



FOUNDATION INVESTIGATION REPORT

for

**JOSHUA'S CREEK ARCH CULVERT EXTENSION
SITE NO. 10-140/C, QUEEN ELIZABETH WAY AND HIGHWAY 403
TOWN OF OAKVILLE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO
G.W.P. 2163-10-00**

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FOUNDATION INVESTIGATION REPORT

for

Joshua's Creek Arch Culvert Extension
Site No. 10-140/C, Queen Elizabeth Way and Highway 403
Town of Oakville
Regional Municipality of Halton, Ontario
GWP 2163-10-00

1. INTRODUCTION

This report summarizes the results of the foundation investigation required for the detail design of the Joshua's Creek Arch culvert extension and associated retaining walls. The study was carried out by Peto MacCallum Ltd. (PML) for Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation of Ontario (MTO).

The existing Joshua's Creek Arch culvert is located on the Queen Elizabeth Way (QEW) at Station 23+223 in the Town of Oakville, Regional Municipality of Halton. This report provides subsurface information encountered at the existing culvert site.

Existing foundation/geotechnical information relevant to Joshua's Creek has been obtained from the MTO GEOCRES library. The report and drawings from MTO GEOCRES No. 30M5-112 were reviewed for pertinent information pertaining to the project site. The Foundation Investigation portion of the previous report is appended for reference in Appendix FIR-A.

All elevations in this report are expressed in meters.

2. SITE DESCRIPTION AND GEOLOGY

The Joshua's Creek culvert is located approximately 160 m south of the Ford Drive underpass of the Queen Elizabeth Way. The site is about 2 km southwest of Peel Regional Road 19, otherwise known as Winston Churchill Boulevard, the border between the City of Mississauga and the Town of Oakville. Site photographs are included in Appendix FIR-B.



The project area lies within the physiographic region known as the South Slope. The South Slope is bounded by the Peel Plain to the north and the Iroquois Plain to the south. The physiographic region extends from the Niagara escarpment to the Trent River and covers approximately 2,435 square kilometers. The South Slope is characterized by glacial till deposits overlying shale bedrock of the Queenston and Dundas Formations. (L.J. Chapman and D.F. Putnam, *The Physiography of Southern Ontario*, 3rd Edition, 1984). Locally, the Queenston Formation shale interbedded with limestone bands is encountered at relatively shallow depths underlain by clayey silt till deposits.

Within the QEW/Highway 403 corridor near the project site, land use comprises vacant land required and consumed by the QEW and Highway 403 right of ways. Outside of the highway right of ways, the land use is comprised primarily of commercial and light industrial buildings and businesses. The Ford Motor Company occupies the majority of the land to the south of the QEW/Highway 403.

Joshua's Creek flows in a west to east direction at the culvert location, eventually discharging into Lake Ontario.

3. INVESTIGATION PROCEDURES

The field work for this study was carried out during the period of January 12 to January 19, 2015 and comprised 5 boreholes drilled to depths ranging from 0.9 m to 8.7 m at the locations shown on Drawing JC-1, appended.

The target termination criterion of 100 blows per 0.3 m penetration or refusal on bedrock was met for all five of the boreholes located near the proposed culvert extension and proposed retaining walls, with two boreholes cored into bedrock to give information pertaining to the underlying bedrock.



Further details are summarized in the following table:

LOCATION	BOREHOLE No.	DEPTH (m)		
		AUGER	ROCK CORE	TOTAL
Proposed Culvert Extension	C-1	1.5	3.1	4.6
Proposed Culvert Extension	C-2	4.8	3.9	8.7
North Retaining Wall	RW-6	2.5	--	2.5
South Retaining Wall	RW-7	6.3	--	6.3
North Retaining Wall	RW-8	0.9	--	0.9

The locations of the boreholes were selected by PML allowing for drill rig accessibility. The ground surface elevations for all five boreholes were established by Callon Dietz Incorporated.

All five boreholes were advanced using continuous flight hollow stem augers through the soil cover. Boreholes C-1, RW-6 and RW-8 were completed with a track-mounted D-120 drill rig while boreholes C-2 and RW-7 were drilled using a truck-mounted D-120 drill rig. All equipment was supplied and operated by a specialist drilling contractor, working under the full-time supervision of a PML field supervisor. Boreholes C-1 and C-2 were extended 3.1 and 3.9 m into bedrock respectively, using HQ diamond rock coring equipment supplemented by wash boring techniques.

Representative soil samples were recovered at 0.75 and 1.5 m depth intervals using the standard penetration test method. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Soils were identified in accordance with the MTO soil classification manual procedures. Observations of auger grinding were recorded and included larger particle sizes such as cobbles, boulders and/or bedrock fragments.

The recovered soil samples were returned to the PML laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program for Joshua's Creek foundation investigation included the following tests:

- Natural moisture content determinations (12)
- Atterberg Limits (4)
- Grain size distribution analyses (4)



The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open boreholes. However, groundwater observations were minimal due to the frozen winter conditions present during the investigation.

The boreholes were backfilled in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment.

The laboratory grain size distribution envelopes for the investigation for the fill material and native till are presented in Figure JC-GS-1 and Figure JC-GS-2 respectively. The results of the Atterberg Limits tests for the fill material and native till are presented in Figure JC-PC-1 and Figure JC-PC-2 respectively. All of the test results are summarized on the Record of Borehole sheets.

Two rock core specimens were taken from boreholes C-1 and C-2 and the results are summarized in section 4.4 of this report and shown on the Record of Borehole sheets.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, bedrock descriptions, inferred stratigraphy, boundary elevations, standard penetration test data and groundwater observations. The results of laboratory Atterberg limits testing, grain size distribution analyses and moisture content determinations are also shown on the Record of Borehole sheets.

The borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are shown on Drawings JC-1 and JC-2. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the soil boundaries are assumed and may vary.

The subsurface stratigraphy revealed in the boreholes generally comprised of topsoil underlain by mixed fill layers over the native clayey silt to silty clay glacial till. Cobbles were encountered within



the fill material while weathered bedrock (shale) fragments were encountered in the clayey silt to silty clay glacial till deposit. The glacial till was underlain by relatively flat lying soft to medium strength shale bedrock with interbedded limestone layers. Groundwater was only observed in one borehole due to the frozen winter conditions.

The strata encountered are summarised below.

4.1 Topsoil

A 100 to 300 mm thick topsoil unit was encountered surficially in all five boreholes and extended to elevation 120.2, 123.5, 122.3, 125.1 and 121.8 in boreholes C-1, C-2, RW-6, RW-7 and RW-8 respectively.

4.2 Fill

Organic inclusions were encountered throughout the cohesive and non cohesive fill material in all five boreholes drilled for the Joshua's Creek culvert extension.

Borehole RW-7 encountered a 0.9 m thick non cohesive silty sand fill that extended from 0.2 to 1.1 m, (elevation 124.2) underlying the topsoil deposit. Below the non cohesive fill, a 0.3 m cohesive clayey silt fill was contacted. The total fill height encountered in borehole RW-7 was 1.2 m, which extends to elevation 123.9.

Underlying the topsoil deposits in boreholes C-1, C-2, RW-6 and RW-8, cohesive fill material was encountered. The thickness of the clayey silt to silty clay fill deposit varied widely from 0.4 to 2.8 m and extended to 0.7, 3.0, 2.5 and 0.9 m (elevation 119.8, 120.7, 119.9 and 121.1) in boreholes C-1, C-2, RW-6 and RW-8 respectively.

N values of the cohesive fill typically ranged from 7 to 15 blows, indicating firm to stiff consistency. A random high N value of 29 reflected the presence of weathered shale fragments within the fill in borehole RW-7. Similarly, cobbles were encountered in the cohesive fill in borehole C-2.

The results of the grain size distribution analyses for the one sample tested of the clayey silt to silty clay with sand with gravel fill is included in Figure JC-GS-1. The Atterberg plasticity chart for



the fill material is presented in Figure JC-PC-1. The liquid and plastic limits of the clayey silt to silty clay fill sample were 39 and 23, respectively, with the corresponding plasticity index 16 for soil sample 2 of borehole RW-6. Within the clayey silt to silty clay fill of all five boreholes, the moisture content determinations ranged from 10 to 33%, corresponding to a moist soil condition.

The fill material extended to bedrock at 2.5 and 0.9 m in boreholes RW-6 and RW-8 (elevation 119.9 and 121.1) respectively.

