



FOUNDATION INVESTIGATION REPORT

CONTRACT NO 83 - 44



Ministry of
Transportation and
Communications

1

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NOTE: For purposes of this contract, this report
supersedes all other foundation reports done
by or for the Ministry in connection with the
above-mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_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_f	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_f}$

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

FOR

W.P. 184-79-01, SITE 31-237
RAISIN RIVER BRIDGE, HWY. 2
DISTRICT 9, (OTTAWA) EASTERN REGION

INTRODUCTION

Golder Associates, Consulting Geotechnical Engineers, have been retained by the Ministry of Transportation and Communications, Ontario to carry out a geotechnical investigation at the site of the existing bridge crossing of the Raisin River by Highway 2 at South Lancaster, Ontario.

The purpose of the investigation was to determine the general subsurface conditions across the site by means of sampled borings, and based on an assessment and interpretation of the factual data obtained to provide engineering recommendations regarding the geotechnical aspects of the design of the proposed works, including any special construction considerations which could influence design decisions.

Previous investigation at this site included two boreholes, one with rock coring, on the south side of the proposed structure near the shores of the river. The factual information obtained from these two boreholes by Ministry personnel has been included in this report.

DESCRIPTION OF SITE AND GEOLOGY

The site of the proposed bridge replacement is at the existing Highway 2 crossing of the Raisin River at South Lancaster in the Township of Charlottenburgh, County of Glengarry. The site is located about 1 kilometre south of the intersection of Highways 2 and 401, and is designated as Site 31-237, District 9, Ottawa.

In the area of the crossing, the Raisin River is about 2 metres deep and some 50 metres wide. The existing river

banks in the crossing area rise at about a 4 horizontal to 1 vertical slope to some 2 metres above normal water level. The ground surface adjacent to the river is flat to gently rolling. The existing Highway 2 bridge approach embankments rise to some 3 metres above the level of the natural ground adjacent to the river.

The site is located within the physiographic region known as the Lancaster flats, a lowland area in which the glacial till plain has been subsequently buried under water-laid deposits leaving exposed only the stoney crests of a few drumlins and ridges. The water-laid deposits typically range from clay to very fine sand. Locally, surficial deposits of river alluvium form terraces adjacent to and within major river and drainage channels. The till plain, in general, is relatively thick and underlain by sedimentary shale or limestone bedrock of the Rockcliffe and/or St. Martin formations.

SUBSURFACE CONDITIONS

General

The detailed subsurface stratigraphy encountered in each borehole and augerhole put down during this investigation is shown on the Record of Borehole and Augerhole sheets following the text of this report. The locations of the borings and a section showing the relative borehole stratigraphy at the proposed bridge crossing are shown on Drawing . It should be noted that the soil boundaries indicated on the Record of Borehole sheets and on the drawing are inferred from non-continuous samples and from observation of resistance to auger advance and auger cuttings and do not necessarily indicate an exact plane of geological change.

Summarized Stratigraphy

In summary, the river bank areas at the site are underlain by up to 3 metres of fill material followed by a 1 to 2 metre thick mantle of native sand with some silt and gravel. The riverbed area, in contrast is underlain by 1 to 2 metres of organic sandy silt river alluvium. The main subsoil across the site consists of a relatively thick stratum of

sandy silt glacial till which contains numerous cobbles and boulders at depth. The glacial till is in turn underlain by limestone bedrock.

Surficial Deposits

Borehole 1 and augerholes 6 and 7 encountered some 2 to 3 metres of approach embankment fill consisting basically of silty sand with some clay, gravel, boulders and decayed organic material. In general, the fill deposit was found to be in a loose state of packing, although the presence of boulders made penetration augering somewhat difficult.

Borehole 2, put down adjacent to the west approach embankment, encountered thin surficial deposits of peat and stiff silty clay. Based on field observations, these deposits are expected to be limited in plan area to immediately adjacent to the river.

Alluvium

Boreholes 3, 4 and 5, put down within the riverbed, encountered a 1 to 2 metre thickness of dark brown organic silty sand and gravel (see Figure for grading). This deposit is considered to represent flood-plain deposited material of alluvial origin. Boreholes 1 and 2 also encountered about 1 metre of sand with some silt and gravel at near river level. Standard penetration tests carried out in these basically granular deposits gave N values ranging from 3 to greater than 50 blows per 0.3 metres. The high N values reflect oversize materials (cobbles) within the deposit and it is considered that the relative density is generally in the loose to compact range.

Glacial Till

The above strata were found to be underlain at all the borehole and augerhole locations by an extensive deposit of glacial till. The upper boundary of the glacial till was encountered at some 2 to 4 metres below the road and ground surface adjacent to the river, and some 1 to 2 metres below the river bottom level. At the borehole locations, the

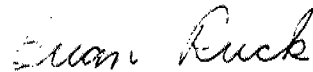
thickness of the glacial till was found to vary from 7.5 to in excess of 9 to 10 metres. The results of grading analyses carried out on representative samples of the glacial till are shown on Figure and indicate that the till consists basically of a silty sand in a matrix of clay and gravel. As well, the glacial till contained numerous cobble and boulder size material, especially below about elevation 39 to 40 (approximately 10 and 5 metres below roadway level and river bottom level respectively). Below these levels it was generally necessary to revert to diamond drilling techniques in order to advance the borings. Standard penetration tests carried out in the glacial till gave N values ranging from 17 to 50 blows per 0.3 metres in the upper 2 to 4 metres of the deposit, increasing to greater than 100 blows per 0.3 metres at depth as the cobble and boulder content increased. Based on these values, the relative density of the glacial till is considered to be compact to dense, becoming very dense with depth.

Bedrock

Bedrock was encountered and proven by core drilling in BX size in boreholes 1 and 5. The surface of the bedrock at these locations was at elevation 34.1 to 35.9, i.e. at depths of 10.1 and 11.5 metres below riverbed and ground surface level respectively. From visual examination of the rock core recovered, and from the recorded core recovery (80 to 90 percent) and R.Q.D. values (0 to 80 percent), the bedrock is considered to be slightly weathered to fresh with a probable fairly sound to sound overall structure. The bedrock recovered was a near horizontally bedded grey limestone.

Groundwater

The groundwater level was determined in Boreholes 1 and 2 in 1980 by measurements within the cased boreholes. At that time the groundwater level adjacent to the river was found to be at about elevation 47. The level of the water in the Raisin River at the time of the present investigation in late May, 1981 was at about elevation 46.4.



BRIAN RUCK
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Senior Foundation Engineer

NOTE:

This is a copy of the factual information contained in the foundation report prepared for the Ministry by Golder Associates (July, 1981).



Ministry of
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Ontario

RECORD OF BOREHOLE No 1

METRIC

8

W P 184-79-01 LOCATION 7.5 m South of Hwy. 2, 2.0 m West of East Abutment
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BX Casing, BXL Rock Core
DATUM Geodetic DATE 1980 04 24

ORIGINATED BY MM

COMPILED BY MM

CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
27.4	Ground Surface																
0.0	Fill Sand, Some Silt, Some Gravel with Decayed and Undecayed Organic Material		1	SS	1		26								W = 56%		17 61 18 4
24.9			2	SS	50/	150 mm											30 43 21 6
2.5	Sand, Some Silt, Some Gravel		3	SS	69		24										26 45 23 6
23.4	Dense to Very Dense		4	SS	45												
4.0	Heterogeneous Mixture Sand, Silt and Gravel Very Dense		5	SS	55		22										
	With Cobbles and Boulders		6	SS	100/	150 mm	20										29 37 31 3
			7	BXL RC	REC 60%												
			8	SS	100/	150 mm											
	(Glacial Till)		9	BXL RC	REC 20%		18										
			10	SS	100/	75 mm											
15.9			11	BXL RC	REC 10%		16										
11.5	Sound Limestone		12	SS	100/	100 mm											
14.5	Bedrock		13	BXL RC	REC 80%	80%											
12.9	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



Ministry of
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Communications
Ontario

RECORD OF BOREHOLE No 2

METRIC

9

W P 184-79-01 LOCATION 14.3 m South of Hwy. 2, 5.0 m West of West Abutment
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BK Casing BXL Rock Core
DATUM Geodetic DATE 1980-04-27

ORIGINATED BY MM
COMPILED BY MM
CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
27.3	Ground Surface																
0.0	Peat																
26.0	Silty Clay Stiff		1	SS	4		26										21 36 35 8
1.3	Sand, Some Silt		2	SS	19												
25.1	Some Gravel Compact		3	SS	17												
2.2	Heterogeneous Mixture Sand, Silt and Gravel (Glacial Till)		4	SS	22		24										52 29 16 3
	Compact to Dense		5	SS	24		22										
	Very Dense with Cobbles & Boulders		6	BXL RC	REC	20%	20										
			7	SS	43												
			8	SS	100/	150 mm	18										
			9	BXL RC	REC 40%												
			10	SS	70/	10 mm	16										
			11	BXL RC	REC 40%												
14.9																	
12.4	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



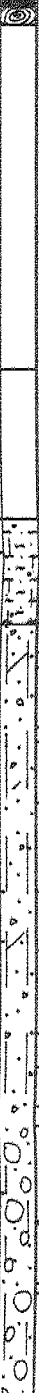

Ministry of
Transportation and
Communications

RECORD OF BOREHOLE No 3

METRIC

10

W P 184-79-01 LOCATION Sta. 19+541.6 o/s 2.3 m Lt. 2 Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem, Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 05 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	SHEAR STRENGTH						WATER CONTENT (%)
50.08	Existing Bridge Deck							○ UNCONFINED	+ FIELD VANE	20 40 60					
0.00	Asphalt								● QUICK TRIAXIAL	x LAB. VANE					
0.09	Wood														
0.27															
46.33	Water Level (River)														
3.75	Water														
44.81	River Bottom														
5.27	Alluvium, organic silty sand and gravel		1	SS	6										
	Dark Grey Loose														
43.68			2A	SS	18										
6.40	Glacial till, Compact silty sand and gravel, trace clay.		2B	SS	26										38 43 15 4
			3	SS	60										51 36 9 4
	Grey Dense														
			4	SS	30										
			5	SS	35										
			6	RC BX	31%										
			7	SS	>100										
			8	RC BX	38%										
			9	RC BX	83%										
			10	RC BX	57%										
35.66															
14.42	End of Borehole														

