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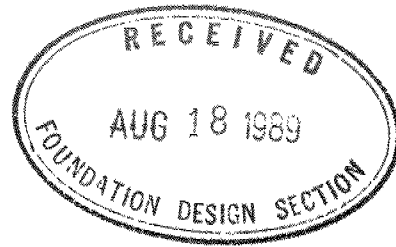
LOCATION Fourteen Mile Creek Arch Widening
North Service Rd.

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-90



Ministry of
Transportation and
Communications

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

EXPLANATION OF TERMS USED IN REPORT

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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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u_o	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_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	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						

Foundation Investigation Report
for
Fourteen Mile Creek Arch Widening
North Service Rd.; Q.E.W.
Town of Oakville, Lot 26, Con. II
W.P. 47-82-02; Site 10-156
District #4 (Burlington)

Introduction

This report contains the results of a foundation investigation carried out at the aforementioned site on 84 08 29 and on 84 08 30. The field work consisted of two sampled boreholes. The borings were advanced by a continuous flight auger machine mounted on a muskeg vehicle and equipped with 83 mm hollow stem augers and BXL rock coring equipment.

Site Description

The site is located just north of the existing North Service Road (Q.E.W.) and west of Third Line Road at Fourteen Mile Creek in the Town of Oakville. The surrounding terrain is gently rolling and in part tree covered. Physiographically the site is located in a region referred to as the South Slope.

Subsurface Conditions

General

The borings were carried out from the creek bed and indicated the presence of an approx. 1.0 m thick overburden followed by shale bedrock in B.H. #2 and shale bedrock from the surface in B.H. #1.

The boundaries of the different strata together with the obtained field test results are shown on the Record of Borehole Sheets contained in the Appendix of this Report. A stratigraphical section shown on Drawing No. 478202-A is based upon this information. A description of the different strata encountered is given below.

Overburden

This zone was encountered in Borehole #2, from ground level (El. 103.7) to El. 102.7. The material in the deposit is a mixture of silty clay and weathered shale fragments.

The consistency may be classified as very stiff.

Bedrock

The bedrock was encountered either at creek bed level or below the above described overburden at the following levels:

B.H. #1 El. 103.6
B.H. #2 El. 102.7

The bedrock is shale of the Queenston Formation. The colour of the shale is predominantly red with green siltstone bands. The upper portion of the shale is weathered to varying degrees and becomes more sound with depth. It was easily penetrated with conventional augering methods to El. 102.1 (B.H. #1) and to El. 101.0 (B.H. #2). For details, references should be made to the 'description of rock core' sheet appended to this report. The core description was carried out by Mr. E.R. Magni, M.T.O. Geologist.

Groundwater Conditions

In both borings water was observed at ground level. It is our assessment that this water was left in the borings due to the drilling operations and/or entered through cracks from the adjacent creek. The water level in the creek is believed to fluctuate due to the amount of rainfall and spring run-off process.

In view of these facts and the relatively unprevious nature of the rock mass the true level of groundwater could not be established with certainty. For all practical (design and construction) purposes, it can be assumed that the groundwater level is the same as the prevailing water level in the creek at a particular time period.

No artesian conditions were encountered.



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

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1										METRIC					
W P 47-82-02		LOCATION Co-ords. N 4 808 974.4; E 286 327.2				ORIGINATED BY TM									
DIST 4 HWY Q.E.W.		BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring				COMPILED BY JC									
DATUM Geodetic		DATE 84 08 29				CHECKED BY									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p		
103.6	Ground Level		1	SS	46										
0.0	Extensively Weathered		2	SS	82/28 cm										
	Shale Moderately Weathered		3	RC BXL	REC 84%										
	Unweathered Bedrock		4	RC BXL	REC 88%										
99.0															
4.6	End of Borehole														