4.3 Clayey Silt to Silty Clay Till

A 0.8 to 4.9 m thick hard clayey silt to silty clay glacial till deposit was contacted below the cohesive fill at 0.7, 3.0 and 1.4 m (elevation 119.8, 120.7 and 123.9) and terminated on shale bedrock at 1.5, 4.8 and 6.3 m (elevation 119.0, 118.9 and 119.0) in boreholes C-1, C-2 and RW-7 respectively. Weathered shale fragments were encountered throughout the till deposit.

N values of the till material ranged from 35 to 50 blows per 5 cm penetration indicating hard consistency. The results of Atterberg limits testing and grain size distribution analyses conducted on three samples of the till deposit are presented in respective Figures JC-PC-2 and JC-GS-2. The clayey silt to silty clay till had a liquid limit that ranged between 31 and 40, a plastic limit that ranged between 20 and 23 and a corresponding plasticity index ranging between 11 and 17. The moisture content of the glacial till was determined to range between 10 to 15%, well below the plastic limit indicating a heavily over consolidated cohesive deposit of low to medium plasticity.

4.4 Bedrock

Bedrock was contacted in all five boreholes C-1, C-2, RW-6, RW-7 and RW-8 at 1.5, 4.8, 2.5, 6.3 and 0.9 m (elevation 119.0, 118.9, 119.9, 119.0 and 121.1), respectively. The slight to highly weathered bedrock comprises a grey to dark grey soft to medium strength shale bedrock with interbedded limestone.

The measured core recovery varied between 22 and 100%. The RQD determined from the rock cores ranged between 0 to 70%, thus indicating very poor to fair quality rock. The upper 1.6 m



core sample in borehole C-2 had very poor rock quality (RQD ranged from 0 to 33%) and a measured core recovery between 22 and 100%.

Weathered bedrock was exposed within the creek bed of Joshua's Creek. Detailed descriptions of the rock cores retrieved from boreholes C-1 and C-2 is given in Table A, appended. Photographs of the rock cores are shown in Appendix FIR-C.

4.5 Groundwater

In the process of augering, water was detected in borehole RW-6 at 2.2 m (elevation 120.2). The groundwater was flowing on top of the bedrock which was encountered in borehole RW-6 at 2.5 m (elevation 119.9).

Upon completion of drilling, groundwater was not measurable in borehole RW-6. No water was observed in boreholes C-1, C-2, RW-7 and RW-8 during or upon completion of drilling. The absence of groundwater in the remaining four boreholes can be attributed to the frozen winter conditions present on site during the investigation.

The groundwater level at the site is governed by the water level in Joshua's Creek. The water level of Joshua's Creek was taken as the top of the ice surface relative to borehole C-1 at elevation 120.2 m on January 19, 2015. The groundwater levels are subject to seasonal fluctuations and precipitation patterns.



5. CLOSURE

The field work was carried out under the supervision of Mr. S. Aziz and direction of Mr. K. R. Daly, B.Eng., EIT. The equipment was supplied by Altech Ltd Drilling and Investigative Services. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

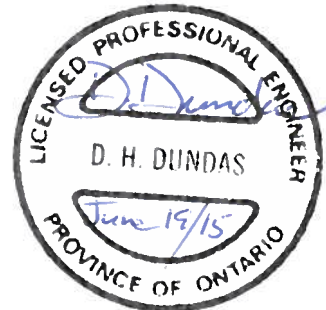
This Foundation Investigation Report was prepared by Mr. K. R. Daly, B.Eng, EIT and reviewed by Mr. B. R. Gray, MEng, P. Eng., Principal Consultant and Mr. D. Dundas, P. Eng., Senior Geotechnical Engineer. Mr. C. M. P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, reading "Kyle Daly".

Kyle R. Daly, B.Eng, EIT
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Project Manager and
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KD/CN/BRG:kd-jk



TABLE A – ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
BH C-1	1	1.5 ⁽¹⁾ – 2.1	67	38	1.5 – 4.6	SHALE WITH INTERBEDDED LIMESTONE: Grey, fine grained, occasional interbedded grey limestone (effervesces freely in dilute (5%) hydrochloric acid), soft to medium strength, bedding in shale horizontal, laminated and fissile, slightly weathered to highly weathered, close spaced flat partings, smooth planar, tight, poor to fair quality.
	2	2.1 – 3.0	100	50		
	3	3.0 – 4.6	97	70		
BH C-2	1	4.8 ⁽²⁾ – 5.0	58	0	4.8 – 8.7	SHALE WITH INTERBEDDED LIMESTONE: Grey to dark grey, fine grained, with quartz vein and occasional interbedded grey limestone (effervesces freely in dilute (5%) hydrochloric acid), soft to medium strength, bedding in shale horizontal, laminated and fissile, slightly to moderately weathered, close spaced flat partings, smooth planar, tight, very poor to poor quality.
	2	5.0 – 5.5	22	0		
	3	5.5 – 5.8	33	0		
	4	5.8 – 6.1	93	33		
	5	6.1 – 6.4	100	0		
	6	6.4 – 7.0	88	29		
	7	7.0 – 7.3	92	0		
	8	7.3 – 8.1	93	50		
	9	8.1 – 8.7	83	50		

Notes:

Drilled: January 12 to January 19, 2015

Logged: January, 2015

RQD = Rock Quality Designation

1.5⁽¹⁾, 4.8⁽²⁾: Bedrock starts at 1.5 m at BH C-1 and 4.8 m at BH C-2

Originated: JO/SAT
 Compiled: SA
 Checked: MA

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{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_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No C-1

1 of 1

METRIC

G.W.P. 2163-10-00 **LOCATION** Coords: 4 817 049.5 N; 290 723.3 E **ORIGINATED BY** S.A.
DIST Central **HWY** QEW / 403 **BOREHOLE TYPE** C.F.H.S.A. and HQ Diamond Coring **COMPILED BY** K.D.
DATUM Geodetic **DATE** January 19, 2015 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
120.5	Ground Surface																			
0.0 120.2	Topsoil																			
0.3 119.8	Clayey silt organic inclusions		1	SS	2		120													
0.7	Soft Grey/ Moist brown (FILL)		2	SS	50/10cm															
119.0 1.5	Clayey silt, with sand, with gravel weathered shale fragments		3	RC HQ	REC 67%		119													
	Hard Grey/ Moist brown (TILL)																			
	Shale bedrock with embedded limestone		4	RC HQ	REC 100%		118													
	Soft to medium strength																			
	Slightly to highly weathered																			
	Poor to fair quality clay seams		5	RC HQ	REC 97%		117													
115.9 4.6	End of borehole						116													
	Sample 2: Sampler bouncing																			
	* Borehole charged with drilling water																			

RECORD OF BOREHOLE No C-2

1 of 1

METRIC

G.W.P. 2163-10-00 **LOCATION** Coords: 4 817 030.7 N; 290 733.2 E **ORIGINATED BY** S.A.
DIST Central **HWY** QEW / 403 **BOREHOLE TYPE** C.F.H.S.A. and HQ Diamond Coring **COMPILED BY** K.D.
DATUM Geodetic **DATE** January 12, 2015 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					w _p	w	w _L					
								SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
123.7	Ground Surface																			
123.5	Topsoil																			
0.2	Clayey silt organic and sand fill inclusions		1	SS	10								○							
	Stiff Reddish Moist brown/grey		2	SS	15								○							
	cobbles		3	SS	17								○							
	firm dark brown/black		4	SS	7								○							
120.7	(FILL)																			
3.0	Silty clay trace sand, trace gravel, weathered shale fragments		5	SS	47								○	┌───┐						
118.9 4.8	Hard Grey/ Moist brown																			
	(TILL)		6	SS	50/5cm															
	Shale bedrock with embedded limestone		7	RC HQ	REC 58%															
	Soft to medium strength		8	RC HQ	REC 22%															
	Slightly to moderately weathered		9	RC HQ	REC 33%															
	Very poor to poor quality clay seams		10	RC HQ	REC 93%															
			11	RC HQ	REC 100%															
			12	RC HQ	REC 88%															
			13	RC HQ	REC 92%															
			14	RC HQ	REC 93%															
115.0			15	RC HQ	REC 83%															
8.7	End of borehole																			
	* Borehole charged with drilling water																			

RECORD OF BOREHOLE No RW-6

1 of 1

METRIC

G.W.P. 2163-10-00 **LOCATION** Coords: 4 817 072.1 N; 290 723.3 E **ORIGINATED BY** S.A.
DIST Central **HWY** QEW / 403 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** K.D.
DATUM Geodetic **DATE** January 19, 2015 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
122.4	Ground Surface						20	40	60	80	100									
122.3 0.1	Topsoil		1	SS	5	122							○							
	Silty clay with sand, with gravel organic inclusions																			
	Stiff Reddish Moist brown		2	SS	13		121							┌─○─┐						
	(FILL)		3	SS	12															
119.9 2.5	hard wet		4	SS	50/3cm	120														
	End of borehole																			
	Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			