+3, x5: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 4

METRIC

11

W P 184-79-01 LOCATION Sta. 19+552.4 o/s 2.1 m Rt. 2 Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 05 28 and 06 02 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD-VANE ● QUICK TRIAXIAL x LAB VANE					
50.10	Existing Bridge Deck													
0.00	Asphalt													
0.09	Wood													
0.27														
46.29	Water Level (River)													
3.81	Water													
44.92	River Bottom													
5.18	Alluvium, organic silty sand and gravel, shells.		1	SS	13									
	Dark Grey Loose		2	SS	3									
			3	SS	>50									
42.79														
7.31	Glacial till, Compact silty sand and gravel, trace clay.		4	SS	24									
	Grey Dense													
			5	SS	60									
			6	RC BX	83%									
	Very Dense		7	SS	>100									
	Numerous cobbles and boulders.		8	RC BX	58%									
36.38			9	RC BX	72%									
13.72	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

SHEET 1 OF 2

RECORD OF BOREHOLE No 5

METRIC

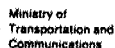
12

W P 184-79-01 LOCATION Sta. 19+561.3 o/s 2.3 m Lt. 2 Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem, Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981.06.01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
50.09	Existing Bridge Deck							20 40 60 80 100							
0.00	Asphalt						50								
0.09	Wood														
0.27															
							49								
							48								
							47								
	Water Level (River)						46								
3.63	Water						45								
							44								
5.85	River Bottom						43								
43.54	Alluvium, organic silty sand, gravel, shells. Dark Grey Compact		1	SS	14		42							32 43 20 5	
6.55	Glacial till, Compact silty sand and gravel, trace clay.						41								
	Grey Dense		2	SS	25		40							22 42 33 2	
							39								
			3	SS	82		38								
	Very Dense		4	SS	>100										
			5	RC BX	38%										
	Numerous cobbles and boulders.		6	SS	>100										
			7	RC BX	29%										
	Continued on Sheet 2														

+3, x5; Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5 Cont

METRIC

13

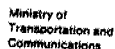
W P 184-79-01 LOCATION Sta. 19+561.3 o/s 2.3 m Lt. of Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem, Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 06 01 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%) 20 40 60
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
Continued from Sheet 1															
34.15	Glacial till, silty sand and gravel, trace clay. Grey Very Dense Numerous cobbles and boulders.		7	RC BX	29%		37							29 47 19 5	
			8	SS	>100		36								
			9	RC BX	28%		35								
			10	RC BX	37%		34								
			11	SS	>100		33								
15.94	Limestone bedrock, slightly weathered to fresh, calcite seams.		12	RC BX	Rec 90% RQD 0%										
32.90															
17.19	End of Borehole														

+3, x5 : Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



14

W P	184-79-01	LOCATION	Sta. 19+521.8 o/s 2.3 m Lt. of Hwy. 2 (Existing)	METRIC
DIST	9 HWY 2	BOREHOLE TYPE	Hollow Stem Augers, Cone Test	ORIGINATED BY
DATUM	Geodetic	DATE	1981 05 29	DN
				CHECKED BY

[illegible]

+³, x⁵ : Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

10

OFFICE REPORT ON SOIL EXPLORATION

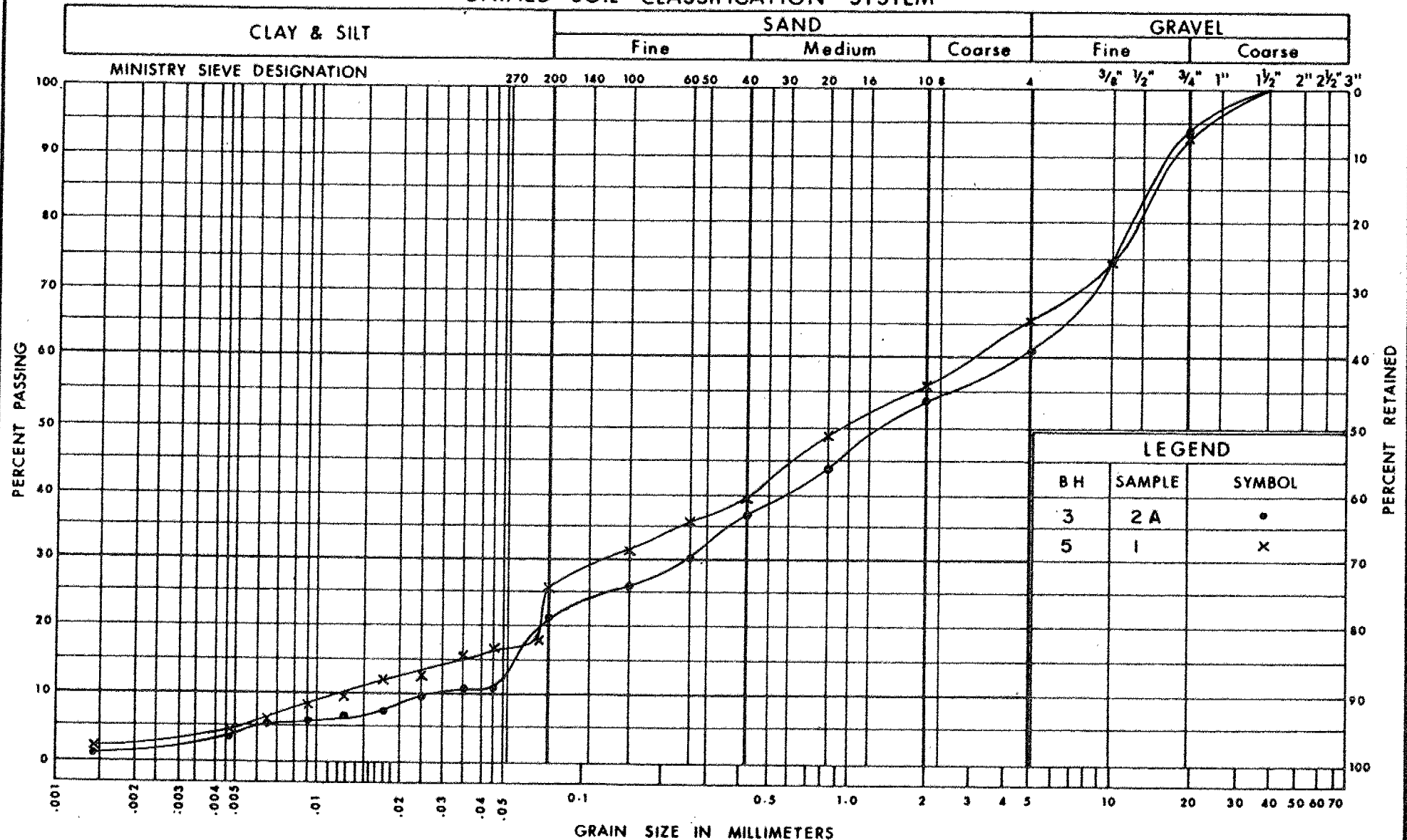
METRIC

W P 184-79-01 LOCATION Sta. 19+581.7 o/s 2.2 m Lt. of Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DN
DATUM Geodetic DATE 1981 05 29 CHECKED BY _____

[illegible]

+3, x⁵: Numbers refer to Sensitivity

UNIFIED SOIL CLASSIFICATION SYSTEM



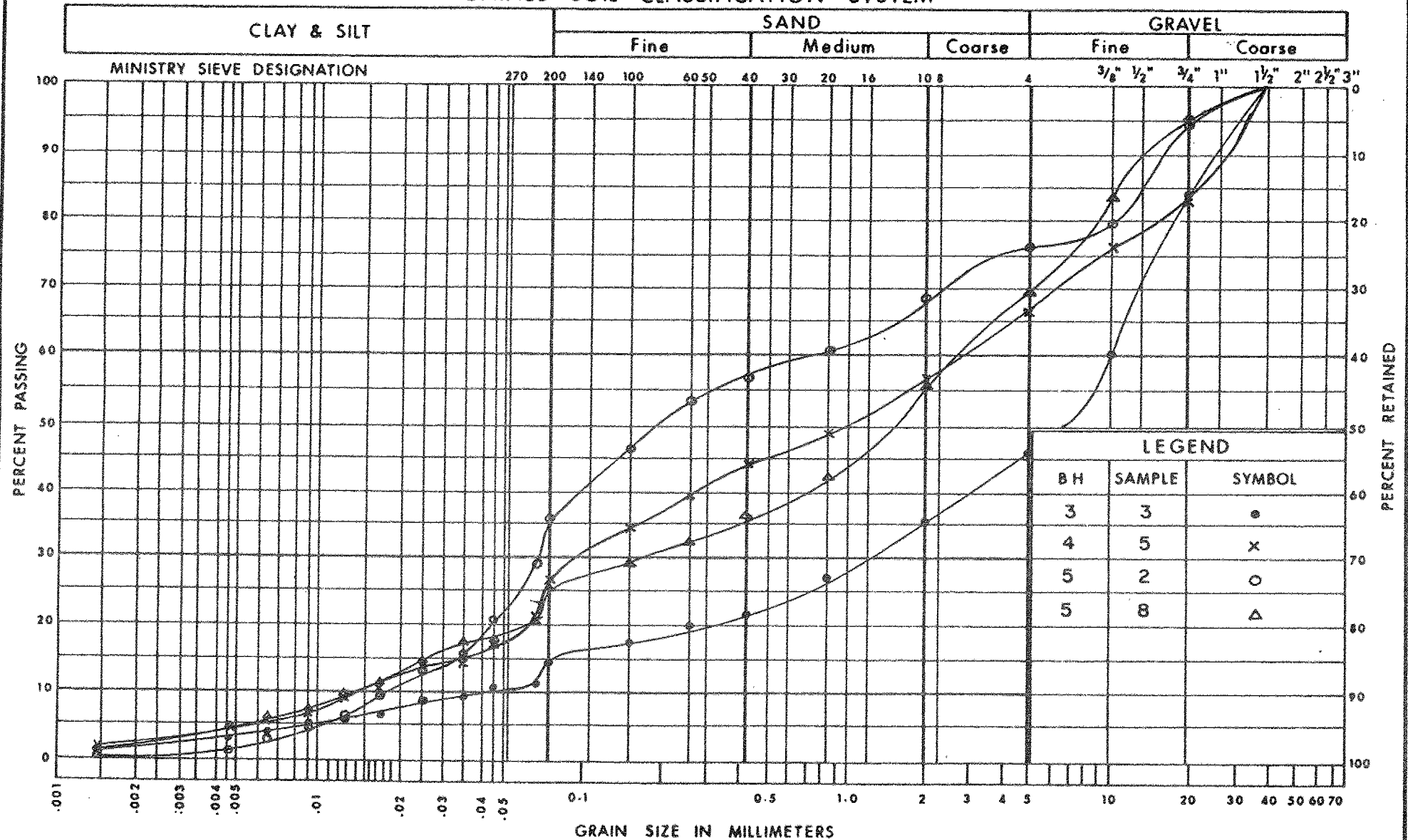
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
ALLUVIUM
ORGANIC SILTY SAND AND GRAVEL

FIG No 1

W P 184-79-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
GLACIAL TILL SILTY SAND AND GRAVEL TRACE
CLAY COBBLES AND BOULDERS

FIG No 2

WP 184-79-01



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT

TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

GEOTECHNICAL INVESTIGATION

RAISIN RIVER BRIDGE
HIGHWAY 2

W.P. 184-79-01 SITE 31-237

SOUTH LANCASTER ONTARIO

Distribution:

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The results of an investigation to determine the subsurface conditions at the site of the proposed bridge replacement crossing of the Raisin River at Highway 2, near South Lancaster, Ontario, are reported herein. Geotechnical recommendations are given for the foundation design of the proposed bridge replacement structure and approach embankments.

