FOUNDATION INVESTIGATION AND DESIGN REPORT
SNOWMOBILE CROSSING NORTH OF BOUNDARY ROAD
STATION 10+800 MACHAR TOWNSHIP
HIGHWAY 11, BURK'S FALLS TO SOUTH RIVER
G.W.P. 759-93-00

Geocres Number: 31E-247

Report to

Marshall Macklin Monaghan

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed snowmobile crossing under the proposed four-lane Highway 11 south of the village of South River, Ontario. The crossing will be located at Station 10+800 Machar Township.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile, and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and backfill for the structure.

Thurber carried out the investigation as a sub-consultant to Marshall Macklin Monaghan, under the Ministry of Transportation Ontario (MTO) Agreement Number 5005-A-000188.

2 SITE DESCRIPTION

The site is located approximately 2.0 km west of existing Highway 11 and approximately 2.5 km south of the Village of South River, in Machar Township immediately north of the boundary with Strong Township.

The general site area is located within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock typically occurring as rounded knobs and ridges where exposed. Locally however, the site lies in an area infilled with relatively deep deposits of glacio-fluvial sands, overlying the bedrock. The immediate area of the site is heavily wooded.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out on November 23 and 24, 2005, and consisted of three boreholes drilled along the proposed snowmobile crossing alignment. One borehole was drilled at each end of the crossing and one borehole was drilled at the centreline of proposed Highway 11. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C.

The sampled boreholes were terminated at depths of 12.8 to 15.7 m, and were supplemented by dynamic cone penetration testing (DCPT) conducted to depths of 12.2 to 13.7 m.

Prior to the start of drilling, the borehole locations were staked in the field and utility clearances were obtained. The coordinates and elevations of the boreholes are given on the Borehole Locations and Soil Strata Drawing in Appendix C and on the individual Record of Borehole Sheets in Appendix A.

Hollow stem augers were used to advance the boreholes. Samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

A standpipe piezometer, consisting of 19 mm PVC pipe with slotted tip, was installed in the centre borehole to monitor the groundwater level. The completion details for the piezometer are shown in Table 3.1.

Table 3.1 – Piezometer Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation	Completion Details
BH SCN-2	15.2/348.6	Piezometer with 1.5 m tip installed at bottom of borehole. Sand filter to 13.4, bentonite seal to 12.8, grout to the surface.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The inspector logged the boreholes, secured the recovered samples in labelled containers, and transported the samples to Thurber's laboratory.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer) and the results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B. A total of 10 samples were selected for this testing

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A stratigraphic profile is presented on the Borehole Locations and Soil Strata Drawing, Appendix C, for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the borehole logs governs any interpretation of the site conditions.

The soil stratigraphy encountered at this site generally consists of a surficial topsoil layer and local peat deposit overlying deep deposits of cohesionless silts and fine sands. More detailed descriptions of the individual strata are presented below.

5.2 Topsoil and Peat

Topsoil was identified surficially in all boreholes. The topsoil thickness was established only at the borehole locations and was generally 50 to 75 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

A deposit of silty fibrous peat was encountered in the borehole drilled at the east end of the proposed crossing (borehole SCN-3). The peat extended to a depth of 0.8 m. A moisture content of 533% was determined in this material.

5.3 Silt to Fine Sand

The site is underlain by a thick deposit of cohesionless silt to fine sand extending to the borehole termination depths of 12.8 to 15.7 m (elevation 347.3 to 352.5 m). This deposit typically graded from silty sand to sandy silt. However, silt with some sand was encountered between 6.1 and 7.6 m depth at one location (borehole SCN-3), and fine sand with some silt was encountered below depths of 9.1 and 7.6 m (elevation 356.2 and 355.4 m) at the west and east ends of the crossing. The results of grain size distribution analyses conducted on the soils are presented in Appendix B.

SPT N-values obtained in the silt/sand ranged from 9 to 51 blows/0.3 m penetration, indicating a generally compact to dense condition. An N-value of 3 blows/0.3 m was obtained at 6.4 m depth in borehole SCN-1, but this may reflect hydraulic disturbance and was not confirmed by DCPT testing. A loose condition was indicated by DCPT testing in borehole SCN-3, in variance with a compact condition indicated by SPT N-values of 13 blows/0.3 m obtained at this level.

Moisture contents in the sand (below the observed water level) were typically near 21%, ranging from 18 to 28%. A moisture content of 9% was obtained in one sample from above the groundwater level.

5.4 Water Levels

The initial and final groundwater depths and elevations are shown in Table 5.1.

Table 5.1 – Groundwater Depths and Elevations

Location	Borehole	Date	Water Level (m)	
			Depth	Elevation
West End of Crossing	SCN-1	23-Nov-05 (upon completion)	2.1	363.2
Centre of Crossing	SCN-2	28-Nov-05 (in piezometer)	1.0	362.8
East End of Crossing	SCN-3	23-Nov-05 (upon completion)	1.2	361.8

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Marshall Macklin Monaghan completed field layout of the boreholes for the site investigation and provided borehole coordinates and ground surface elevations.

All-Terrain Drilling Limited supplied and operated the drilling and sampling equipment used for the investigation. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. George Azzopardi of Thurber.

Interpretation of the field data and preparation of the investigation report was conducted by Mr. Murray Anderson, P.Eng. Overall supervision of the field program and review of the report was performed by Mr. Alastair E. Gorman, P.Eng. The report was also reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.
Murray R. Anderson, P.Eng., M.Eng.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
MAR 31/06
PROVINCE OF ONTARIO

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer

LICENSED PROFESSIONAL ENGINEER
PKChatterji
P. K. CHATTERJI
Mar 31/06
PROVINCE OF ONTARIO

P.K. Chatterji, P.Eng., Ph.D.
Review Principal.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for selection and design of the proposed snowmobile culvert.

The proposed snowmobile crossing will be constructed at Station 10+800, Township of Machar, under the new twinned Highway 11 immediately north of the Boundary Road interchange. The crossing will consist of a culvert that will be 94 m long, 4.0 m wide and 5.0 m high. The base of the culvert will be placed near elevation 363 m. The maximum embankment height at the culvert location will be approximately 7.5 m above existing grade, and 2.5 m above the top of the culvert.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigation.

8 STRUCTURE FOUNDATIONS

The subsurface stratigraphy revealed in the boreholes drilled at the culvert location consists of a surficial layer of topsoil/peat overlying cohesionless deposits of silt, sandy silt, silty sand and fine sand to the exploration depths of 12.8 to 15.7 m. The silts/sands are typically compact to dense. The observed water level is 1.0 to 2.1 m below the existing ground surface.