RECORD OF BOREHOLE No RW-7

1 of 1

METRIC

G.W.P. 2163-10-00 **LOCATION** Coords: 4 817 028.5 N; 290 714.6 E **ORIGINATED BY** S.A.
DIST Central **HWY** QEW / **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** K.D.
DATUM Geodetic 403 **DATE** January 12, 2015 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
125.3	Ground Surface						20	40	60	80	100									
125.1	Topsoil																			
0.2	Silty sand some gravel, trace clay organics, rootlets		1	SS	15								○							
	Compact Reddish Moist brown		2	SS	29								○							
123.9	Clayey silt, some sand weathered shale fragments organic inclusions																			
1.4	Very stiff Reddish Moist brown (FILL)		3	SS	35								○							
	Clayey silt some sand, trace gravel weathered shale fragments		4	SS	62								○	┌─┐		5 17 50 28				
	Hard Reddish Moist brown/ Grey (TILL)		5	SS	50/10cm															
			6	SS	50/5cm															
			7	SS	50/8cm															
119.0	End of borehole		8	SS	50/15cm															
6.3	Refusal on probable bedrock																			
	Sample 8: Sampler bouncing																			
	* Borehole dry																			

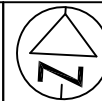
RECORD OF BOREHOLE No RW-8

1 of 1

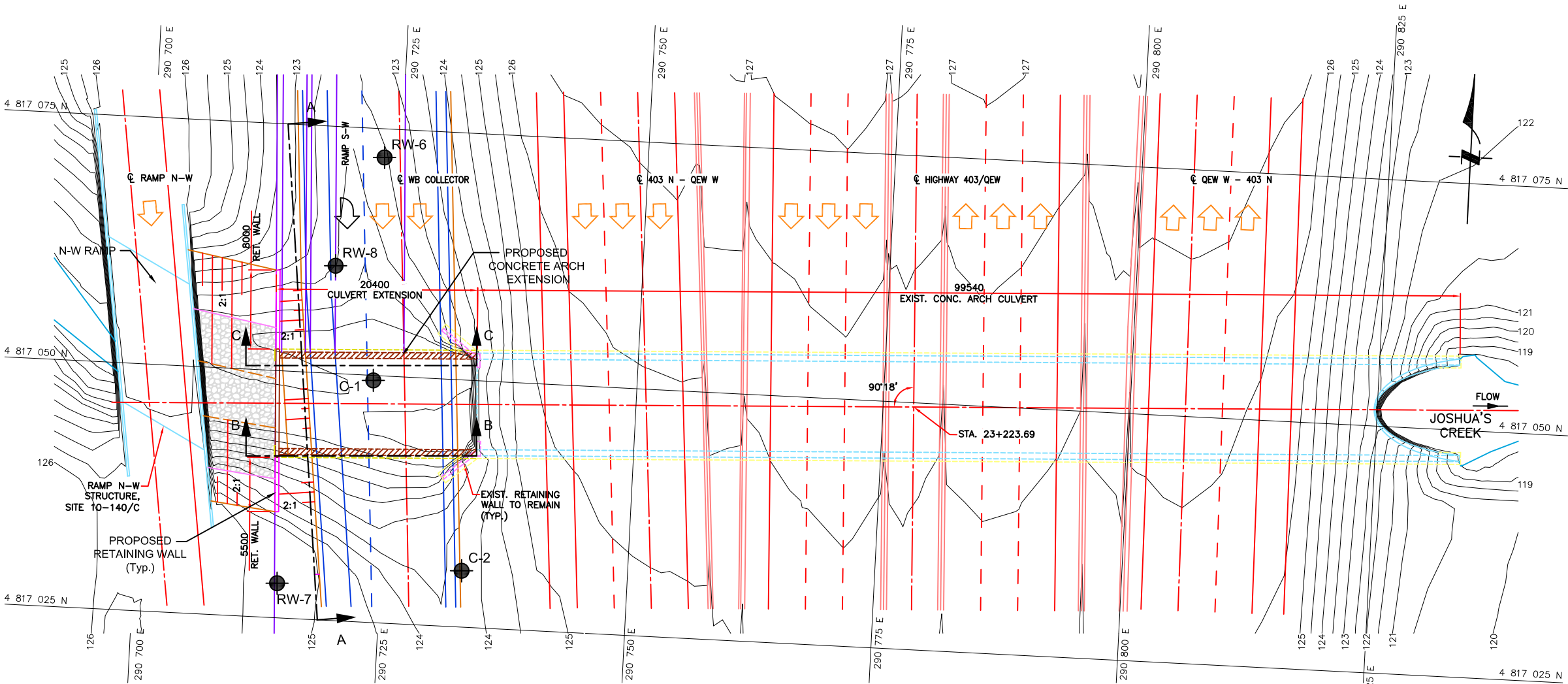
METRIC

G.W.P. 2163-10-00 **LOCATION** Coords: 4 817 060.9 N; 290 718.9 E **ORIGINATED BY** S.A.
DIST Central **HWY** QEW / 403 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** K.D.
DATUM Geodetic **DATE** January 19, 2015 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
122.0	Ground Surface																
121.8 0.2	Topsoil		1	SS	14												
121.1 0.9	Clayey silt, some sand organics, rootlets																
	Stiff to Reddish Moist hard brown (FILL)		2	SS	50/3cm												
	weathered shale fragments																
	End of borehole																
	Refusal on probable bedrock																
	Sample 2: Sampler bouncing																



KEY PLAN
200m 0 200m 400m 600m 800m 1km



PLAN

SCALE



LEGEND

- Borehole
- Cone
- Borehole and 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 Jan. 2015
- * Water level not established
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
C-1	120.5	4 817 049.5	290 723.3
C-2	123.7	4 817 030.7	290 733.2
RW-6	122.4	4 817 072.1	290 723.3
RW-7	125.3	4 817 028.5	290 714.6
RW-8	122.0	4 817 060.9	290 718.9

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

REVISIONS	DATE	BY	DESCRIPTION

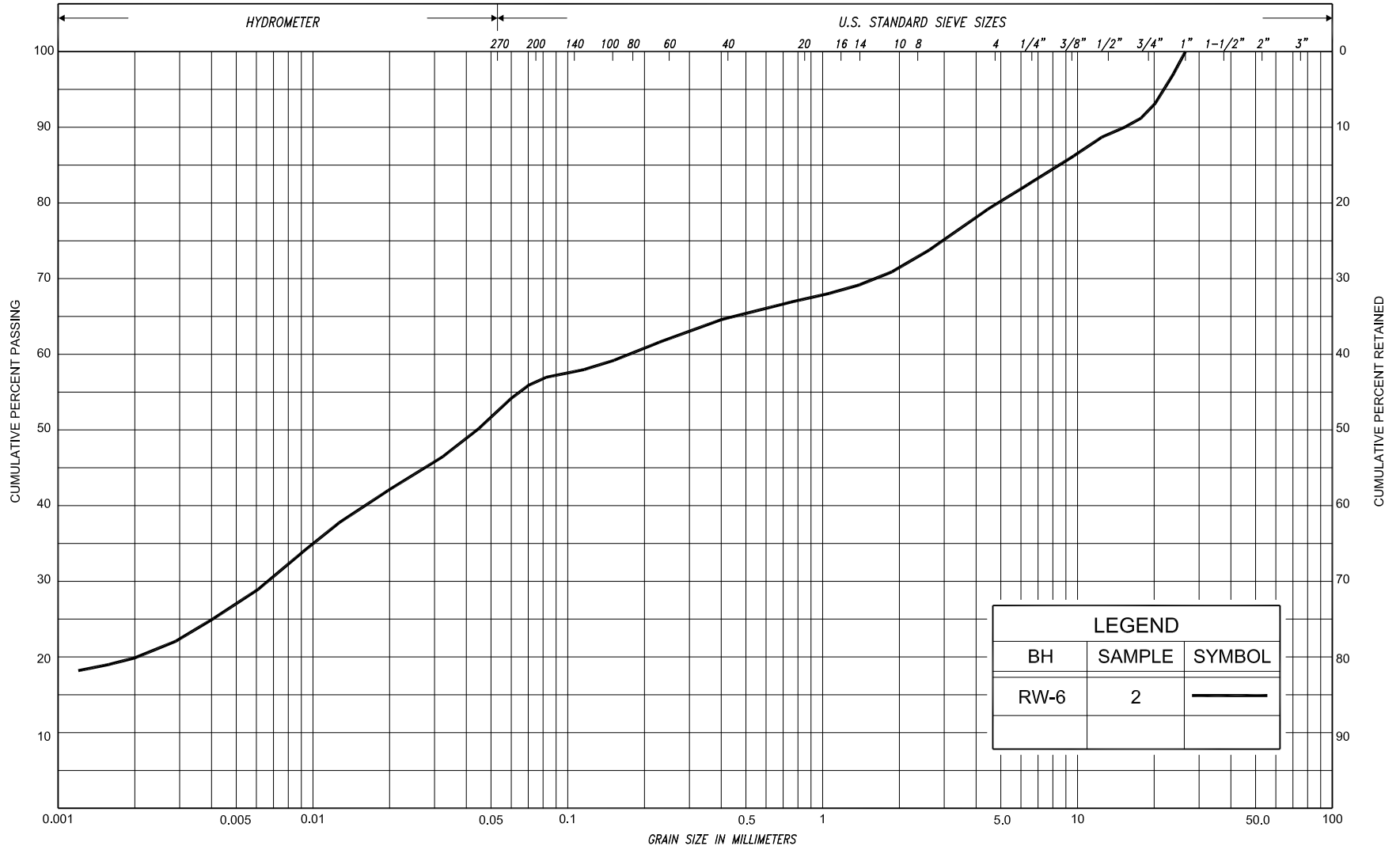
Geocres No. 30M5-314	HWY No QEW/403	DIST CENTRAL
SUBM'D NA	CHECKED KD	DATE JUNE 19, 2015
DRAWN NL	CHECKED DD	APPROVED CN



