Foundation Investigation Report

Culvert Replacement at Samuel Creek

GWP 146-98-00

Highway 11
25 km west of Hearst, Ontario

Site No.: 39W-130/C
Geocres No.: 42F-16

Prepared for:

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Ref. No. 05-101

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Part A FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering has been retained by Engineering Northwest Ltd. to carry out a Foundation Investigation for the replacement of Samuel Creek Culvert at Hwy 11, in the District of Cochrane and Township of Studholme.

The site is located on Highway 11, approximately 25 km west of Hearst.

A foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes drilled in the vicinity of the proposed new structure location, laboratory testing and geotechnical analysis of the data. This report provides a summary of that work and of the conditions encountered.

The foundation section has assigned GEOCRES No. 42F-16 to this site.

2 Site Description

The site is located on Highway 11, approximately 25 km west of Hearst. At this location Highway 11 runs generally in an east-west direction. Samuel Creek crosses the highway generally in a north-south direction and flows to the south. The existing culvert consists of a 3.00 X 1.92, 33.8 m long Concrete Box Culvert.

The area surrounding the culvert site consists of low lying terrain within the creek flood plane with grassy vegetation and shrubbery. Beyond the floodplain spruce trees were noted.

The creek and its flood plain are about 3 m below the current road grade. The creek width is the order of 2 m. At the culvert inverts, the visible creek bed consists of coarse sands and gravels. The water level in the creek was approximately at elevation 250.6 m at the time of this investigation.

The mapped surficial geology based on The surficial geology for the area is mapped as a zone of ground moraine consisting of clay till with subordinate terrain units consisting of either rock knob and/or organic terrain. In general, the clay till is underlain by varved clay and silt. (1 - Northern Ontario Engineering Geology Terrain Study 30)

The topography is generally of low local relief areas of plains and undulating to rolling terrain.

The road embankment is about 3 metres high with fore slopes varying from 4 h:1v to 5 h:1v.

South Side of Samuel Creek Culvert, Looking North-West (downstream side)

North Side of Samuel Creek Culvert, Looking North (upstream side)

3 Investigation Procedures

A site investigation was undertaken in two phases between November 6, 2005 and April 29, 2006. Various investigation techniques were used depending on the conditions encountered. Both a truck mounted CME 55 and a track mounted Star100 drill rig were used for geotechnical sampling and testing. A total of 5 boreholes were completed to depths varying between 15 and 21 m below grade.

Soil samples were obtained at the boreholes with a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m, known as the SPT blow count (N), was recorded. In addition, field vane testing and relatively undisturbed thin walled tube sampling was carried out at selected depths within clay soils.

Borehole locations were referenced in the field and ground surface elevations were surveyed and referenced to BM 525.764, top of "T" Rail, 56.5 RT, 18+722.4 (Reference: Horizontal & Vertical Control, Plate No. 847-11 / 30-0, CONT NO 90-235, WP NO 318-85-00, Sheet 44).

The borehole characteristics and drill techniques utilized are summarized in Table 1.

Table 1. Drill Summary

Location	Surface Elevation (metres)	Bedrock / Refusal (Elevation/Depth) (metres)	Bottom of Hole (Elevation/Depth) (metres)	Comments
BH 1	253.9	N/A	233.2 / 20.7	Casing used to advance hole beyond 13 m
BH 2	252.6	N/A	236.7 / 15.9	
BH 3	254.0	N/A	238.2 / 15.9	
BH 4	252.1	N/A	236.9 / 15.2	
BH 5	253.7	N/A	237.8 / 15.9	

The boreholes were backfilled at the completion of the investigations using a cement/bentonite backfill to ensure the environmental integrity of the site.
Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content, grain size analysis and Atterberg Limits. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B). In addition, two consolidation tests were carried out on selected thin walled tube samples. The results of this testing has been included in Appendix B.

4 General Site Geology and Sub-Surface Conditions

4.1 Site Geology

The surficial geology of the area consists predominantly of clay till ground moraine with subordinate land forms consisting of rock knob and organic terrain. The clay till is generally underlain with varved clay and silt. The varved clay and silt deposit was identified through the field investigation carried out at this site. It is likely that the upper clay till is not present within the localized flood plain of the creek.

4.2 Subsurface Conditions

Details of the subsurface conditions are provided on the Borehole Logs, Appendix A, and on the Section Plans, Drawing 1. In general, the subsurface stratigraphy consists of variable fills and/or organics overlying a stratum of layered silts and clays which is further underlain by a deep silt stratum to the depth of the investigation.

Groundwater levels within the boreholes at the time of drilling were similar to the level of the Samuel Creek at the time of the investigation.

4.2.1 Fill

Fill was encountered at Boreholes 1, 3 and 5 which were put down within the shoulders and fore slopes of the highway embankment. The fill is variable and consists of either sands with trace gravel, silt, clay with trace sand and gravel. At the borehole locations, the fill was found to vary from 1.3 to 2.1 m in thickness and generally extends to elevations of 252.0 to 252.5 m. The granular fill was generally found to be in a very loose condition, or have of stiff consistency in the case of cohesive soils..

The pavement investigation boreholes for this project encountered fills consisting of sands and gravels with variable proportions of silt to depths of approximately 3.6 -3.9 m (elevation 251.4- 251.2 m) below the paved road surface.

4.2.2 Peat

Peat was encountered below the fill at Boreholes 3 and 5. The sample of peat at Borehole 3 contained silt. The thickness of the peat layer was approximately 0.3 m. The natural moisture content varied from 53 to 255 %.

4.2.3 Silt / Clay - Layered

An upper stratum of layered silts and clays was found to vary from about 3.5 to 5 m in thickness and extends to elevations of 246.9 to 248.9 m. This stratum extends approximately 1.4 to 3.4 m below the invert of the existing culvert (250.27 m). The alternating layers of silts and clays were observed to vary in thickness from 10 to over 600 mm. The clay layers are soft to stiff while the silt layers vary from very loose to compact. SPT "N" values varied from 3 to 19 blows / 0.3 m. Field vane testing results varied from 20 to 55 kPa. Shear strength sensitivities as indicated by field vane testing varied from 2 to 4.

Atterberg limit testing (Appendix B, Enclosure 1) carried indicate the silt layers are non-cohesive while the clay layers were found to vary from medium to high plastic. The natural moisture content of the clay layers exceeds the liquid limit.

Grainsize analyses carried out on selected silt layers (Appendix B, Enclosure 2) indicates the silt layers contain from 1 to 26 % sand and from 12 to 20 % clay sized particles. This material is considered to be susceptible to frost heave.

