

G.I.-30 SEPT. 1976

GEOCRES No. 31L-57DIST. 13 REGION W.P. No. 645-92-01CONT. No. 95-214W. O. No. STR. SITE No. 44-40HWY. No. 11LOCATION Mc Gilloray Creek
CulvertNo of PAGES - =====
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

METRIC
DIMENSIONS ARE IN METRES
AND / OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DISTRICT 13 NORTH BAY
CONT No
WP No 645-92-01



McGILLVRAY CREEK CULVERT
PROPOSED HWY. 11 N.B.L.
GENERAL ARRANGEMENT

SHEET
91

northland
engineering
limited
Consulting Engineers and Planners

GENERAL NOTES

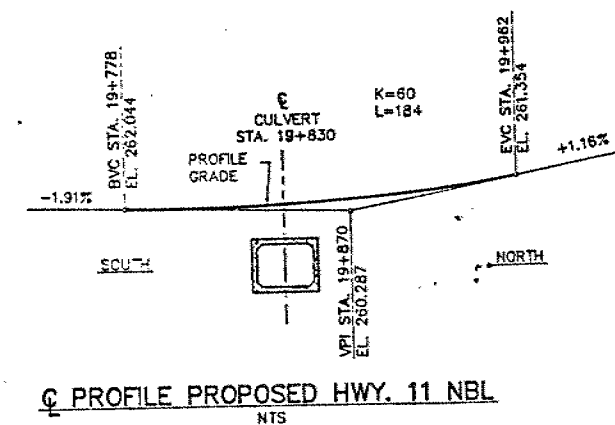