REF Stantec Drawing:
165000893_joshuas_cr_culv_r3_p1.dwg dated Feb. 2015

NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- FOR PROFILE A-A, AND SECTIONS B-B AND C-C, REFER TO DRAWING JC-2.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

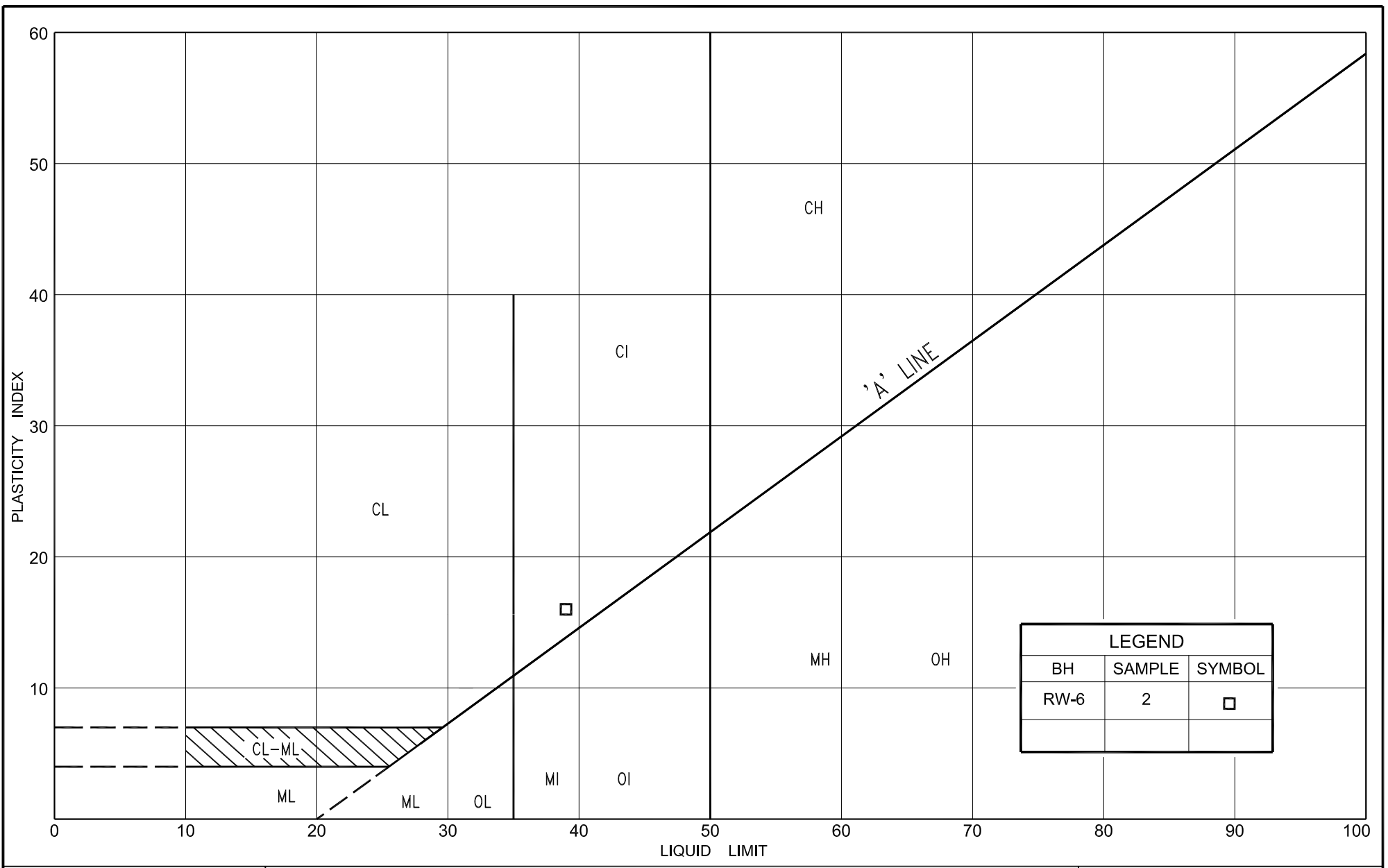


SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED
				SAND									
CLAY	FINE	MEDIUM	COARSE	FINE		MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.
	SILT			SAND									
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL					U.S. BUREAU
				SAND									