The borings revealed that the site is covered by surficial deposits of silty sand fill, sand with some silt and gravel, and in the river bed area, organic sandy silt alluvium. The main subsoil at the site consists of up to 10 metres of compact to very dense sandy silt glacial till which contains numerous cobbles and boulders at depth. The glacial till is in turn underlain by limestone bedrock, the surface of which was encountered at depths of 10 to 11 metres below river bed and ground surface level at two of the borehole locations. The groundwater level was found to be close to river bank level; that is, slightly above the adjacent Raisin River water level.

It is recommended that the abutments and piers of the proposed bridge replacement structure be founded on end-bearing piles driven to final set within the very dense glacial till. Steel H-piles would be suitable pile types. Preliminary design values of 1150 kN per pile are given based on assumed pile size, set, and driving energy criteria. Built up pile tips and/or the fitting of rock points have been recommended due to the cobble and boulder size material present throughout the glacial till stratum.

There should be no overall stability problems associated with the proposed raising and widening of the existing approach embankment fills although some settlement of the surficial subsoil may be expected during construction. Nominal rip rap protection should be provided to the existing river banks in the area of the bridge alignment.

1. INTRODUCTION

Golder Associates, Consulting Geotechnical Engineers, have been retained by the Ministry of Transportation and Communications, Ontario to carry out a geotechnical investigation at the site of the existing bridge crossing of the Raisin River by Highway 2 at South Lancaster, Ontario. Preliminary details of the proposed project were provided to us by Mr. M.S. Devata, P.Eng., Supervisory Engineer, Soil Mechanics Section, Ministry of Transportation and Communications, Downsview, Ontario. The proposed scope of the investigation was outlined in our proposal letters of April 14 and May 4, 1981 to Mr. M.S. Devata.

The purpose of the investigation was to determine the general subsurface conditions across the site by means of sampled borings, and based on an assessment and interpretation of the factual data obtained to provide engineering recommendations regarding the geotechnical aspects of the design of the proposed works, including any special construction considerations which could influence design decisions.

This report is presented in two parts. Part A details the factual results of the borings while Part B gives our interpretation of the factual data, together with recommendations for the geotechnical design of the proposed works. It should also be noted that the results of a feasibility investigation carried out at this site have been incorporated into both Parts A and B of this report. The detailed results of this Feasibility Foundation Investigation are contained in report 316-187 of the Engineering Materials Office, Pavement and Foundation Design Section, dated May 27, 1980.

2. DESCRIPTION OF SITE AND GEOLOGY

The site of the proposed bridge replacement is at the existing Highway 2 crossing of the Raisin River at South Lancaster in the Township of Charlottenburgh, County of Glengarry. The site is located about 1 kilometre south of the intersection of Highways 2 and 401, and is designated as Site 31-237, District 9, Ottawa.

In the area of the crossing the Raisin River is about 2 metres deep and some 50 metres wide. The existing river banks in the crossing area rise at about a 4 horizontal to 1 vertical slope to some 2 metres above normal water level. The ground surface adjacent to the river is flat to gently rolling. The existing Highway 2 bridge approach embankments rise to some 3 metres above the level of the natural ground adjacent to the river.

The site is located within the physiographic region known as the Lancaster flats, a lowland area in which the glacial till plain has been subsequently buried under water-laid deposits leaving exposed only the stoney crests of a few drumlins and ridges. The water-laid deposits typically range from clay to very fine sand. Locally, surficial deposits of river alluvium form terraces adjacent to and within major river and drainage channels. The till plain, in general, is relatively thick and underlain by sedimentary shale or limestone bedrock of the Rockcliffe and/or St. Martin formations.

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PART A

SUBSURFACE CONDITIONS

3. SUBSURFACE CONDITIONS

3.1 Subsoil

The detailed subsurface stratigraphy encountered in each borehole and augerhole put down during this investigation is shown on the Record of Borehole and Augerhole sheets following the text of this report. The locations of the borings and a section showing the relative borehole stratigraphy at the proposed bridge crossing are shown on Drawing 1847901-A. It should be noted that the soil boundaries indicated on the Record of Borehole sheets and on the drawing are inferred from non-continuous samples and from observation of resistance to auger advance and auger cuttings and do not necessarily indicate an exact plane of geological change.

3.1.1 Summarized Stratigraphy

In summary, the river bank areas at the site are underlain by up to 3 metres of fill material followed by a 1 to 2 metre thick mantle of native sand with some silt and gravel. The riverbed area, in contrast, is underlain by 1 to 2 metres of organic sandy silt river alluvium. The main subsoil across the site consists of a relatively thick stratum of sandy silt glacial till which contains numerous cobbles and boulders at depth. The glacial till is in turn underlain by limestone bedrock.

3.1.2 Surficial Deposits

Borehole 1 (M.T.C. Feasibility Investigation) and augerholes 6 and 7 encountered some 2 to 3 metres of approach embankment fill consisting basically of silty sand with some clay, gravel, boulders and decayed organic material. In general, the fill deposit was found to be in a loose state of packing, although the presence of boulders made penetration augering somewhat difficult.

Borehole 2 (M.T.C. Feasibility Investigation), put down adjacent to the west approach embankment, encountered thin surficial deposits of peat and stiff silty clay. Based on field observations, these deposits are expected to be limited in plan area to immediately adjacent to the river.

3.1.3 Alluvium

Boreholes 3, 4 and 5, put down within the riverbed, encountered a 1 to 2 metre thickness of dark brown organic silty sand and gravel (see Figure 1 for grading). This deposit is considered to represent flood-plain deposited material of alluvial origin. Boreholes 1 and 2 also encountered about 1 metre of sand with some silt and gravel at near river level. Standard penetration tests carried out in these basically granular deposits gave N values ranging from 3 to greater than 50 blows per 0.3 metres. The high N values reflect oversize materials (cobbles) within the deposit and it is considered that the relative density is generally in the loose to compact range.

3.1.4 Glacial Till

The above strata were found to be underlain at all the borehole and augerhole locations by an extensive deposit of glacial till. The upper boundary of the glacial till was encountered at some 2 to 4 metres below the road and ground surface adjacent to the river, and some 1 to 2 metres below the river bottom level. At the borehole locations, the thickness of the glacial till was found to vary from 7.5 to in excess of 9 to 10 metres. The results of grading analyses carried out on representative samples of the glacial till are shown on Figure 2 and indicate that the till consists basically of a silty sand in a matrix of clay and gravel. As well, the glacial till contained numerous cobble and boulder size material, especially below about elevation 39 to 40 (approximately 10 and 5 metres below roadway level and river bottom level respectively). Below these levels it was generally

necessary to revert to diamond drilling techniques in order to advance the borings. Standard penetration tests carried out in the glacial till gave N values ranging from 17 to 50 blows per 0.3 metres in the upper 2 to 4 metres of the deposit, increasing to greater than 100 blows per 0.3 metres at depth as the cobble and boulder content increased. Based on these values, the relative density of the glacial till is considered to be compact to dense, becoming very dense with depth.

3.2 Bedrock

Bedrock was encountered and proven by core drilling in BX size in boreholes 1 and 5. The surface of the bedrock at these locations was at elevation 34.1 to 35.9, i.e. at depths of 10.1 and 11.5 metres below riverbed and ground surface level respectively. From visual examination of the rock core recovered, and from the recorded core recovery (80 to 90 percent) and R.Q.D. values (0 to 80 percent), the bedrock is considered to be slightly weathered to fresh with a probable fairly sound to sound overall structure. The bedrock recovered was a near horizontally bedded grey limestone.

3.3 Groundwater

The groundwater level was determined in Boreholes 1 and 2 in 1980 by measurements within the cased boreholes. At that time the groundwater level adjacent to the river was found to be at about elevation 47. The level of the water in the Raisin River at the time of the present investigation in late May, 1981 was at about elevation 46.4.

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PART B

DISCUSSION AND RECOMMENDATIONS

4. DESCRIPTION OF PROJECT

This section of the report presents our interpretation of the factual geotechnical data obtained during this investigation. It is stressed that the information in this section of the report is provided for the guidance of the design engineers and is based on our present understanding of the project. It is recommended that the final design of the bridge structure be discussed with the geotechnical engineer to ascertain that the recommendations given in this report are applicable to the actual design requirements and that the general intent of the geotechnical report has been met.

Planning is currently underway to replace the existing 50.3 metre single span steel truss bridge crossing of the Raisin River by Highway 2. Preliminary details of the project were provided to us on a marked -up M.T.C. Plan E-7000-2, "Bridge Site Plan, Proposed Crossing at Raisin River and Kings Highway 2", dated April, 1981.

It is understood that present plans call for replacement of the existing bridge with a new structure along basically the same horizontal alignment (possible slight shift to the south). The gradeline of the new bridge structure and adjacent approach embankments is to be raised by about 0.5 metres above that presently existing. The proposed new bridge will be a 51.8 metre long by 10.5 metre wide structure to carry two traffic lanes and a sidewalk. The structure will be either two or three spans, supported by two abutments on land and one or two piers within the river channel.

5. BRIDGE FOUNDATIONS

5.1 Abutments

The proposed bridge abutment locations are indicated to be underlain by existing approach fill material, 1 to 2 metres of loose to compact granular alluvium, followed by several metres of compact glacial till. Although the compact glacial till at this site would in general be considered a competent bearing strata capable of supporting an

allowable bearing pressure of about 200 kilopascals, two factors may make the use of spread footing design impractical at this site:

- 1) excavations for abutment footings would have to extend through the granular alluvium to 1 to 2 metres below river level. Water inflow through the relatively pervious alluvium material could therefore be significant and, unless adequately controlled, could significantly disturb the silty sand till at founding level
- 2) some settlement of the abutment footings must be anticipated using this scheme. If a rigid frame structure is adopted, differential settlement between the piers and abutments could exceed the tolerable structural limits.