RECORD OF BOREHOLE No 2										METRIC			
W P 47-82-02		LOCATION Co-ords. N 4 808 973.8; E 286 319.4				ORIGINATED BY TM							
DIST 4 HWY Q.E.W.		BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring				COMPILED BY JC							
DATUM Geodetic		DATE 84 08 30				CHECKED BY <i>sc</i>							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
103.7	Ground Level												
0.0	Mixture of Silty Clay and Weathered Shale	1	1	SS	16								
102.7		2	2	SS	103	20 cm							
1.0	Extensively to Moderately Weathered Shale						102						
	Unweathered												
	Bedrock		3	RC BXL	REC 82%		100						
97.9			4	RC BXL	REC 88%								
5.8	End of Borehole						98						

DESCRIPTION OF ROCK CORE - W.P. 47-82-02

OREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (M)	% CR*	% RQD*	DEPTH (M)	DESCRIPTION
1	1.53 - 3.05	83.3	35.0	1.53 - 2.14	Shale, Queenston, red, slightly to moderately weathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, very closely spaced joints
	- 4.58	88.3	81.7	2.14 - 4.58	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, widely spaced joints
2	2.75 - 4.27	80.0	80.0	2.75 - 5.80	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, very widely spaced joints
	- 5.80	86.6	86.6		

* CR = CORE RECOVERY; RQD = ROCK QUALITY DESIGNATION

FOUNDATION INVESTIGATION REPORT

for

Twin Box Culvert
New SE Service Rd. (Q.E.W.) & 14 Mile Creek
W.P. 47-82-03; Site: 10-82-336
District #4 (Burlington)

Introduction

This report contains the results of the foundation investigation carried out at the aforementioned site between 84 08 27 and 84 08 29. The field work consisted of four sampled boreholes and one dynamic cone penetration test. The borings were advanced by a continuous flight auger machine mounted on a muskeg vehicle and equipped with 83 mm hollow stem augers and BXL rock coring equipment.

Site Description

The site is located SE of the crossing of Q.E.W. and Third Line Road at 14 Mile Creek in the Town of Oakville. The surrounding terrain is gently rolling and tree covered.

Physiographically the site is located in a region referred to as the South Slope.

Subsurface Conditions

Two different types of deposits were encountered at this site:

- a) Silty clay overburden
- b) Shale bedrock

The boundaries of the different strata, together with the obtained field test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. The stratigraphical sections shown on Drawing No. 478203-A are based upon this information. A description of the different strata encountered is given below.

Overburden

This zone was encountered in all but B.H. #3. The thickness varies from 1.1 m to 3.0 m. The material consists mainly of silty clay with occasional shale fragments. In addition, traces of undecayed organic (roots) substances were also found in the upper about 0.3 m portion of the deposit. The colour of the material is reddish-brown. It is believed that this stratum derived from the underlying shale bedrock.

Standard penetration tests gave 'N' values to vary from 5 to over 100 blows per 30 cm penetration. The lower 'N' values were obtained in the extreme upper zone of the stratum.

The consistency may be classified as firm to hard.

Bedrock

The bedrock was encountered in all boreholes either at ground level or the above described silty clay deposit at the following elevations:

B.H. #1	El. 98.8
#2	El. 96.6
#3	El. 99.5
#4	El. 99.2

The shale bedrock is of the Queenston Formation. The shale is predominantly red in colour containing (about 5%) green siltstone layers. The upper portion of the bedrock is weathered to varying degrees and becomes more sound with depth. For details references should be made to the 'Description of Rock Core' sheet appended to this report. The core description was carried out by Mr. E.R. Magni, M.T.O. Geologist.

Groundwater Conditions

The groundwater level was found to be at or in the vicinity of the creek water level (El. 99.4) at the time (August, 1984) of the field investigation. Seasonal fluctuation of the ground level can be expected.



