years ago), the ice which moulded this drumlin field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

As a result of the glacial activity, the general landform pattern in the area consists of drumlins or groups of drumlins fringed by gravel terraces. The dominant soil materials are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways. Overburden in the site area is underlain by dolostones of the Amabel and Guelph Formations. Native overburden thicknesses are shallow at the site and usually less than three(3) metres.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

A desk study that entailed the review of the foundation report produced for the existing

Hwy. 6/ Speed River Crossing structures (see W.P. 109-68-02/ 03) and also the examination of the structure foundations (type, elevation, etc.) preceded the fieldwork and laboratory testing program. This information was used to define the extent of the fieldwork and also in providing recommendations for the foundation design and construction of the proposed widening. Reference can be made to the foundation report and the contract drawings for the existing structures in conjunction with this report.

Field Investigation

The recent fieldwork for this project was conducted between 93 02 16 and 93 02 17 and consisted of a total of three(3) boreholes. However, subsurface information was also obtained from a previous investigation conducted between 69 10 08 and 69 10 23 executed for the existing Hwy. 6/ Speed River Crossing structures as discussed above. The three(3) boreholes advanced during the recent investigation ranged in depth from 5.9 m to 12.1 m. Boreholes originally advanced ranged in depth from 3.8 m to 7.8 m.

The three(3) boreholes that were recently advanced were done so using conventional track and truck mounted drilling units. Hollow stem augering techniques were used to penetrate the overburden at the site. Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). The samples were generally retrieved at 1.5 m intervals. Automatic hydraulic tripping hammers were used to impart the standard driving energy.

Bedrock underlying the overburden was cored 1.5 metres in depth using conventional rock coring techniques. A NX core barrel within NW casing was used in the coring process.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes and the river level was also monitored throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Southwestern Region Surveys and Plans.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil

Classification Manual. Physical property tests included natural moisture contents, grain size distributions and Atterberg Limit Tests. Particle size distributions were determined by mechanical sieve and hydrometer analysis. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The rock core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

GENERAL

The subsurface conditions at the site reflect the previous placement of fill material and hence consists primarily of an irregular mixture of silt, sand and gravel at the proposed abutment locations and also at the east pier location. The thickness of the fill material varies up to 9.1 metres. At the locations beyond the fill placement, the native surficial deposit consists of a heterogeneous mixture of gravel, sand and silt. This deposit underlies the fill material where the fill material exists and underlies the waters of the Speed River at the proposed west and centre piers. The deposit also contains boulders and cobbles

which were explored and also visible at the river bottom. The thickness of this deposit varies from 0.8 to 5.3 m.

Across the entire site, the native heterogeneous mixture of gravel, sand and silt is underlain by dolostone bedrock. The bedrock was encountered at Elevations ranging from 298.9 to 302.6 indicating an irregular bedrock surface.

A plan of the site illustrating the locations and elevations of the boreholes and proposed structure foundations is shown on Dwg. No. 6049001/02-A. The plan also includes boreholes advanced as part of the original investigation conducted in 1968. A subsoil stratigraphical profile section has also been included on the drawing.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical section and also on the individual Record of Borehole sheets in the Appendix.

SOIL/ROCK DESCRIPTIONS

Water

Approximately 0.5 to 1 metre of standing water was present in the Speed River at the time of the investigation. Flow was generally laminar but turbulent flow was apparent at overflow weir location.

Irregular Mixture of Silt, Sand and Gravel (Fill Material)

The composition of the fill material located adjacent to the abutments of the existing Hwy. 6/ Speed River Crossing structures and within the median of the highway and also between the east piers of the existing structures is predominantly an irregular mixture of brown silt, sand and gravel. Random zones of an irregular mixture of clayey silt, sand and gravel are also present within the fill material. The thickness of the fill material varies from 3.0 m to 9.1 m and contains traces of black organics at random depths. A grain size distribution envelope as determined by hydrometer and mechanical sieve analysis is shown on Figure 1 in the Appendix. The figure illustrates the broad gradation of the fill material.

The 'N' values as determined by the Standard Pentration Test ranged from 1 blow/ 0.3 m to 61 blows/ 0.3 m indicating a denseness ranging from very loose to very dense. The larger 'N' values however are suspected to be attributable to the larger gravel sizes in the fill. In general, 'N' values range from 14 blows/ 0.3 m to 36 blows/ 0.3 m indicating a compact to dense state of denseness.

Heterogeneous Mixture of Gravel, Sand Silt (Glacial Till)

The fill material and waters of the Speed River are underlain by a heterogeneous mixture of gravel, sand and silt. This deposit, which is predominantly brown in colour also contains traces of black organics. Boulders and cobbles are also present in this deposit as determined by actual sampling, visual observation in the Speed River and inference from frequent auger grinding that was encountered. The thickness of this deposit ranges from 0.8

m to 5.3 m.

Grain size distribution curves produced by mechanical sieve and hydrometer analysis are given in Figure 2 in the Appendix. The results reveal a broad range of particle sizes ranging primarily from silt to gravel. The envelope does not include particle sizes larger than gravel. The broad range of particle sizes is typical of deposits of glacial till origin.

An Atterberg Limit test on one representative sample of the material containing organic percentages revealed a liquid limit (W_L) of 43% and a plasticity index (I_p) of 13%. The fine grained portion of the material can be described as a plastic silt of intermediate plasticity (MI). In general, however, the fine grained portion of the deposit is cohesionless and non-plastic.

The 'N' values as determined by the Standard Penetration Test range from 6 blows/0.3 m to 200 blows/0.3 m. The larger 'N' values are the result of the larger boulder and cobble sizes and hence may not necessarily accurately represent the denseness of the deposit. In general, the 'N' values range between 10 blows/0.3 m and 80 blows/0.3 m indicating a compact to very dense state of denseness.

Bedrock

The bedrock that underlies the heterogeneous mixture of gravel, sand and silt at the site is primarily a light brown coloured dolostone of the Guelph Formation. Bedrock surface elevations varied across the site and are summarized in Table 1 below.

elevations varied across the site and are summarized in Table 1 below.

TABLE 1 - BEDROCK SURFACE ELEVATIONS	
Area	Elevation (m)
West Abutment	298.9 - 302.2
West Pier	299.4 - 302.1
Centre Pier	301.3 - 301.7
East Pier	300.3 - 302.6
East Abutment	301.9 - 302.5

The results tabulated in Table 1 reveal that the bedrock surface elevation is variable across the site indicating a reef type structure to the bedrock.

The dolostone bedrock is a chemical sedimentary rock that is very pale orange to yellowish brown in colour and medium grained. The rock which is of the Guelph Formation is unweathered to slightly weathered and characterized by a porous "vug" texture and stylolites. The rock contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Rock Core Description".

An assessment of the quality and strength of the rock was carried out by measuring core

and RQD's ranged from 0% to 53%. Rock quality can be categorized as very poor to fair.

Rock strengths can be described as weak as determined by physical index property tests. Rock core penetration rates were generally rapid which confirms the weaker nature of the sedimentary rock.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes and monitoring the lake level throughout the duration of the field investigation. The river level was approximately 303.7 m at the time of the recent investigation and remained constant throughout the duration of the investigation.

On shore, the water level measured at the time of the recent investigation ranged from elevation 302.8 m to 305.7 m which is approximately equal to the elevation of the water level.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

To facilitate the widening of Hwy. 6 to a six(6) lane divided highway, it is proposed to widen the existing Hwy. 6/ Speed River structures. The Southbound structure will be widened by 1.765 m south of the structure and the Northbound structure will be widened by 1.765 m south of the structure and also 1.265 m north of the structure. Substructures are therefore required to support the widening beyond and between the existing structures. The structure foundations have been proposed colinear to the alignment of the existing foundations. Dwg. 6049001/02-A in the Appendix illustrates a plan and also a typical section of the proposed widening.

It is assumed that the profile grade will be similar to the existing Hwy. 6 NB and SB grades varying from approximately 311.5 m at the west approach and increasing to approximately 313.5 m at the east approach. Existing ground surface elevations within the proposed areas of widening are generally within a metre or two of this profile elevation. However, existing grades decrease beyond the exterior widening locations consistent with the existing slopes.

Soils/rock data and information to facilitate the design and construction of the proposed widenings was obtained by reviewing the foundation investigation report for the existing structures, reviewing the footing layout plan of the existing structures and conducting an additional foundation investigation. Some of the previous borehole information has been integrated into this report. However, should additional information pertaining to the original foundation investigation be sought, this can be obtained from the original report (see W.P. 109-68-02).

Recommendations pertaining to the design and construction of the proposed structure foundations and related earthworks are contained in the purview of this report. Foundation and geotechnical related recommendations provided include:

1) Structure Foundations
2) Backfill to Structure
3) Approach Embankments
4) Construction Considerations

1) STRUCTURE FOUNDATIONS

The abutments and east pier of both the existing Hwy. 6 NB and SB structures are supported on deep foundation steel H-piles driven to the bedrock. The west pier and centre pier located in the water are supported on spread footings founded on the bedrock surface. It is recommended that the substructure design for the widenings beyond the structures (1.765 m south of SB structure, 1.265 m north of NB structure) be in accordance with the foundation layout for the existing respective structures. A summary of the foundation layout is given in Table 2 below. Concrete caissons can be considered as a deep foundation alternative. The most economical design shall be selected.