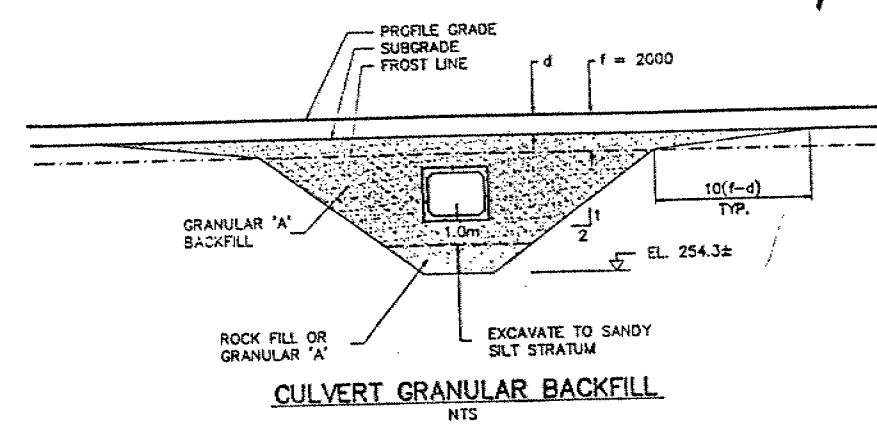
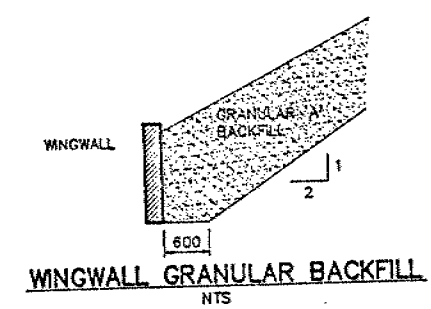
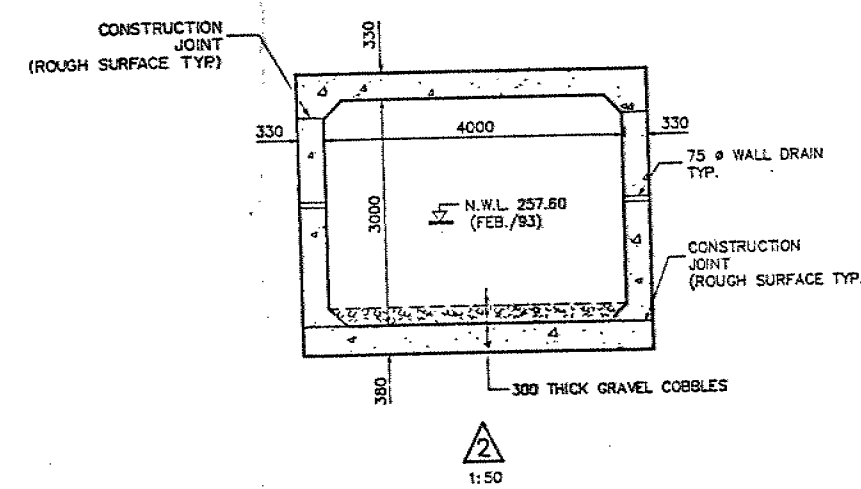
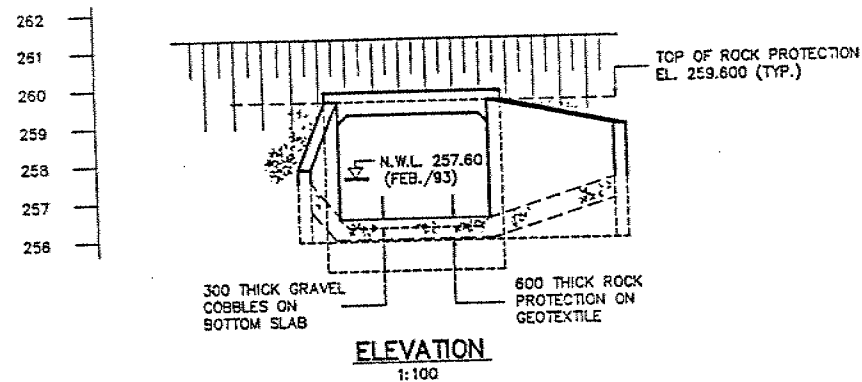
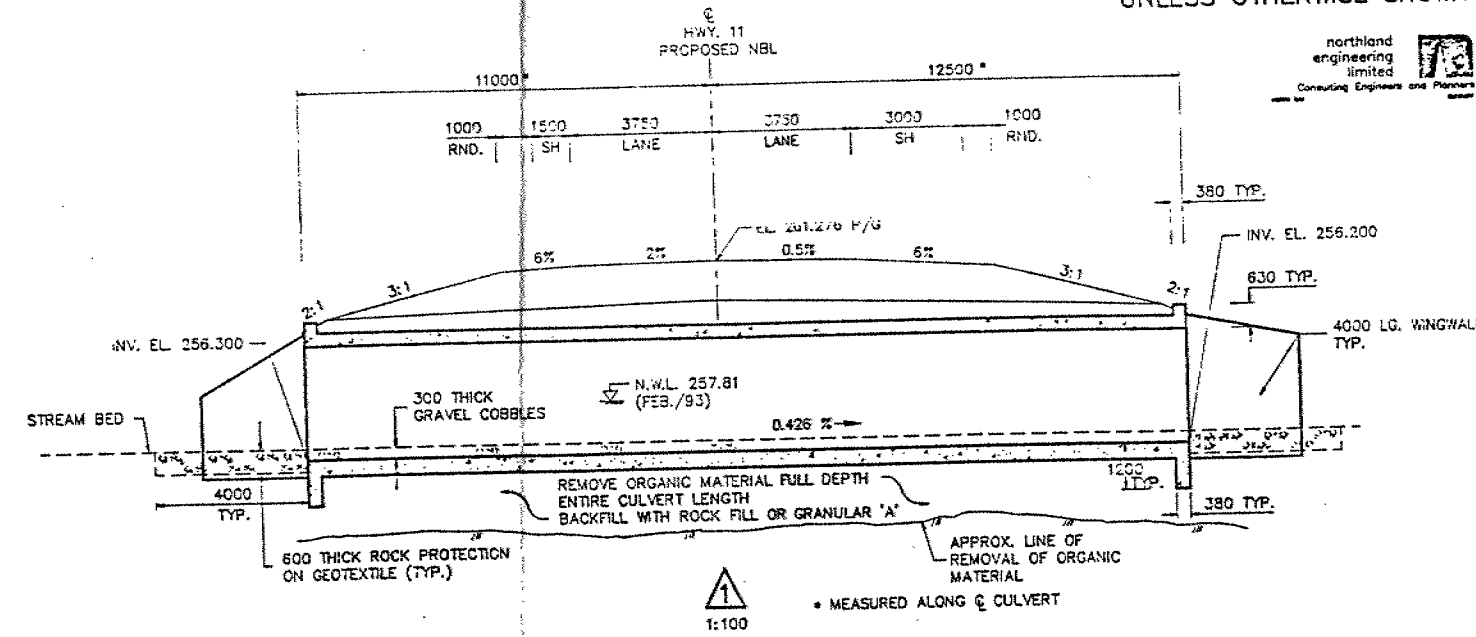
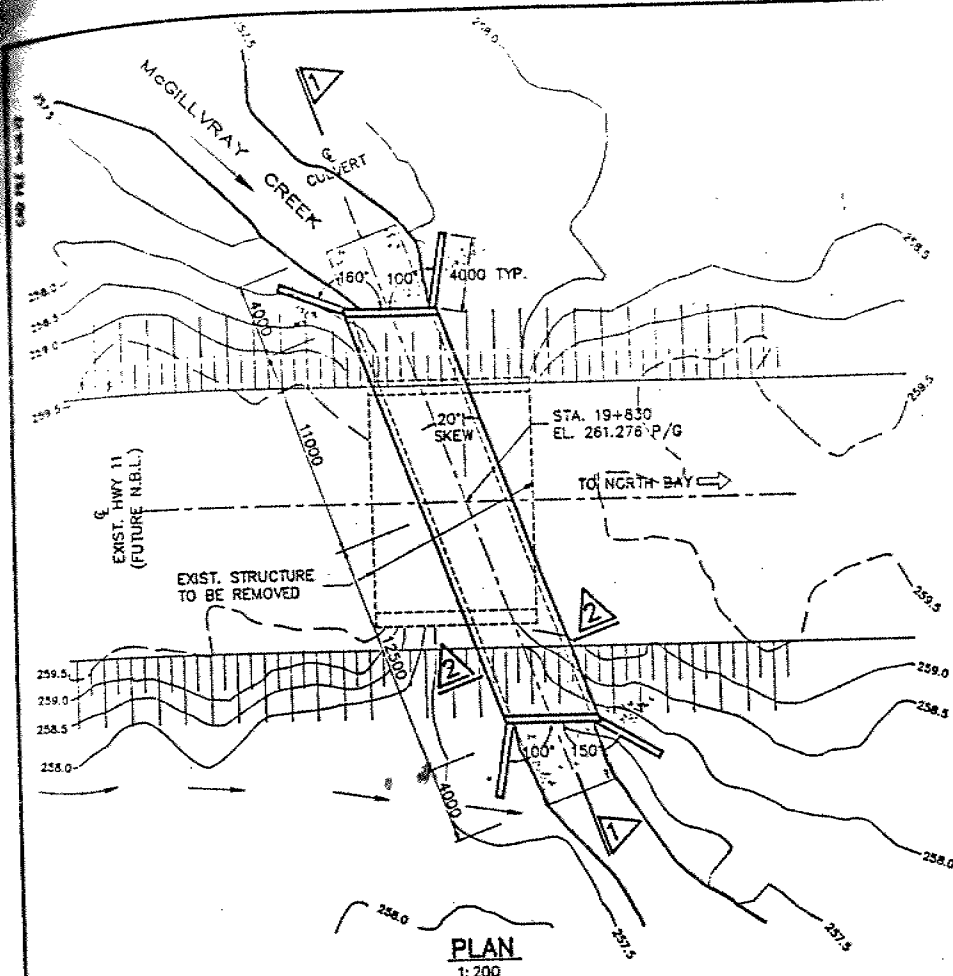
1. CLASS OF CONCRETE TO BE 30MPa.
2. CLEAR COVER TO REINFORCING STEEL
BOTTOM OF TOP SLAB 50 ± 10
BOTTOM OF BOTTOM SLAB 100 ± 25
REMAINDER 70 ± 20
3. UNLESS OTHERWISE NOTED
REINFORCING STEEL SHALL BE GRADE 400 UNLESS
OTHERWISE SPECIFIED. BARS MARKED WITH SUFFIX C
DENOTE COATED BARS.
4. MAX. SIZE OF GRAVEL COBBLES
TO BE 150 mm