An alternative to spread footings for the support of the bridge abutment loads at this site would be the use of a piled foundation. It is considered that steel H-piles, driven to end bearing, would be the most suitable pile type at this site. The piles could be designed for the maximum allowable load per pile section chosen. For preliminary design purposes, the allowable load for an HP 310 by 110 H-pile section driven to a final set of about 15 blows per 25 millimetres with a hammer developing a minimum of about 48 kilojoules of energy per blow may be taken as 1150 kN per pile. For Limit State Design as per the new M.T.C. Bridge Design Code, the capacity of the piles at the S.L.S. Type II may also be taken as 1150 kN. The factored capacity at the Ultimate Limit State would be 1600 kN. The steel H-pipes, however, would have to be fitted with reinforced tips to prevent structural damage from the cobbles and boulders present within the glacial till at depth. For estimating purposes it is considered that the H-piles would probably encounter the required set and thus the allowable load at about elevation 38 to 39 metres.

5.2 Piers

The piers of a two or three span structure may also be founded on steel H-piles as discussed above. As for the abutment piles, an allowable load of 1150 kN per pile may be used for a 310 millimetre H-pile. It may be expected that the pier piles will encounter the recommended set values at about the same elevation as the abutment piles.

5.3 Construction Considerations

As noted previously, significant cobble and boulder size material was encountered within the glacial till stratum, especially below about elevation 40. Consequently, difficulties may be expected in driving the piles to the design batter and location. As recommended, the pile tips should be built up or fitted with a rock point. This will aid in not only strengthening the pile tip but will also help ensure that the piles do not encounter the recommended set prematurely on cobbles and boulders.

A closed steel sheet pile cofferdam will have to be constructed at each pier location in order to construct the pier pile caps in the dry. If spread footing design is used, cofferdams would be required at both pier and abutment locations to enable unwatering to be carried out. In order to limit the potential for "piping" of the fine subsoils at the base of the excavation, and to cut off potential water inflow through the relatively pervious granular alluvium, it is recommended that the sheet piling be driven to several metres below the base of the excavation, and/or at least 1 to 2 metres into the compact to dense silty sand till. Dewatering may then be carried out using sumps located within the cofferdams.

It should be pointed out that as a result of the significant cobble and boulder content of the glacial till, some difficulty in penetrating the till to achieve an adequate seal

or cut-off with steel sheeting may be encountered. Consideration could also be given to construction of earth fill cofferdams for the river piers using local sources of glacial till for the dykes. In this case, the alluvial soil would require removal prior to construction of the earth fill cofferdams to avoid the problems of piping and groundwater inflow through this medium.

6. ABUTMENTS

Abutment pile caps and/or footings should be provided with at least 1.5 metres of earth cover for frost protection purposes. If retaining type abutments are used, the backfill behind the abutments should consist of free-draining, non-frost susceptible granular material compacted in horizontal lifts. This non-frost susceptible backfill should extend at least 1.5 metres horizontally from the back face of the abutment walls to prevent the formation of hydrostatic or ice pressure build-up. With full effective drainage of this backfill, the abutments may be designed using a coefficient of earth pressure at rest, K_o , of 0.5 and a total unit weight of 21.2 kilonewtons per cubic metre. This value of K_o provides some allowance for compaction induced stresses. If some movement of the top of the abutment wall can be tolerated, an active earth pressure coefficient, K_a , = 0.3 may be used in design. Earth pressures as per the new Bridge Design Code should be computed in accordance with Section 6.6.1.2.2 of the O.H.B.D.C.

7. APPROACH EMBANKMENTS

As presently planned the existing approach embankments will be raised slightly and extended south of the existing alignment. Prior to construction, all surficial organic material should be stripped from the embankment widening area. The embankment fill, to consist of acceptable granular material, should be placed in relatively thin even lifts and compacted to at least 95 percent of the maximum standard Proctor dry density values using suitable vibratory equipment.

Provided the foregoing is carried out no deep seated instability or settlement problems are anticipated. However, it should be noted that some minor sloughing may occur with 2 to 1 side slopes and the embankment slopes should therefore be seeded and/or mulched to minimize surface water erosion and gullyng. As well, some minor settlement may occur in the embankment widening area. However, most of this settlement should take place during and immediately following the construction period.

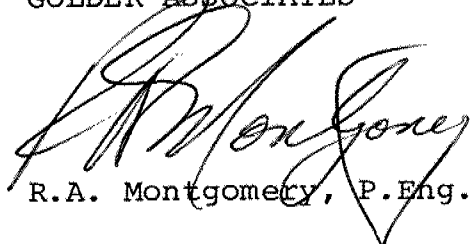
8. RIVER BANK PROTECTION

Some minor erosion of the river banks is presently taking place in the general area of the proposed alignment. Although not considered critical, it is recommended that a minimum thickness of 0.5 metres of rockfill be placed on the river bank slopes, to at least 1 metre above flood level and to a minimum of 10 metres upstream and downstream of the final alignment.

RAM:cn
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GOLDER ASSOCIATES


R.A. Montgomery, P.Eng.

July, 1981

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APPENDIX A

INVESTIGATION PROCEDURES

INVESTIGATION PROCEDURES

The field work for this investigation was carried out between May 27 and June 2, 1981. During this period, three sampled boreholes (numbers 3, 4 and 5) were put down at possible bridge pier locations. These borings were put down using a track mounted hollow stem auger machine operating off the existing bridge deck. In addition, two augerholes (numbered 6 and 7) were put down through the existing approach embankment fills in the bridge abutment areas to compliment the M.T.C. borings 1 and 2 put down during the Feasibility Investigation. The field work was carried out using a drill rig supplied and operated by the F.E. Johnston Drilling Co. Ltd. of Ottawa, working under the supervision of an experienced soils technician from our field engineering staff.

Boreholes 3 and 4 were terminated within the bouldery glacial till while borehole 5 was extended to the surface of the underlying bedrock. In all boreholes, diamond drilling techniques using BW casing and BX casing equipment had to be used below a depth of about 5 metres below river bottom level in order to successfully complete the borings. Borehole 4 had to be terminated upon breakage and loss of the diamond casing shoe and lower portion of the casing stem. Standard penetration tests (N values) were carried out and samples of the subsoils recovered from the boreholes using conventional 51 millimetre OD split spoon sampling equipment. The underlying bedrock was cored in BX size for about 2 metres in borehole 5. Dynamic cone penetration tests were attempted within the glacial till in augerholes 6 and 7 but in each case met premature refusal on boulders within the stratum.

Details of the drilling and sampling operations carried out in each of the boreholes and augerholes are given on the Record of Borehole and Record of Augerhole sheets following the text of this report. The field work was supervised throughout by a member of our engineering staff who directed the drilling, sampling and in situ testing operations, logged the boreholes and packaged the samples. The samples recovered from the boreholes were sealed in watertight jars and returned

to our laboratory in Ottawa for detailed examination and classification testing. The results of the laboratory testing are given on the Record of Borehole sheets and on Figures 1 and 2.

The locations of the borings are given on the Record of Borehole and Augerhole sheets and are shown on Drawing 1847901-A located in the pocket following the text of this report. The test hole locations were set in the field by us with reference to chainage and offset set out by the Ministry. The elevations of the ground surface at the borehole and augerhole locations were also determined by us with reference to a bench mark set by the Ministry. This bench mark, consisting of a nail and washer in the root of a 0.60 metre spruce tree, 15.3 metres right of Station 19+688.4 Highway 2, was given to us as elevation 48.494 (metres), referred to Geodetic datum.

It should also be noted that the Feasibility Foundation report gave elevations of 27.4 and 27.3 for boreholes 1 and 2 respectively. These have been converted to elevations 47.4 and 47.3 respectively based on the bench mark used in this investigation.

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

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_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 = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

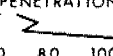


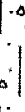
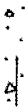


ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3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

RECORD OF BOREHOLE No 1

W P 184-79-01 LOCATION 7.5 m South of ¢ Hwy. 2, 2.0 m West of ¢ East Abutment
 DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BX Casing, BXL Rock Core
 DATUM Geodetic DATE 1980 04 24

METRIC

ORIGINATED BY MM
 COMPILED BY MM
 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
47.4	Ground Surface																
0.0	Fill Sand, Some Silt, Some Gravel with Decayed and Undecayed Organic Material		1	SS	1		47										17 61 18 4
			2	SS	50/	150 mm	46										
44.9			3	SS	69		45										30 43 21 6
2.5	Sand, Some Silt, Some Gravel Dense to Very Dense		4	SS	45		44										26 45 23 6
43.4							43										
4.0	Heterogeneous Mixture Sand, Silt and Gravel Very Dense		5	SS	55		42										
			6	SS	100/	150 mm	41										
	With Cobbles and Boulders		7	RC	60%		40										
			8	SS	100/	150 mm	39										29 37 31 3
			9	BXL RC	REC 20%		38										
	(Glacial Till)		10	SS	100/	75 mm	37										
			11	BXL RC	REC 10%		36										
35.9			12	SS	100/	100 mm	35										
11.5	Sound Limestone		13	BXL RC	REC 80% RQD	80%	34										
34.5	Bedrock																
12.9	End of Borehole																

+³, x⁵: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 184-79-01 LOCATION 14.3 m South of g Hwy. 2, 5.0 m West of g West Abutment
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BX Casing BXL Rock Core
DATUM Geodetic DATE 1980 04 27

ORIGINATED BY MM
COMPILED BY MM
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
47.3	Ground Surface																
0.0	Peat						47										
46.0	Silty Clay Stiff		1	SS	4		46										
1.3	Sand, Some Silt																
45.1	Some Gravel Compact		2	SS	19												
2.2	Heterogeneous Mixture Sand, Silt and Gravel		3	SS	17		45										
			4	SS	22		44										
	(Glacial Till)						43										
			5	SS	24		42										
	Compact to Dense		6	BXL RC	REC	20%	41										
			7	SS	43		40										
	Very Dense with Cobbles & Boulders						39										
			8	SS	100/	150 mm	38										
			9	BXL RC	REC	40%	37										
							36										
			10	SS	70/	10 mm	35										
			11	BXL RC	REC	40%	34										
34.9																	
12.4	End of Borehole																