Table 2 - Widening Beyond Structures

Structure Foundation	Foundation Type SB Widening	El▲	Foundation Type NB Widening	El▲
W. Abutment	*Deep Foundations on Bedrock	299.5±	*Deep Foundations on Bedrock	298.5±
W. Pier	Spread Footings on Bedrock	300.5±	Spread Footings on Bedrock	300.5±
C. Pier	Spread Footings on Bedrock	301±	Spread Footings on Bedrock	301±
E. Pier	Deep Foundations on Bedrock	300.5±	Deep Foundations on Bedrock	299±
E. Abutment	Deep Foundations on Bedrock	302±	Deep Foundations on Bedrock	301.5±

*Driven Steel H-Piles or Concrete Caissons

For the proposed widening between the two existing structures, a similar foundation layout is also applicable. However, having retrieved soils/rock data at the specific foundation location, Table 3 below provides the recommended foundation layout and founding elevations.

Table 3 - Widening Between Structures

	Foundation Type	Tip El* (m)
W. Abutment	Deep Foundations Units* on Bedrock	301±
W. Pier	Spread Footings on Bedrock	300.5±
C. Pier	Spread Footings on Bedrock	301±
E. Pier	Deep Foundation Units* or Spread Footings on Bedrock	302.6±
E. Abutment	Deep Foundation Units* on Bedrock	302.7

*Driven Steel H-piles or Concrete Caissons

A comparison of Table 2 and Table 3 reveals that (1) the west and centre pier design recommendations remain unchanged, (2) the tip elevations at the abutment locations and east pier are slightly different and lastly (3) a spread footing alternative has been provided at the east pier.

Thus far the foundation layout only has been given. Foundation design details and parameters are given below. These design details apply to all foundations irrespective of the widening locations.

Deep Foundations

General

The following recommendations and design guidelines apply to the west abutment, east abutment and east pier. Deep Foundation Units are particularly suitable at the abutment locations because it allows the abutments to be "perched" within the fill material enabling a more economical "open-type" abutment design.

Driven Steel H-Piles

The above mentioned structure foundations can be founded on steel H-piles driven to the bedrock surface. For purposes of the O.H.B.D.C., the steel H-piles can be designed employing the axial capacities as tabulated in Table 4 below.

Table 4 - Driven Steel H-Piles

Structure	Pile Type	Factored Capacity at U.L.S. (kN)	Axial Capacity at S.L.S. (kN)
West Abutment	HP310x110	1600	1100
East Pier & East Abutment	HP310x79	1150	890

To facilitate the pile driving process, it is recommended that all piles be equipped with reinforced tips. Driving shoe details are given in OPSD 3301.00.

Axial capacities provided in Table 4 are for vertical piles only. Reductions of axial capacities for inclined loadings shall conform to factors provided in Section 6-8.3.4.3 of the O.H.B.D.C.

Pile spacing shall conform with Section 6-8.3.10 of the O.H.B.D.C. For centrally loaded piles, equal load sharing on the deep foundation units can be assumed. The design of eccentric loaded deep foundation units shall comply with Section 6-8.3.4.2 of the O.H.B.D.C.

The lateral resistance for both vertical and battered piles shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. Pertinent unfactored soil parameters to facilitate the design of the lateral capacity of vertical piles is given in Table 5 below. The corresponding soil depths can be obtained from the relevant borehole logs and having knowledge of the proposed heights of fill.

Table 5 - Lateral Resistance Design Parameters

Soil	Unfactored Angle of Internal Friction (ϕ)	Bulk Unit Weight (kN/m^3) (γ)
Irregular Mixture of Silt, Sand and Gravel (Fill Material)	30°	20
Het. Mixt. of Gravel, Sand and Silt (Glacial Till)	30°	20

In view of the variable nature of the fill material, it is recommended that the upper 60% of the embedment length within the fill (taken from the frost penetration depth) be disregarded for horizontal resistance. Futhermore, to account for uncertainties in material selection and method of placement, it is recommended that the shear strength parameters in Table 5 be reduced by 10%.

Pile caps shall be protected against frost penetration by providing a minimum 1.2 m earth cover or equivalent frost protection.

Concrete Caissons

Alternatively, the west abutment, east abutment and east pier can be founded on concrete caissons augered and placed on bedrock at or below the elevations provided in Tables 2 or 3. To facilitate the design of the concrete caissons, a vertical factored bearing capacity equivalent to 3500 kPa can be employed for the dolostone bedrock at the U.L.S. In view of the unyielding nature of the bedrock, the Serviceable Limit State (SLS) will not govern the design because the stresses required to induce detrimental settlements at the S.L.S. will exceed the factored capacity at U.L.S. The designer can use the bearing capacity provided to select the size of the caisson and the respective ultimate capacity. For instance, a 0.9 m diameter caisson will yeild a capacity equivalent to approximately 2300 kN at U.L.S.

The lateral resistance for vertical or battered concrete caissons can be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. and using the data given in Table 5. Lateral resistance can be further augmented by socketting the caissons into the bedrock.

The socket shall be a minimum 0.5 m and an unconfined compressive strength (qu) of 10 MPa can be used to compute the horizontal capacity of the caisson in the rock. Again, only the Ultimate Limit State (U.L.S.) will govern the lateral capacity design for caissons socketted in the bedrock.

Pile caps shall be protected against frost penetration by providing a minimum 1.2 m earth cover or equivalent frost protection.

Construction of the concrete caissons will require augering holes through the native heterogeneous mixture of gravel, sand and silt which in most cases is submerged beneath the groundwater table. As a result, special measures will be required to prevent the collapse of the shaft of the hole under the created condition of the unbalanced hydrostatic head. The construction of the caissons will be discussed under the title "Construction Considerations" later in this report.

Shallow Foundations

Spread Footings on Bedrock

In view of the shallow overburden thickness at the proposed west, centre and perhaps east pier locations, it is recommended that these piers be founded on conventional spread footings bearing on the competent unweathered dolostone bedrock. For purposes of the O.H.B.D.C., all footings founded on the dolostone bedrock can be designed as summarized in Table 6 below.

Table 6 - Spread Footings on Bedrock - Vertical Bearing Capacity		
Structure	Factored Capacity at U.L.S. (kPa)	Bearing Capacity at S.L.S. Type II (kPa)
Centre Pier	1500	N/A
West Pier	1500	N/A
East Pier	1500	N/A

As indicated in Table 6 above, only the factored capacity at U.L.S. governs the design because of the unyielding nature of the bedrock. Stresses required to induce detrimental settlements at the Serviceability Limit State (S.L.S.) would exceed the factored capacity at U.L.S.

The capacities tabulated in Table 6 pertain to vertical normal loads only. Reductions of bearing capacities to account for inclinded loadings shall conform to factors provided in Section 6-7.3.3.5 of the O.H.B.D.C.

The resistance of the spread footing founded on the bedrock surface can be computed by employing an unfactored angle of friction of 30° between the concrete footing and the bedrock surface. Should additional horizontal resistance to sliding be required, shear keys

or dowels can be incorporated. An unconfined compressive strength of 10 MPa and a bond stress of 100 kPa (between cement grout and bedrock) at U.L.S. are relevant shear key/dowel design parameters within the dolostone bedrock. The lateral resistance of shallow foundations shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C.

It is prudent that the footing base be protected against weathering during construction. To preserve the integrity of the bedrock surface during construction, it is recommended that a 100 mm thick lean mix concrete coating be placed on the footing bedrock surface within four(4) hours of exposure. Any previously weathered or loosened rock shall be removed prior to the placement of the concrete coating.

The construction procedure of the footings within the Speed River including the dewatering method will be discussed under the subheading "Construction Considerations" later in this report.

2) BACKFILL TO STRUCTURE

Material

It is recommended that Granular 'A' or Granular 'B' material be placed within a wedge behind the abutments bounded by a plane rising at 60° to the horizontal as shown in Figure 6.9.6.1 of the O.H.B.D.C. The application of granular material combined with weep holes in the abutment walls or pipe subdrains to drain any accumulation of water in the backfill

will prevent hydrostatic pressure build-up. Excavation of existing fill material will be required to facilitate the placement of this granular material.

Table 7 - Backfill Properties

	Granular 'A'	Granular 'B'
Angle of Internal Friction (ϕ) (unfactored)	35°	30°
Unit Weight (kN/ m^3), γ	22.8	21.2
*Coefficient of Active Earth Pressure (K_a)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.40
*Coefficient of Earth Pressure at Rest (K_o)		
- S.L.S.	0.43	0.50
- U.L.S.	0.50	0.58

*These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping backfill. The coefficient at rest shall be applied for rigid and unyielding walls.

Backfilling and Compacting

The backfill shall be placed in 300 mm lifts in accordance with OPSS 902 series and compacted to achieve the target maximum dry density as outlined in OPSS 501.07.08.

Heavy vibratory equipment should be avoided in the backfill construction adjacent to the structure. It is therefore recommended that hand compaction equipment be employed in backfilling behind the abutment within a lateral distance equal to the current height of fill above the wall footing, in order to minimize deflection or possible damage of the wall.

3) APPROACH EMBANKMENTS

General

The proposed widenings will require the placement of varying heights of fill in advance of the structure. The fill heights will vary from the placement of approximately 1 to 2 metres within the median to perhaps as much as ten(10) metres for the widening of the northbound structure. The stability, settlement and construction of these embankments are discussed below.

Stability

Global

In view of the cohesionless nature of the fill material and underlying native heterogeneous mixture of gravel, sand and silt (Glacial Till), there are no deep seated global stability problems anticipated for embankment slopes constructed at 2H:1V both in the transverse

and longitudinal directions.

Internal

To preserve the internal stability of the proposed embankments and to avoid surficial slope failures, the following guidelines shall be followed.