P. Payer

P. Payer, P. Eng.
Senior Foundation Engineer

M. Devata

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 47-82-03 LOCATION Co-ords. N 4 809 023.6 E 286 855.5 ORIGINATED BY TM
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring COMPILED BY JC
 DATUM Geodetic DATE 84 08 27 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
100.3	Ground Level										
0.0	Silty Clay Traces of organics occ. shale fragments Vary Stiff to Hard		1	SS	16		100				
98.8			2	SS	68						
1.5	Extremely Weathered Slightly Shale - Weathered Unweathered		4	RC BXL	REC 90%		98				
94.8	Bedrock		5	RC BXL	REC 100%		96				
5.5	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 47-82-03 LOCATION Co-ords. N 4 809 022.5; E 286 837.0 ORIGINATED BY TM
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring COMPILED BY JC
 DATUM Geodetic DATE 84 08 28 CHECKED BY 10

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					
99.6	Ground Level													
0.0	Silty Clay traces of organics occ. shale fragments Hard Reddish Brown		1	SS	97/25	8 cm								
			2	SS	80/78									
96.6			4	SS	61/7	14 cm								
3.0	Extensive W. Shale Unweathered to Moderately Weathered Bedrock		5	RC BXL	REC 85%									
93.5			6	RC BXL	REC 100%									
6.1	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3										METRIC						
W P 47-82-03		LOCATION Co-ords. N 4 809 040.9; E 286 867.1		ORIGINATED BY TM												
DIST 4 HWY Q.E.W.		BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring		COMPILED BY JG												
DATUM Geodetic		DATE 84 08 28		CHECKED BY <i>[Signature]</i>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20	40	60	80	100	W _p	W		
99.5	Ground Level		1	SS	11/2	cm										
0.0	Extremely Weathered Shale Bedrock					8 cm										
	Unweathered		3	RC BXL	REC 83%											
			4	RC BXL	REC 100%											
93.7																
5.8	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 47-82-03 LOCATION Co-ords. N 4 809 036.5; E 286 833.2 ORIGINATED BY TM
DIST 4 HWY Q.E.W. BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring COMPILED BY JC
DATUM Geodetic DATE 84 08 29 CHECKED BY [Signature]

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					
100.3	Ground Level																
99.2	Silty Clay, trace of organics, occ. shale fragments Firm to Stiff		1	SS	5		100										
1.1	Extremely to Moderately Weathered		2	SS	65/25												
	Unweathered Shale Bedrock		3	SS	65/8		98										
			4	RC BXL	REC 94%												
94.2			5	RC BXL	REC 96%		96										
6.1	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

DESCRIPTION OF ROCK CORE - W.P. 47-82-03

REHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (M)	% CR*	% RQD*	DEPTH (M)	DESCRIPTION
1	2.49 - 3.97 - 5.49	89.7 98.3	69.0 93.3	2.49 - 3.25	Shale, Queenston, red, slightly weathered, occasional (5%) green siltstone bands about 50 mm wide, closely spaced joints
				3.25 - 5.49	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 50 mm wide, widely spaced joints
2	3.05 - 4.58 - 6.10	83.3 98.3	83.3 98.3	3.05 - 3.30	Assumed core loss
				3.30 - 5.24	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 mm wide, widely spaced joints
				5.24 - 6.10	Shale, Queenston, red, moderately weathered, occasional mud seams, occasional (5%) green siltstone bands about 25 mm wide, widely spaced joints
3	2.75 - 4.27 - 5.80	81.7 98.3	75.0 93.3	2.75 - 3.03	Assumed core loss
				3.03 - 5.80	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 50 mm wide, closely spaced joints
4	3.05 - 4.58 - 6.10	93.3 95.0	93.3 95.0	3.05 - 6.10	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 to 120 mm wide, widely spaced joints

* CR = CORE RECOVERY; RQD = ROCK QUALITY DESIGNATION

P. PAYER
CONT 89-90



Ministry of
Transportation and
Communications

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 47-82-⁰²~~01~~ DIST 4
HWY Q.E.W. STR SITE 10-156

Fourteen Mile Creek Arch Widening
North Service Road

DISTRIBUTION

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Foundation Investigation Report
for
Fourteen Mile Creek Arch Widening
North Service Rd.; Q.E.W.
Town of Oakville, Lot 26, Con. II
W.P. 47-82-01; Site 10-156
District #4 (Burlington)

Introduction

This report contains the results of a foundation investigation carried out at the aforementioned site on 84 08 29 and on 84 08 30. The field work consisted of two sampled boreholes. The borings were advanced by a continuous flight auger machine mounted on a muskeg vehicle and equipped with 83 mm hollow stem augers and BXL rock coring equipment.