LEGEND

ALT DENOTES ALTERNATE
IF DENOTES INSIDE FACE
OF DENOTES OUTSIDE FACE
EF DENOTES EACH FACE

CONSTRUCTION NOTES

1. NO CONCRETE SHALL BE PLACED UNTIL THE DEPTH OF
THE EXCAVATION AND THE CHARACTER OF THE FOUNDATION
HAVE BEEN APPROVED BY THE ENGINEER.
2. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND
BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE
BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL
THE DIFFERENCE IN ELEVATION BE GREATER THAN
500mm.
3. SITE No. AND DATE FIGURES SUPPLIED BY MTO

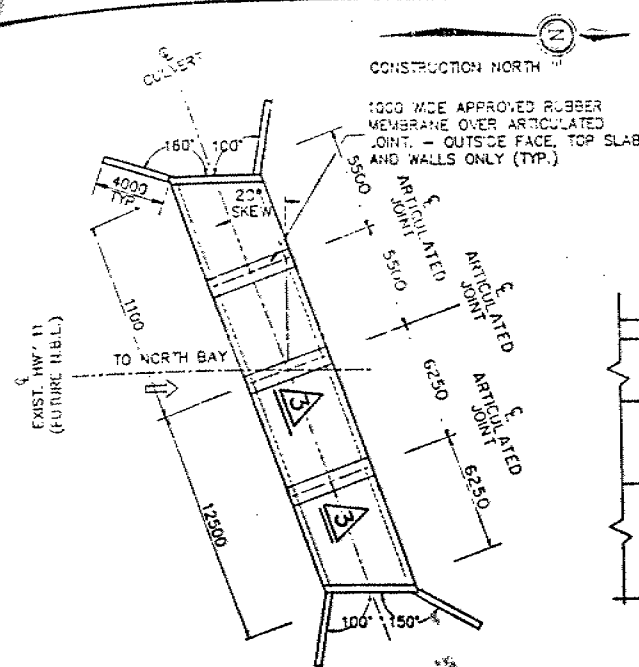


- #### LIST OF DRAWINGS
1. GENERAL ARRANGEMENT
 2. CULVERT DETAILS
 3. WINGWALL DETAILS
 4. STANDARD DETAILS

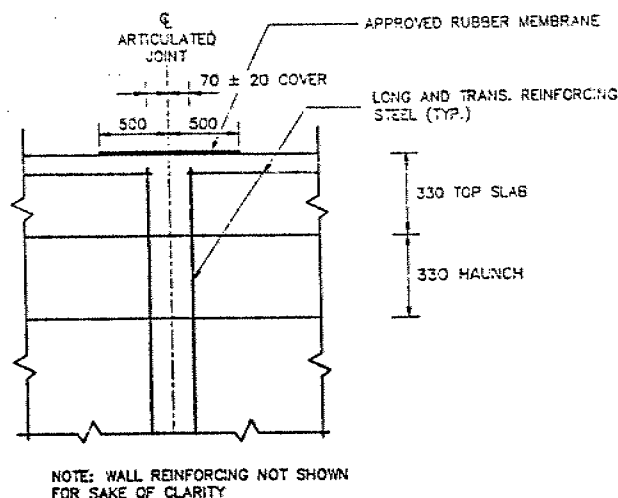
B.M. EL. 258.475
TOP OF 'T' BAR
STA. 19+788.3 LINE 'A'
87.9 RT.