Consolidation testing (Appendix B, Enclosures 5 and 6) carried out on clay layers within this stratum indicate the clay is normally consolidated. Within the anticipated design stress range, the volume compressibility (m_v) varies from 6.7×10^{-4} to 8.3×10^{-4} m^2/kN ($1/m_v$ = 1.2 to 1.5 MPa).

Based on grain size analyses, the hydraulic conductivity of the silt layers has been estimated to be 10^{-5} cm/sec or less. Based on consolidation testing, the hydraulic conductivity of the clay layers is less than 10^{-6} cm/sec.

4.2.4 Sand

A 0.3 m thick sand layer with some silt was encountered below the above noted layered clays and silts at Borehole 4. The hydraulic conductivity of this sand layer is estimated to be in the order of 10^{-2} to 10^{-3} cm/sec.

4.2.5 Silt

The lower silt stratum was found to start at elevation 246.9 to 248.9 m and is in a compact to very dense condition as indicated by SPT "N" values of 11 to 77 blows / 0.3 m.

Grainsize analyses carried out on selected samples of this stratum (Appendix B, Enclosures 3 and 4) indicates the gravel content varies from 0 to 6 %, the sand content varies from 2 to 32 %, the silt content varies from 52 to 92%, and there is 3 to 13 % clay sized particles. The hydraulic conductivity has been estimated to be 10^{-5} cm/sec or less. This material is considered to be susceptible to frost heave.

4.2.6 Ground Water

The ground water levels observed were generally at or above (within 1 m) of the water levels within the Samuel Creek at the time of the investigation (Elevation 250.6 m).

5 Miscellaneous

The field drilling services for this project were provided by TBT Engineering. Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The field operations were supervised by T. Dupuis, rcji. This report was prepared by G. Maki, P.Eng. and reviewed by W. Hurley, P.Eng.

6 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot be readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

7 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Prepared by:

Gordon Maki, P.Eng
Manager of Geotechnical Engineering

Reviewed By

Wayne Hurley, P.Eng
Vice-President, Engineering

References

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3. Ontario Ministry of Transportation, Surveys and Design Office, Pavement Design and Rehabilitation Manual, The Queens Printer for Ontario, 1990, ISBN 0-7729-6379-7

4. Canadian Geotechnical Society, Canadian Foundation Engineering Manual, Third Edition, BiTech Publishers Ltd., 1992, ISBN 0-920505-09-0

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APPENDIX A

BOREHOLE LOGS

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

TBT Engineering

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. **GWP 146-98-00** LOCATION **Samuel Creek Sta 18+719 8.8m RT, Twp Studhome** ORIGINATED BY **T.D.**

DIST **Cochrane** HWY **11** BOREHOLE TYPE **HSA/N Casing** COMPILED BY **T.B.**

DATUM **Geodetic** DATE **06/11/2005** CHECKED BY **G.M.**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
253.9						
0.0	- 150mm TOPSOIL					
252.4	FILL - CLAY - Silty, trace sand & gravel, trace organics, brown, firm		1	SS	6	
1.5	SILT/CLAY - layered, trace sand to Sandy, grey/brown, layers from 10 to 60 mm, very loose /soft to compact/firm		2	SS	3	▼
			3	SS	19	
			4	SS	6	
			5	TW		
248.9			6	VANE		
5.0	SILT - trace sand to Sandy, trace clay, occasional cobbles, grey, moist, compact to very dense		7	SS	55	
			8	SS	50	
			9	SS	65	
			10	SS	51	
			11	SS	53	
			12	SS	77	
			13	SS	65	
			14	SS	16	
			15	SS	67	
			16	SS	50	
			17	SS	34	
			18	SS	44	
233.2			19	SS	41	
20.7	End of Borehole @ 20.7m below grade.					

ELEVATION SCALE: 252, 250, 248, 246, 244, 242, 240, 238, 236, 234

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ 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 (%)

GR SA SI CL

0 30 60 10

0 2 92 6

$\times^{3}$, $\star^{3}$ Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. **GWP 146-98-00** LOCATION **Samuel Creek Sta 18+742 16.3m RT, Twp Studhome** ORIGINATED BY **T.D.**

DIST **Cochrane** HWY **11** BOREHOLE TYPE **HSA/N Casing** COMPILED BY **T.B.**

DATUM **Geodetic** DATE **27/04/2006** CHECKED BY **G.M.**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.6							
0.0	- 150 mm TOPSOIL SILT/CLAY - layered, trace sand to Sandy, grey/brown, layers from 10 to 60 mm, very loose /soft to compact/stiff, trace to some organics within upper 2.1 m		1	AS			
			2	SS	9		
			3	SS	13		
			4	SS	3		
			5	TW VANE			
248.3							
4.3	SILT - trace sand to Sandy, trace clay, occasional cobbles, grey, moist, compact to very dense		6	SS	18		6 32 53 10
			7	SS	28		
			8	SS	12		
			9	SS	36		
			10	SS	30		
			11	SS	19		
			12	SS	15		0 5 91 4
236.7			13	SS	33		
15.9	End of Borehole @ 15.9m below grade.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED × FIELD VANE
■ SPT (N) ★ LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

ELEVATION SCALE 252 250 248 246 244 242 240 238

UNIT WEIGHT γ kN/m³

$\times^{3}$, $\star^{3}$ Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. **GWP 146-98-00** LOCATION **Samuel Creek Sta 18+744 9.8m RT, Twp Studhome** ORIGINATED BY **T.D.**

DIST **Cochrane** HWY **11** BOREHOLE TYPE **HSA/N Casing** COMPILED BY **T.B.**

DATUM **Geodetic** DATE **27/04/2006** CHECKED BY **G.M.**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.0							
0.0	- 150 mm TOPSOIL FILL - SAND - some gravel, trace silt, brown		1	AS			
	- - - - -		2	SS	3		
251.9	- SILT - trace sand, brown, loose		3	SS	3	▼	
252.6	REAT - some silt, black		4	SS	3		
2.4	SILT/CLAY - layered, trace sand to Sandy, grey/brown, layers from 10 to 60 mm, very loose /soft to compact/firm, trace organics within upper 0.3m		5	SS	13		
			6	SS	3		
			7	TW			0 1 86 13
				VANE			
246.9			8	SS	5		
7.1	SILT - trace sand to Sandy, trace clay, occasional cobbles, grey, moist, compact to very dense		9	SS	33		
			10	SS	11		
			11	SS	41		
			12	SS	46		0 8 88 4
238.1			13	SS	44		
15.9	End of Borehole @ 15.9m below grade.						