The proposed culvert base level of elevation 363 m is at existing grade (east) to 2.3 m below the existing ground surface (west) at the borehole locations. The soil at this level typically consists of compact silty sand to sandy silt, locally overlain by 0.7 m of peat at the east end of the culvert. It is recommended that all topsoil and peat be stripped. Where necessary, the subgrade should be raised to the founding level using engineered fill consisting of OPSS Granular A placed in 150 mm lifts and compacted to 100% of its SPMDD at ±2% of optimum moisture content.

The following geotechnical resistance is available for a 4.0 m wide culvert subjected to vertical concentric loading:

Factored Geotechnical Resistance at ULS = 350 kPa

Geotechnical Resistance at SLS = 150 kPa

Settlement of the culvert is expected to be controlled primarily by the settlement of the subgrade under the embankment loading. Embankment heights of approximately 7.5 and 5.5 m are planned for the northbound and southbound lanes, respectively. The estimated settlement along the culvert resulting from the embankment loading is provided in Table 8.1:

Table 8.1 – Estimated Settlement at Culvert

Highway 11	**Estimated Foundation Settlement (mm)**		
	Embankment Centreline	**Shoulder Rounding**	**Embankment Toe**
Northbound Lanes	70	60	15
Southbound Lanes	50	40	10

The predicted settlements are considered to be immediate in nature and should be essentially completed by the end of construction. The culvert design should include appropriate cambering and articulated joints, if necessary, to accommodate the differential settlement along the culvert. The culvert settlement could be reduced by constructing the embankment fill in advance of culvert installation, then excavating as necessary to construct the culvert. A delay of four weeks between the initial fill construction and excavation for culvert installation is considered adequate.

In general, surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the culvert area and embankment footprint prior to culvert installation.

The design depth of frost penetration at this site is 1.9 m.

According to the MTO Construction Manual, the susceptibility to frost action of the sandy silt to silty sand at the culvert base level is described as low, based on the gradation of these soils. At this level of susceptibility, it is considered that the weight of the culvert plus the overlying fill will effectively counter any frost heave forces. However, as the water table may be close to the founding level, free-draining backfill must be specified for the culvert and a minimum granular base thickness of 600 mm is recommended to reduce the potential effects of frost action on the culvert.

If past experience with snowmobile crossings demonstrates a need, more positive measures can be provided by either:

- Placing a 50 mm layer of extruded polystyrene insulation below the culvert base, or
- Extending the base slab at least 300 mm beyond the line of the wall on each side so as to mobilize the weight of the granular backfill against frost heave forces.

9 CULVERT BEDDING, BACKFILL AND LATERAL EARTH PRESSURES

All topsoil, peat and excessively loose material should be stripped/subexcavated from the culvert subgrade prior to placement of culvert bedding material. Based on the borehole data, subexcavation should extend to or below the following levels:

Table 9.1 – Minimum Depth of Subexcavation

Location along Culvert	Borehole	Required Excavation (m)	
		Minimum Depth	Maximum Elevation
West End	SCN-1	1.0	364.3
Centre	SCN-2	0.8	363.0
East End	SCN-3	0.8	362.2

Culvert bedding and backfill should be placed to the extents shown in OPSD 803.010. The backfill should consist of free-draining granular material conforming to OPS Granular A or B specifications. The bedding material should be at least 600 mm thick and conform to OPS Granular A specifications.

Backfill should be placed and compacted in simultaneous equal lifts on both sides of the culvert, and the top of backfill elevation should be within 400 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert.

Earth pressures acting on the culvert walls may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p = K(\gamma h + q)$$

where: p = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

γ = bulk unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert are dependent on the material used as backfill. Recommended unfactored values are shown in Table 9.2. The at-rest coefficients should be employed for closed box culvert walls. Active pressures shall be used for any wingwalls or unrestrained walls.

Table 9.2 – Earth Pressure Coefficients (K)

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.43*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

* For wing walls, if employed.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.9.1 (a) of the Commentary to the CHBDC.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

The design of the culvert must incorporate measures such as weepholes or subdrains to permit drainage of the culvert backfill, or alternatively the culvert walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

10 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

• Velocity Related Seismic Zone	1
• Zonal Velocity Ratio	0.05
• Acceleration Related Seismic Zone	1
• Zonal Acceleration Ratio	0.05
• Peak Horizontal Acceleration	0.08

The Soil Profile Type at this site has been classified as Type I. Thus, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” of 1.0 should be used in seismic design.

The seismic earth pressure coefficients for active (K_{AE}) and passive (K_{PE}) conditions to be used in design at this site are shown in Table 10.1. In accordance with Clause 4.6.4 of the CHBDC, structures should be designed using earth pressure coefficients that incorporate the effects of earthquake loading.

Table 10.1 – Earth Pressure Coefficients (K) for Seismic Design

Condition	Earth Pressure Coefficient (K) for Earthquake Loading					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \delta = 17°$		OPSS Granular B Type I $\phi = 32°, \delta = 16°$		Rock Fill (Limited to 300 mm size) $\phi = 42°, \delta = 21°$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active*, K_{AE} (Unrestrained Wall)	0.30	0.45	0.33	0.54	0.23	0.31
At rest**, K_{OE} (Restrained Wall)	0.59	-	0.63	-	0.43	-
Passive*, K_{PE} (Movement Towards Soil Mass)	6.3	-	5.4	-	12.0	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

In Table 10.1, the angle of friction between the wall and the backfill, δ, is taken as 50% of the angle of internal friction of the backfill, ϕ.

The potential for liquefaction of the foundation soils has been assessed using the Seed and Idriss (1971) method[1]. Using this method, it was determined that the foundation soils at the abutments are not in danger of liquefaction under earthquake loading.

11 EXCAVATION AND GROUNDWATER CONTROL

Excavation for culvert installation will extend approximately to the level of the groundwater observed in the boreholes. The proximity of the excavation base to the groundwater level at the time of construction will depend upon prevailing weather conditions and seasonal variations.

Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater may cause boiling and disturbance of the soil at the culvert subgrade, and consequent post-construction settlement of the culvert. For the anticipated shallow depth of excavation below the groundwater level, a system employing pumps in filtered sumps should be

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[1] Seed, H.B. and Idriss, I.M. 1971, “Simplified Procedure for Evaluating Soil Liquefaction Potential” *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 101, No. SM9, pp. 1249 – 1273.

suitable to depress the groundwater below the deepest excavation level and maintain a dry, stable base.