1. Earth fills up to eight(8) metres in height shall be constructed at 2H:1V or flatter.

2. Earth fills exceeding eight(8) metres as proposed at the north approach are typically constructed at 2H:1V slopes with a nominal two(2) metre midheight berm constructed with a 2% gradient towards the toe of the embankment to promote surface runoff or alternatively 2.5H:1V slopes. However, in view of the fact that the existing embankment is constructed at 2H:1V and to avoid an abutment offset between the new and existing abutment, the new fills can be placed at 2H:1V provided that the embankment material is of adequate composition that limits the silt percentages to less than 30% and the material is properly placed, compacted in accordance with OPSS 501 series and protected with seeding or sodding as per MTO standards.

3. Embankment slopes adjacent to the Speed River shall be protected against scouring and erosive water forces. A revetment system consisting of a 0.3 metre thick rip rap or gabion stone material as outlined in OPSS 1004.05.06 is recommended. A filter material between the rock protection and the base embankment material is also recommended. Specifications for the gradation and thickness of the filter material are dependent on the gradation of the base embankment material and can be provided by this office once the composition of the base material is known.

4. In the construction of new fills that must be integrated into existing fills, it is essential that the construction be done in accordance with OPSD 208.01. This drawing

describes a procedure of "Keying" the new fills into the existing embankment to prevent plane translational instabilities.

Settlement

Settlements induced as a result of the applied embankment loading will be the result of the elastic compression of the native subsoil and as a result of settlements within the fill material itself including the fill material that already exists at the site. It is anticipated that approximately 50 mm of settlement attributable to the elastic compression of the existing fill and native soil will be realized at the approaches to the exterior widenings. This settlement is expected to be elastic in nature and hence should be realized during or shortly after the construction period.

Settlements within the embankment fill material are also anticipated as the result of internal stresses induced by the self weight of the material. It is anticipated that approximately 25 mm to 50 mm of settlement will occur for the proposed additional fill thicknesses.

Settlements within the earth fill should occur almost instantaneously and hence should occur during or immediately following construction for a granular material. Settlements of cohesive fill embankments will be more time dependent and anticipated to be realized within a three(3) month time period following placement.

Embankment Construction

All organic material shall be excavated at the surface of the proposed embankment fills prior to the construction of the embankment property. Embankment fills shall be placed and compacted as specified in OPSS 206 and OPSS 501 series.

As mentioned earlier, embankment construction of the new fills shall be integrated into the existing fills in accordance with OPSD 208.01.

4) CONSTRUCTION CONSIDERATIONS

Roadway Protection Scheme

To facilitate the construction of the abutment foundations, a roadway protection scheme will be required to maintain traffice on Hwy. 6 during construction. A timber lagging-soldier pile wall can be used as a shoring system to achieve the roadway protection. Cantilevered walls can be considered provided that reasonable depths of penetration are required to satisfy the necessary earth pressure equilibrium. Alternatively, rock anchors or rakers can be used to support the shoring wall. The shoring system that proves to be the most economical and technical feasible shall be selected.

The design of the shoring system shall include the appropriate earth pressures computed in accordance with Section 6-6.1.2 of the O.H.B.D.C. Adjustment for any sloping surfaces must be incorporated in the computation of the earth pressures. The design parameters to

compute earth pressures can be obtained from Table 5.

Rock anchors can be installed in the dolostone bedrock if required. A bond stress of 100 kPa can be used for the design of rock anchors in the dolostone bedrock.

Alternatively, the shoring wall can be supported by rakers installed in front of the wall. Rakers must be installed while an earth berm remains in front of the pile. Slots should be cut into this berm to install rakers before the supporting berm is removed. Raker footings can be founded on the bedrock surface at either approach location (see Table 1 for Bedrock Surface Elevations) or alternatively at the west approach, raker footings can be founded at Elevation 302 m within the heterogeneous mixture of gravel, sand and silt (Glacial Till). An allowable bearing capacity of 250 kPa at S.L.S. Type II and 900 kPa at U.L.S. can be used in the raker footing design.

The soldier piles can be installed employing conventional augering or driving techniques. A dewatering scheme will be required for soldier piles penetrating the heterogenous mixture of gravel, sand and silt submerged below the groundwater table. The dewatering scheme described below in conjunction with caisson construction is also applicable for the soldier pile installation.

The Contractor shall provide working drawings for the traffic protection scheme as outlined in OPSS 902.04. Our office can assist in the review and approval of these drawings.

Pier Construction in the Speed River

A dewatering scheme will obviously be required to facilitate the construction of the centre pier and west pier located within the Speed River. In view of the larger boulder and cobble sizes that comprise the native soil situated at the lake bottom and overlying the bedrock, the driving of an interlocking steel sheet pile wall to form a watertight enclosure is not considered a practical alternative because of the impediment that would result. It is therefore recommended that temporary barriers or dams be constructed to divert the water flow from the structure foundations and then a "box excavation scheme" with sump pumps be employed to excavate the overburden. The scheme involves the excavation and then subsequent displacement of a prefabricated enclosure until the bedrock surface is encountered while pumping water to facilitate the excavation. Once the overburden has been excavated, and the prefabricated enclosure is positioned on the bedrock, the enclosure can be sealed effectively at the bedrock surface interface to minimize water inflow. Conventional sump pumps can then be used to discharge any additional water.

It is recommended that the Contractor submit dewatering scheme plans prior to construction. Our office can then assist in the review of these drawings to determine acceptability of the proposal.

Caisson Construction

Any caisson construction within augered holes penetrating the cohesionless heterogeneous mixture of gravel, sand and silt (Glacial Till) submerged below the prevailing water table will require a dewatering system. This is for the reason that soil sloughing and cave-in will result due to the unbalanced hydrostatic head condition produced during construction. One method of controlling this condition is to use mind drilling and tremie techniques. In

employing this technique the quality of the bentonite slurry (density, viscosity) should be kept under constant control to ensure that it performs satisfactorily.

Alternatively, the caisson can be constructed within a temporary steel liner installed at the appropriate depth to prevent cave in of the cohesionless submerged soils. After, the liner has been cleaned and the required reinforcing installed, the concrete should be placed in the dry. An overzealous rapid withdrawal of the temporary casing should be avoided to prevent the intrusion of soil in the concrete (necking). Conversely, the temporary liner should not be allowed to get stuck in partial set concrete.

The proposed method of caisson installation shall be in accordance with OPSS 903.07.03 and subject to review by this office. It is prudent that the contractor submit a caisson construction scheme for approval as outlined in OPSS 902.04.01.

East Pier Construction

A caisson foundation or shallow foundation design for the widening between the existing structures will be necessitate a dewatering system because excavation of the submerged heterogeneous mixture of gravel, sand and silt will be required. A caisson construction dewatering scheme has been previously described. For a shallow foundation construction, it is recommended that the excavation be carried out using an oversized excavation scheme with sump pumps. The excavation should start with a pilot trench within the middle of the excavation and proceed laterally while pumping continuously to control the sloughing of soil.

It is recommended that the Contractor submit dewatering scheme plans prior to construction as referred in OPSS 902.04. Our office can then assist in the review of these drawings to determine acceptability of the proposal.

Foundation Excavation/Construction Adjacent to Existing Foundations

It is imperative that the Contractor exercise extreme care during the excavation and construction of the new footings to avoid any damage or undermining of the existing foundations. Very strict quality control is recommended during these foundation construction activities.

Environmental Considerations

Instream and shoreline construction can increase sediment depositions to a waterbody. Special environmental construction precautions such as silt fencing shall be used to mitigate damage to the environment.

Temporary Slopes

Temporary excavation slopes within the fill material or native material shall not be steeper than 1.5H:1V.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Malone's Soil Samples. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.