REVISIONS	DATE	BY	DESCRIPTION

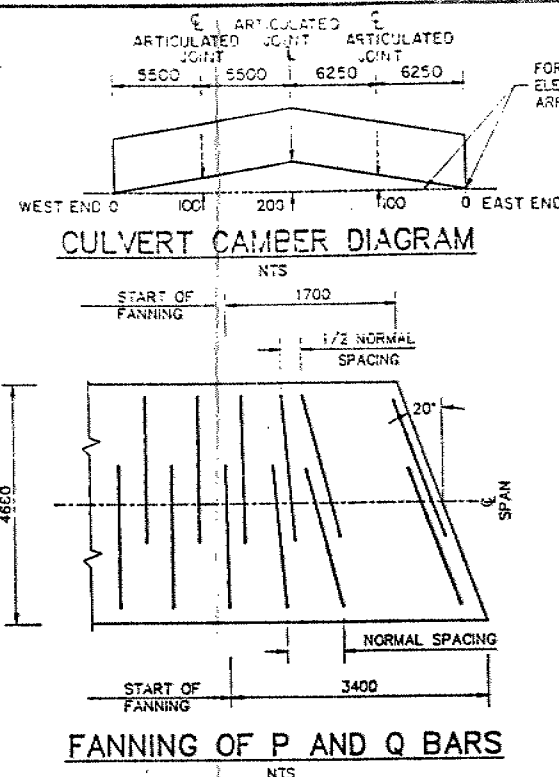
DESIGN S.M. CHK S.K.P. CODE OHBGC 1991 1 LOAD DATE FEB/94
DRAWN D.A.M. CHK S.K.P. SITE 44-40 1 INSTRUCT SCHEME 1 DWG 1



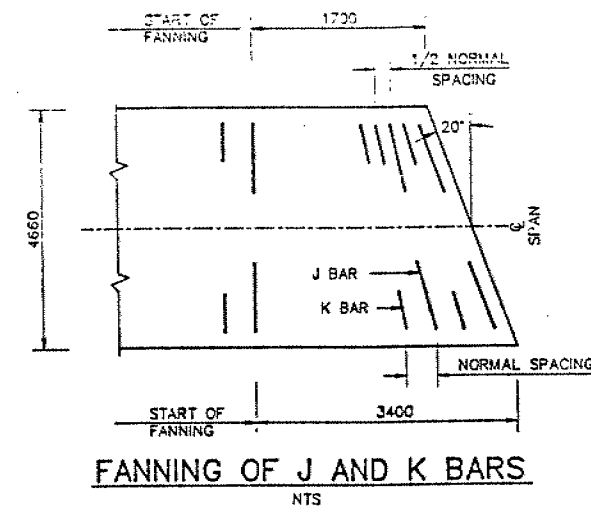
KEY PLAN
1:200



NOTE: WALL REINFORCING NOT SHOWN FOR SAKE OF CLARITY



FANNING OF P AND Q BARS
NTS



FANNING OF J AND K BARS
NTS

METRIC
DIMENSIONS ARE IN METRES
AND / OR MILLIMETRES
UNLESS OTHERWISE SHOWN

northland
engineering
limited
Consulting Engineers and Planners

CONT No
WP No 645-92-01

McGILLVRAVY CREEK CULVERT
PROPOSED HWY 11 N.B.L.
CULVERT DETAILS

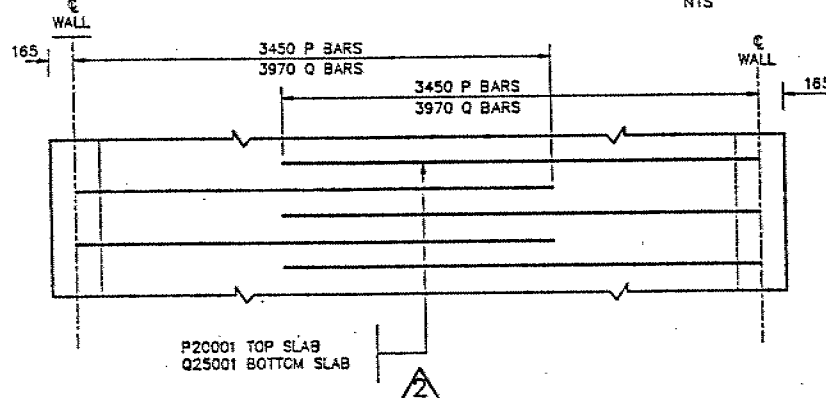
SHEET
92

GENERAL NOTES

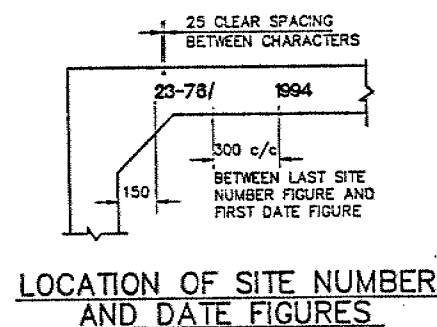
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BOTTOM OF BOTTOM SLAB 100 ± 25
REMAINDER 70 ± 20 UNLESS OTHERWISE NOTED
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- LONGITUDINAL REINFORCING STEEL SHALL BE DISCONTINUED AT ARTICULATED JOINTS.
- LEGEND
ALT DENOTES ALTERNATE
IF DENOTES INSIDE FACE
OF DENOTES OUTSIDE FACE
EF DENOTES EACH FACE