Site Description

The site is located just north of the existing North Service Road (Q.E.W.) and west of Third Line Road at Fourteen Mile Creek in the Town of Oakville. The surrounding terrain is gently rolling and in part tree covered. Physiographicall the site is located in a region referred to as the South Slope.

Subsurface Conditions

General

The borings were carried out from the creek bed and indicated the presence of an approx. 1.0 m thick overburden followed by shale bedrock in B.H. #2 and shale bedrock from the surface in B.H. #1.

The boundaries of the different strata together with the obtained field test results are shown on the Record of Borehole Sheets contained in the Appendix of this Report. A stratigraphical section shown on Drawing No. 478202-A is based upon this information. A description of the different strata encountered is given below.

Overburden

This zone was encountered in Borehole #2, from ground level (El. 103.7) to El. 102.7. The material in the deposit is a mixture of silty clay and weathered shale fragments.

The consistency may be classified as very stiff.

Bedrock

The bedrock was encountered either at creek bed level or below the above described overburden at the following levels:

B.H. #1	El. 103.6
B.H. #2	El. 102.7

The bedrock is shale of the Queenston Formation. The colour of the shale is predominantly red with green siltstone bands. The upper portion of the shale is weathered to varying degrees and becomes more sound with depth. It was easily penetrated with conventional augering methods to El. 102.1 (B.H. #1) and to El. 101.0 (B.H. #2). For details, references should be made to the 'description of rock core' sheet appended to this report. The core description was carried out by Mr. E.R. Magni, M.T.C. Geologist.

Groundwater Conditions

In both borings water was observed at ground level. It is our assessment that this water was left in the borings due to the drilling operations and/or entered through cracks from the adjacent creek. The water level in the creek is believed to fluctuate due to the amount of rainfall and spring run-off process.

In view of these facts and the relatively unprevious nature of the rock mass the true level of groundwater could not be established with certainty. For all practical (design and construction) purposes, it can be assumed that the groundwater level is the same as the prevailing water level in the creek at a particular time period.

No artesian conditions were encountered.

Discussion and Recommendations

General

It is proposed to convert the existing overpass (at Q.E.W. and Third Line Road Interchange) to a new interm interchange by building a new service road and utilizing the existing service roads as ramps. The Q.E.W., the North and South Service Roads are carried over the Fourteen Mile Creek on the existing 10 m span concrete arch culvert. Due to the proposed relocation of the North Service Road, an 18 m⁺ extension on the north side of this arch will be required.

Structure Foundation

In view of the encountered subsurface conditions, it is recommended that the footings of the widened portion of the existing concrete arch be founded within the sound portion of the shale bedrock - i.e.,:

West Footing: El. 100.9
East Footing: El. 101.3

The allowable bearing pressure should not exceed 1000 kPa.

For the purposes of the O.H.B.D.C. the following values are recommended:

Factored Bearing Capacity at U.L.S.: 1500 kPa

Bearing Capacity at S.L.S. Type II: Will not govern design since the loads required to produce detrimental settlement of the structure will be much larger than the recommended values for Factored Bearing Capacity at U.L.S.

For granular backfill the following values are recommended:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction:	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight:	$\gamma = 22.8 \text{ KN/m}^3$	$\gamma = 21.2 \text{ KN/m}^3$

Earth pressures should be computed (assuming non-yielding foundation and 'at rest' condition) as per subsection 6.6.1.2.2 of the code.