The design of the dewatering system that may be required is the responsibility of the Contractor. An NSSP should be included in the Contract Package to advise the Contractor of the need for dewatering and/or special construction procedures to excavate below the groundwater level. Suggested wording for the NSSP is provided in Appendix D.

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils at this site may be classed as Type 3 soils above the water table, and Type 4 below the water table. This classification is based on the lack of cohesion in the soils and the resulting possibility that excavation slopes will slough if excavated vertically for the lower 1.2 m. Excavation slopes should not exceed 1V:1H above the groundwater level.

12 CONSTRUCTION CONCERNS

- Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater may cause boiling and disturbance of the culvert subgrade.
- Care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade should be protected from physical disturbance and a granular bedding and/or concrete placed on the approved subgrade expeditiously following excavation.

13 CLOSURE

Engineering analysis and preparation of the foundation design report was conducted by Mr. Murray Anderson, P.Eng. The report was reviewed by Mr. Alastair E. Gorman, P.Eng. The report was also reviewed by Dr. P.K. Chatterji, Ph.D., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.
Murray R. Anderson, P.Eng., M.Eng.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
MAR31/06
PROVINCE OF ONTARIO

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 31/06
PROVINCE OF ONTARIO

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample
WS Wash Sample
AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample
TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure
PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight
RC Rock Core
SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▽ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No SCN-1

1 OF 2

METRIC

W.P. 759-93-00
LOCATION N 5 075 741.5 E 312 782.9 (Snowmobile Crossing North Culvert)
ORIGINATED BY GA
HWY 11
BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone
COMPILED BY WM
DATUM Geodetic
DATE 23.11.05 - 23.11.05
CHECKED BY MRA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
365.3										
0.0 0.1	**TOPSOIL** (50 mm) **SAND**, trace silt, trace organics Very Loose Brown	1	SS	2						
364.7 0.6	Silty **SAND** to Sandy **SILT**, trace gravel, occasional iron oxide staining Compact to Dense Brown Dry	2	SS	9						
	becoming wet, grey	3	SS	28			4	64	33 (SI+CL)	
		4	SS	37						
		5	SS	25						
		6	SS	15			0	29	68	3
		7	SS	3						
		8	SS	18			0	41	56	3
356.2 9.1	**SAND**, fine grained, some silt Compact Grey Wet	9	SS	15						

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

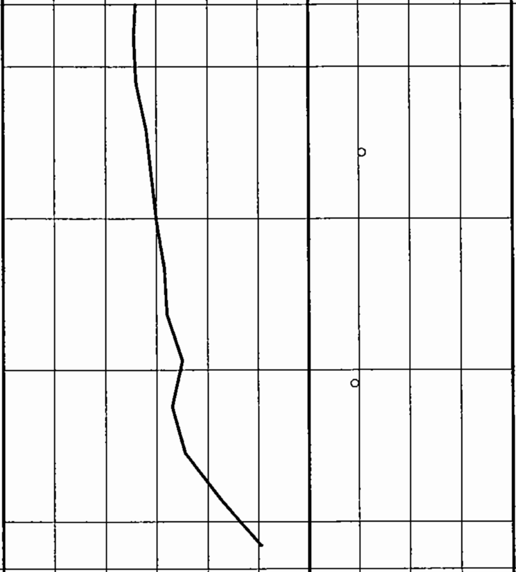
RECORD OF BOREHOLE No SCN-1

2 OF 2

METRIC

W.P. 759-93-00
LOCATION N 5 075 741.5 E 312 782.9 (Snowmobile Crossing North Culvert)
ORIGINATED BY GA
HWY 11
BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone
COMPILED BY WM
DATUM Geodetic
DATE 23.11.05 - 23.11.05
CHECKED BY MRA

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				GR	SA	SI	CL
							355							
			10	SS	18						0	86	14 (SI+CL)	
							354							
			11	SS	29		353							
352.5 12.8	END OF SAMPLED BOREHOLE AT 12.80 m.													
							352							
351.6 13.7	END OF DCPT AT 13.71 m. BOREHOLE OPEN TO 12.20 m AND WATER LEVEL AT 2.13 m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.													



ONTMT4S 414.GPJ 01/03/06

+ ³, × ³: Numbers refer to Sensitivity

20
15-⊕-5
10
(%) STRAIN AT FAILURE

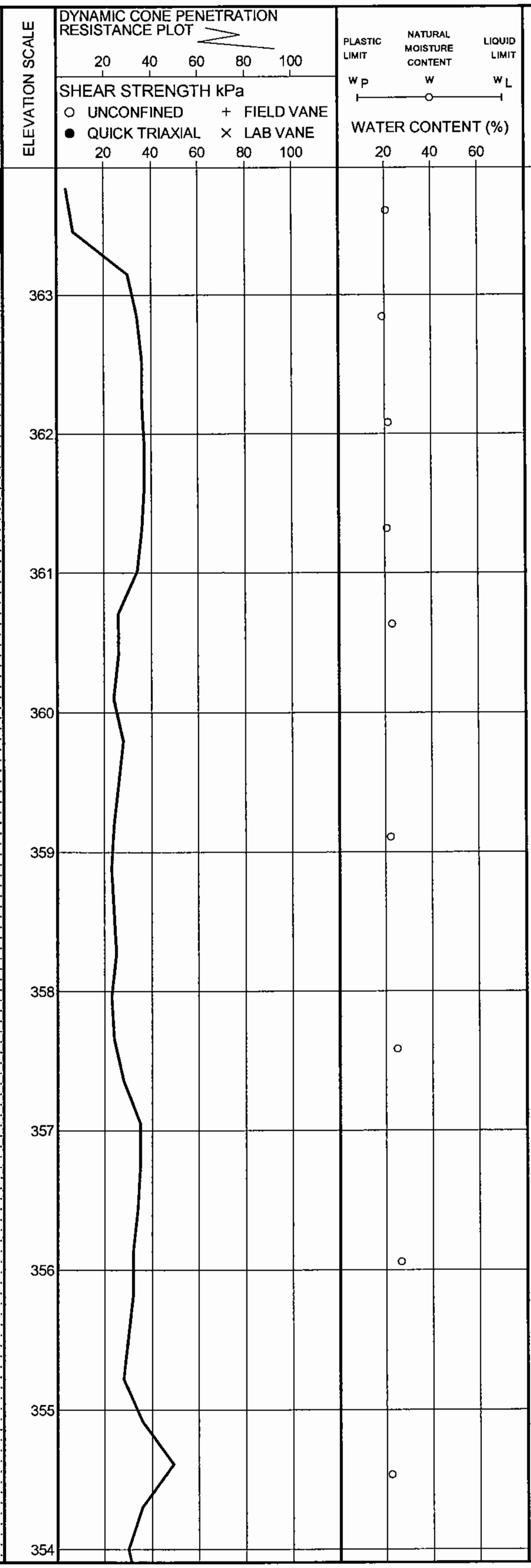
RECORD OF BOREHOLE No SCN-2

1 OF 2

METRIC

W.P. 759-93-00	LOCATION N 5 075 721.0 E 312 823.2 (Snowmobile Crossing North Culvert)	ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone	COMPILED BY WM
DATUM Geodetic	DATE 24.11.05 - 24.11.05	CHECKED BY MRA