RECORD OF BOREHOLE No 3

METRIC

W P 184-79-01 LOCATION Sta. 19+541.6 o/s 2.3 m Lt. 2 Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem, Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 05 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
50.08	Existing Bridge Deck							SHEAR STRENGTH						
	Asphalt							○ UNCONFINED + FIELD VANE						
0.09	Wood							● QUICK TRIAXIAL x LAB VANE						
0.27								WATER CONTENT (%)						
								20	40	60				GR SA SI CL
46.33	Water Level (River)													
3.75	Water													
44.81	River Bottom													
5.27	Alluvium, organic silty sand and gravel		1	SS	6									
	Dark Grey Loose													
43.68			2A	SS	18									
6.40	Glacial till, Compact silty sand and gravel, trace clay.		2B	SS	26									
	Grey Dense		3	SS	60									
			4	SS	30									
			5	SS	35									
			6	RC BX	31%									
			7	SS	>100									
			8	RC BX	38%									
			9	RC BX	83%									
			10	RC BX	57%									
35.66														
14.42	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

METRIC

W P 184-79-01 LOCATION Sta. 19+552.4 o/s 2.1 m Rt. 2 Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 05 28 and 06 02 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
50.10	Existing Bridge Deck																
0.00	Asphalt																
0.09	Wood																
0.27																	
46.29	Water Level (River)																
3.81	Water																
44.92	River Bottom																
5.18	Alluvium, organic silty sand and gravel, shells.		1	SS	13												
	Dark Grey Loose		2	SS	3												
			3	SS	>50												
42.79																	
7.31	Glacial till, Compact silty sand and gravel, trace clay.		4	SS	24												
	Grey Dense		5	SS	60												
			6	RC BX	83%												
	Very Dense		7	SS	>100												
	Numerous cobbles and boulders.		8	RC BX	58%												
36.38			9	RC BX	72%												
13.72	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

SHEET 1 OF 2

RECORD OF BOREHOLE No 5

METRIC

W P 184-79-01 LOCATION Sta. 19+561.3 o/s 2.3 m Lt. of Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem, Wash Boring BW Casing, BX Rock Core COMPILED BY DN
DATUM Geodetic DATE 1981 06 01 CHECKED BY _____

[illegible]

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 184-79-01

LOCATION

Sta. 19+561.3 o/s 2.3 m Lt. of Hwy. 2 (Existing)

ORIGINATED BY DJS

DIST _____

HWY 2

BOREHOLE TYPE

Hollow Stem, Wash Boring BW Casing, BX Rock Core

COMPILED BY DN

DATUM Geodetic

DATE _____

1981 06 01

CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									SHEAR STRENGTH			WATER CONTENT (%) 20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE														
Continued from Sheet 1																						
34.15	Glacial till, silty sand and gravel, trace clay. Grey Very Dense Numerous cobbles and boulders.		7	RC BX	29%		37									29 47 19 5						
			8	SS	>100		36															
			9	RC BX	28%		35															
			10	RC BX	37%		34															
			11	SS	>100		33															
15.94	Limestone bedrock, slightly weathered to fresh, calcite seams.		12	RC BX	Rec 90% RQD 0%		32															
32.90																						
17.19	End of Borehole																					

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

10

METRIC

ORIGINATED BY DJS
COMPILED BY DN
CHECKED BY _____

+3, x5: Numbers refer to Sensitivity

20
5
10

RECORD OF AUGERHOLE No 7

METRIC

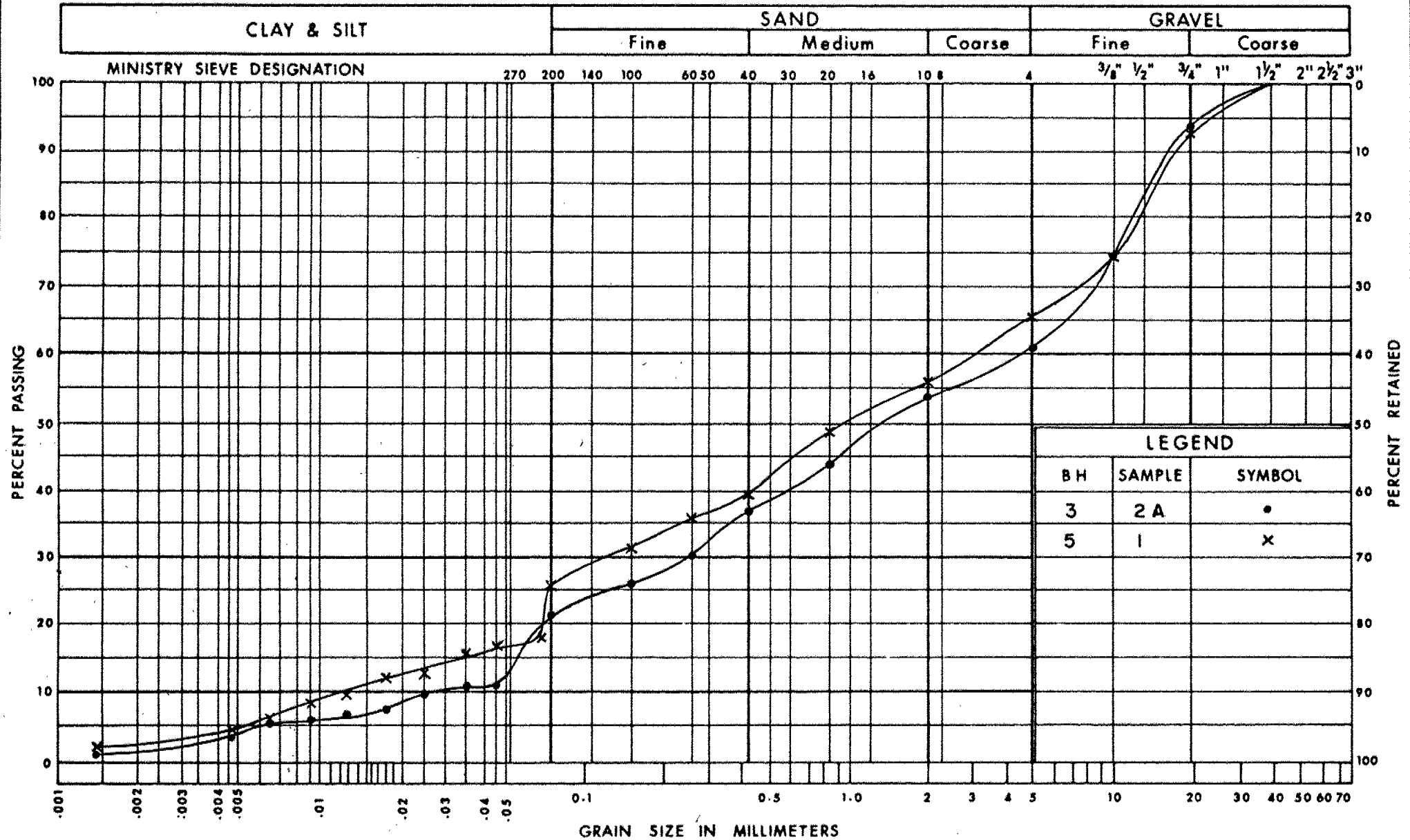
W P 184-79-01 LOCATION Sta. 19+581.7 o/s 2.2 m Lt. of Hwy. 2 (Existing) ORIGINATED BY DJS
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DN
DATUM Geodetic DATE 1981 05 29 CHECKED BY _____

[illegible]

+³, x⁵ : Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



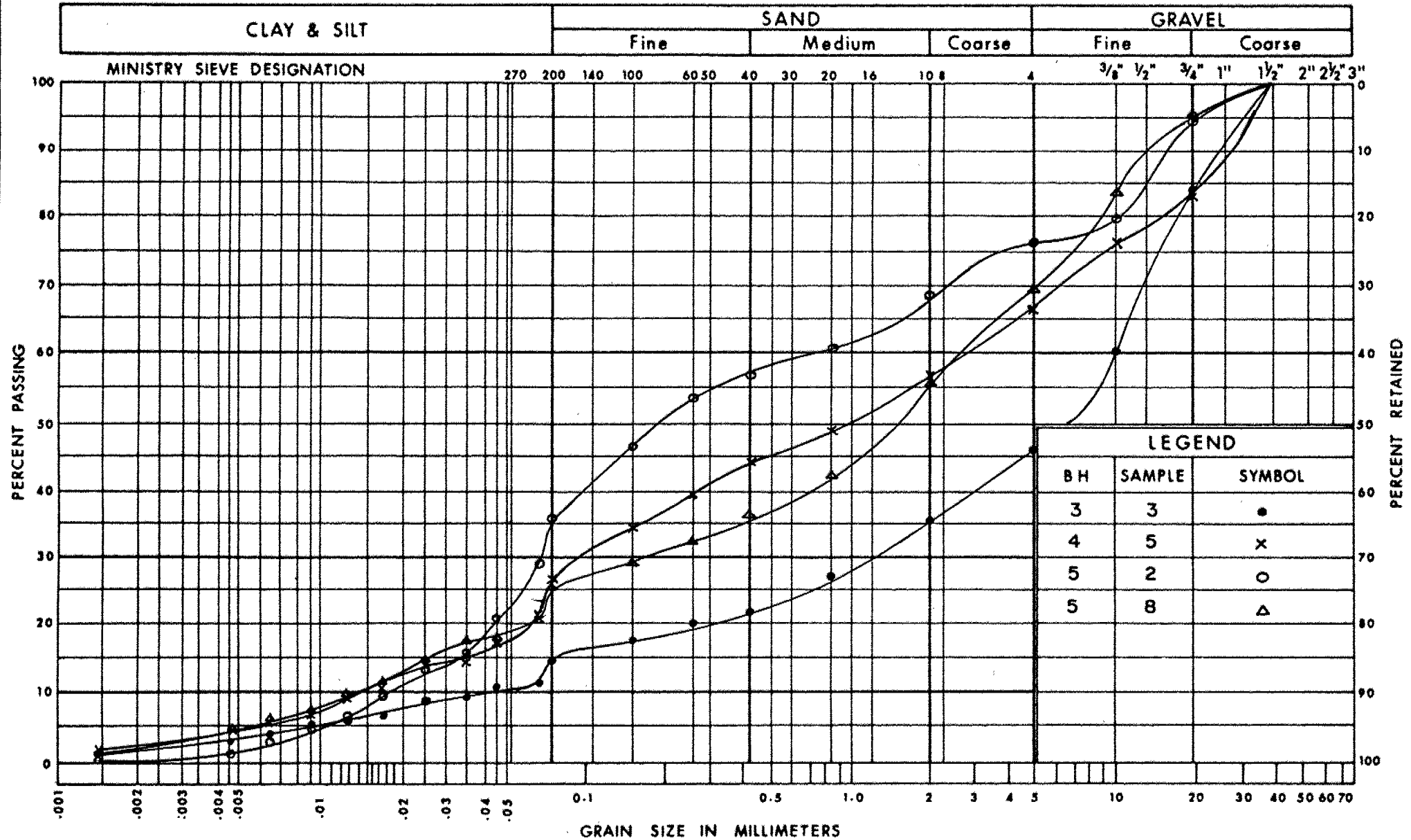
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
ALLUVIUM
ORGANIC SILTY SAND AND GRAVEL