The horizontal thrust on the arch footing can be resisted by friction along the footing base and by the passive resistance of the rock against the vertical side of a 'key' constructed below the footing base. It is recommended that a coefficient of friction equal to $\tan 25^\circ$ be assumed for computing resistance to sliding along the footing base. The minimum depth of the 'key' is 0.5 m into the sound shale bedrock. Provided that the concrete is placed against the 'undisturbed' rock face the 'key' should provide a resisting pressure of 1.0 MPa against lateral forces. The excavation within the bedrock for the footing should be carried out by techniques other than blasting. The exposed rock surface at the footing level should be covered with a 15 cm thick mass concrete pad within 8 hours of exposure.

Other Considerations

The minimum frost protection requirements in this area is about 1.2 m of cover.

The backfill operations should be carried out simultaneously on both sides of the widened portion of the arch type culvert. Compaction of backfill should adhere to Ministry Directive B-131. ('Restriction on use of heavy vibratory equipment behind earth retaining structure.' Date: 81 11 24).

The concrete of the footing should be placed 'in the dry'. Therefore, waterflow from the adjacent creek into the footing excavation should be prevented. Erosion protection should be provided as per hydrology requirements.

A construction joint should be provided between the old and new segments of the concrete arch culvert.

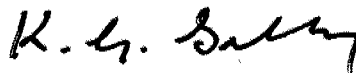
No stability problems are anticipated for approach embankments constructed with 2:1 slopes.

Miscellaneous

The fieldwork for this project was supervised by Mr. T. Miller, Student Engineer. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by Mr. P. Payer and reviewed by Mr. K.G. Selby.



P. Payer, P. Eng.
Foundations Engineer



K.G. Selby, P. Eng.
Chief Foundations Engineer
(West)

APPENDIX

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	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						

DESCRIPTION OF ROCK CORE - W.P. 47-82-02

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (M)	% CR*	% RQD*	DEPTH (M)	DESCRIPTION
1	1.53 - 3.05 - 4.58	83.3 88.3	35.0 81.7	1.53 - 2.14	Shale, Queenston, red, slightly to moderately weathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, very closely spaced joints
				2.14 - 4.58	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, widely spaced joints
2	2.75 - 4.27 - 5.80	80.0 86.6	80.0 86.6	2.75 - 5.80	Shale, Queenston, red, unweathered, occasional (5%) green siltstone bands about 25 - 100 mm wide, very widely spaced joints

* CR = CORE RECOVERY; RQD = ROCK QUALITY DESIGNATION

RECORD OF BOREHOLE No 1

METRIC

W P 47-82-02 LOCATION Co-ords. N 4 808 974.4; E 286 327.2 ORIGINATED BY TM
DIST 4 HWY Q.E.W. BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring COMPILED BY JC
DATUM Geodetic DATE 84 08 29 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					
103.6	Ground Level		1	SS	46											
0.0	Extensively Weathered		2	SS	82/	28 cm										
	Shale Moderately Weathered		3	RC BXL	REC 84%											
	Unweathered Bedrock		4	RC BXL	REC 88%											
99.0																
4.6	End of Borehole															

RECORD OF BOREHOLE No 2

METRIC

W P 47-82-02 LOCATION Co-ords. N 4 808 973.8; E 286 319.4 ORIGINATED BY TM
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Cont. Flight Auger & BXL Rock Coring COMPILED BY JC
 DATUM Geodetic DATE 84 08 30 CHECKED BY [Signature]

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									
103.7	Ground Level																
0.0	Mixture of Silty Clay		1	SS	16	20 cm											
102.7	and Weathered Shale		2	SS	103												
1.0	Extensively to Moderately Weathered Shale																
	Unweathered Shale		3	RC BXL	REC 82%												
	Bedrock		4	RC BXL	REC 88%												
97.9							98										
5.8	End of Borehole																