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
363.8					
0.0 0.0	**TOPSOIL** (50mm) **SAND**, trace silt, occasional rootlets Loose Brown Damp	1	SS	9	
363.1 0.8	Silty **SAND**, fine grained Compact Brown Wet	2	SS	24	
		3	SS	29	0 69 31 (SI+CL)
		4	SS	16	
		5	SS	16	
		6	SS	15	0 80 20 (SI+CL)
		7	SS	19	
		8	SS	17	
		9	SS	18	



UNIT WEIGHT γ kN/m^3

Continued Next Page

+^{3}, ×^{3}: Numbers refer to Sensitivity   15-⦶-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

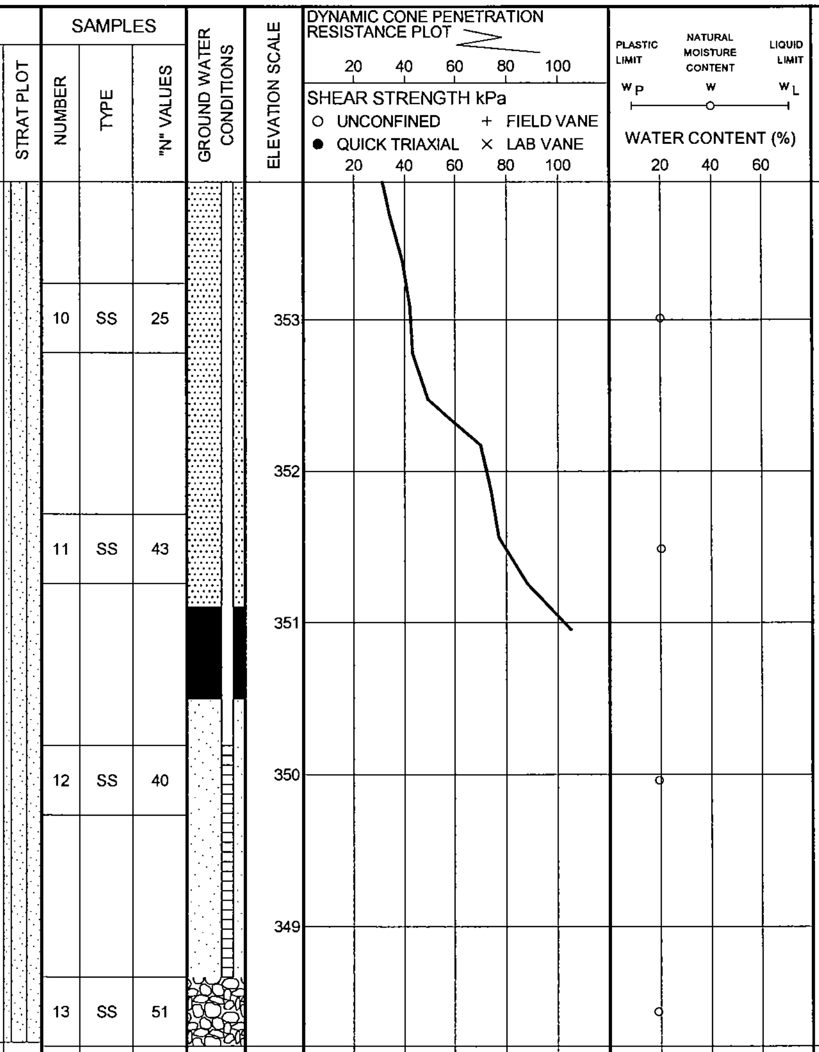
THURBER

RECORD OF BOREHOLE No SCN-2

2 OF 2

METRIC

W.P. 759-93-00
LOCATION N 5 075 721.0 E 312 823.2 (Snowmobile Crossing North Culvert)
ORIGINATED BY GA
HWY 11
BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone
COMPILED BY WM
DATUM Geodetic
DATE 24.11.05 - 24.11.05
CHECKED BY MRA



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Becoming Dense to Very Dense	10	SS	25		
		11	SS	43		0 75 25 (SI+CL)
		12	SS	40		
348.1		13	SS	51		
15.7	END OF BOREHOLE AT 15.68m. BOREHOLE OPEN TO 15.24m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.					

WATER LEVEL READINGS:

DATE	DEPTH (m)
Nov 28 2005	1.02

ONTMT4S 414.GPJ 01/03/06

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

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

Ministry of Transportation
Ontario

THURBER

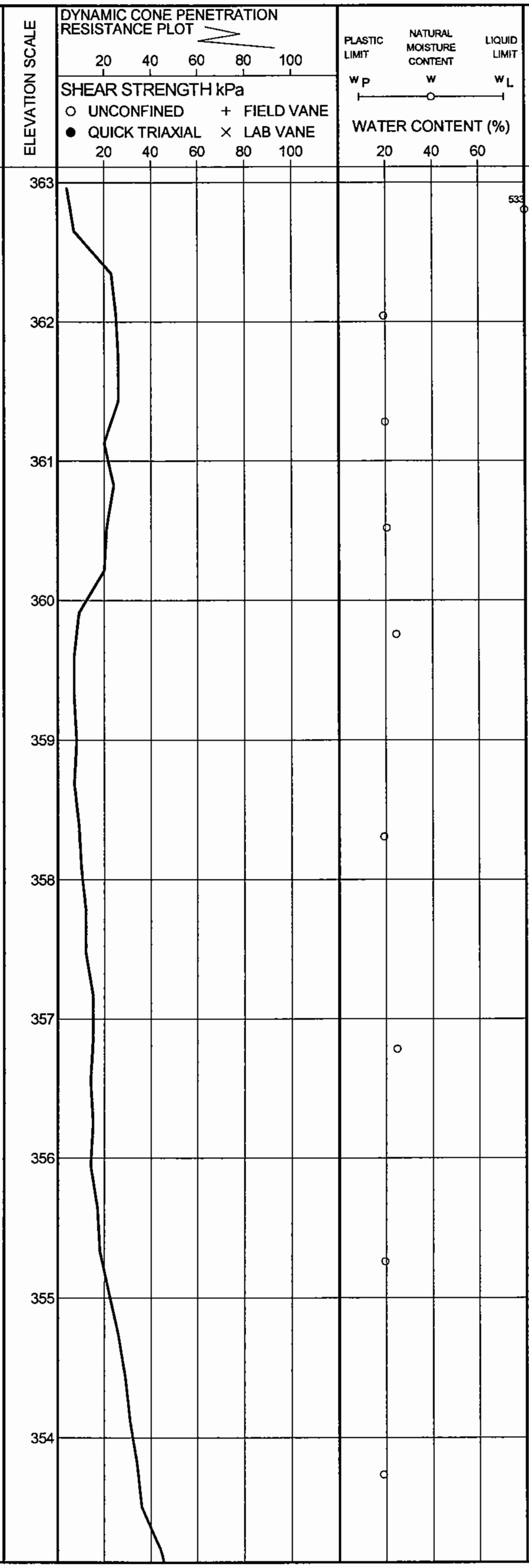
RECORD OF BOREHOLE No SCN-3

1 OF 2

METRIC

W.P. 759-93-00	LOCATION N 5 075 698.6 E 312 866.5 (Snowmobile Crossing North Culvert)	ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone	COMPILED BY WM
DATUM Geodetic	DATE 23.11.05 - 23.11.05	CHECKED BY MRA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
363.0											
0.0	**TOPSOIL** (75mm)										
0.1	Silty **PEAT**, fibrous, trace sand Very Loose Dark Brown Wet		1	SS	4						
362.3 0.8	Silty **SAND**, fine grained Compact Brown Wet		2	SS	22						
			3	SS	21						
			4	SS	19			0	79	21 (SI+CL)	
			5	SS	13						
			6	SS	13						
356.9 6.1	**SILT**, some sand, trace clay Compact Brown Wet		7	SS	25			0	17	79	4
355.4 7.6	**SAND**, fine grained, some silt Compact to Dense Brown Wet		8	SS	28						
			9	SS	35						



Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15-20-5-10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

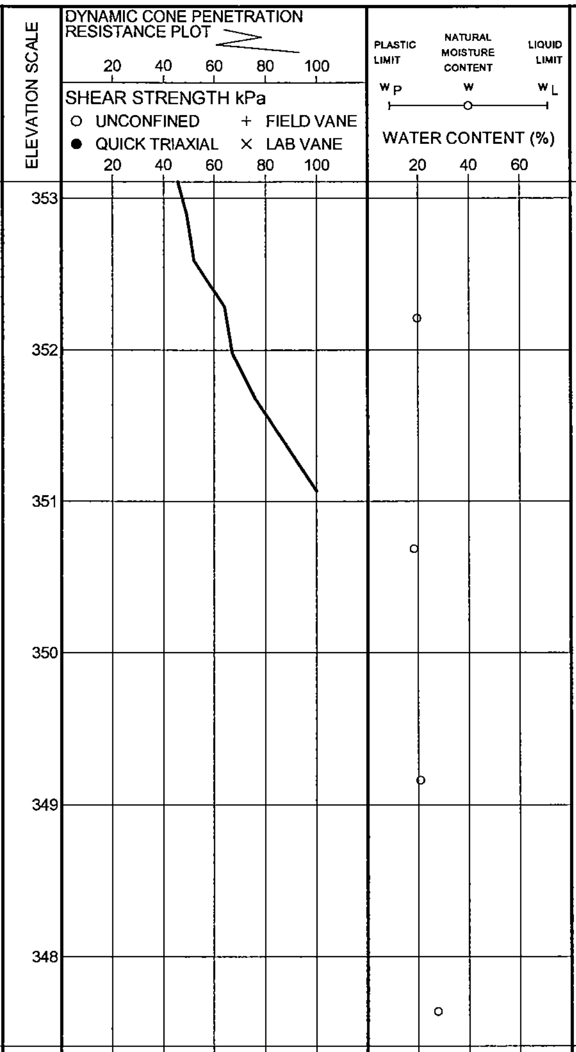
RECORD OF BOREHOLE No SCN-3

2 OF 2

METRIC

W.P. 759-93-00
LOCATION N 5 075 698.6 E 312 866.5 (Snowmobile Crossing North Culvert)
ORIGINATED BY GA
HWY 11
BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone
COMPILED BY WM
DATUM Geodetic
DATE 23.11.05 - 23.11.05
CHECKED BY MRA

SOIL PROFILE ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
		10	SS	44			0	88	12 (SI+CL)	
		11	SS	20						
		12	SS	32						
		13	SS	38						
347.3 15.7	END OF BOREHOLE AT 15.70m. BOREHOLE OPEN TO 15.24m AND WATER LEVEL AT 1.22m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.									