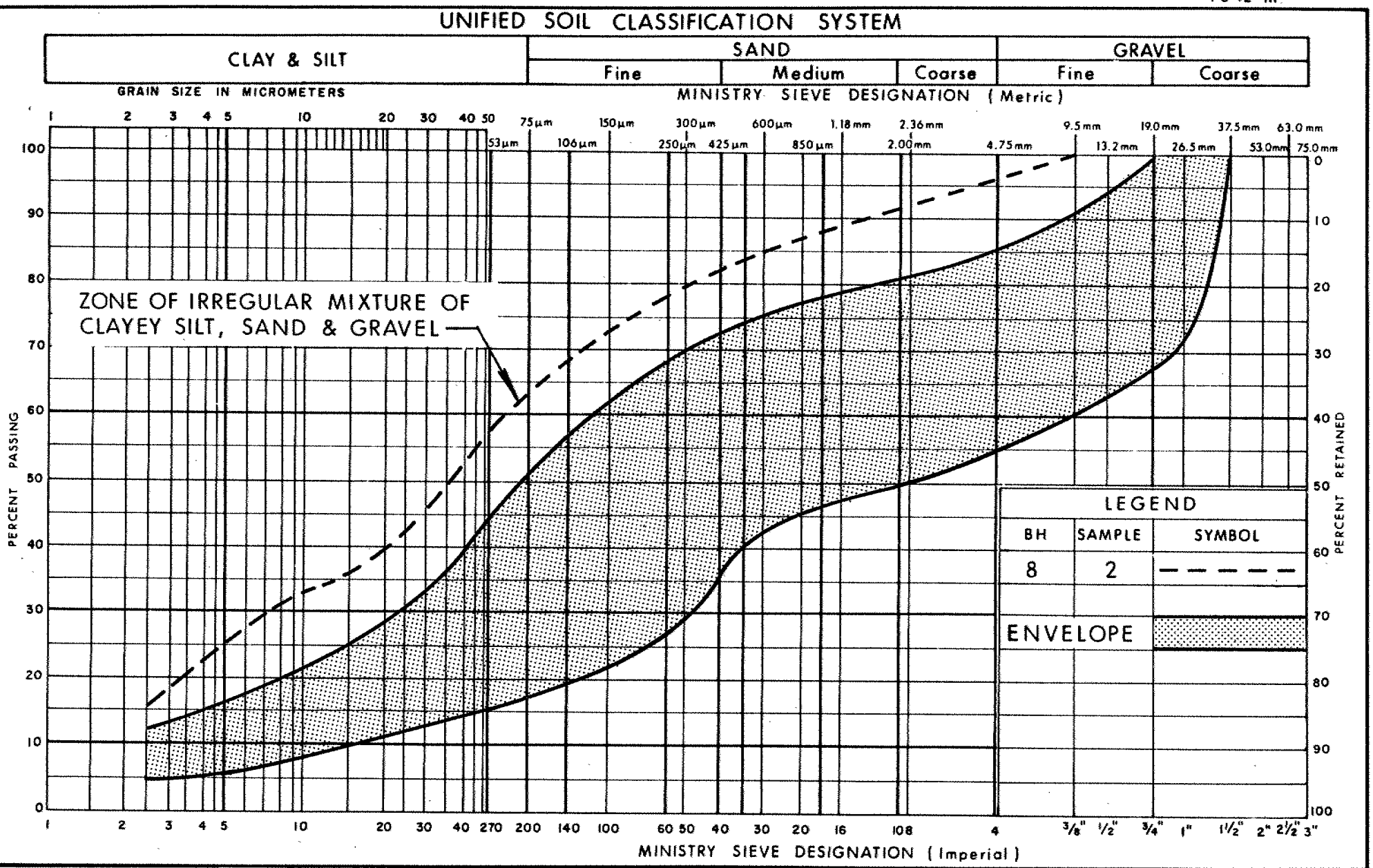
T. Sangiuliano, P.Eng.

Foundation Engineer

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

IRREGULAR MIXTURE OF

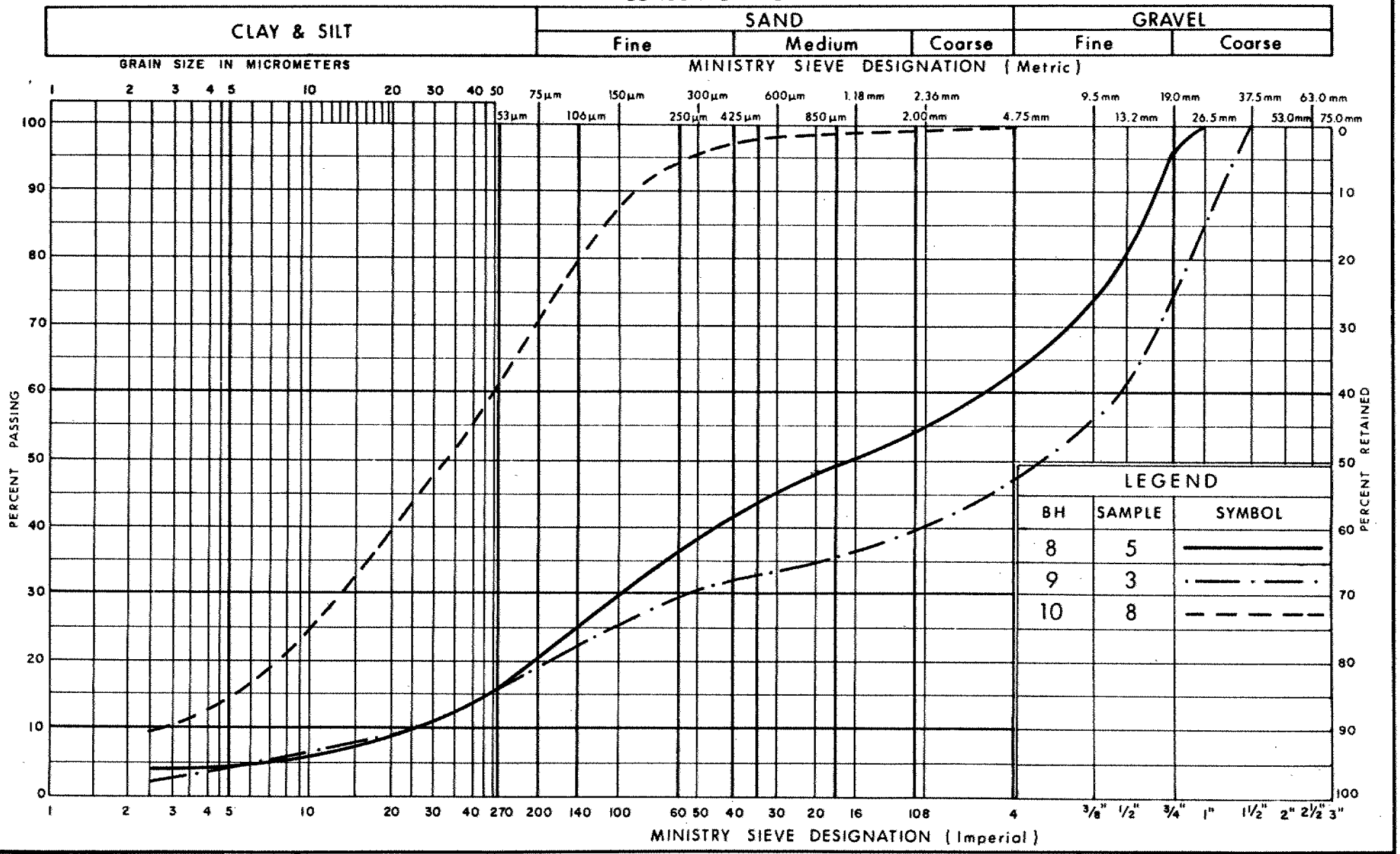
SILT, SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 604-90-01/02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

GRAVEL, SAND & SILT (Glacial Till)

FIG No 2

W P 604-90-01/02

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 1A

1 OF 1 METRIC

(Formerly BH 1A, WP 109-68-02) *

W.P. 604-90-01/02 LOCATION Co-Ords: N 4 820 827.4; E 243 248.6 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 09 CHECKED BY HR

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.3	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Dense to Very Dense		1	SS	34	▼	304		o		36 45 (19)
			2	SS	42		302		o		
			3	SS	69				o		
299.7			4	SS	110/15cm		300		o		
4.6	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		5	RC	REC 95%						
297.8			6	RC	REC 95%		298				
6.5	End of Borehole * Embankment Fill presently exists at Borehole location										

+3, ×5: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 1B

1 OF 1 METRIC

(Formerly BH 1B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 805.3; E 243 242.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 08 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.2	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Loose						304				
	Brown Dense to Very Dense		1	SS	6	▼			○		
			2	SS	30				○		
							302				
			3	SS	87				○		
			4	SS	70				○		56 34 (10)
							300				
298.9			5	SS	59				○		
5.3	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		6	RC	REC 98%						
			7	RC	REC 98%		298				
296.4			8	RC	REC 95%						
7.8	End of Borehole										

* Embankment Fill presently exists at Borehole location

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2A 1 OF 1 METRIC

(Formerly BH 2A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 825.5; E 243 265.3 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 16-17 CHECKED BY HR

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0 304.0	Raft Deck									
302.8	Water									
1.2	Compact Very Dense Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand & Silt (Glacial Till)		1	SS	24		302	o		
			2	SS	69			o		
			3	SS	106		300	o		
299.4			4	SS	152 /17cm			o		
4.6 298.0	Dolostone Bedrock Weak, Slightly Weathered to Unweathered		5	RC	REC 97%		298			
6.0	End of Borehole									

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2B

1 OF 1 METRIC

(Formerly BH 2B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 803.7; E 243 257.9 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 14 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.1	Raft Deck										
0.0											
302.9	Water										
1.2	Heterogeneous Mixture of Boulders, Cobbles, Gravel Sand and Silt (Glacial Till) Brown, Dense		1	SS	31		302				
			2	SS	**						
			3	RC	REC 94%						
300.2			4	RC	REC 33%						
3.9	Weathered / Unweathered Dolostone Bedrock Weak		5	RC	REC 75%		300				
			6	RC	REC 100%						
298.4											
5.7	End of Borehole ** Sampler Bouncing										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3A

1 OF 1 METRIC

(Formerly Bh 3A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 824.2; E 243 277.4 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 17 CHECKED BY HR

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.1	Raft Deck										
0.0											
302.9	Water										
1.2	Heterogenous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Compact		1	SS	22				o		
302.1											
2.0	Weathered / Unweathered						302				
	Dolostone Bedrock Weak		2	RC	REC 95%						
			3	RC	–		300				
299.0											
5.1	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3B

1 OF 1 METRIC

(Formerly BH 3B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 802.4; E 243 270.1 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
304.0	Raft Deck										
0.0											
302.8	Water										
1.2	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		1	SS	113 /20cm		302		○		
301.7											
2.3	Dolostone Bedrock Weak, Unweathered		2	RC	REC 95%						
300.2											
3.8	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4A

1 OF 1 METRIC

(Formerly BH 4A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 822.0; E 243 295.4 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 20-21 CHECKED BY HR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.2	Raft Deck										
0.0							304				
303.2	Water										
			1	SS	50/5cm						
1.0	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Brown, Compact to Very Dense		2	SS	27		302				
301.3			3	SS	65/5cm				o		
2.9	Dolostone Bedrock Weak, Unweathered		4	RC	REC 98%		300				
299.9											
4.3	End of Borehole										