GRAIN SIZE DISTRIBUTION **SILTY CLAY, with sand, with gravel (CI)** **(FILL)**

FIG No.	JC-GS-1
HWY:	403 / QEW
G.W.P. No.	2163-10-00

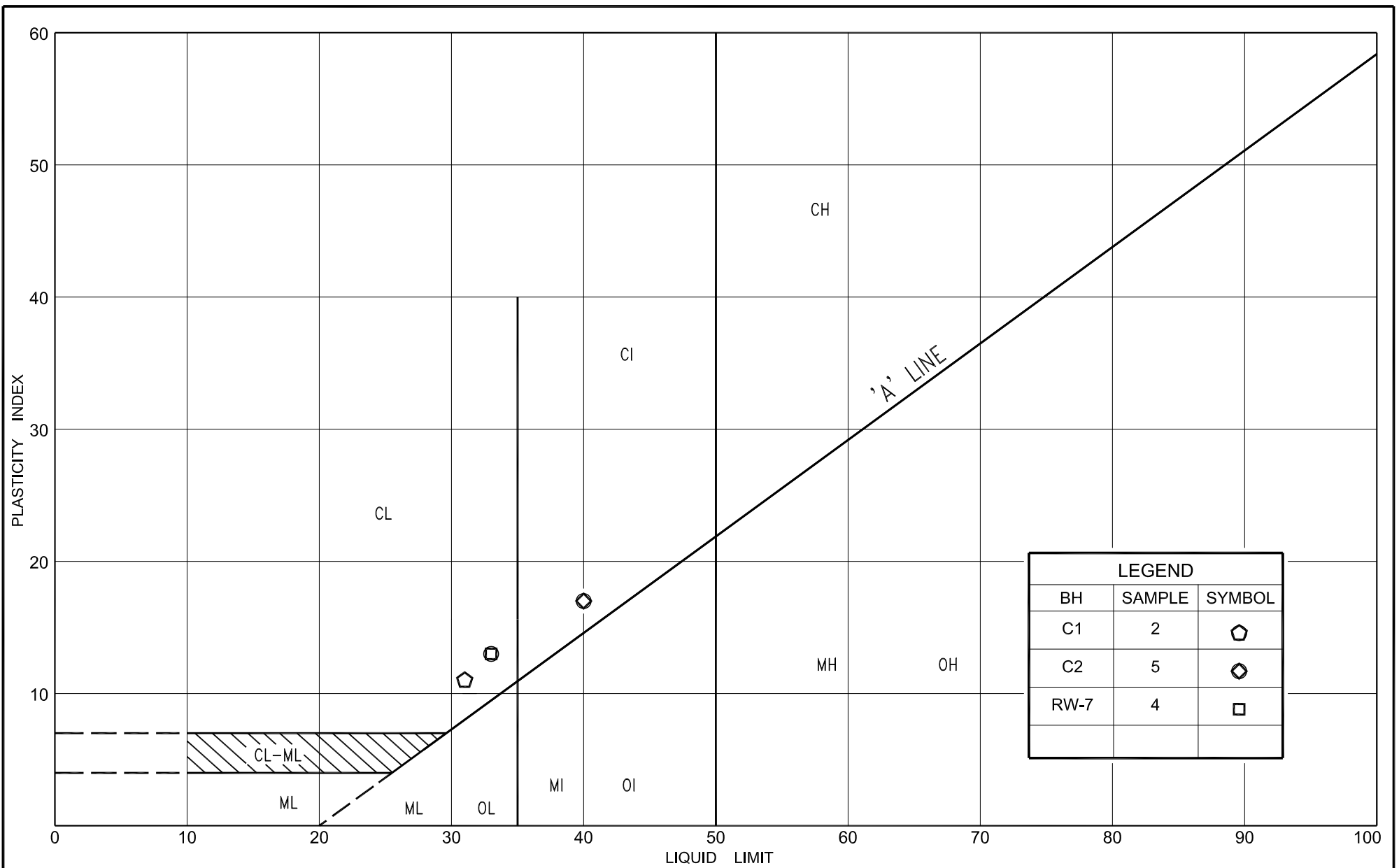


LEGEND		
BH	SAMPLE	SYMBOL
RW-6	2	□



PLASTICITY CHART
 SILTY CLAY, with sand, with gravel (CI)
 (FILL)

FIG No.	JC-PC-1
HWY:	403 / QEW
G.W.P. No.	2163-10-00



PLASTICITY CHART
 CLAYEY SILT TO SILTY CLAY, with sand, trace to with gravel (CL-CI)
 (TILL)

FIG No.	JC-PC-2
HWY:	403 / QEW
G.W.P. No.	2163-10-00



APPENDIX FIR-A

Relevant GEOCREs Data

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

WP ~~159-75-05~~

DIST 4

125-66-20

HWY 403

STR SITE 10-140A

Extension to Joshuas Creek Arch Structure
and Proposed Stream Realignment

DISTRIBUTION

G.C.E. Burkhardt (3)
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G.A. Wrong
B.J. Giroux
R.S. Pillar

R. Hore

R. Fitzgibbon)
J. Anderson) cover only
G. Sloan)

Files ✓

FOUNDATION INVESTIGATION REPORT

For

Extension to Joshuas Creek Arch Structure
and Proposed Stream Realignment
QEW/403/Ford Drive Interchange
W.P. ~~159-75-05~~, Site 10-140A
District 4, Hamilton

125-65-20

INTRODUCTION

This report contains the results of a foundation investigation performed by the Soil Mechanics Section at the site of the above mentioned project. Fieldwork was carried out during June 17 to June 21, 1977, using 3¼" hollow stem, continuous flight augers and BXL coring techniques to advance 4 boreholes to depths ranging from 10 to 17 feet below ground surface.

SITE DESCRIPTION AND GEOLOGY

The site is immediately west of QEW, about ¼ mile south of the Ford Drive underpass, in the Regional Municipality of Halton, Town of Oakville.

Runoff from QEW drains into Joshuas Creek through catch-basins and grass covered ditches. In this area the creek meanders southeasterly in a steep-sided valley (slopes about 1:1), 15 to 25 feet deep, and appears to have eroded at least 10 feet into the bedrock, as evidenced by outcrops on the north valley sides. The sides of the creek in the vicinity of QEW are protected from erosion with gabion walls. The surrounding land is wooded; with a house, stable and kennel located at the top of the south valley embankment.

The creek bed is strewn with gravel and cobbles. Water flow through the creek during the fieldwork was estimated to be less than one cubic foot per minute.

SUBSURFACE CONDITIONS

General

Borings were put down adjacent to the existing Joshuas Creek within the Ministry's property limits because of property restrictions as discussed in the Appendix. The locations of the borings are shown in Dwg. No. 1597505-A. In the area investigated, shale bedrock was found to exist under a layer of cobbles and gravels of variable thickness, up to 4 feet thick at certain locations. The shale bedrock was investigated to a maximum depth of $16\frac{1}{2}$ feet. In the vicinity of the existing structure, an isolated pocket of silty clay about 2 feet thick was found sandwiched between the cobble layer and the shale bedrock at a depth of 2 feet below the ground surface. A description of the soil types and bedrock is given below:

Cobbles and Gravel

Some of this material appears to have been transported to the site by Joshuas Creek and some derived from erosion of the valley sides. The thickness of this material is extremely variable, ranging from a few scattered cobbles up to 4 feet thick in places. While gravel was found in the waterway as well as on the flood plains on either side of the creek, cobbles were found mainly in the creekbed.

Silty Clay

This material was encountered in one isolated location in the vicinity of the existing structure. It has a thickness of up to 2 feet and is sandwiched between the cobble-gravel layer and shale bedrock, at a depth of 2 feet below ground surface.

Shale Bedrock

Bedrock is a shale with frequent horizontal limestone beds. The shale layers are more predominant and they constitute up to 85% of the bedrock. The shale is soft and fissile, with a fine texture and closely spaced horizontal bedding. The limestone layers are randomly spaced and are generally 2 to 8 inches thick, and pitted with calcite vugs. The upper 2 feet of the shale is badly weathered.

Rock Quality Designation (RQD) is used to judge the engineering quality of the bedrock. According to the low values of RQD recorded here, which generally vary from 20% to 50%, the quality of the shale bedrock is considered to be generally poor.

A detailed description of the bedrock given by Mr. B. Glassford, Geologist for M.T.C., is enclosed in the Appendix.

GROUNDWATER CONDITIONS

Groundwater level is controlled by the creek water level. For construction purposes, the groundwater level can be assumed equal to the prevailing water level in the creek.

125-66-20

RECORD OF BOREHOLE No 17

W P 159-75-05 LOCATION Co-ords. N 15,803,222; E 953,842 ORIGINATED BY JRW
 DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Augering - EXL Core COMPILED BY JRW
 DATUM Geodetic DATE June 17, 1977 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					
393.7	Creek Bottom																
391.7	Cobbles and gravel																
389.7	Silty clay some sand		1	AS			390										
4.0	Bedrock		2	AS													
	Shale-Soft & weathered		3	SS	109												
	Frequent laminations of limestone		4	RC	Rec 60%												RQD 50%
	Up to 8" thick		5	RC	Rec 75%		380										RQD 20%
376.8			6	RC	Rec 80%												RQD 20%
16.9	End of Borehole																

+³, x⁵: Numbers refer to Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

125-66-2a

RECORD OF BOREHOLE No 18

W P 459-75-05 LOCATION Co-ords. N 15,803,247; E 953,804 ORIGINATED BY JRW
 DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Augering - BX Coring COMPILED BY JRW
 DATUM Geodetic DATE June 17 & 20, 1977 CHECKED BY JRS

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					
395.2	Creek Bottom																GR SA SI CL
393.4	Cobbles & gravel																
1.8	Bedrock		1	RC	60%		390										RQD 50%
	85% Shale-Soft & weathered Frequent laminations of lime-stone up to 8" thick		2	RC	50%												RQD 35%
385.3			3	RC	Rec 95%												RQD 80%
9.9	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15-20.5 (%) STRAIN AT FAILURE
10

125-66-20

RECORD OF BOREHOLE No 19

W P 159-75-05 LOCATION Co-ords. N 15,803,500; E 953,533 ORIGINATED BY JRW
 DIST 4 HWY 403 BOREHOLE TYPE Solid Stem & Hollow Stem Augering COMPILED BY JRW
 DATUM Geodetic DATE June 21, 1977 CHECKED BY KS

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					
399.0	Creek Bottom																
397.5	Cobbles & gravel																
1.5	Bedrock Soft weathered shale with Frequent Limestone laminations		No sampling														
389.2							390										
9.8	End of Borehole Note: Stratigraphy inferred from augering.																