+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

Appendix B

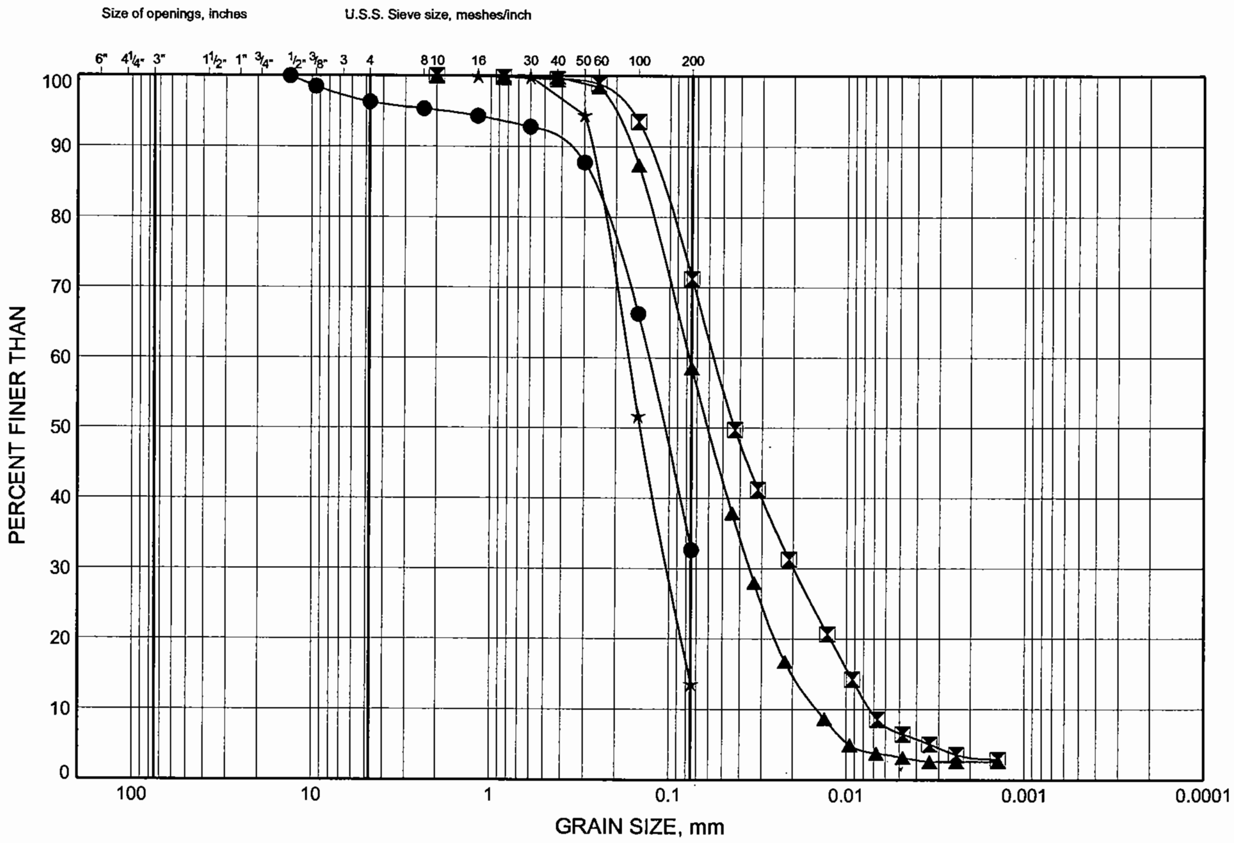
Laboratory Test Results

Hwy 11 Four Laning

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sandy SILT to Fine SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	SCN-1	1.83	363.49
☒	SCN-1	4.88	360.44
▲	SCN-1	7.92	357.39
★	SCN-1	10.97	354.35

Date February 2006

Project 759-93-00

THURBER

Prep'd JL

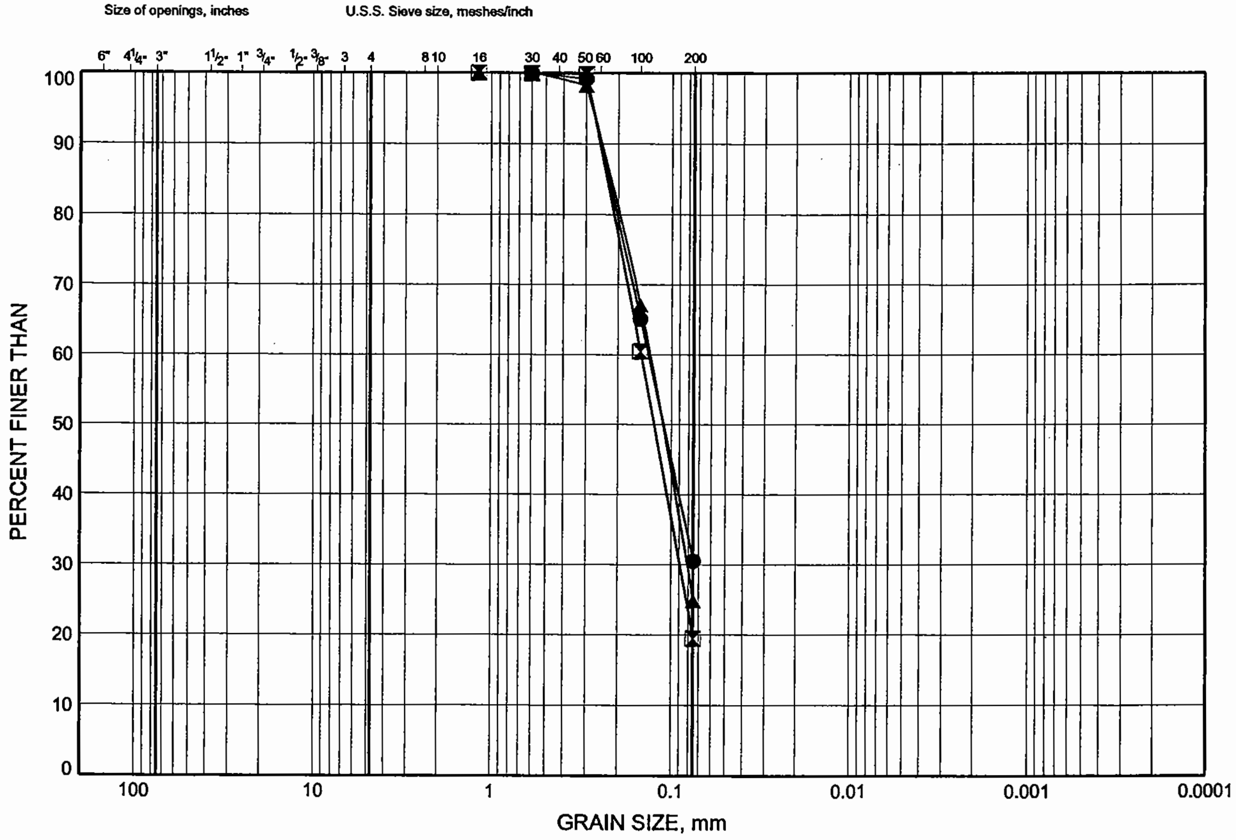
Chkd. MEF

Hwy 11 Four Laning

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	SCN-2	1.83	361.99
☒	SCN-2	4.80	359.02
▲	SCN-2	12.42	351.40