CONSTRUCTION NOTES

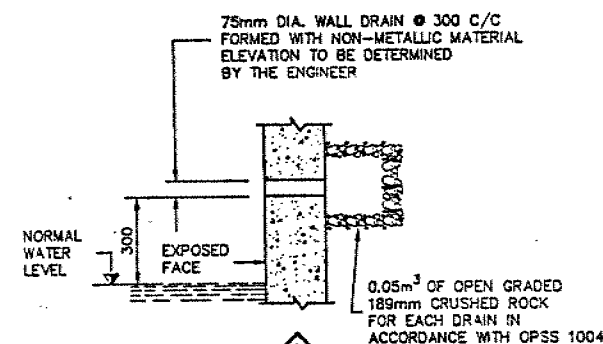
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- NO CONCRETE SHALL BE PLACED UNTIL THE DEPTH OF THE EXCAVATION AND THE CHARACTER OF THE FOUNDATION HAVE BEEN APPROVED BY THE ENGINEER.
- SITE No. AND DATE FIGURES SUPPLIED BY MTO



P20001 TOP SLAB
Q25001 BOTTOM SLAB



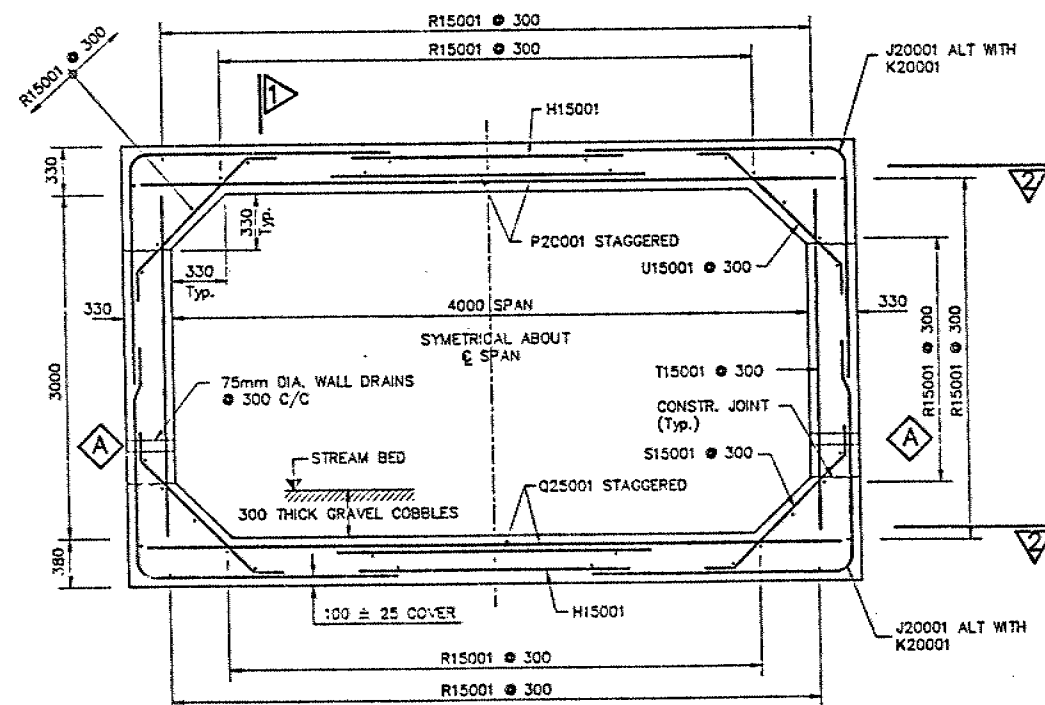
LOCATION OF SITE NUMBER
AND DATE FIGURES



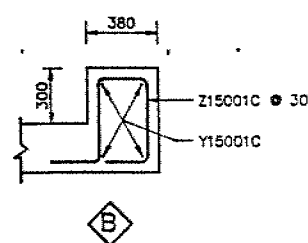
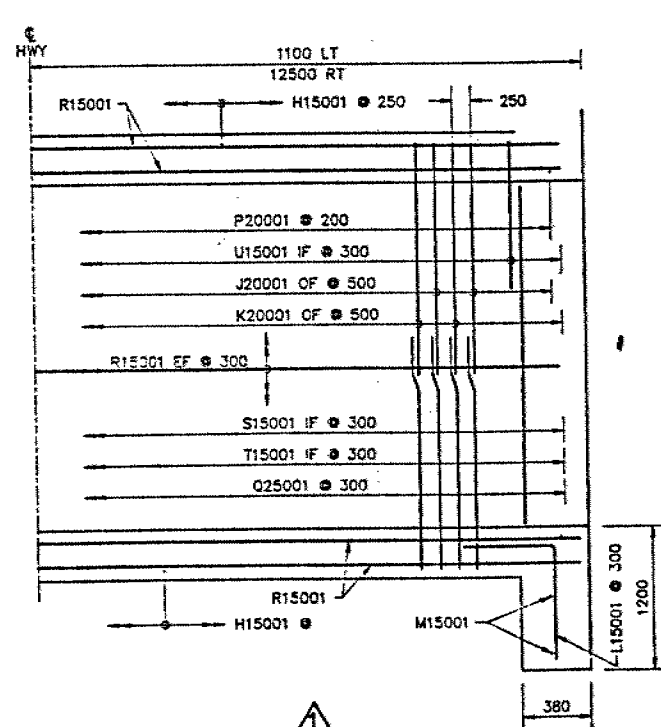
NORMAL WATER LEVEL