FIG No 1

WP 184-79-01

UNIFIED SOIL CLASSIFICATION SYSTEM

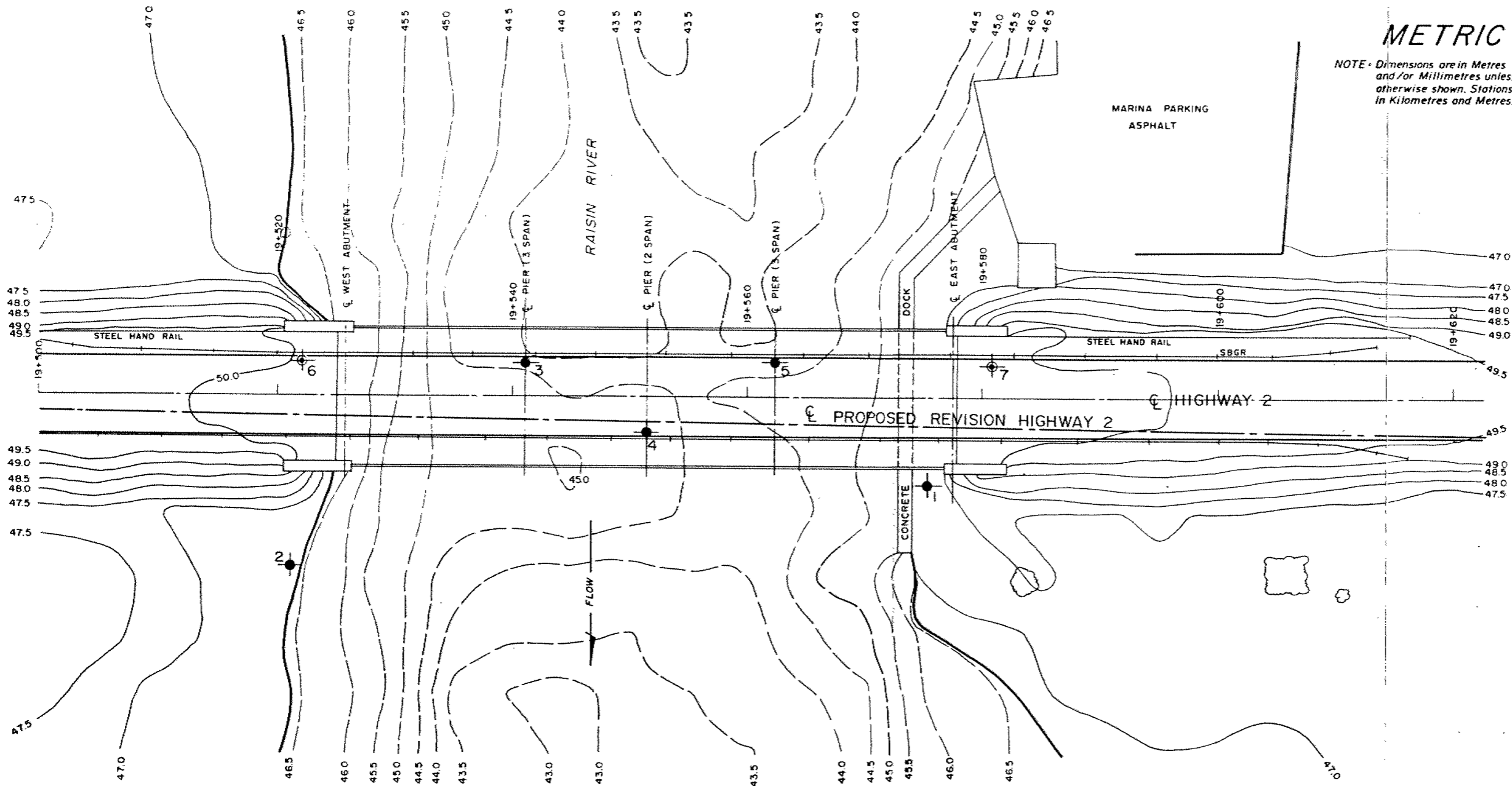


Ministry of
Transportation and
Communications

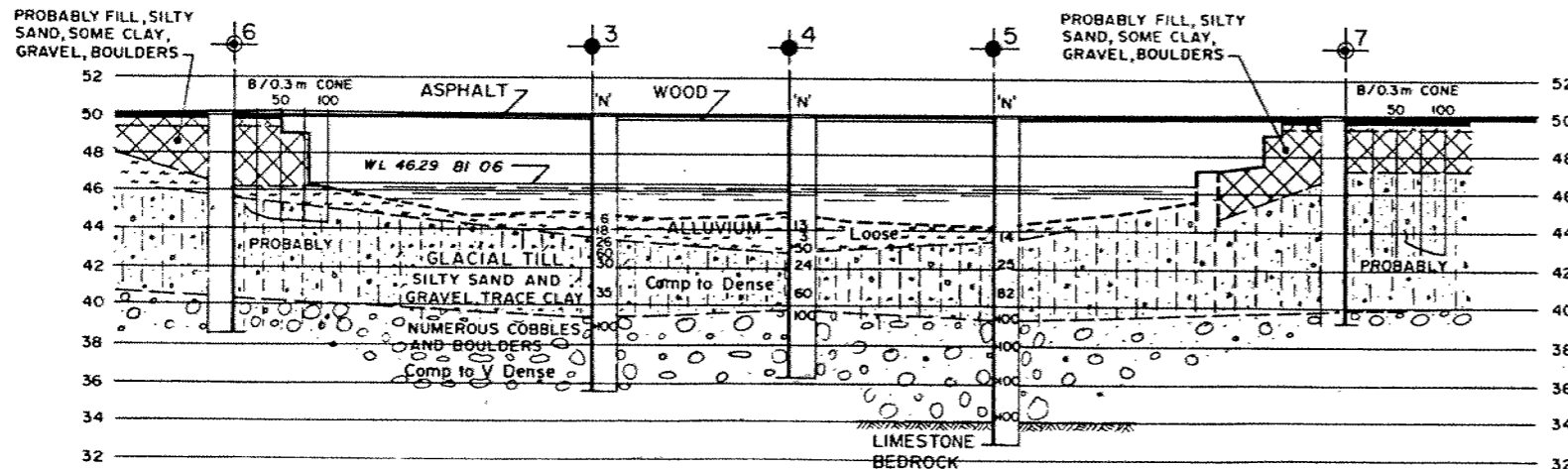
GRAIN SIZE DISTRIBUTION
GLACIAL TILL SILTY SAND AND GRAVEL TRACE
CLAY COBBLES AND BOULDERS

FIG No 2

W P 184-79-01



PLAN
SCALE
5m 0 5m



PROFILE HIGHWAY 2
SCALE
5m 0 5m

METRIC

NOTE: Dimensions are in Metres
and/or Millimetres unless
otherwise shown. Stations
in Kilometres and Metres.

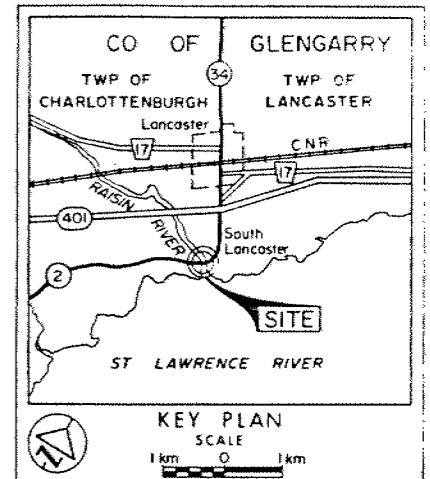
CONT No
WP No 184-79-01

RAISIN RIVER
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

GOLDER ASSOCIATES



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
- ⊕ Auger Hole

No	ELEVATION	STATION	OFFSET
* 1	47.4	19+575.8	7.6m Rt
* 2	47.3	19+521.1	14.0m Rt
3	50.08	19+541.6	2.3m Lt
4	50.10	19+552.4	2.1m Rt
5	50.09	19+561.3	2.3m Lt
6	50.02	19+521.8	2.3m Lt
7	50.07	19+581.7	2.2m Lt

* Bore Hole No 1 B2 by M.T.C. 1980 04

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No			
HWY No 2		DIST 9	
SUBM'D	CHECKED	DATE 1981 07 16	SITE 31-237
DRAWN DN	CHECKED RM	APPROVED	DWG 1847901-A



ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 184-79-01 DIST 9
HWY 2 STR SITE 31-237

Feasibility Study
of
Raisin River Bridge

DISTRIBUTION

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FEASIBILITY
FOUNDATION INVESTIGATION REPORT
FOR

Raisin River Bridge
Hwy. 2, District 9, Ottawa
W.P. 184-79-01, Site 31-237

INTRODUCTION

This report contains the results of a foundation investigation carried out at the site of the above noted project. The field-work was carried out on 80-04-24 to 80-04-29 and consisted of two sampled boreholes advanced by means of hollow stem augers and diamond drilling techniques using BX casing to a depth of about 12 metres below ground surface. Bedrock was proven in one borehole by obtaining 1.4 metres of BXL size rock core.

SITE DESCRIPTION ON GEOLOGY

This site is located at the existing crossing of Hwy. 2 and Raisin River approximately 1.1 km south of Hwy. 401 in the Township of Charlottesburgh, County of Glengary.

Topographically the surrounding areas is gentilly rolling with land use being rural residential. East of the River and north of Hwy. 2 is a private marina.

Raisin River originates some 20 to 30 km west of the site and empties into the St. Lawrence River some 0.5 km east of the one job

site. At this site location the Raisin River is some 50 metres wide at a depth of 3 metres.

Physiographically the site is located in the region known as the Lancaster Flats. This lowland is a till plain which has been buried by water laid deposits leaving only stony crests and a few drumlins and ridges. The water laid deposits range from clay to very fine sand.

SUBSOIL CONDITIONS

Subsurface conditions of the site are quite uniform. The surficial deposits consist of either 1.3 metres of peat and silty clay or up to 2.5 metres of fill material. Immediately below the surficial deposits is a compact to very dense granular deposit composed of sand, some silt and some gravel. This granular strata is in turn underlain by a compact to very dense glacial till which contains numerous cobbles and boulders; this glacial till is in turn underlain by sound limestone bedrock.

The boundaries between the various soil strata are given on the Record of Borehole sheets. The location and elevations of the boreholes are shown in the attached sketch Drawing No. 1847901-A.

Following is a brief description of the various subsoil and

bedrock types encountered.