+^{3}, ×^{5}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4B

1 OF 1 METRIC

(Formerly BH 4B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 800.9; E 243 286.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

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 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 10 20 30		GR SA SI CL
304.1 Raft Deck											
0.0											
303.1	Water										
1.0	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till) Very Dense		1	SS	140				○		
301.7			2	RC	REC 98%		302				
2.4	Dolostone Bedrock Weak, Unweathered		3	RC	REC 97%						
300.2											
3.9	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5A

1 OF 1 METRIC

(Formerly BH 5A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 820.3; E 243 307.8 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 20 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) 303.8 GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.8	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown Compact, Trace Organics		1	SS	24	▼			o		
	Dense		2	SS	43		302		o		
301.1											
2.7	Dolostone Bedrock Weak, Unweathered		3	RC	REC 100%						
			4	RC	REC 100%		300				
299.6											
4.2	End of Borehole										

+3, ×5: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5B

1 OF 1 METRIC

(Formerly BH 5B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords:N 4 820 798.4; E 243 299.2 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, BX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 16-17 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
303.9	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)					▼					
			1	SS	34						
	Dense, Trace Organics										
	Very Dense		2	SS	101	/20cm	302		○		58 30 (12)
300.3			3	SS	200				○		
3.6	Dolostone Bedrock Weak, Unweathered		4	RC	REC 98%		300				
			5	RC	REC 98%						
			6	RC	REC 99%		298				
297.4											
6.5	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6A 1 OF 1 METRIC

(Formerly BH 6A, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 817.5; E 243 313.5 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring COMPILED BY GA

DATUM Geodetic DATE 69 10 22-23 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
306.2	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Loose to Compact		1	SS	14		306		○		
303.9			2	SS	7		304		○		
2.3	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Compact to Very Dense trace Organics		3	SS	21	▼					
			4	SS	58						
			5	SS	84	/23cm	302		○		
300.1			6	SS	100	** /18cm			○		
6.1	End of Borehole										

** Sampler Bouncing

+3, ×5: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6B

(Formerly BH 6B, WP 109-68-02) *

1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-Ords:N 4 820 798.0; E 243 305.9 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
304.2	Ground Surface										
0.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)						304				
			1	SS	11	▼			o		0 51 (49)
	Compact		2	SS	**						
302.3											
1.9	Dolostone Bedrock Weak, Unweathered		3	RC	REC 100%		302				
			4	RC	REC 98%						
299.9							300				
4.3	End of Borehole										

* Fill Material presently exists at Borehole location

** Sampler Bouncing

+³, ×⁵ ; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7A

1 OF 1 METRIC

(Formerly BH 7A, WP 109-68-02)*

W.P. 604-90-01/02 LOCATION Co-ords:N 4 820 815.5; E 243 337.0 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 10 & 14 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
306.8	Ground Surface										
0.0	Irregular Mixture of Gravel, Sand and Silt (Fill Material) Compact		1	SS	22		306				
			2	SS	12				o		51 27 20 2
			3	SS	21		304		o		
303.3											
3.5	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Dense		4	SS	36	▼					
301.9			5	SS			302				
4.9	Dolostone Bedrock Weak, Unweathered		6	RC	REC 75%						
			7	RC	REC 100%						
299.9							300				
6.9	End of Borehole										

* Embankment Fill presently exists at Borehole location

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7B

1 OF 1 METRIC

(Formerly BH 7B, WP 109-68-02)

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 792.4; E 243 327.3 ORIGINATED BY GA

DIST 3 HWY 6 BOREHOLE TYPE Washboring, NX Casing COMPILED BY GA

DATUM Geodetic DATE 69 10 14-15 CHECKED BY HR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
307.5	Ground Surface										
0.0	Irregular Mixture of Silt to Clayey Silt, Sand and Gravel (Fill Material) Loose to Compact/Stiff		1	SS	9		307				
			2	SS	10						
							305		o		
			3	SS	14						
303.6											
3.9	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		4	SS	13				o		
302.4	Compact		5	SS	127	▼ /25cm	303		o		
5.1	Dolostone Bedrock Weak, Unweathered		6	RC	REC 95%						
301.0											
6.5	End of Borehole										
	* Embankment Fill presently exists at Borehole location										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \overset{20}{\diamond} 5$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 815.7 E 243 235.7 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 16 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.3	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material)						310				
			1	SS	1						
	Brown, Very Loose										
	Brown with Black, trace Organics		2	SS	19		308		o		39 44 11 6
	Compact to Very Dense										
			3	SS	51		306				
	Grey		4	SS	23				o		46 29 21 4
303.7						▼	304				
7.6	Heterogeneous Mixture of Gravel, Sand and Silt Trace Organics (Glacial Till), Compact Brown with Black		5	SS	23				o		37 42 18 3
302.2											
9.1	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		6	SS	60 /5cm		302				
			7	RC	REC 100%						RQD = 53%
300.4											
10.9	End of Borehole										
	+ 93 02 17										

$+^{3}$, $\times^{5}$; Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 807.1 E 243 312.9 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 16 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
307.0	Ground Surface										
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Compact to Dense		1	SS	32		306		o		37 32 24 7
			2	SS	17				o		15 35 40 10
304.0							304				
3.0	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till), Loose Trace Organics Grey with Black Inclusions		3	SS	7	▼*			o		53 27 18 2
302.6			4	SS	60	/5cm					
4.4	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		5	RC	REC 100%		302				RQD = 36%
301.1											
5.9	End of Borehole										

* 93 02 17

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 604-90-01/02 LOCATION Co-ords: N 4 820 803.1 E 243 340.7 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 17 CHECKED BY PP

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.1	Ground Surface										
0.0	Loose Compact to Dense Irregular Mixture of Silt, Sand and Gravel with Random Zones of Clayey Silt, Sand and Gravel (Fill Material) Trace Organics Brown		1	SS	2		312				
			2	SS	36		310		○		4 34 45 17
			3	SS	61						
			4	SS	29		308				
			5	SS	17						
			6	SS	38		306		○		32 43 20 5
			7	SS	14	▼*					
304.0							304			4.3	
9.1	Block, Trace Organics Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Compact		8	SS	15						0 29 63 8
302.5											
10.6	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		9	RC	REC 100%		302				RQD = 0%
301.0											
12.1	End of Borehole * 93 02 18										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

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

ROCK CORE DESCRIPTION
WP 604-90-01/02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	7	9.35-10.87	100	53	9.35-10.87	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
9	5	4.42-5.94	100	36	4.42-5.94	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 3 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
10	9	10.62-12.14	100	0	10.62-12.14	**DOLOSTONE** (with abundant small vugs and some larger vugs up to 2 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

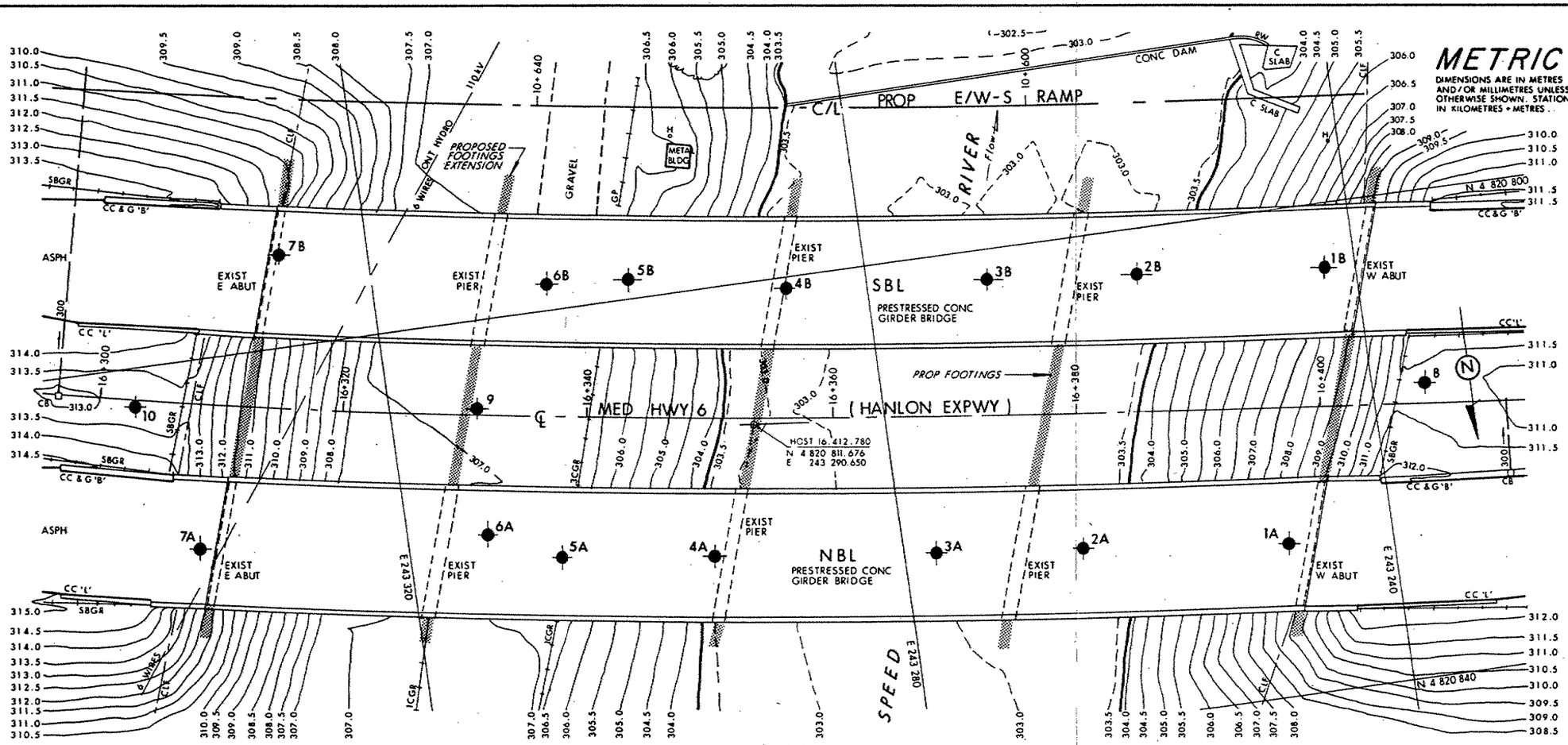
MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10