+³, x⁵: Numbers refer to
Sensitivity

20
15-5 [%] STRAIN AT FAILURE
10

125-62-20

RECORD OF BOREHOLE No 20

W P 159-75-05 LOCATION Co-ords. N 15,803,245; E 953,727 ORIGINATED BY JKW
 DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Augering COMPILED BY JRW
 DATUM Geodetic DATE June 21, 1977 CHECKED BY JS

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					
395.6	Creek Bottom																
0.0 392.1	Cobbles & gravel																
3.5	Bedrock		No sampling				390										
386.1	Soft weathered shale with frequent limestone laminations																
9.5	End of Borehole																
	Note: Stratigraphy inferred from augering																

+³, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



Ministry of
Transportation and
Communications

DIAMOND DRILL RECORD

HOLE NO. _____ SHEET NO. _____

125-66-20

DIP

PROPERTY _____
LOCATION W.P. 159-75-05
QEW and Ford Drive
Joshuas Creek
LATITUDE _____
DEPARTURE _____
BEARING _____

90°

TOTAL FOOTAGE _____

ELEV. COLLAR _____
DATUM _____
DATE STARTED _____
DATE COMPLETED _____
DRILLED BY _____
LOGGED BY _____

FOOTAGE		FORMATION	SAMPLE NUMBER	%		REMARKS
FROM	TO			Shale		
HOLE #17						
5'0"	5'6"	Shale, soft, dark grey, fine texture, fissile.		80%		RQD 5%
5'6"	6'2"	Limestone, soft, light grey, fine texture.				RQD 90%
6'2"	16'8"	Shale and limestone beds, broken and missing core				RQD 5%
		8" limestone at 13' pitted with calcite vugs				
		6" limestone at 12' pitted with calcite vugs				
		4" limestone at 15'6" pitted with calcite vugs				
HOLE #18						
1'8"	9'7"	Shale, soft, dark grey, fine texture, fissile, broken and ground core throughout entire length of core.		85%		RQD 10%
		5" limestone at 2'6" pitted with calcite vugs				
		2" limestone at 3'0"				
		3" limestone at 5'0"				
		3" limestone at 5'8"				
		8" limestone at 8'10"				

DATE OF EXAMINATION June 28, 1977

B. K. Glassford

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

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

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

DESCRIPTION OF SOIL

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

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

TERMS TO BE USED IN DESCRIBING SOILS:-

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

TYPE OF SAMPLE

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

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

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

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

GENERAL

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

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

STRESS AND STRAIN

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

EARTH PRESSURE

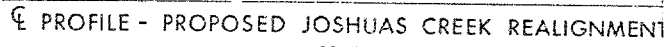
$\bar{\sigma}$	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

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

SLOPES

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

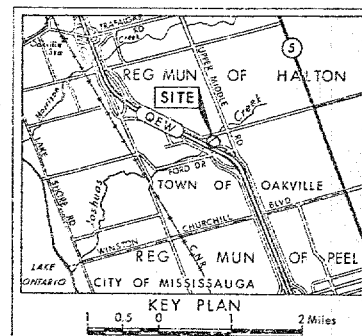


CONT No 125-66-10
WP No 159-75-05

PROP CULVERT EXTENSION
& JOSHUAS CR REALIGNMENT
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- 'N' Blows/ft (Std Pen Test 350 ft lbs energy)
- CONE Blows/ft (60° Cone, 350 ft lbs energy)
- W.L. at time of investigation June 1977

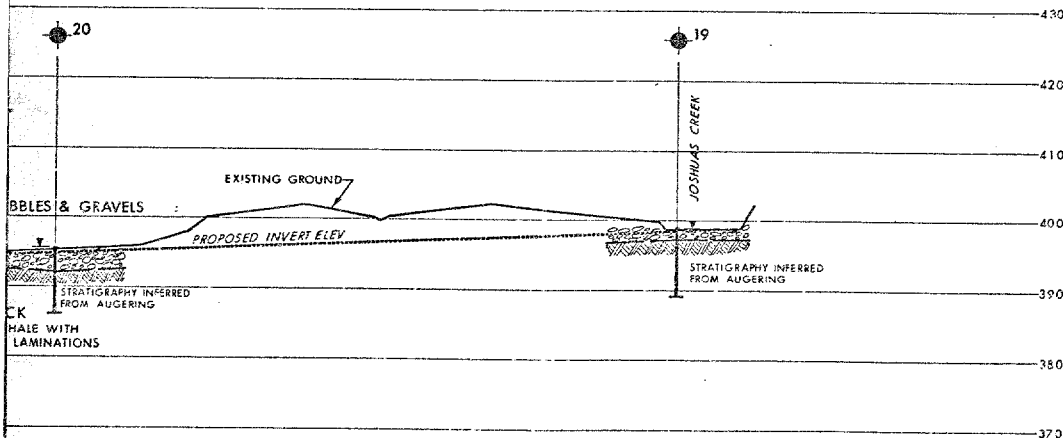
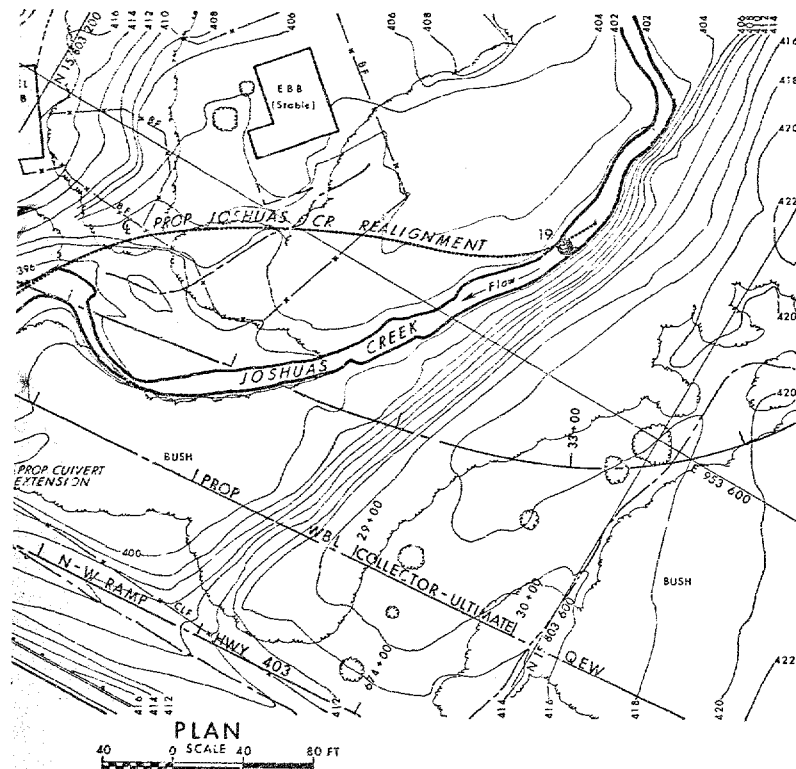
No	ELEVATION	CO ORDINATES	
		NORTH	EAST
17	393.7	15 803 222	953 842
18	395.2	15 803 247	953 804
19	399.0	15 803 500	953 533
20	395.6	15 803 245	953 727