Fill Material

Fill Material was encountered in the borehole put down east of of the river and south of the highway. This fill extends from the ground surface to a depth of up to 2.5 metres and is composed of a sand, some silt, some gravel with boulders and with decayed and undecayed organic material.

Two split spoon samples were obtained in the fill material giving Standard Penetration Test 'N' values of 1 blow per 0.3 metre and 50 blows per 0.15 metre. Based on the nature of the augering, the very low 'N' value of 1 blow is generally more representative. The high 'N' value of 50 blows per 0.15 metre is due to the presence of boulders. Based on the single low 'N' value and the nature of the augering operation it is inferred that the fill has undergone a slight compactive effort.

Peat

This parent surficial deposit was encountered in the borehole placed south of the highway and west of the river. Based on field observations the extent of this surficial deposit is expected to be limited in plan to areas immediately adjacent to the river. The upper 1 metre of this deposit contains a highly organic deposit of peat with the lower 0.3 metres being comprised

of slightly organic silty clay. Based on the Standard Penetration Test 'N' value of 4 blows per 0.3 metre and visual observations the consistency of the peat is described as soft while the consistency of the silty clay is described as stiff.

Sand, some Silt, some Gravel

This granular deposit was encountered in both boreholes immediately below the surficial deposits. The thickness of this parent deposit is estimated to range from 0.9 to 1.5 metres thick. This granular deposit is composed of sand, some silt and some gravel. Based on Standard Penetration Test 'N' values of 19 to 69 blows per 0.3 metres the relative density of this granular strata is estimated to range from compact to very dense.

Glacial Till

Immediately below the sand, some silt and some gravel deposit is an extensive deposit of glacial till. The upper boundary of this glacial till is present at a depth of 2.2 to 4.0 metres below the ground surface and the deposit extends to a depth of 11.5 metres in one borehole. In the second borehole, the lower boundary of the glacial till was not encountered but the deposit was proven to extend to a depth of up to 12.4 metres below ground surface. Accordingly, the thickness of the deposit varies from 7.5 to in excess of 10.2 metres thick. The composition

of the overall deposit is a heterogeneous mixture of sand, silt and gravel with numerous cobbles and limestone boulders up to 1 metre thick in the lower portion of the deposit beyond a depth of about 4 metres below ground surface.

The Standard Penetration Test 'N' values in this granular deposit range from 17 blows per 0.3 metre to over 100 blows per 0.08 metres. Based on these 'N' values, the relative density is described as compact to very dense.

Limestone Bedrock

Bedrock was proven to underlie the glacial till deposit in the borehole put down east of the river and south of the highway. The surface of the bedrock was found to be at elevation 15.9, some 11.5 metres below the ground surface. The bedrock was proven by obtaining 1.4 metres of BXL size rock core. Based on the recovery ratio of 80% and the R.Q.D. of 80% the bedrock is described as sound limestone bedrock.

Groundwater Level

The groundwater level was determined by measuring the water level in the cased borehole. The groundwater level was found to be at elevation 27.0 which was at or slightly above the prevailing River water level.

DISCUSSION AND RECOMMENDATIONS

Currently a study is underway to determine the most cost effective solution for the crossing of Hwy. 2 over Raisin River. The existing structure is a 51.8 metre single span steel truss structure which requires extensive repairs to insure the integrity of the structure. An alternative to repair is to replace the structure. In order to make cost comparison of replace/repair it was necessary to determine subsurface conditions and hence to provide preliminary recommendations for design and construction. Our preliminary recommendations for design and constructions of the possible replacement structure foundations and associated approaches are given in the paragraphs to follow.

Structure Abutments

In view of the encountered subsurface conditions the structure abutments can be supported on steel 'H' piles driven into the glacial till deposit. The piles can be designed for the maximum allowable load per pile section chosen (i.e. a HP 310 x 110 can be designed for 1150 kN per pile). The steel 'H' piles should have reinforced tips to prevent structural damage from the cobbles and boulders present in the end bearing stratum. For estimating purposes it can be assumed the piles will attain the design load at elevation 17.0 metres.

Because of the pervious nature of the overburden a dewatering

scheme will be necessary for the construction of the abutment footings if the base of the abutment footing is below the prevailing river water level.

Alternatively if large settlements of the abutment footing up to 50 mm can be tolerated by utilizing a single span simply supported structure then the abutments can be founded on selected rockfill extending out from the river banks as far as hydrological requirements would permit. In this scheme it would be necessary to remove the surficial fill material and peat deposits beneath the plan limits of the rock fill embankment. This scheme is presently being designed for the Madawaska River Crossing at Latchford, W.P. 126-78-02.

Structure Piers

The piers of a two or three span structure scheme can be founded on steel 'H' piles as previously discussed. The construction of piers would require an interlocking sheet pile cofferdam to enable unwatering of the pier footing. Further boring will be necessary in the area of proposed piers to determine specific subsurface conditions in these areas and hence enable design of the cofferdam and piers. These borings will be carried out if it is decided to replace the existing structure with a multispan structure.

Approach Fills

If the approach fills are to be extended or relocated south of the existing alignment some limited subexcavation, and backfilling with granular material, of the surficial 1.5 to 2.0 metres of organic silt and fill material with organics will be required to ensure the integrity of the approach fills. Provided the foregoing is carried out no stability or settlement problems are anticipated for approach fills up to 10 metres high.

M. Maclean

M. MacLean
Project Foundations Engineer



M. Devata

M. Devata
Senior Foundations Engineer

May 26, 1980

RECORD OF BOREHOLE No 1

METRIC

W P 184-79-01 LOCATION 7.5 m South of Hwy. 2, 2.0 m West of East Abutment
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BX Casing, BXL Rock Core Bearings
DATUM Gendric DATE 1980 04 24
ORIGINATED BY MM
COMPILED BY MM
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
27.4	Ground Surface													
0.0	Fill Sand, Some Silt, Some Gravel with Decayed and Undecayed Organic Material		1	SS	1		26					w = 56%		17 61 18 4
24.9			2	SS	50/	150 mm								
2.5	Sand, Some Silt, Some Gravel		3	SS	69		24							30 43 21 6
23.4	Dense to Very Dense		4	SS	45									26 45 23 6
4.0	Heterogeneous Mixture Sand, Silt and Gravel Very Dense		5	SS	55		22							
	With Cobbles and Boulders		6	SS	100/	150 mm								
			7	BXL RC	REC 60%		20							
			8	SS	100/	150 mm								29 37 31 3
	(Glacial Till)		9	BXL RC	REC 20%		18							
			10	SS	100/	75 mm								
15.9			11	BXL RC	REC 10%		16							
11.5	Sound Limestone		12	SS	100/	100 mm								
14.5	Bedrock		13	BXL RC	REC 80% RQD	80%								
12.9	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

METRIC

W P 184-79-01 LOCATION 14.3 m South of Hwy. 2, 5.0 m West of West Abutment Bearings
DIST 9 HWY 2 BOREHOLE TYPE Hollow Stem Augers, BX Casing BXL Rock Core COMPILED BY MM
DATUM Geodetic DATE 1980-04-27 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
27.3	Ground Surface													
0.0	Peat													
26.0	Silty Clay Stiff		1	SS	4		26							21 36 35 8
1.3	Sand, Some Silt		2	SS	19									
25.1	Some Gravel Compact													
2.2	Heterogeneous Mixture Sand, Silt and Gravel (Glacial Till)		3	SS	17		24							52 29 16 3
			4	SS	22									
			5	SS	24									
	Compact to Dense		6	BXL RC	REC	20%	22							
			7	SS	43									
	Very Dense with Cobbles & Boulders						20							
			8	SS	100/	150 mm								
			9	BXL RC	REC 40%		18							
			10	SS	70/	10 mm	16							
14.9			11	BXL RC	REC 40%									
12.4	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

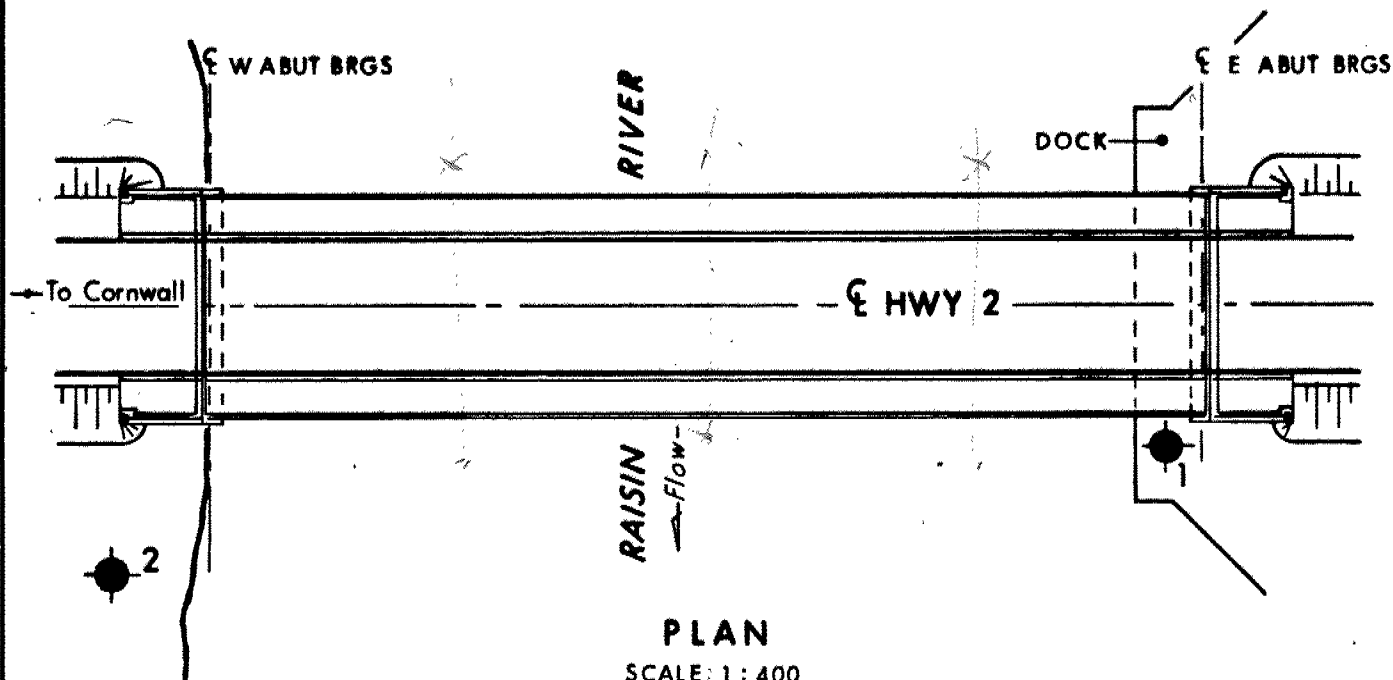
20
15 5 (%) STRAIN AT FAILURE
10

METRIC
 DIMENSIONS ARE IN METRES
 UNLESS OTHERWISE SHOWN

WP No 184-79-01



RAISIN RIVER BRIDGE
 (FEASIBILITY)
 BORE HOLE LOCATIONS



LEGEND		
	BORE HOLE	
BH	ELEVATION	OFFSET
1	27.4	7.5m South of ϵ Hwy 2 2.0m West of ϵ East Abut Brgs
2	27.3	14.3m South of ϵ Hwy 2 5.0m West of ϵ West Abut Brgs

GEOCRES No 31G - 187

HWY No 2			DIST 9
SUBM'D M M	CHECKED	DATE 80 05 16	SITE 31-237
DRAWN R S	CHECKED		DWG1847901-A

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'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

DISTRICT - 9, OTTAWA
CONT No
WP No 184-79-01



SHEET

METRIC

DIMENSIONS ARE IN MILLIMETRES
UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE
AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.