ELEVATION SCALE: 252, 250, 248, 246, 244, 242, 240

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60; 255.2

UNIT WEIGHT γ kN/m³

× 3, ★ 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. **GWP 146-98-00** LOCATION **Samuel Creek Sta 18+724 18.0m LT, Twp Studhome** ORIGINATED BY **T.D.**

DIST **Cochrane** HWY **11** BOREHOLE TYPE **HSA/N Casing** COMPILED BY **T.B.**

DATUM **Geodetic** DATE **28/04/2006** CHECKED BY **G.M.**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
252.1						
0.0	- 150 mm TOPSOIL SILT/CLAY - layered, trace sand to Sandy, grey/brown, layers from 10 to 60 mm, loose/firm, trace organics within upper 2 m		1	AS		
			2	SS	6	
			3	SS	6	
			4	TW		
				VANE		
248.4						
248.2	SAND - some silt, grey		5	SS	27	
4.0	SILT - trace sand to Sandy, trace clay, occasional cobbles, grey, moist, compact to very dense		6	SS	86	
			7	SS	42	
			8	SS	43	
			9	SS	61	
			10	SS	58	
			11	SS	42	
			12	SS	13	
			13	SS	25	
236.9						
15.2	End of Borehole @ 15.2m below grade.					

ELEVATION SCALE: 252, 250, 248, 246, 244, 242, 240, 238

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ✕ FIELD VANE
■ SPT (N) ★ 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 (%)

GR	SA	SI	CL
0	26	63	11
4	27	57	12

$\times^{3}$, $\star^{3}$ Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH LOG 2 05-101-1.GPJ ON_MOT.GDT 8/10/06

TBT Engineering

RECORD OF BOREHOLE No 5

1 OF 1

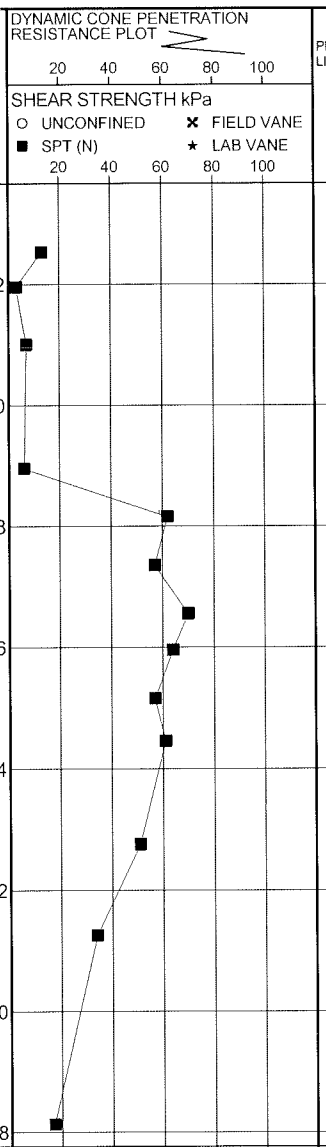
METRIC

W.P. **GWP 146-98-00** LOCATION **Samuel Creek Sta 18+724 10.0m LT, Twp Studhome** ORIGINATED BY **T.D.**

DIST **Cochrane** HWY **11** BOREHOLE TYPE **HSA/N Casing** COMPILED BY **T.B.**

DATUM **Geodetic** DATE **29/04/2006** CHECKED BY **G.M.**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
253.7						
0.0 / 252.4	FILL - CLAY - Silty, trace sand & gravel, brown, stiff		1	AS		
			2	SS	13	
252.3	PEAT - black		3	SS	3	
1.6 / 248.6	SILT/CLAY - layered, trace sand to Sandy, grey/brown, layers from 10 to 60 mm, very loose /soft to loose/stiff, trace organics within upper 2.7m		4	SS	7	▼
			5	TW		
				VANE		
			6	SS	6	
5.1 / 237.8	SILT - trace sand to Sandy, trace clay, occasional cobbles, grey, moist, compact to very dense		7	SS	62	
			8	SS	57	
			9	SS	70	
			10	SS	64	
			11	SS	57	
			12	SS	61	
			13	SS	51	
			14	SS	34	
			15	SS	17	
15.9	End of Borehole @ 15.9m below grade.					



DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ■ SPT (N) × FIELD VANE ★ 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

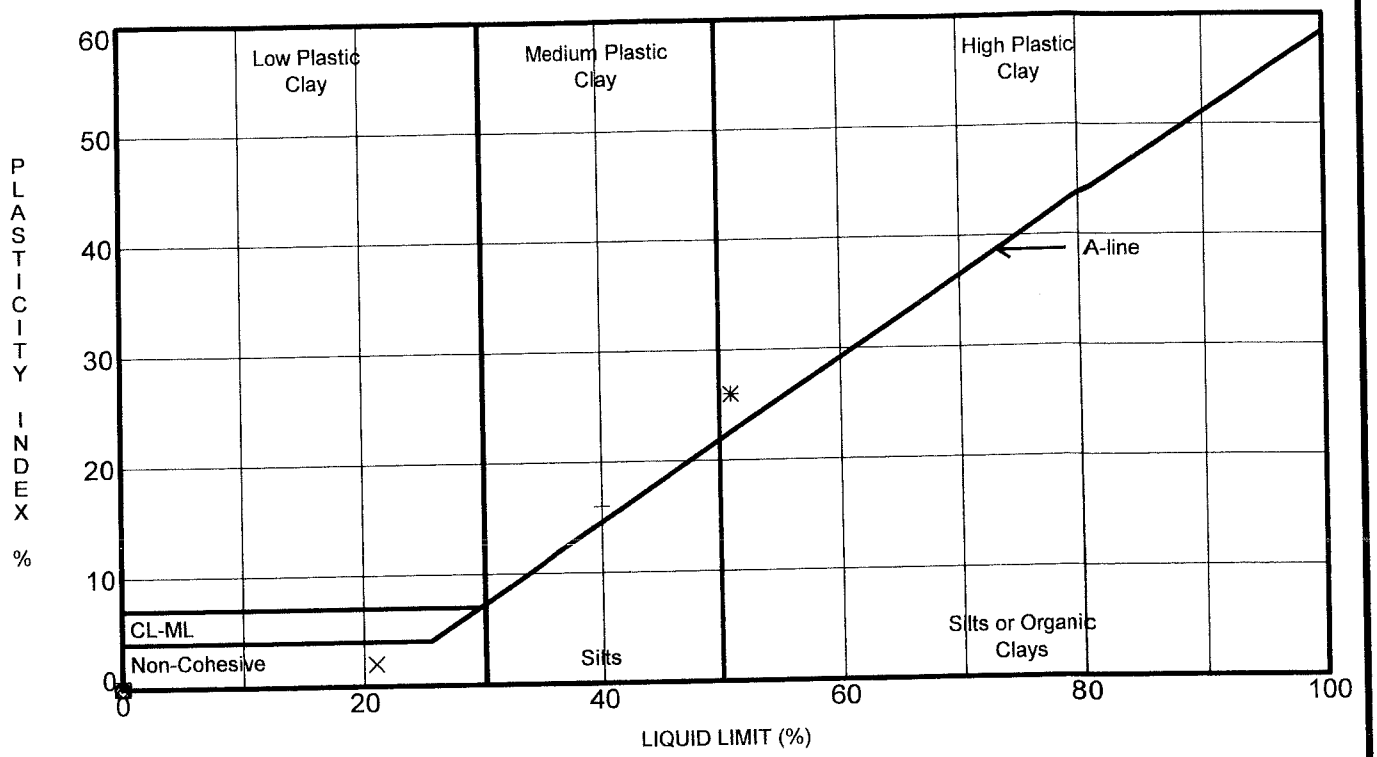
REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	26	55	19
0	11	83	6
0	18	78	4