-NOTE-

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

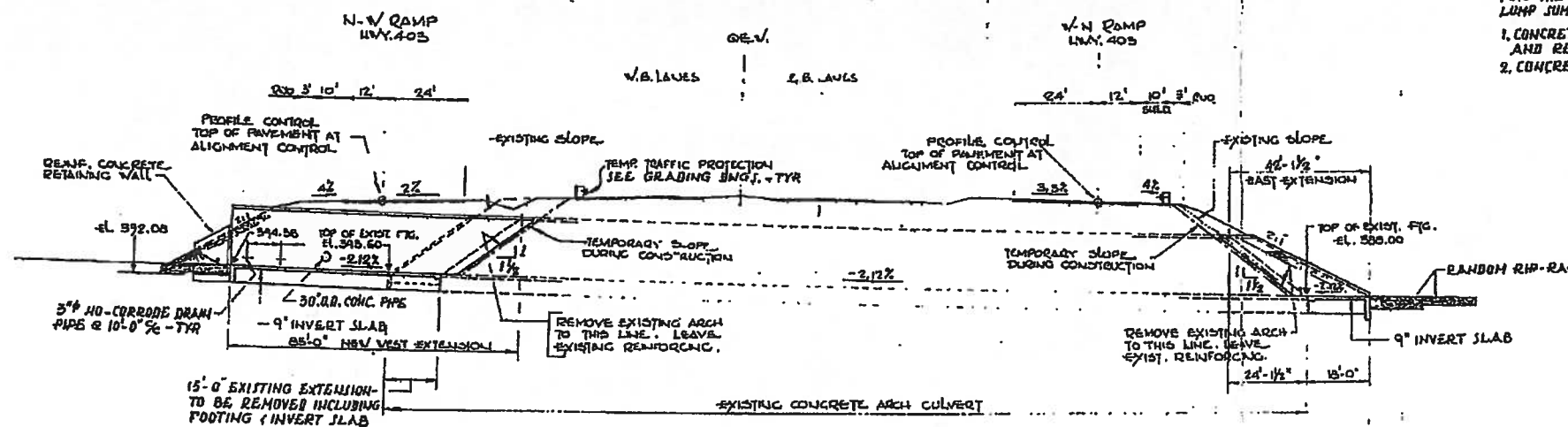
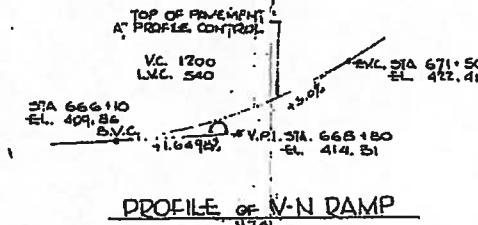
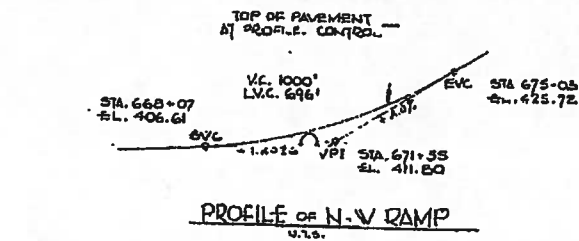
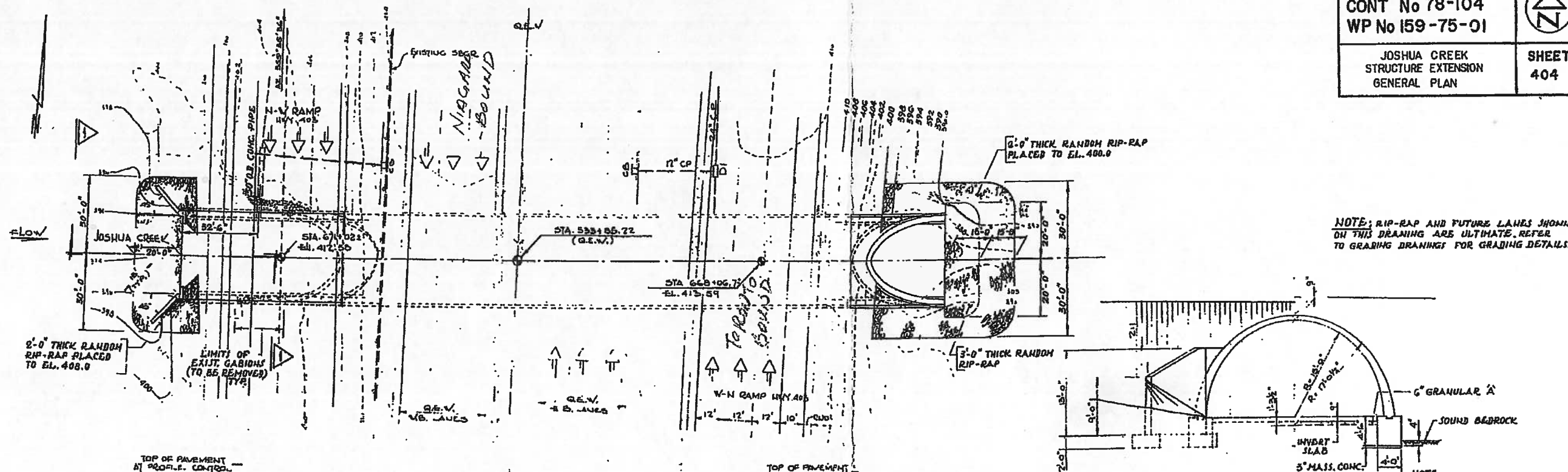
REVISIONS	DATE	BY	DESCRIPTION

MAY 1978
CHECKED BY DATE JULY 15, 1977
DRAWN BY CHECKED BY DATE



PROPOSED JOSHUAS CREEK REALIGNMENT

HOR 40 0 SCALE 40 80 FT
VERT 10 0 10 20 FT



CONCRETE QUANTITIES

CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEM:

1. CONCRETE IN STRUCTURE (4000 R.S.I.) - 217 cu.yd. AND RET. WALLS (3000 R.S.I.) - 21 cu.yd.
2. CONCRETE IN INVERT SLAB - 74 cu.yd.

GENERAL NOTES:

CLASS OF CONCRETE
ARCH - 4000 R.S.I.
FOOTINGS, RET. WALLS, INVERT SLAB - 3000 R.S.I.

CLEAR COVER TO REINF. STEEL
FOOTINGS & RET. WALLS - 3"
ARCH EXTRADOS - 3"
ARCH INTRADOS - 2"

REINF. STEEL SHALL BE C.S.A. G30 SERIES GRADE 60.

CONSTRUCTION NOTES

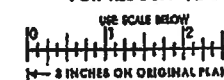
BACKFILL OPERATIONS SHALL PROGRESS SIMULTANEOUSLY ON BOTH SIDES OF THE ARCH AXIS. THE DIFFERENCE IN WORKING LEVELS OF BACKFILL BETWEEN EITHER SIDE SHALL AT NO TIME EXCEED 1'-0".

LIST OF DRAWINGS

DWG. 1 GENERAL PLAN
2 BORE HOLE LOCATIONS & SOIL STRATA
3 WEST EXTENSION
4 EAST EXTENSION
DWG. 5 STANDARD DETAILS



FOR REDUCED PLAN

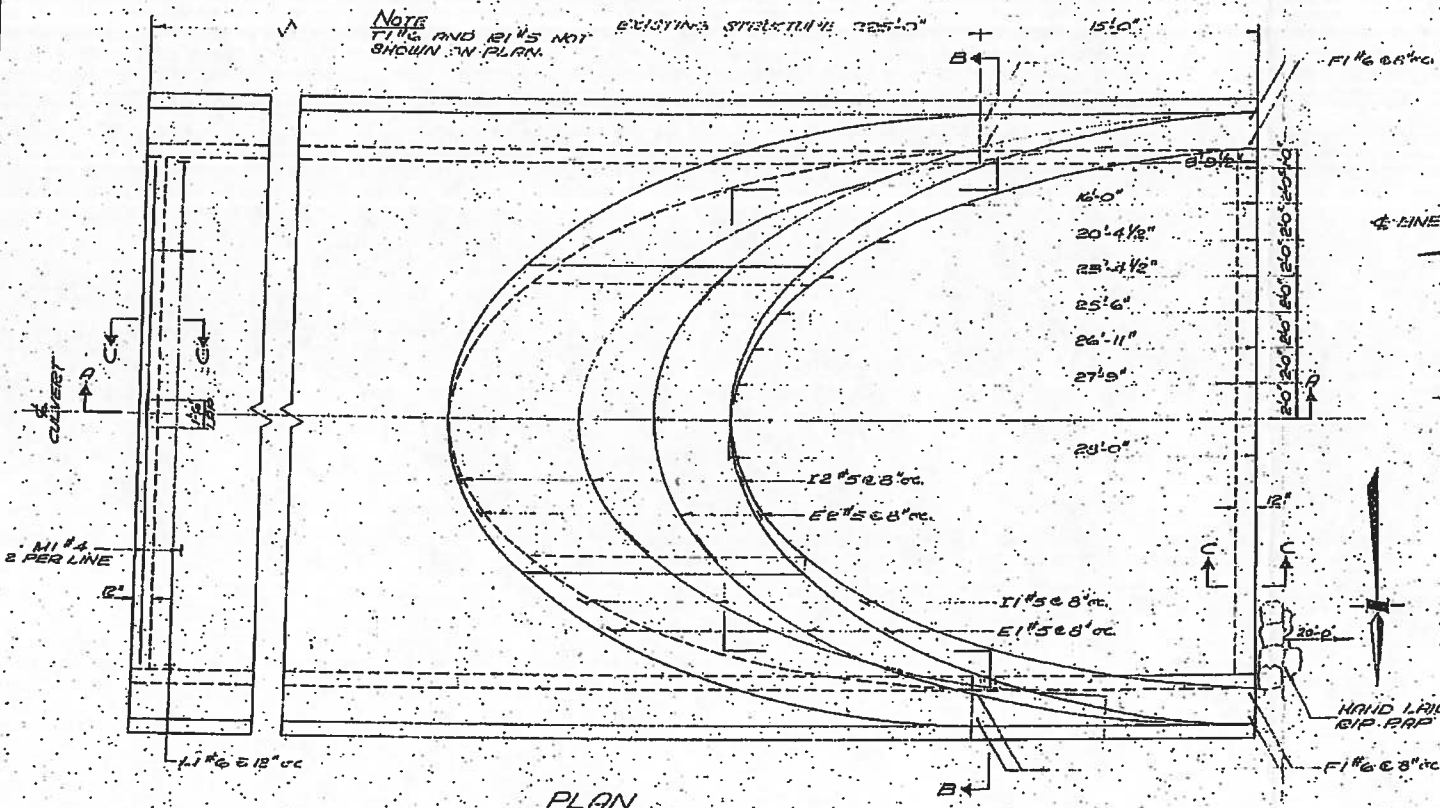


REVISION	DATE	BY	DESCRIPTION
1			DESIGN V.V. CHECK P.K. LOADING 11520-44 DATE MAR/78
2			DRAWING V.V. CHECK P.K. SITE No 10-140A DWG. 1