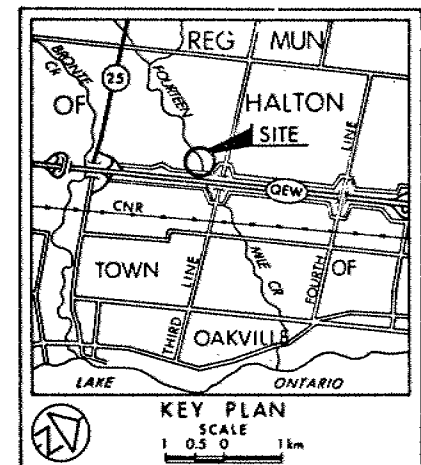
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 47-82-02

NW SERVICE ROAD
(FOURTEEN MILE CREEK)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1984 08

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	103.6	4 808 974.4	286 327.2
2	103.7	4 808 973.8	286 319.4

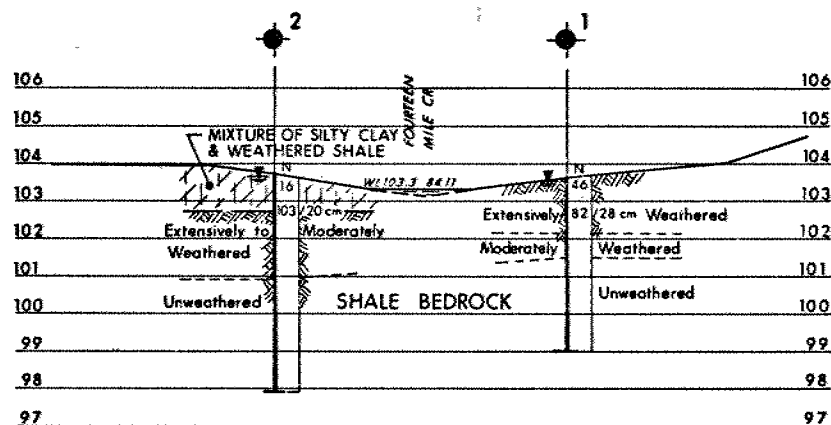
NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