$\times^{3}$, $\star^{3}$ Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

APPENDIX B

Laboratory Test Data



	Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
□	1		3.10	NP	NP	NP	13
✳	2		3.10	51	25	26	61
×	2		3.20	21	19	2	24
+	3		4.60	40	24	16	55
◇	3		4.70	NP	NP	NP	24
△	4		2.40	NP	NP	NP	14
○	5		3.10	NP	NP	NP	17

TBT Engineering
314-101 Syndicate Ave. N
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

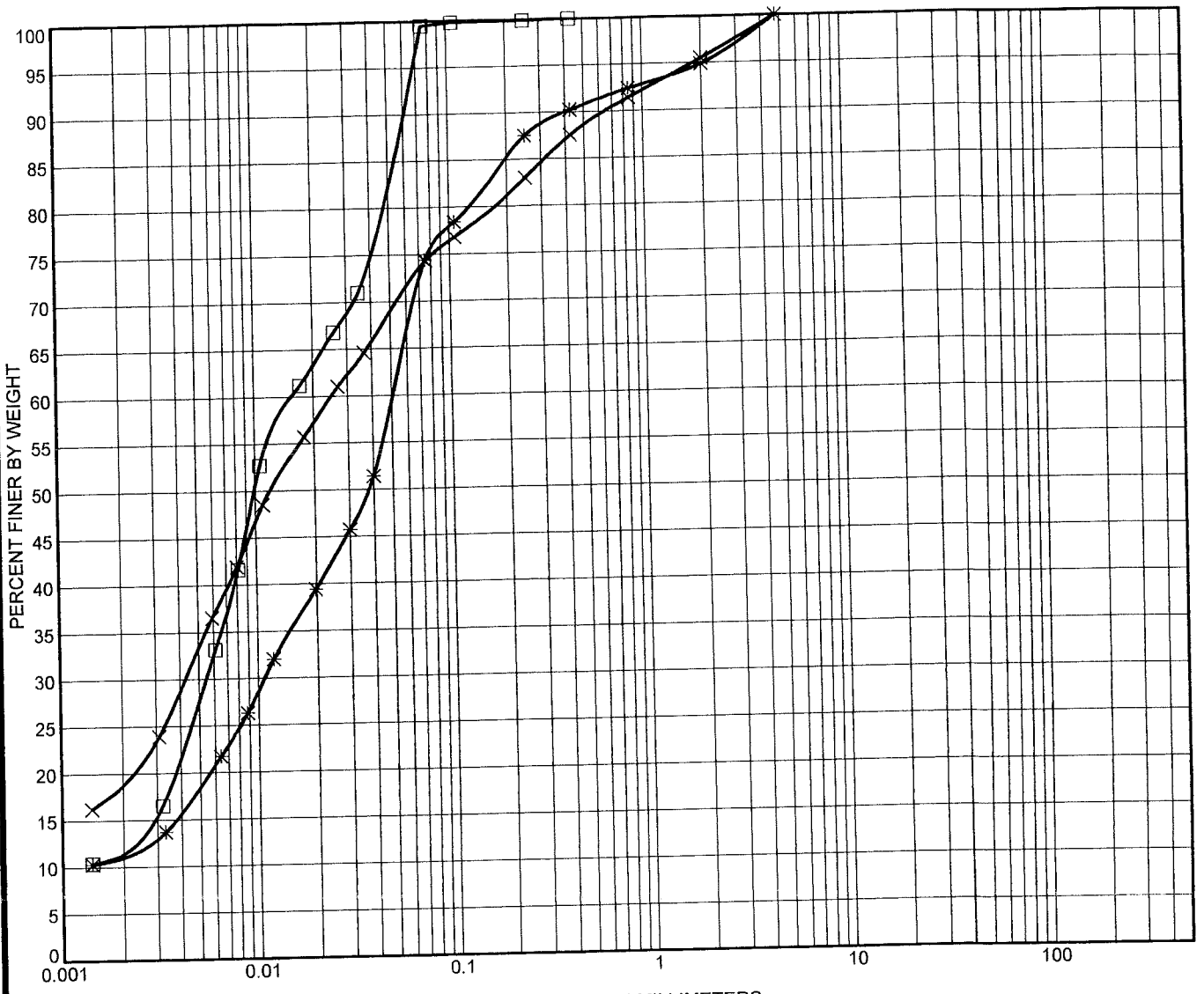
ATTERBERG LIMIT RESULTS

W P: GWP 146-98-00

District: Cochrane

Highway: 11

ENCLOSURE 1



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	3	4.70	0.425	0.016	0.005		0.0	0.5	99.5	
✳	4	2.40	4.75	0.051	0.011		0.0	25.6	74.4	
×	5	3.10	4.75	0.025	0.004		0.0	25.7	74.3	

TBT Engineering
314-101 Syndicate Ave. N
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