EXPOSED FACE

0.05m³ OF OPEN GRADED 189mm CRUSHED ROCK FOR EACH DRAIN IN ACCORDANCE WITH OPSS 1004



TYPICAL CULVERT SECTION



MARK	No. REQ'D	C/C	LENGTH	DETAILS	REMARKS
H15001	202	250	2510	STRAIGHT	TOP OF TOP SLAB BOTTOM OF BOTTOM SLAB
J20001	202	500	3680		J-BARS ALTERNATE WITH K-BARS
K20001	202	500	3360		K-BARS ALTERNATE WITH J-BARS
P20001**	126	200	3450	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
Q25001**	84	300	3970	STRAIGHT	TOP OF BOTTOM SLAB STAGGERED
R15001	600	300	4100	STRAIGHT 100 SETS @ 6 PER SET	LONGITUDINAL DISCONTINUOUS AT ARTICULATED JOINTS
S15001	168	300	1450		HAUNCH
T15001	168	300	3000	STRAIGHT	INSIDE FACE OF WALLS
U15001	168	300	1420		HAUNCH
L15001	34	300	1580		DOWELS TO APRON WALLS
W15001	4	450	4820	STRAIGHT	APRON WALL
Y15001C	8	SEE (S)	4820	STRAIGHT	HEADER WALL
Z15001C	34	300	1625		HEADER WALL

NOTES: - ALL DIMENSIONS SHOWN TO CENTRE LINE OF BAR
--REPRESENTS VERTICAL DIMENSION
---C/C SPACING GIVEN AT MIDSPAN

QUANTITIES				
ITEM	WALLS	SLABS	WINGWALLS	TOTAL
MASS OF REINFORCING STEEL	uncoated	12.0	2.9	14.9
tonnes	coated	0.2	0.14	0.3
VOLUME OF CONCRETE		149.4	22.9	172.3
cubic metres				

STANDARD DRAWING
JUNE 1993
SS114-2
RIGID FRAME BOX CULVERT

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	S.H.	CHK	S.K.P. CODE QHBC 1991
DRAWN	D.A.H.	CHK	S.K.P. SITE 44-40
			15TRUCT
			15SCHEME
			15DWG 2

FILE COPY



Ministry
of
Transportation

Ontario

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 95-214

WP 645-92-01 DIST 13

HWY 11 STR SITE 44-40

McGillvray Creek Culvert
Proposed Northbound Lanes

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FOUNDATION INVESTIGATION REPORT
for
McGillvray Creek Culvert
Proposed Northbound Lanes, Highway 11
W.P.645-92-01, Site No.44-40
District 13, North Bay

INTRODUCTION

This report summarizes the information obtained from the foundation investigation carried out at the above noted site. The investigation was carried out at the request of the Northern Region Structural Section to design a culvert required to replace the existing crossing at this location. The field work, carried out between 93 02 04 and 93 02 09, consisted of two (2) sampled boreholes and two (2) dynamic cone penetration tests. BH 1 was located on the west side of Highway 11 and BH 2 was placed on the east side.

SITE DESCRIPTION

The site is located at the southmost crossing of McGillvray Creek on Highway 11, approximately 4 km south of the intersection of Highway 534 in the Township of South Himsworth, District of Parry Sound. The immediate vicinity is moderately rolling with swampy areas near the creek bed. According to the Northern Ontario Engineering Geology Terrain Study published by the Ministry of Natural Resources, the site is located on the edge of a Sandy Glaciolacustrine Plain.

The existing structure is a rigid frame concrete bridge with short wingwalls. Existing grade is to be raised by about 1 m for the new Highway 11 profile. The existing structure is in poor conditions and is considered incapable of accommodating the proposed grade change. Existing embankment gradient is 3H:1V or flatter. Cracks and patches can be found on the existing pavement at the location of the crossing.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in-situ and laboratory testing. The procedures employed are discussed below.

Field

The field work for the investigation, carried out between 93 02 04 and 93 02 09, consisted of two (2) sampled boreholes and two (2) dynamic cone penetration tests. The boreholes were advanced to refusal at depths of 10.4m on the west side and 12.2 m on the east.

The boreholes were advanced using conventional hollow stem augering techniques with two track mounted continuous flight auger machines. The sampling program consisted of split spoon and shelby tube samples collected in the overburden. Disturbed subsoil samples were retrieved by split spoon sampler in accordance with Standard Penetration Test (ASTM D1586). Standard Penetration ('N') values were recorded for assessment of the denseness of the materials encountered. Relatively undisturbed samples were randomly retrieved in the cohesive stratum using thin walled shelby tube samplers in accordance with Standard Practice (ASTM D1587). All subsoil samples were identified in the field and returned to the laboratory for further examination and appropriate testing.

Dynamic Cone Penetration tests were carried out at the location of each borehole. In situ vane shear tests were also carried out in the cohesive strata to determine the undisturbed and remoulded undrained shear strengths of these soils. The test was conducted employing the standard MTO 'N' vane.