CONT No
WP No 604-90-01/02

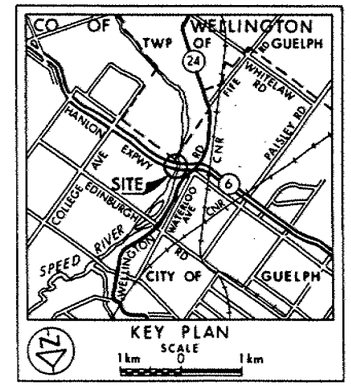
SHEET

SPEED RIVER
[City of Guelph]
BORE HOLE LOCATIONS & SOIL STRATA

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



PLAN
SCALE 4m 0 4m



KEY PLAN
SCALE 1km 0 1km

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1969 10 and 1993 02

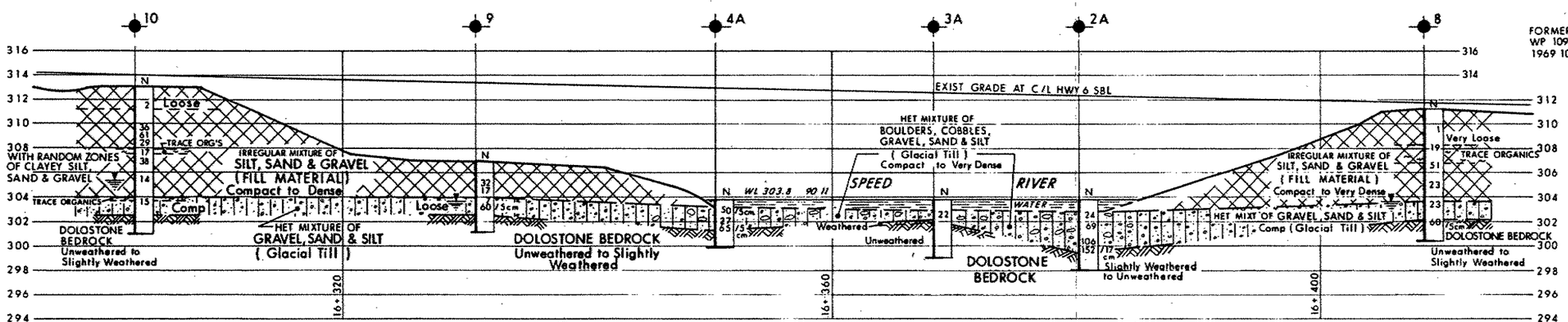
NOTES:

A) FOR SUBSOIL INFORMATION OF B.H.'s 1A, 1B, 2B, 3B, 4B TO 7B (INCLUSIVE) REFER TO RECORD OF BOREHOLE SHEETS:

B) SUBSURFACE CONDITIONS HAVE CHANGED SINCE ADVANCEMENT OF ORIGINAL BOREHOLES DUE TO CONSTUCTION OF EXISTING BRIDGES.

No	ELEVATION	CO-ORDINATES NORTH	EAST
1A	304.3	4820 827.4	243 248.6
1B	304.2	4820 805.3	243 242.5
2A	304.0	4820 825.5	243 265.3
2B	304.1	4820 803.7	243 257.9
3A	304.1	4820 824.2	243 277.4
3B	304.0	4820 802.4	243 270.1
4A	304.2	4820 822.0	243 295.4
4B	304.1	4820 800.9	243 286.5
5A	303.8	4820 820.3	243 307.8
5B	303.9	4820 798.4	243 299.2
6A	306.2	4820 817.5	243 313.5
6B	304.2	4820 798.0	243 305.9
7A	306.8	4820 815.5	243 337.0
7B	307.5	4820 792.4	243 327.3
8	311.3	4820 815.7	243 235.7
9	307.0	4820 807.1	243 312.9
10	313.1	4820 803.1	243 340.7

FORMERLY WP 109-68-02 1969 10



℄ PROFILE HWY 6 (HANLON EXPWY), MEDIAN
SCALE 4m 0 4m

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen.Cond.

REV	DATE	BY	DESCRIPTION

Geocres No 40P9-35

HWY No 6 (HANLON EXPWY), NB & SB			DIST 3
SUBM'D TS	CHECKED TS	DATE 1993 08 23	SITE 35 - 404
DRAWN RS	CHECKED	APPROVED	DWG 6049001/02-A

LICENSED PROFESSIONAL ENGINEER A. J. Sangiuliano PROVINCE OF ONTARIO

REF No E-153-6-5; 1992 11

G.I.-30 SEPT. 1976

GEOCRES No. 40Pg-35

DIST. 3 REGION

W.P. No. 533-91-07

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 6

LOCATION Hwy 6 & Speed River

No of PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 533-91-07 DIST 3

HWY 6 & 24 STR SITE -

Proposed Speed River Weir Relocation

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GEOCRES 40P9-33 DATE JUL 2 8 1993

FOUNDATION INVESTIGATION REPORT

For

Proposed Speed River Weir Relocation

W.P. 533-91-07, Hwy. 6 & Hwy. 24

District 3, Stratford

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted in conjunction with the proposed Speed River weir relocation. The existing weir located immediately downstream of the existing Hwy. 6-Speed River Crossing structure must be relocated because it conflicts with the proposed new E/W-S ramp structure. A weir relocation approximately 20 metres downstream of the existing location has been accepted and approved by all the internal and external agencies involved in the project. The weir will span the width of the Speed River and adjoining floodplain.

SITE DESCRIPTION AND GEOLOGY

General

The site is located downstream of the existing weir within the Speed River. The existing concrete weir is located adjacent to the existing four (4) span concrete beam Hwy. 6 Southbound/ Speed River structure located in turn adjacent to a twin Hwy. 6 Northbound

structure. The site is situated approximately 0.5 km south of the Wellington Street/ Hanlon Expressway intersection in the City of Guelph, Wellington County.

The existing concrete weir is approximately thirty six (36) metres in length and spans the Speed River. Concrete slabs and a retaining wall are located at the western edge of the weir. The water level upstream of the weir was approximately 1 metre and downstream at the proposed weir relocation the water level was approximately 0.3 m to 0.5 m at the time of the investigation. A turbulent water overflow is prevalent at all times, an indication of the dynamic flow conditions at the weir location.

River bank slopes exist on either side of the Speed River at the site. The slopes which are approximately 1H:1V and covered by grassland, low lying shrubs and tall trees exhibit no signs of instability. A water gauge shed used as a monitoring station by the Water Survey of Canada is situated on the east bank at the weir location.

Drainage ditches and CSP's are also located at various locations across the site. These ditches and CSP's are part of the Hwy. 6 hydrological storm water catchment that downfalls into the Speed River.

At the site, the Speed River is bounded by private land owned and managed by Guelph Dolime Ltd. Guelph Dolime Ltd operate a quarry southeast of the site. Stockpiles of crushed dolostone and rock and soil precipice are evidence of the operation. A bridge structure located approximately 100 to 150 metres downstream of the proposed relocated weir is used to access the quarry. A woodlot and office building is located immediately

north of the site.

Geology

Physiographically, the site is located within the region known as the "Guelph Drumlin Field". Within this area, there are approximately 300 drumlins of all sizes. The drumlins in this area are not closely spaced and there is intervening low lying grounds between the drumlins. This is for the reason that during the most recent Wisconsinan Glaciation period (approximate 12,000 years ago), the ice which moulded this field advanced from the southeast whilst the receding glacier moved perpendicular to this direction. As a result, the drainage of the ice front was directed to lower and lower outlets and hence the drumlin field is furrowed by parallel valleys running perpendicular to the trend of the drumlins. Along the sides of these valleys there are broad sand and gravel terraces.

As a result of the glacial activity, the general landform pattern consists of drumlins or groups of drumlins fringed by gravel terraces. The dominant soil materials are the unstratified, unsorted drumlin tills consisting of a heterogeneous mixture of gravels, sand and silts and the deep gravel terraces of the old meltwater spillways. Overburden in the site area is underlain by dolostones of the Amabel and Guelph Formations. Overburden thicknesses are shallow in the site area and usually less than five (5) metres.

INVESTIGATION PROCEDURE

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

Field Investigation

The fieldwork for this project was conducted on February 18, 1993 and consisted of a total of three (3) sampled boreholes. The boreholes were advanced to depths ranging from 2.6 m to 3.2 m.

All boreholes were advanced using a conventional track mounted Central Mining Equipment (CME) 55 drilling unit. Hollow stem auguring techniques were used to penetrate the overburden and conventional rock coring techniques consisting of an NX core barrel and NW Casing was used to core up to 1.5 metres of bedrock.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT-ASTM D1586). The samples were retrieved at 0.76 m intervals until bedrock was encountered.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Rock core samples were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Survey elevations of the river level and river bottom were taken to determine the depth of water present at the time of the investigation. The survey related to the location and elevation of the individual boreholes was provided by Southwestern Region Surveys and Plans.