GRAIN SIZE DISTRIBUTION

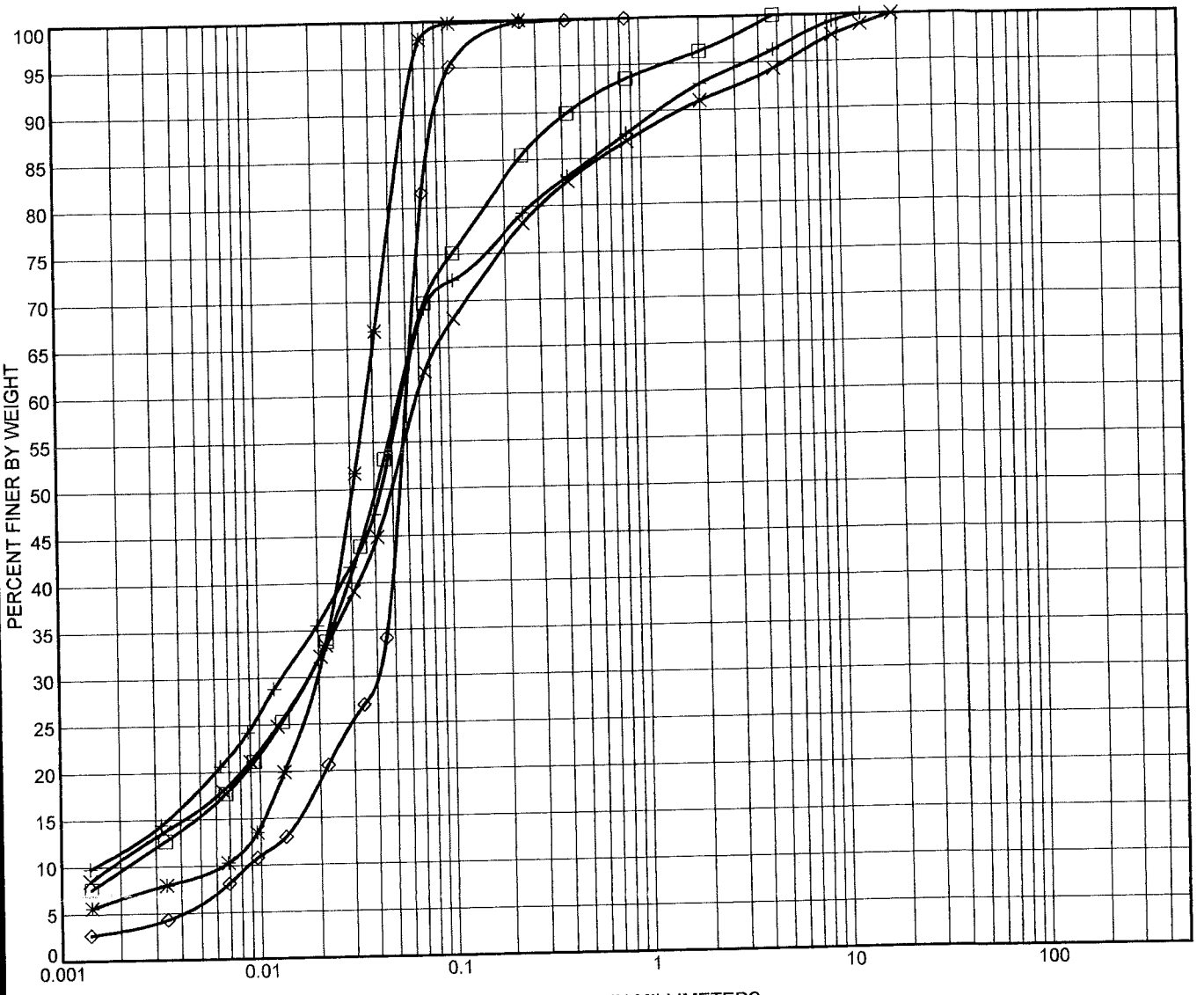
Project:

Location:

Number:

ENCLOSURE 2

MTO_GS_05-101-1.GPJ_CAN_LAB.GDT 6/19/06



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	5.30	4.75	0.056	0.017	0.002	0.0	30.2	69.8	
✳	1	9.10	0.25	0.037	0.019	0.006	0.0	1.9	98.1	
×	2	4.60	19	0.069	0.018	0.002	5.7	31.8	62.5	
+	4	4.60	13.2	0.058	0.013	0.001	3.7	27.1	69.2	
◇	5	12.20	0.85	0.059	0.038	0.009	0.0	18.4	81.6	

TBT Engineering
314-101 Syndicate Ave. N
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