Groundwater level was monitored in open boreholes throughout the investigation. The water level in the creek during the time of the investigation was also measured. All boreholes were backfilled upon completion of the field work.

Surveying required to ascertain borehole locations and elevations was carried out by the Northern Region Surveys and Plans Section.

Laboratory

The laboratory testing on selected soil samples consisted of the following:

- Atterberg Limit Test
- Unit Weight Determination
- Grain Size Distribution
- Natural Moisture Content Determination
- Unconfined Compressive Test

Laboratory results are given in the following section of this

report and are illustrated on figures and Record of Borehole sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes are shown in Dwg. No. 6459201-A.

The four soil strata that were encountered before refusal in each of the boreholes are silt with clayey and sandy layers, silty clay, sandy silt, and non-cohesive glacial till.

Following are the specific descriptions of the materials encountered in the investigation :

Silt

Silt material was encountered at the surface in both boreholes. In BH 1 the material was sandy near the surface but becoming clayey towards the bottom of the layer at a depth of 2.1 m. The material was found to be more organic in nature at BH 2 and extended only to 1.2 m. The Standard Penetration 'N' values recorded for the three split spoon samples taken in this material were all 3 blows/0.3 m indicating a very loose denseness.

Laboratory testing was carried out on a representative sample and the results are 44% moisture content and a grain size distribution of 0% gravel, 21% sand and 79% silt and clay.

Silty Clay with Organics, Trace Sand

This cohesive stratum was encountered from 2.1 to 3.5 m in BH 1 and from 1.2 to 4.3 m in BH 2. The material is typically described as silty clay with organics, trace sand.

The Standard Penetration Resistance 'N' values were 4 and 5 blows/0.3 m. Field vane shear tests conducted at 2.0 m and 2.7 m in BH 2 give undrained shear strengths of 50 kPa and 28 kPa respectively with associated sensitivities of 6 and 5. Undrained shear strength values obtained from unconfined compressive tests carried out in the laboratory are 14 and 25 kPa. The lower values

are probably due to sample disturbance.

Typical properties of the material, as determined by laboratory tests on representative samples are summarized as follows:

<u>Property</u>	<u>Range</u>	<u>No. of Test</u>
Natural Moisture Content (w)	27.0-46.5	3
Unit Weight (kN/m ³)	16.5-18.7	2
Liquid Limit (W _L)	31	1
Plastic Limit (W _p)	19	1
Grain Size Distribution (%)		1
Gravel	0	
Sand	5	
Silt and Clay	95	

Sandy Silt

This material was found in both boreholes below the silt and clay materials. It extends from a depth of 3.5 m to 7.3 m in BH 1 and from 4.3 m to 8.8 m in BH 2. Standard Penetration Resistance 'N' values were 2 and 6 blows/0.3 m in BH 1 indicating a very loose to loose natural state. The 'N' values ranged from 14 to 23 blows/0.3 m in BH 2 indicating a compact natural state. In BH 2, the top of this layer contains occasional clayey silt zones and some organics.

Typical properties of this material, as determined by laboratory tests on representative samples may be summarized as follows:

<u>Property</u>	<u>Range</u>	<u>No. of Test</u>
Natural Moisture Content (w)	17.0-25.0	2
Grain Size Distribution (%)		2
Gravel	0-19	
Sand	29-36	
Silt & Clay	52-64	

Groundwater

Observations of the groundwater level were carried out by measuring the water level in open boreholes.

Groundwater level determined at the time of the investigation was at El. 257.8 m in BH 1 and El. 256.9 m in BH 2. Water level in the creek was at EL. 257.6 m in the vicinity of BH 1. Groundwater level, however, are subject to seasonal fluctuations and hence may vary from the elevations given in this report.

DISCUSSION AND RECOMMENDATIONS

General

The project involves replacement of the existing crossing on Highway 11 at McGillivray Creek by a 6 m X 3 m or 7 m X 3 m open footing rigid frame structure with wingwalls at both ends. Culvert length will be 9.5 m Lt. and 10.5 m Rt. measured on a skew. The proposed grade will result in a fill height over the new structure of about 1.5 m and approach fills of up to 5 m high.

Foundation

The proposed top of footing elevation will be 256.4 m. Assuming a footing thickness of about 0.4 m, the founding elevation is at about 256.0 m. According to the investigation results, the subsoils at or below the proposed footing founding elevation comprises a firm silty clay over loose to compact silty sand. Based on the past performance of the existing structure and the subsoil conditions, it is considered the site is not suitable for shallow foundation construction. Deep foundation construction is considered to be a more cost-effective solution.

It is understood that traffic will be diverted to the new SBL alignment prior to construction. Excavation will be carried out to remove the existing structure and foundation. It is recommended to excavate down to the silty clay stratum at about El. 255+ m within the structure envelope. This would eliminate the concern of downdrag forces on future piles. The excavation should be backfilled with granular material. The grain size of the fill should be less than 75 mm under the pile locations. The new structure can be supported by steel H-piles driven to bedrock with the following design capacities in accordance with the O.H.B.D.C.