THURBGSD 414.GPJ 23/02/06

Date February 2006

Project 759-93-00

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Prep'd JL

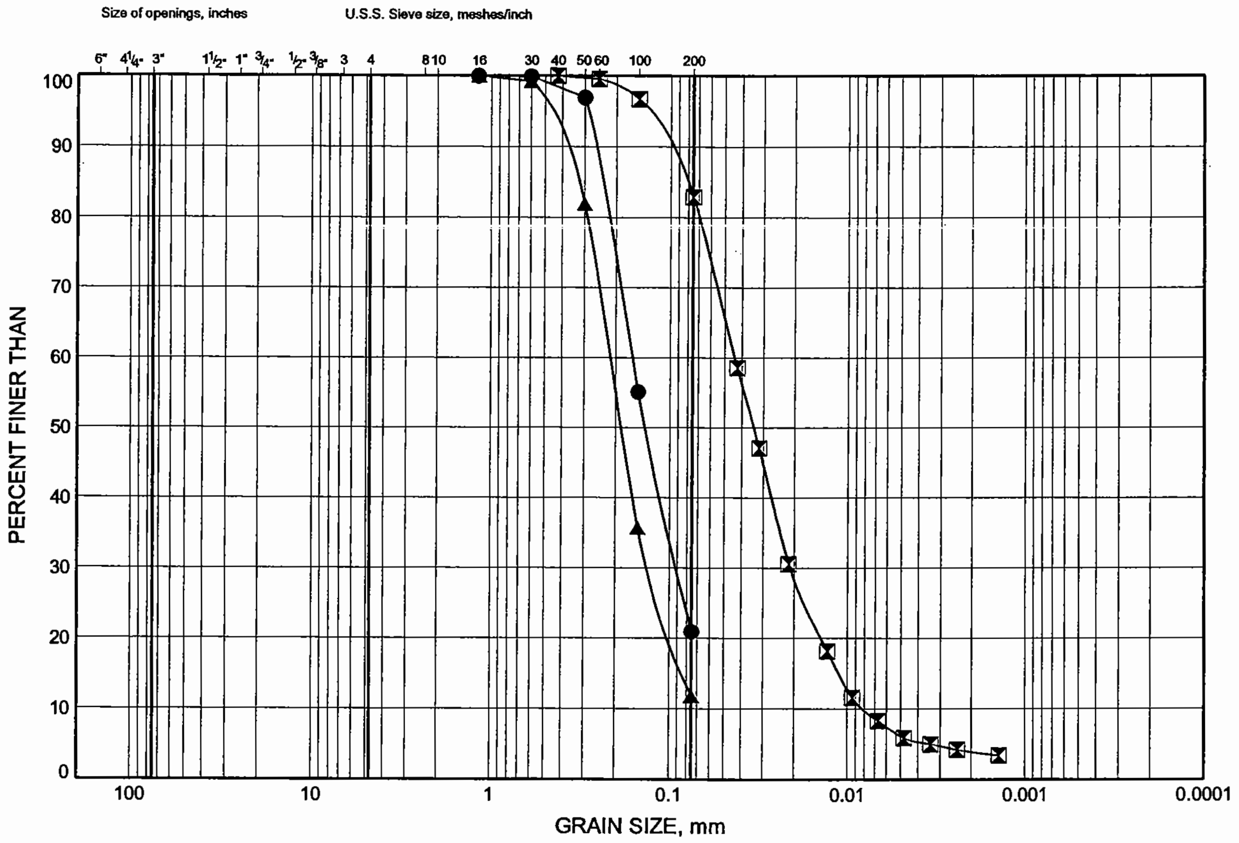
Chkd. MEF

Hwy 11 Four Laning

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILT to Fine SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	SCN-3	2.59	360.43
☒	SCN-3	6.32	356.69
▲	SCN-3	10.90	352.12