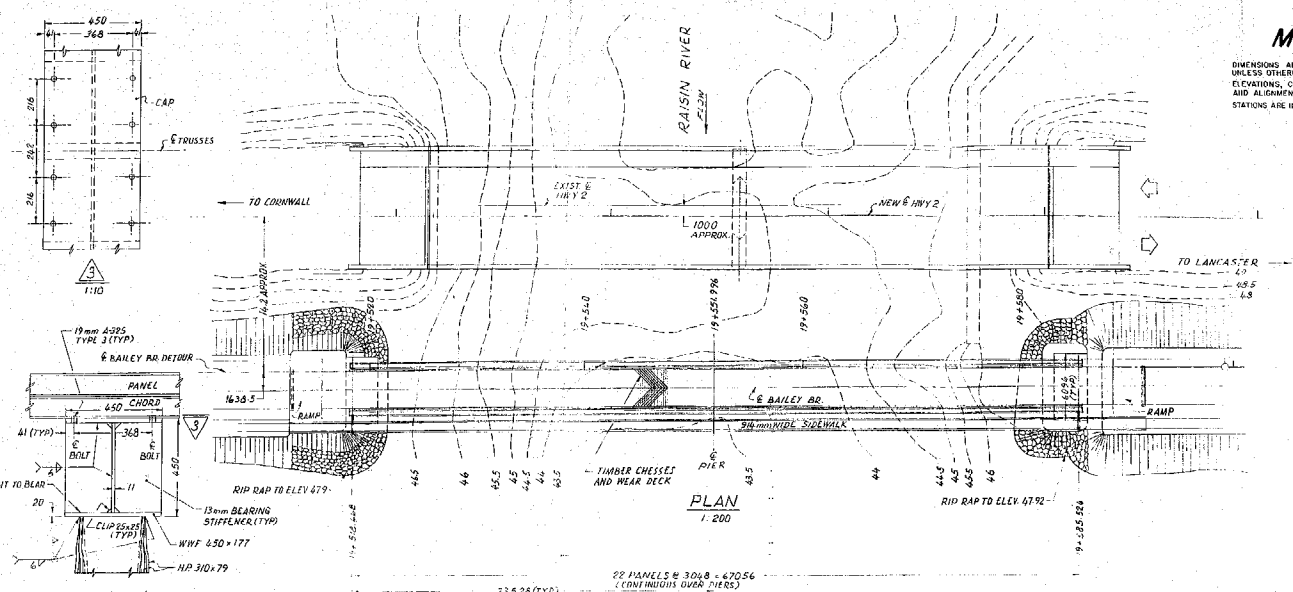
RAISIN RIVER BAILEY BRIDGE DETOUR

NOTES TO CONTRACTOR

1. DECKING TO BE INSTALLED AS SHOWN ON PLAN & DD-1201.
2. SIDEWALK TO BE INSTALLED AS SHOWN ON PLAN & DD-1202.
3. GUIDE RAIL TO BE INSTALLED AS SHOWN ON BRIDGE DRAWINGS AND AS PER DD-1203.
4. FILL AS DETERMINED ON THE SITE.
5. ERECTION AND LAUNCHING.
 - (a) THE CONTRACTOR SHALL NOT ASSEMBLE, LAUNCH OR DELAUNCH THE BAILES UNTIL THE LAYOUT & ELEVATIONS OF THE LAUNCHING AND CONSTRUCTION ROLLERS HAVE BEEN APPROVED BY THE ENGINEER.
 - (b) DOUBLE ROLLERS SHALL BE USED AT ALL LOCATIONS.
 - (c) THE TOPS OF THE ROLLERS MUST BE LEVELLED ACROSS IMPART AT RIGHT ANGLES TO THE CENTRE LINE OF THE STRUCTURE.
 - (d) THE TOPS OF THE ROLLERS MUST ALL BE AT THE SAME ELEVATION UNLESS SPECIFIED OTHERWISE ON THE DRAWINGS.
 - (e) THE LAUNCHING NOSE SHALL CONSIST OF 400 METRES OF DOUBLE SINGLE SKELETON CONSTRUCTION AND 300 METRES OF DOUBLE SINGLE SKELETON CONSTRUCTION.
 - (f) THE LAUNCHING LINKS MUST BE INSERTED 916 MM FROM TIP OF NOSE.
 - (g) ALL PINS, BOLTS AND THREADED PARTS MUST BE FREE OF DIRT AND BE LUBRICATED AT THE TIME OF INSTALLATION.
 - (h) TRANSOM CLAMP TIGHTENING BARS MUST BE WIRED TO THE PANEL VERTICALS. SWAY BRACES MUST BE FULLY TIGHTENED TO GAUGE BLOCKS AND ALL LOCK NUTS SECURED.
 - (i) ALL PANEL PINS ON STRUCTURE MUST BE KEPT.
 - (j) WHEN THE COMBINED HEIGHT OF THE BRIDGE AND NOSE EXCEEDS 55.0 TONNES ON A SINGLE STOREY BRIDGE AND 75.0 TONNES ON A DOUBLE STOREY BRIDGE, THE BALANCE BEAM ASSEMBLY MUST BE USED.
 - (k) WEAR DECK MUST BE INSTALLED AFTER LAUNCHING.
6. ADDITIONAL NOTES FOR CHORD REINFORCED BRIDGES.
 - (a) BRACING FRAME BOLTS MUST BE INSTALLED IN THE REINFORCING CHORDS PRIOR TO THE CHORDS BEING INSTALLED ON THE BRIDGES.
 - (b) TAPERED CHORDS MUST BE USED FOR LAUNCHING AND DELAUNCHING.
7. MAINTENANCE.
 - (a) THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE OF THE STRUCTURE AND APPROACHED INCLUDING THE FOLLOWING:
 - (i) CHECK THAT ALL BRACING BOLTS, CHORD BOLTS, TRANSOM CLAMPS ARE AND FULLY TIGHTENED.
 - (ii) KEEP BASEPLATES AND BEARINGS FREE OF DEBRIS, INSPECT BASEPLATES AND BOLTS PERIODICALLY AND CORRECT ANY UNWEL SETTLEMENT TO THE SATISFACTION OF THE ENGINEER.
 - (iii) JACKING UNDER END TRANSOM AND RAMPS MUST BE KEPT TIGHT.
 - (b) NOTIFY THE ENGINEER IMMEDIATELY OF ANY DAMAGES.
8. PILE DRIVING NOTES.
 - (a) PILES SHALL BE PROVIDED WITH REINFORCED TIES IN ACCORDANCE WITH DD-3301.
 - (b) PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS-103-10 OR SS-103-11 USING AN ultimate capacity of 2300 kN.
9. QUANTITIES:

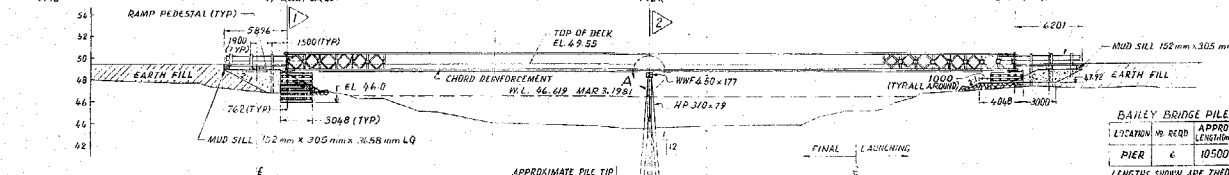
ITEM	QUANTITY
BAILEY BRIDGE	43.75
FOOT WALKS	4.42
LAUNCHING NOSE	6.57
RAMP	1.73
TOTAL 76.08	Longs
10. TIMBER:

ITEM	QUANTITY
FOOT WALKS	3.509
DECK	15.477
GRILLAGES	20.358
MUD SILLS	0.360
TOTAL 43.711	m³

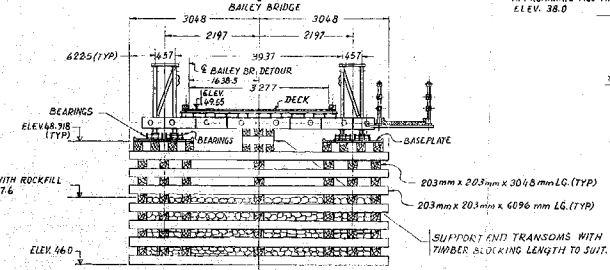


PLAN
1:200

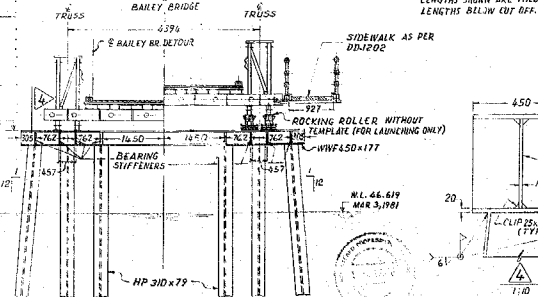
DETAIL-A
1:10



ELEVATION
1:200



CROSS SECTION AT WEST ABUTMENT
1:50



CROSS SECTION AT PIER
1:50

BAILEY BRIDGE PILE DATA

LOCATION	NO	RECD	APPROX LENGTH (m)	TYPE
PIER	6	10500	310 x 79	

LENGTHS SHOWN ARE THEORETICAL LENGTHS BELOW CUT OFF.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
DESIGN	E.L.	LAUNCHING
DRAWING	E.L.	CHECK ECL SITE
		DATE OCT 89
		DWG