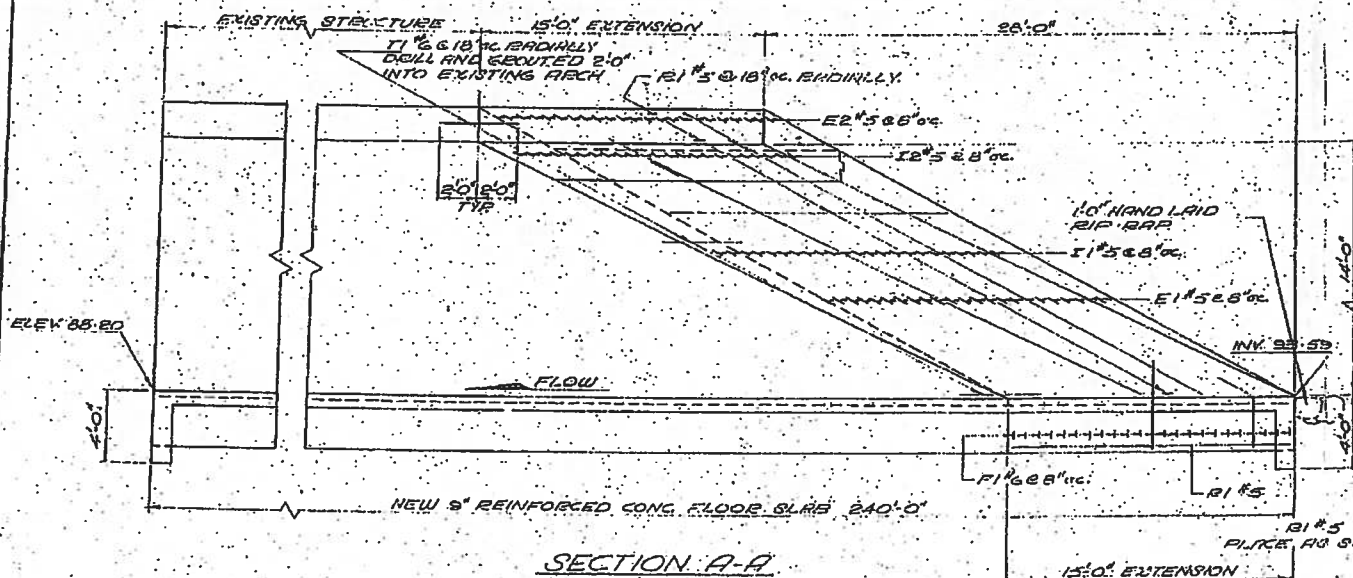
No. 6 STR. 28+30

NOTE
F.T.G. AND B.T.S. NOT
SHOWN IN PLAN.

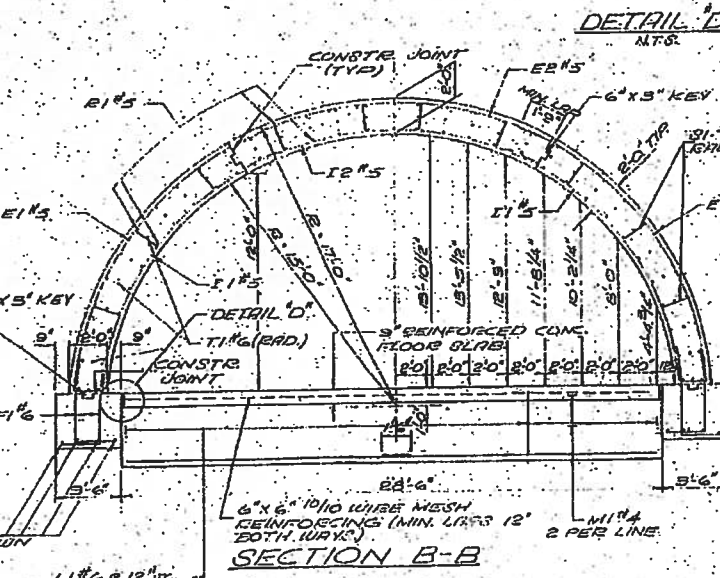
EXISTING STRUCTURE 225'-0"



PLAN



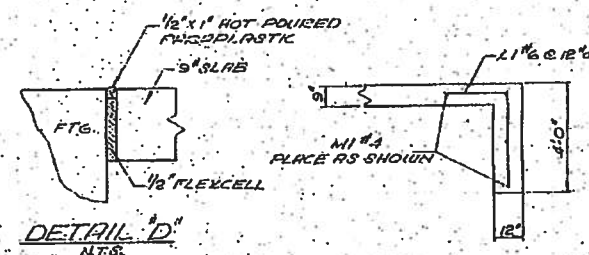
SECTION A-A



SECTION B-B

SITE PLAN
SCALE 1" = 50'-0"

STIRRUP DETAIL
M.T.S.



DETAIL D-D
M.T.S.

SECTION C-C
SCALE 3/8" = 1'-0"

NOTES

- TO CONTRACTOR: CONTRACTOR WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MEASUREMENTS TO ALL CONTROL POINTS HAVE BEEN CHECKED AND CHECKED BY THE ENGINEER.
- TO CONTRACTOR: STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORMS AND THE SPECIAL PROVISIONS, EXCEPT WHERE NOTED OTHERWISE BY THE ENGINEER.
- CONCRETE MIX: 5000 P.S.I. AT 28 DAYS. APPROVED ADMIXTURE, SUPPLIED BY THE CONTRACTOR, WILL BE ADDED TO ALL CONCRETE AS SPECIFIED BY THE ENGINEER.
- CLERK COVER ON REINFORCING STEEL: 3" EXCEPT AS NOTED.
- CONSTRUCTION NOTES: ALL EXPOSED REBARS TO BE CHAMFERED 1"x1" EXCEPT AS NOTED. ALL CONSTRUCTION JOINTS MUST BE APPROVED BY THE ENGINEER.

PRINT RECORD
No. FOR DATE
3 25.11.1964

REVISION
DATE BY DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO			
BRIDGE DIVISION			
TRAFALGAR TWP ARCH CULVERT EXTENSION			
KING'S HIGHWAY NO. 6 E. W.	STR. 28+30	DIST. NO. 6	
CO. HALTON	TWP. TRAFALGAR	LOT 15	CONTS. 2, 3, 5
GENERAL PLAN			
APPROVED: [Signature]	DIST. NO.	W.D. NO.	65-179
DESIGN: [Signature]	CHECK: [Signature]	CONTRACT	65-179
DRAWN: [Signature]	CHECK: [Signature]	DRAWING	D-5475-1
DATE: 1/15/64	LOADING: 1/15/64	DATE: 1/15/64	LOADING: 1/15/64

Twp 22-140-1-D 10-140 1103



APPENDIX FIR-B

Site Photographs



Photograph 1: Taken near borehole C-2, facing northeast (January 12, 2015).



Photograph 2: Taken near borehole C-1, facing east (January 19, 2015).



Photograph 3: Taken near borehole C-1, facing east (January 19, 2015).



Photograph 4: Taken near borehole RW-7, facing northeast (January 12, 2015).



APPENDIX FIR-C

Rock Core Photographs



Photograph 1: Cores retrieved from borehole C-1. Rock cores 1 to 3 from 1.5 to 4.6 m. RQD values ranged from 38 to 70%, indicating poor to fair rock quality.



Photograph 2: Cores retrieved from borehole C-2. Rock cores 1 to 9 from 4.8 to 8.7 m. RQD values ranged from 0% to 50%, indicating very poor to poor rock quality.