Laboratory Analysis

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. Grain size distributions of the soils were determined by mechanical sieve and hydrometer analyses. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The rock core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

GENERAL

The subsurface conditions across the site are uniform and consist of a shallow native deposit comprised of approximately 0.8 to 1.5 metres of a heterogeneous mixture of boulders, cobbles, gravel, sand and silt underlain by dolostone bedrock. The bedrock surface elevation is flat and ranges from 301.3 m to 301.7 m across the site. At the time of the investigation, there was no water present at the extreme ends of the river, but water did exist within these outer limits.

A plan of the site illustrating the locations and elevations of the boreholes is shown on Dwg. No. 5339107-A in the Appendix. A subsoil stratigraphical section produced along the length of the proposed weir is also provided. The boundaries between the various soil types, in situ and laboratory test results as well as water levels established at the time of investigation are shown on the stratigraphical section and also on the individual Record of Borehole sheets

in the Appendix.

SOIL/ROCK DESCRIPTIONS

Water

Approximately 0.3 m of standing water was present in the Speed River at the time of the investigation. The water had frozen at the edges of the river, at the time of the investigation. Some flow was evident within the middle of the river.

Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)

At the river bottom and overlying the bedrock for a thickness ranging from 0.8 m to 1.5 m exists a native deposit consisting of a heterogeneous mixture of boulders, cobbles, gravel, sand and silt. The deposit is generally brown in colour but black organics are also evident within the surficial thicknesses of the deposit. Grain size distribution curves shown on Figure 1 in the Appendix illustrate the broad range of particle sizes that is characteristic of these types of deposits of glacial till origin. Boulders and cobbles, however, are not shown in the gradation curves.

The 'N' values as determined by the Standard Penetration Test range from 13 blows/0.3 m to 20 blows/0.3 m indicating a compact state of denseness. Larger 'N' values such as 60 blows/3 cm that were observed are a reflection of the sampler driven on boulders or bedrock.

Bedrock

The bedrock that underlies the heterogeneous mixture of boulders, cobbles, gravel , sand and silt at the site is a dolostone of the Guelph Formation. The dolostone bedrock is a chemical sedimentary rock that is medium grained. The rock is unweathered to slightly weathered and is featured by a porous "vug" texture and stylolites. The rock is very pale orange to yellowish brown in colour and contains thin horizontal beds and very close to moderately close spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality and strength of the rock was carried out by measuring core recoveries and Rock Quality Designations (RQD's) in the field and by physical index property testing. Recoveries were all at 100% and RQD's ranged from 28% to 85% indicating that the rock is of poor to good quality. Rock strengths can be described as weak.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes and monitoring the lake level throughout the duration of the field investigation. The river level was approximately 302.8 m at the time of the investigation and the water level for BH 1 (located on a small island within the water) also had a water level elevation equivalent to 302.8 m.

Groundwater and river levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

A conflict in the location of an existing concrete weir and the proposed E/W-S ramp structure will necessitate the relocation of the existing weir. It has been agreed by the Ministry of Transportation and various external agencies (Water Survey of Canada, Grand River Conservation Authority and the Ministry of Natural Resources) to relocate the weir approximately 20 metres downstream. The proposed concrete weir will span across the Speed River.

The Water Survey of Canada relies on this weir for flow measurement and flood predictions. They have advised that the existing weir must not be removed until the new one has been installed and calibrated.

Both the Ministry of Natural Resources and the Grand River Conservation Authority initially expressed their desires to have the weir completely removed since it obstructs fish passage and creates an area of impoundment. However, the weir must be replaced as specified by the Water Survey of Canada.

A plan illustrating the existing and proposed weir location is shown on Dwg. 5339107-A. Recommendations to facilitate the foundation design and construction of this weir is included in this report and described below.

Foundation Design

It is recommended that the structure foundations be supported on conventional spread footings founded on the bedrock surface. The bedrock surface is horizontal and at an uniform elevation of approximately 301.5± at the site. For purposes of the O.H.B.D.C., all footings founded on the dolostone bedrock can be designed using a factored capacity at U.L.S. of 1500 kPa. The bearing capacity at the Serviceability Limited State does not govern the design because of the unyielding nature of the bedrock. Stresses required to induce detrimental settlements at the Serviceability Limit State will exceed the factored capacity at U.L.S.

The bearing capacity given pertains to vertical normal loads only. Reductions of bearing capacities to account for inclined loadings shall conform to factors provided in Section 6-7.3.3.5 of the O.H.B.D.C.

The resistance of the spread footing founded on the bedrock surface can be computed by employing an unfactored angle of friction of 30° between the concrete footing and the bedrock surface. Should additional horizontal resistance to sliding be required, shear keys or dowels can be incorporated. An unconfined compressive strength of 10 MPa and a bond stress of 100 kPa (between cement grout and bedrock) at U.L.S. are relevant shear key/dowel design parameters within the dolostone bedrock. The lateral resistance of shallow foundations shall be computed in accordance with Section 6.7.3.3.2 of the O.H.B.D.C.

It is prudent that the footing base be protected against weathering during construction. To preserve the integrity of the bedrock surface during construction, it is recommended that a 100 mm thick lean mix concrete coating be placed on the footing bedrock surface within four (4) hours of exposure. Any previously weathered or loosened rock shall be removed prior to the placement of the concrete coating.

Foundation Construction

Footing construction should be conducted in the dry and therefore a temporary dam and/or temporary diversion is recommended. A construction staging sequence may also be necessary. Once the water flow has been diverted, excavation and construction can be executed within a "box-type" excavation using sump pumps if necessary. The box excavation scheme involves the excavation and then subsequent displacement of a prefabricated enclosure until the bedrock surface is encountered while pumping water to facilitate the excavation. Once the overburden has been excavated, and the prefabricated enclosure is positioned on the bedrock surface and sealed effectively at the bedrock surface to minimize water inflow, conventional sump pumping techniques can be used to discharge any additional water.

It is recommended that the Contractor submit dewatering scheme plans prior to construction as specified in OPSS 902.04. Our office can then assist in the review of these drawings to determine acceptability of the proposal.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Malone's Soil Samples. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by Mr. M. Devata, Chief Foundation Engineer.

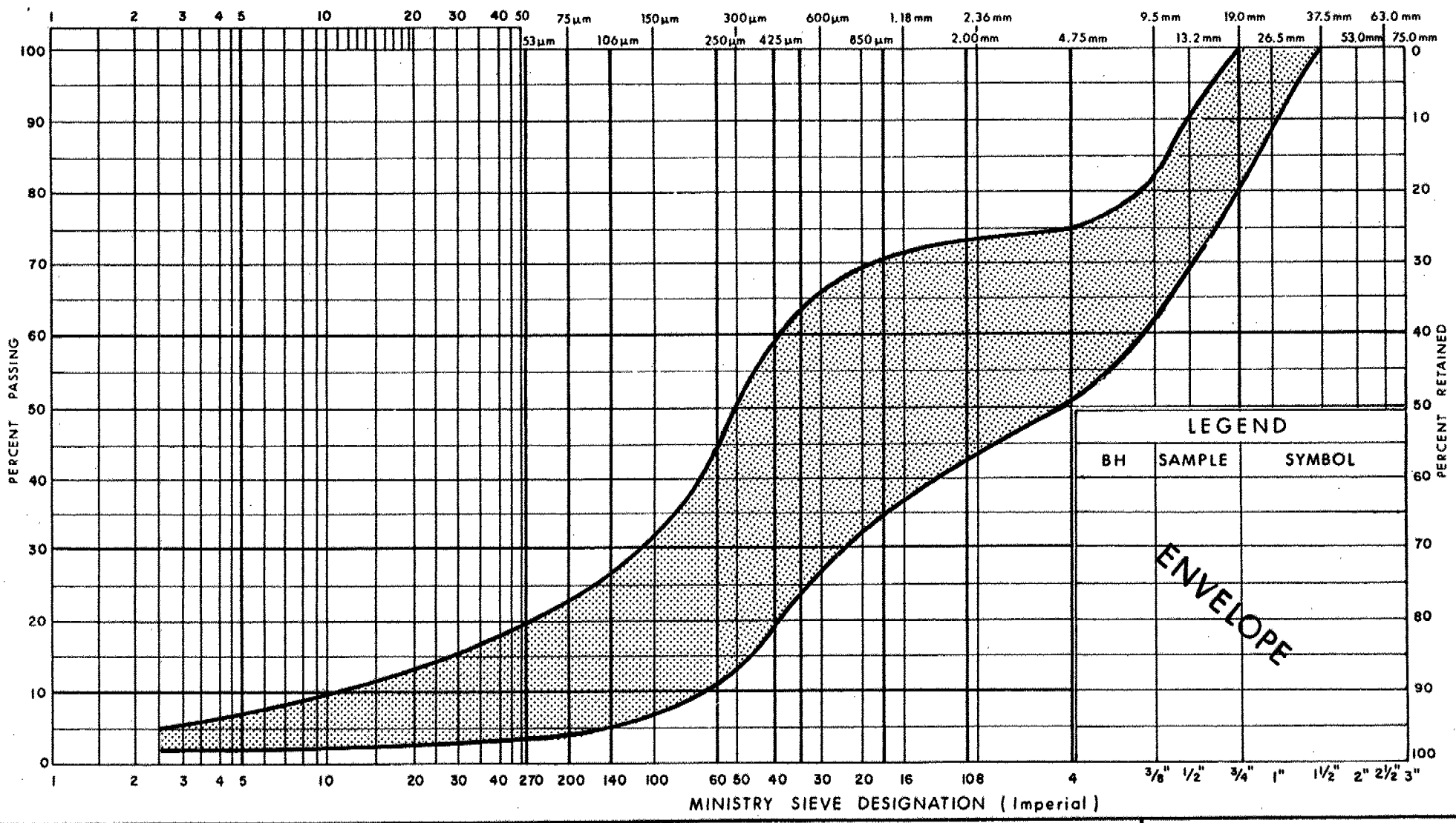
T. Sangiuliano, P.Eng.
Foundation Engineer