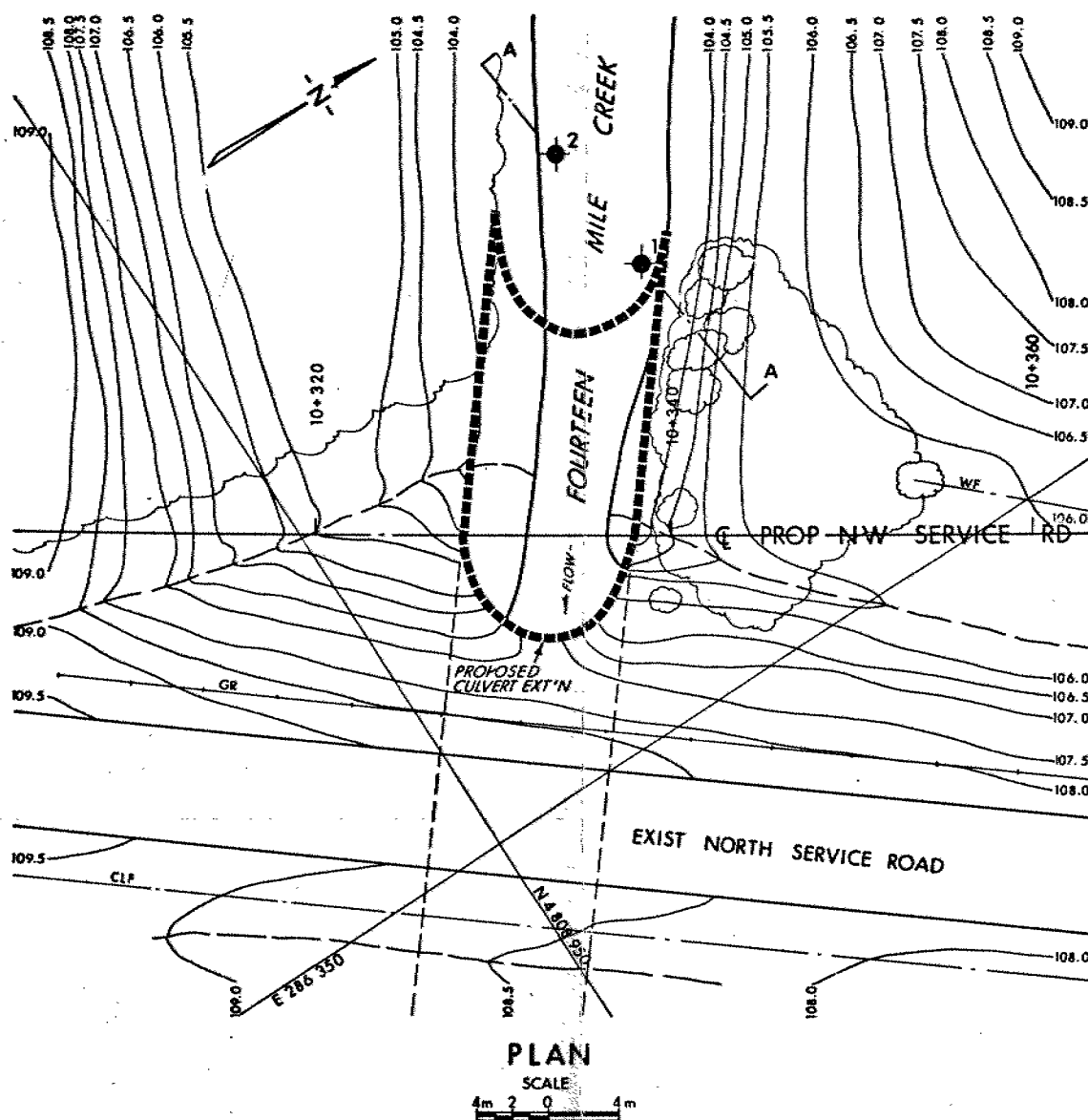
REV.	DATE	BY	DESCRIPTION
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Geocres No 30M5-147
HWY No QEW & THIRD LINE DIST 4
SUBMD PP CHECKED DATE 84 11 19 SITE
DRAWN SO CHECKED APPROVER DWG 478202-A



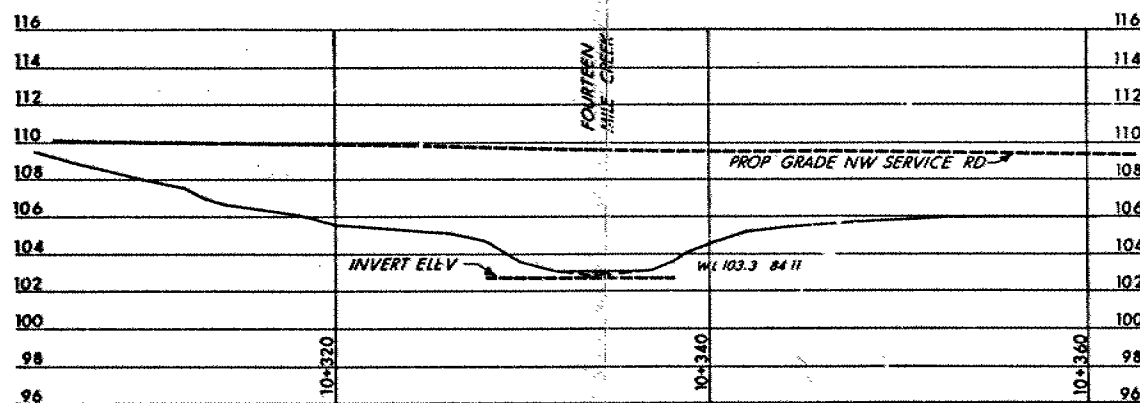
SECTION A-A

SCALE
2m 1 0 2m



PLAN

SCALE
4m 2 0 4m



PROFILE NW SERVICE RD

SCALE
4m 2 0 4m