THURBGSD 414.GPJ 23/02/06

Date February 2006

Project 759-93-00

THURBER

Prep'd JL

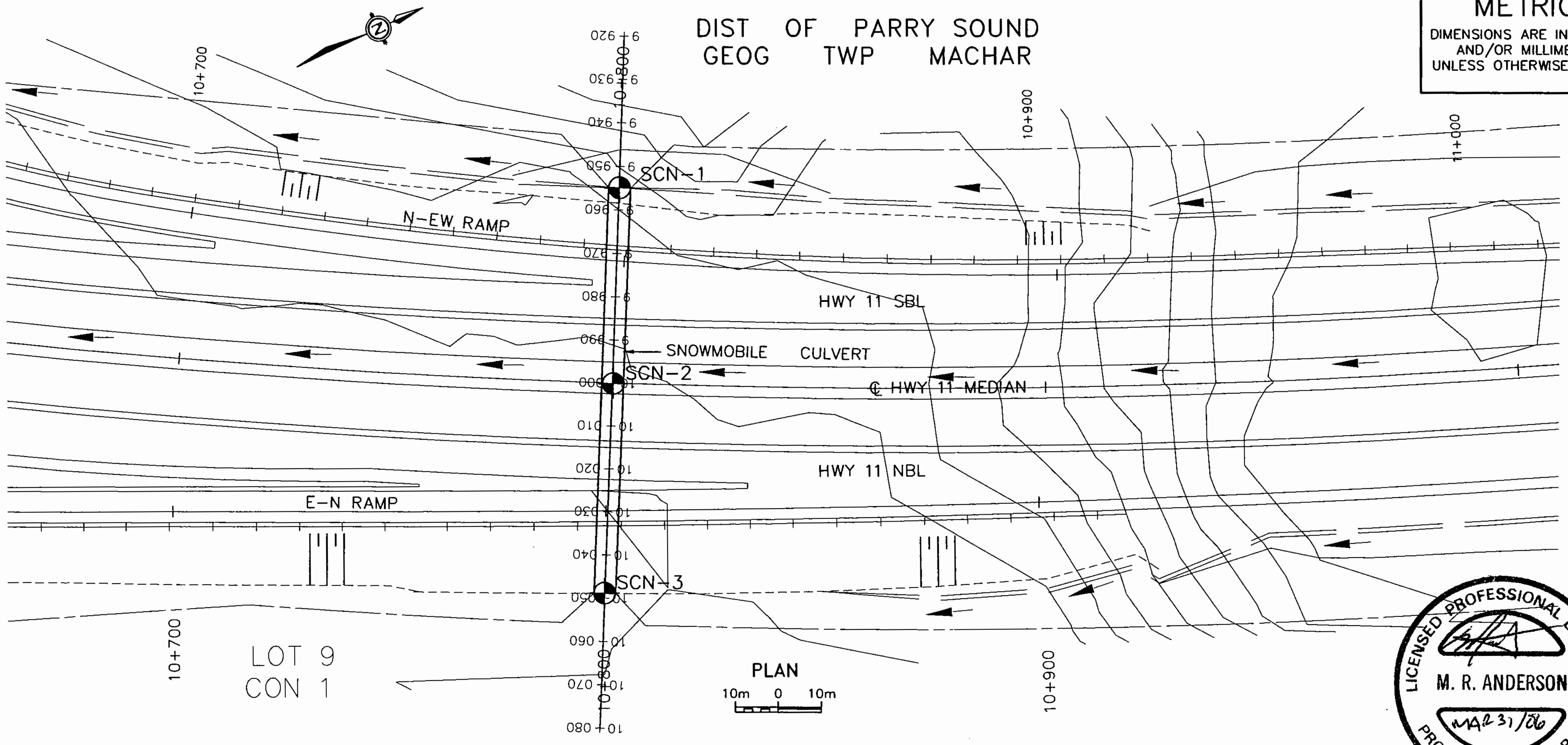
Chkd. MEF

Appendix C

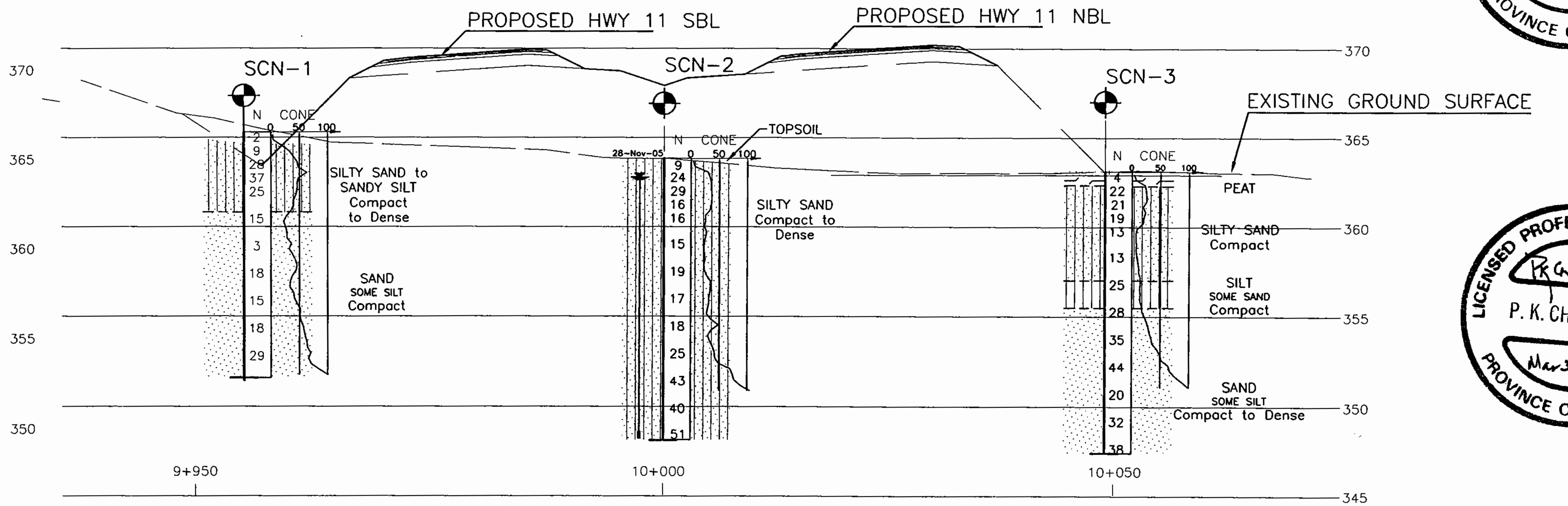
Drawings

DIST OF PARRY SOUND
GEOG TWP MACHAR

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



PLAN



PROFILE OF SNOWMOBILE CROSSING

HOR: 0m 5 10 20m
VERT: 0m 2.5 5 10m

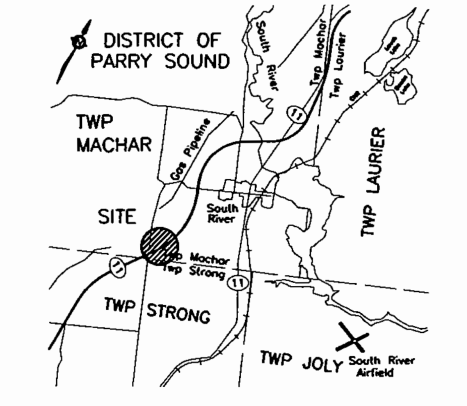
HWY 11
CONT No
GWP No 759-93-00

SHEET

HIGHWAY 11 MAINLINE
STA. 10+800 MACHAR TOWNSHIP
PROPOSED SNOWMOBILE CROSSING
BOREHOLE LOCATIONS AND SOIL STRATA

Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS

THURBER
THURBER ENGINEERING LTD.



KEYPLAN

	LEGEND
●	Bore Hole
⊕	Dynamic Cone Penetration Test (cone)
◑	Bore Hole & Cone
N	Blows/0.3m (Std pen Test, 475J/blow)
CONE	Blows/0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▼	WL in Piezometer at Time of Investigation (Date)
⊤	Head Artesian Water Piezometer
▼	WL in Open Borehole Upon Completion of Drilling
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal
C/R	Cone Refusal

NO	NORTHING	EASTING	ELEVATION (m)
SCN-1	5075741.5	312782.9	365.3
SCN-2	5075721.0	312823.2	363.8
SCN-3	5075698.6	312866.5	363.0

— NOTE —

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

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
MAR 31/06
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. Chatterji
P. K. CHATTERJI
Mar 31/06
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN MRA | CHK AEG | CODE | LOAD | DATE MARCH2006
DRAWN SLL | CHK MRA | SITE | STRUCT | SCHEME | DWG

C:\\Susan\drawings\19-1423-12hwy11 embankment\Snowmobile Culver\site plan.dwg

Appendix D

Non Standard Special Provision

Suggested text for a NSSP on Excavation Dewatering should contain the following:

> *"The soils underlying this site are cohesionless in nature and the observed groundwater table lies close to the surface. Excavation below the groundwater level is expected to lead to instability and slough of the sides of the excavation and boiling of the base, accompanied by loss in geotechnical resistance of the soils. If excavation is required to be carried out below the groundwater level prevailing at the time of construction, appropriate means of dewatering must be implemented to depress the groundwater level sufficiently far below the base of the excavation to prevent any instability, sloughing, or boiling and so as to preserve the stability of the excavation and to allow the work to proceed in the dry."*