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
HET. MIXTURE OF BOULDERS, COBBLES, GRAVEL, SAND & SILT (Glacial Till)

FIG No 1

W P 533 - 91 - 07

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 533-91-07 LOCATION Co-ords: N 4 820 772.5; E 243 248.0 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 18 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
303.2	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Black, trace Organics		1	SS	17	▼*			o		37 52 10 1
	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		2	SS	16		302				
301.7	Grey, Compact		3	SS	60/3cm						
1.5	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		4	RC	REC 100%						RQD = 85%
300.1											
3.1	End of Borehole										
	• 93 02 19										

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 533-91-07 LOCATION Co-ords: N 4 820 767.7; E 243 261.5 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 18 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
302.8	Water Surface										
0.0	Water										
0.3	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		1	SS	16		302		○		49 47 3 1
301.7	Grey, Compact to Very Dense		2	SS	60/5cm						
1.1	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		3	RC	REC 100%						RQD = 56%
300.2											
2.6	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 533-91-07 LOCATION Co-ords: N 4 820 768.8; E 243 270.7 ORIGINATED BY TS

DIST 3 HWY 6 BOREHOLE TYPE HS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 93 02 18 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
302.8	Water Surface										
0.0	Water										
0.3	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand and Silt (Glacial Till)		1	SS	13		302				
			2	SS	20						26 52 20 2
301.3	Grey, Compact		3	SS	*						
1.5	Dolostone Bedrock Weak, Unweathered to Slightly Weathered		4	RC	REC 100%		300				RQD = 28%
299.6											
3.2	End of Borehole										

* Sampler Bouncing

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 533-91-07

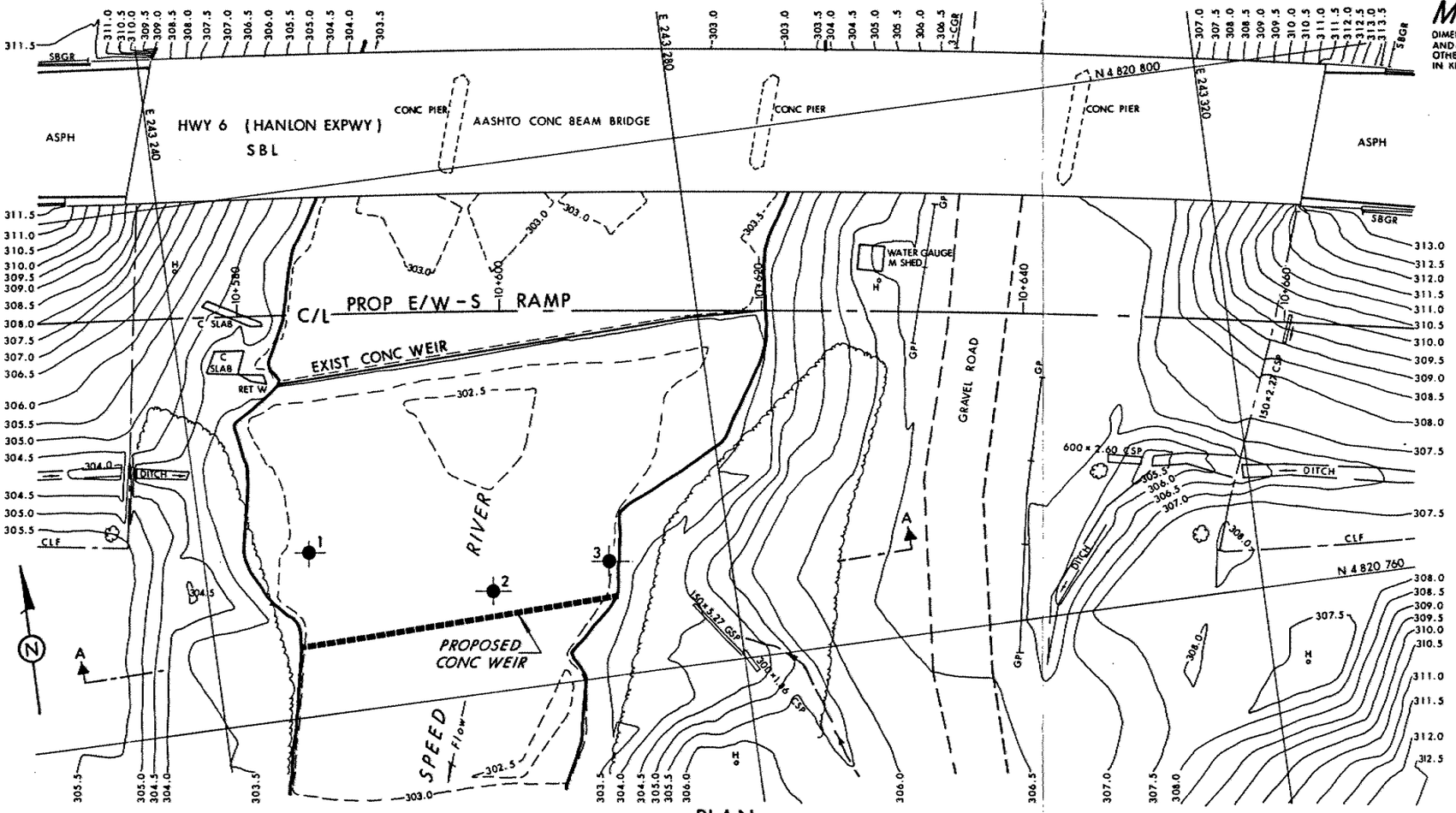
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	4	1.55-3.07	100	85	1.55-3.07	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 3 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to close spaced, flat to dipping, undulating to planar, smooth to rough.
2	3	1.07-2.59	100	56	1.07-2.59	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to 3 cm in diameter), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, undulating to planar, smooth to rough.
3	4	1.70-3.22	100	28	1.70-3.22	**DOLOSTONE** (with stylolites, abundant small vugs, and some larger vugs up to at least 4 cm in diameter, commonly containing calcite crystals), very pale orange to pale yellowish brown; medium grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

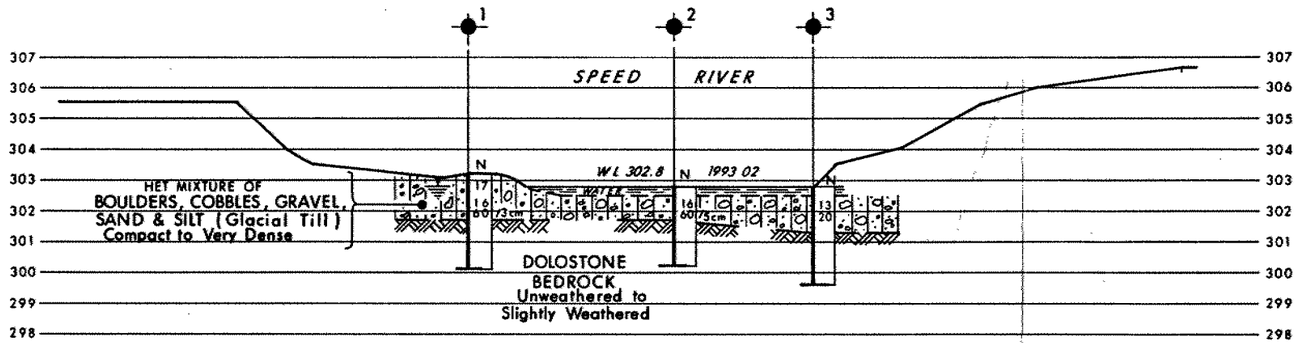
MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10



PLAN

SCALE

4m 2 0 4m



SECTION A-A

SCALES

4m 2 0 4 m HOR

2m 1 0 2m VERT

METRIC

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

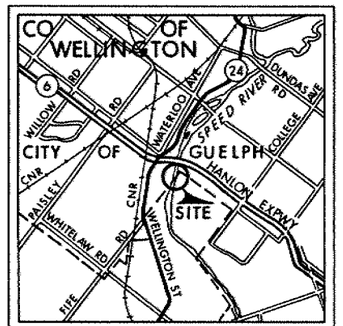
CONT No

WP No 533-91-07

SHEET

PROP SPEED RIV WEIR RELOCATION
(INTERCHANGE AT HWY 6 & WELLINGTON ST)

BORE HOLE LOCATIONS & SOIL STRATA



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 1993 02

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	303.2	4820772.5	243248.0
2	302.8	4820767.7	243261.5
3	302.8	4820768.8	243270.7

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen.Cond.

LICENSED PROFESSIONAL ENGINEER A. J. Sangiuliano PROVINCE OF ONTARIO

REV.	DATE	BY	DESCRIPTION

Geocres No 40P9-33

HWY No 6 (HANLON EXPWY)			DIST 3
SUBM'D TS	CHECKED TS	DATE 1993 07 20	SITE
DRAWN RS	CHECKED	APPROVED	DWG 5339107-A

REF No E-153-6-2, 1992 06