	<u>HP 310 X 79</u>	<u>HP 310 X 110</u>
Factored Axial Capacity at U.L.S.	1150 kN	1600 kN
Axial Capacity at S.L.S. Type II	890 kN	1150 kN

For preliminary design purpose, the pile tip elevation can be assumed to vary from El. 247 m at the upstream (west) end to El. 245 m at the downstream (east) end.

Due to the existence of boulders and cobbles in the glacial till stratum, the piles should be equipped with standard MTO tip

reinforcement as per OPSD 3301.00 to minimize damage.

Alternatively, pressure treated timber piles may be used. Size 36 timber piles driven to bedrock may be designed for a capacity of 250 kN.

Wingwalls may also be supported by piles. Alternatively, considerations may be given to designing them as flexible reinforced earth type wall construction. If this option is chosen, our office should be contacted for details.

Frost Protection

Frost protection for pile caps should be 2.0 m of earth cover or equivalent insulation.

Earth Pressure

Backfill to culvert walls should consist of granular material in accordance with MTO Standard Special Provision No. 121 (83 10).

Computation of earth pressures should be in accordance with Section 6-6.1.2.1 of the O.H.B.D.C. The at-rest condition will govern earth pressure design for unyielding condition. For design purposes, the following properties for backfill are recommended:

<u>Material</u>	<u>ϕ</u>	<u>γ</u>	<u>k_0</u>
Granular "A"	35°	22.8 kN/m ³	0.43
Granular "B"	30°	21.2 kN/m ³	0.50

Embankment Slopes

Approach embankment slopes may be safely constructed at a gradient of 2H:1V or flatter up to a maximum height of 5.0 m. Surficial organic material should be removed prior to filling. Only free draining granular material should be used below the water level.

Construction Considerations

To remove the existing structure and the foundation, temporary excavation up to 5 m from the road surface in the longitudinal direction may be required. Cut slopes should be formed to 2H:1V

gradient or flatter.

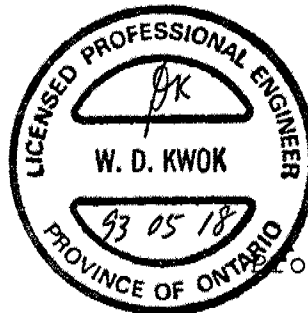
The existing slope face should be benched to receive new fill. Excavation for the construction of pile caps will require temporary creek diversion and dewatering. An oversized excavation is recommended which can allow sump pumping from perimeter ditches to maintain the ground water below the pile cap bottom.

Culvert inlet and outlet treatments should comply with MTO Standards.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer, B. Liegler, Engineering Trainee and L. Sheppard, Pavement Design and Evaluation Officer, using the equipment owned and operated by Dominion Soil Investigation Inc.

The project was carried out by D. Kwok under the general supervision of B. Iyer, Senior Foundation Engineer. The report was co-written by D. Kwok and L. Sheppard, reviewed by B. Iyer, and approved by M. Devata, Chief Foundation Engineer.



D. Kwok, P. Eng.
Project Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

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

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	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

1 OF 1

METRIC

W.P. 645-92-01 LOCATION Co-ords : N5 100 776.6 ; E 316 920.6 ORIGINATED BY BL
 DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY LS
 DATUM Geodetic DATE 93 02 04 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa	UNCONFINED	FIELD VANE	W _p	W	W _L		
257.8	Ground Surface															
0.0	Silt Very Loose		1	SS	3		257									
255.7	Sandy Trace Organics Dark Grey		2	SS	3		256									
2.1	Clayey Some Organics Brown to Grey		3	SS	5		255									
254.3	Silty Clay with Organics Trace Sand Occasional Sand Seams & Woodchips Brown to Grey Firm		4	TW	PH		254									
3.5	Sandy Silt Trace Clay Pink and Brown Very Loose to Loose		5	SS	2		253									
250.5			6	SS	6		252									
7.3	Heterogeneous Mixture of Silt Sand and Gravel Occasional Cobbles and Boulders (Glacial Till) Grey, Compact		7	SS	22		251									
247.4			8	SS	11		250									
10.4	End of Borehole Auger Refusal Probable Bedrock						249									
	* Water level at ground surface on 93 02 05						248									

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 845-92-01 LOCATION Co-ords: N5 100 808.0; E 316 938.5 ORIGINATED BY DK/LS
 DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY LS
 DATUM Geodetic DATE 93 02 08 - 93 02 09 CHECKED BY BJ

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			20	40						60	80	100
								SHEAR STRENGTH kPa							WATER CONTENT (%)		

258.1	Ground Surface													
0.0	Silt with Organics Some Sand and Clay Dark Brown, Very Loose		1	AS	-									
256.9			2	SS	3									0 21 66 13
1.2	Silty Clay with Organics, Trace Sand Brown to Grey Firm		3	SS	4									0 5 74 21
255.2			4	TW	PH								18.7	
2.9	Occasional Clayey Silt Zones Some Tree Roots and Organics		5	SS	14									
	Sandy Silt Some Gravel Pink and Brown, Compact		6	SS	23									19 29 44 8
			7	SS	22									
249.3			8	SS	102 /21cm									
8.8	Heterogeneous Mixture of Silt, Sand and Gravel Occasional Cobbles and Boulders (Glacial Till) Pink and Brown Very Dense													
245.9														
12.2	End of Borehole Auger Refusal Probable Bedrock • 93 02 09													

High blowcount due to frozen ground

w=44

+6

+5

120/28cm