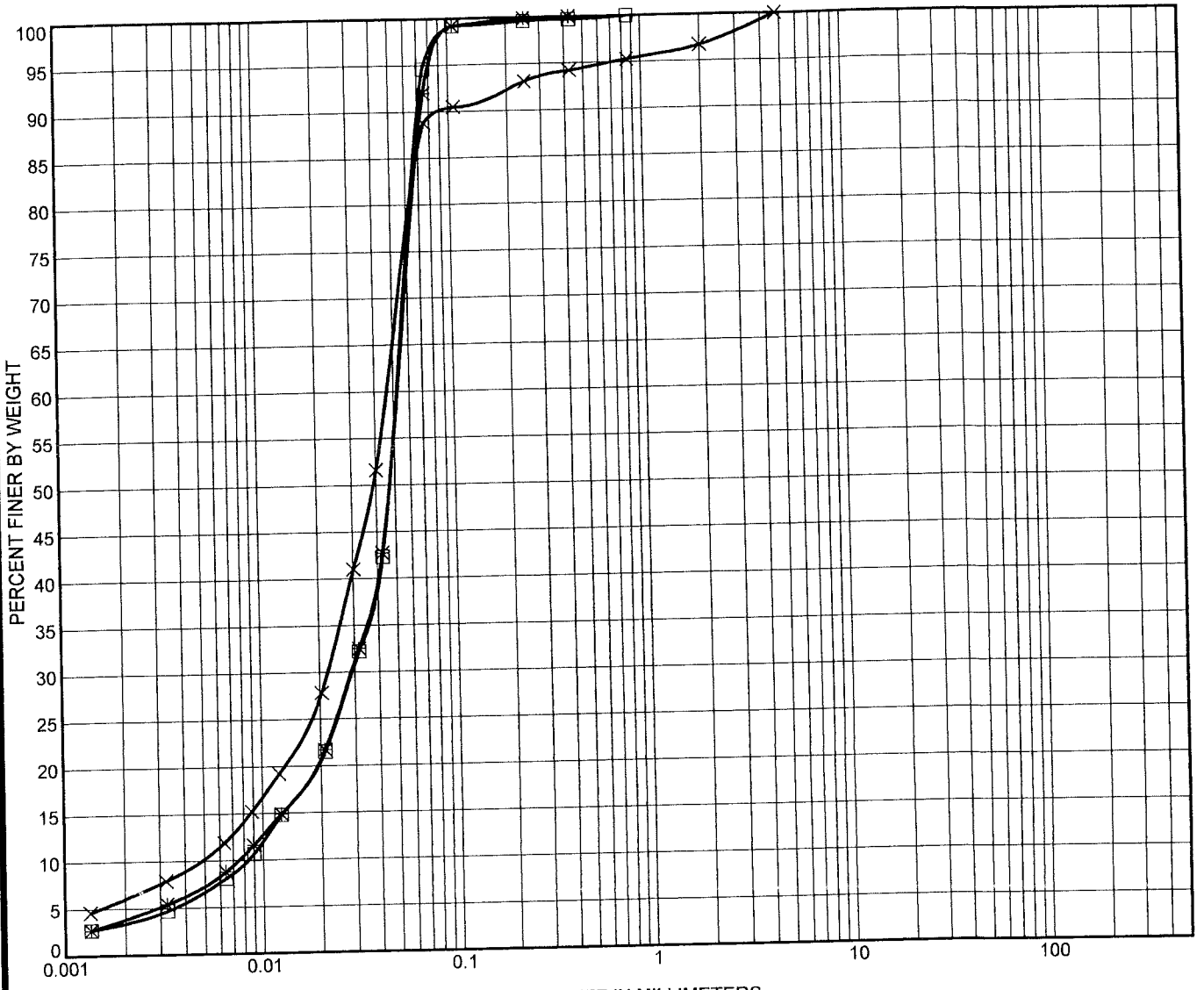
GRAIN SIZE DISTRIBUTION

Project:

Location:

Number:

ENCLOSURE 3



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:

Test Hole		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	2	13.72	0.85	0.052	0.029	0.008	0.0	5.4	94.6	
✳	3	12.19	0.425	0.052	0.029	0.007	0.0	8.0	92.0	
×	5	9.14	4.75	0.046	0.022	0.005	0.0	11.2	88.8	

TBT Engineering
314-101 Syndicate Ave. N
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

GRAIN SIZE DISTRIBUTION

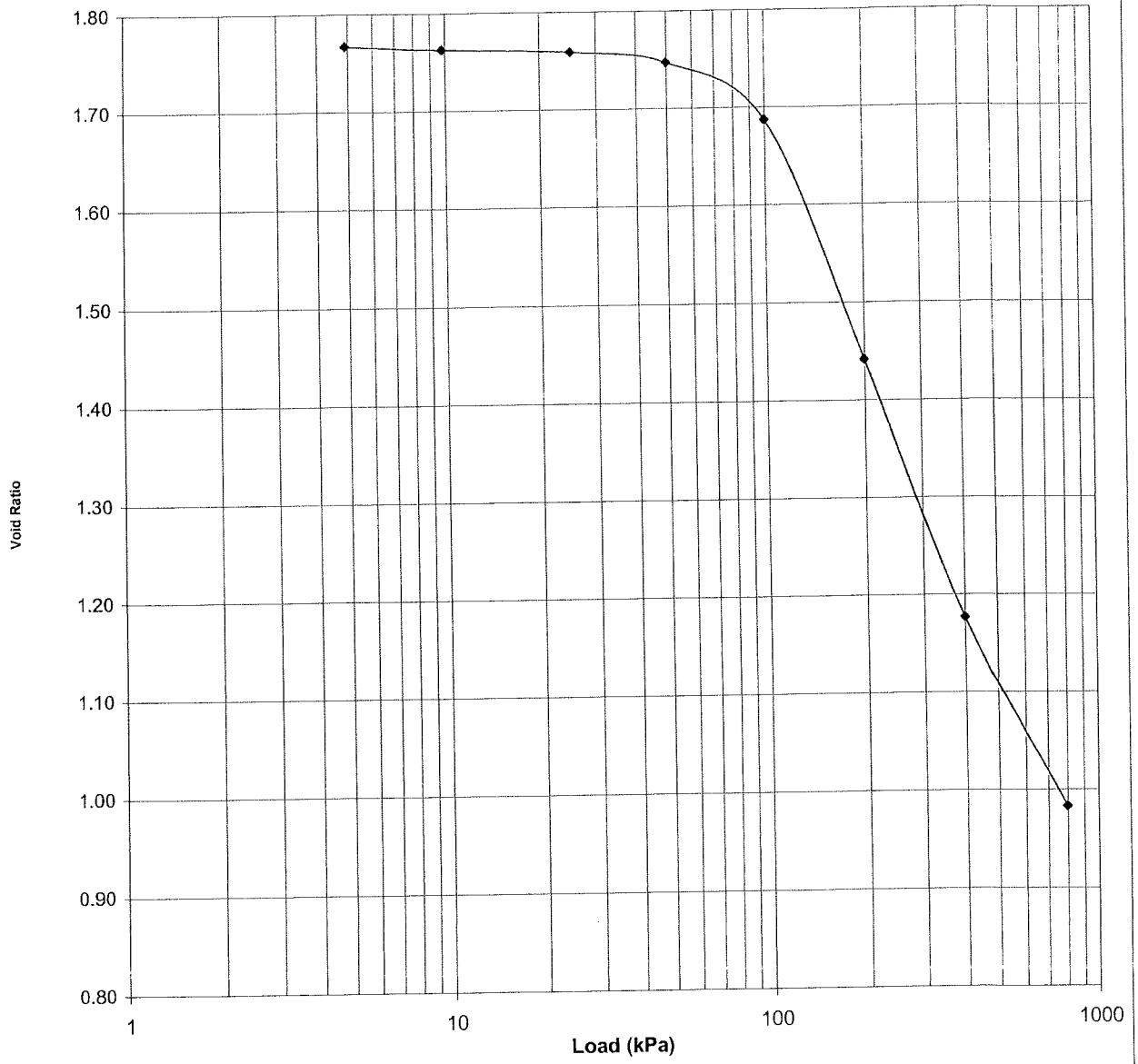
Project:

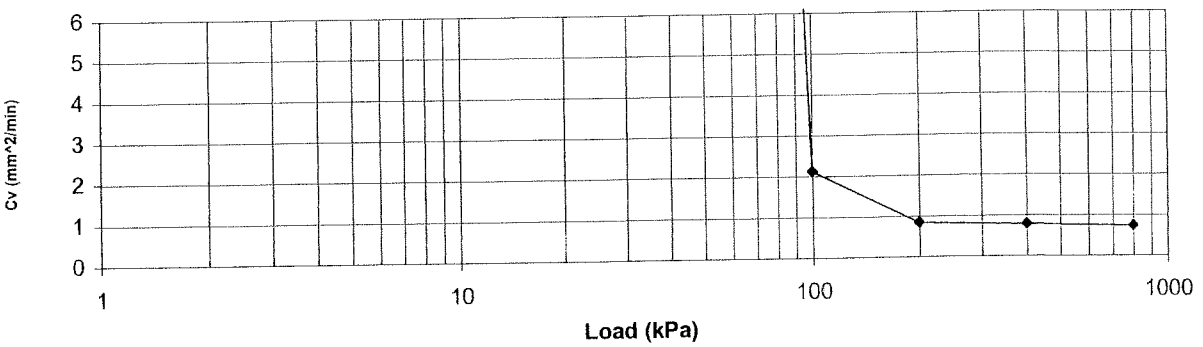
Location:

Number:

ENCLOSURE 4

MTO GS 05-101-1.GPJ CAN LAB.GDT 6/19/06



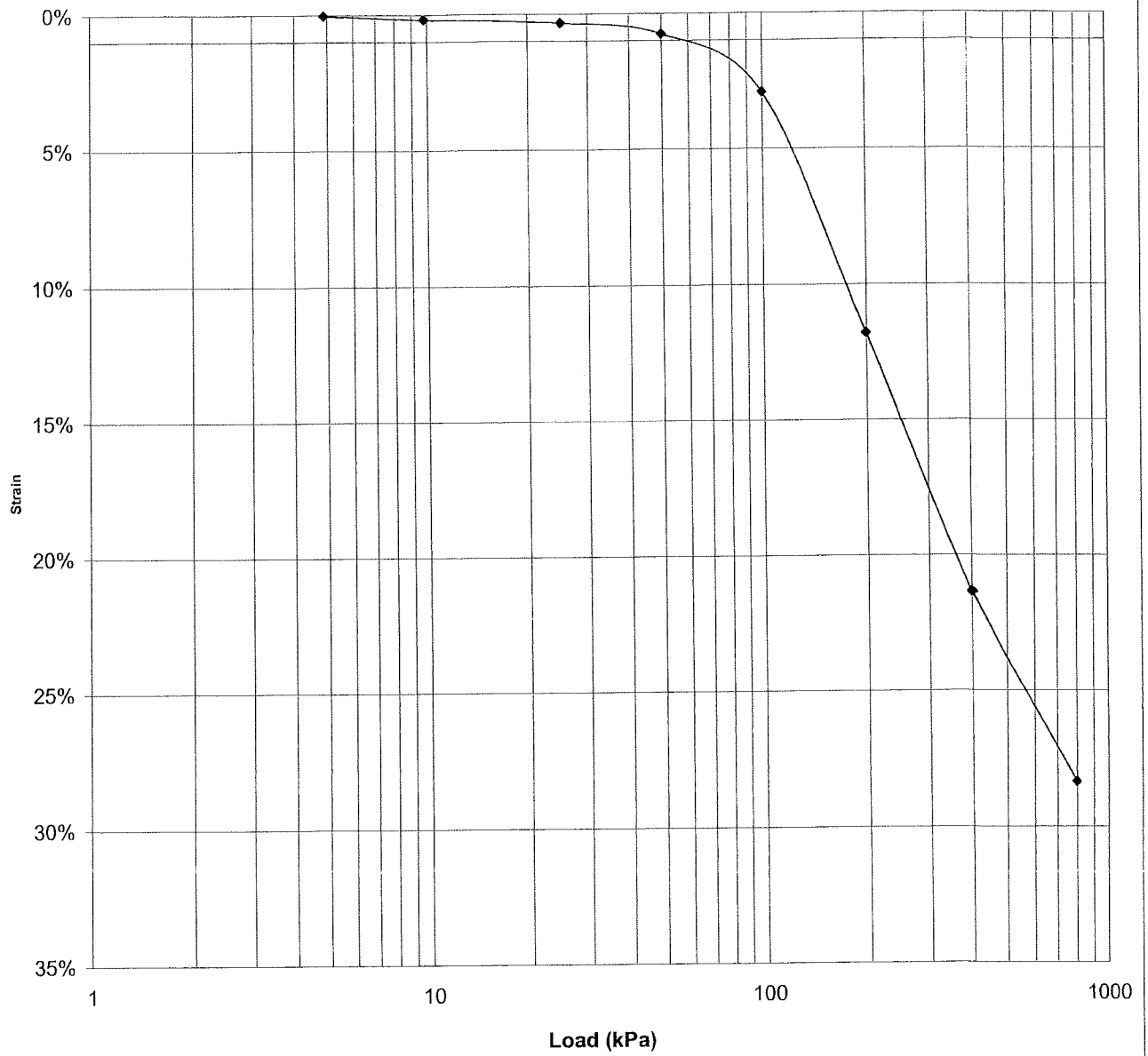


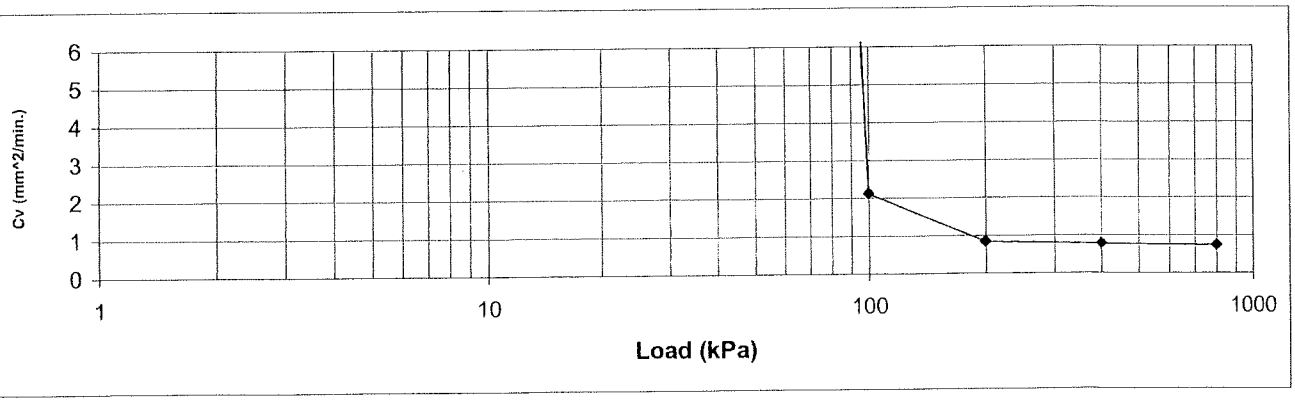
CONSOLIDATION TEST
Calstock

Borehole 2 Depth: 3.1 m Lab No. 06-293

Project No.: 05-101

Enclosure No.5



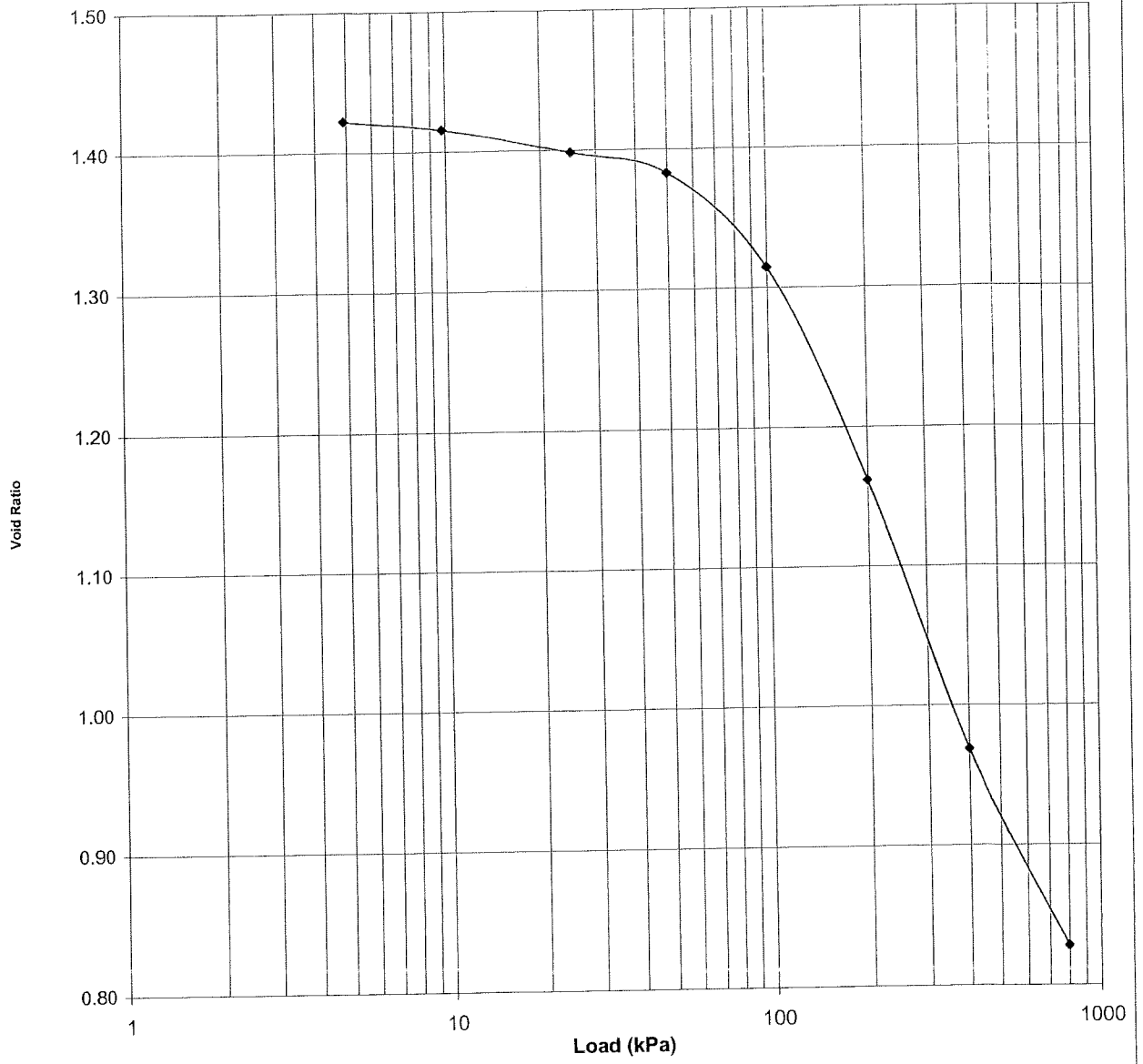


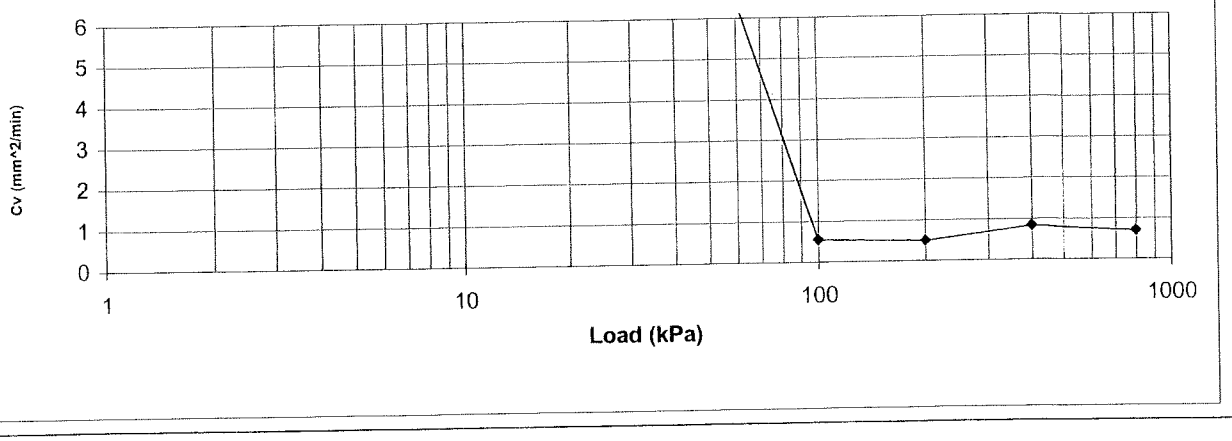
CONSOLIDATION TEST
Calstock

Project No.: 05-101

Borehole 2 Depth: 3.1 m Lab No.: 06-293

Enclosure No.6



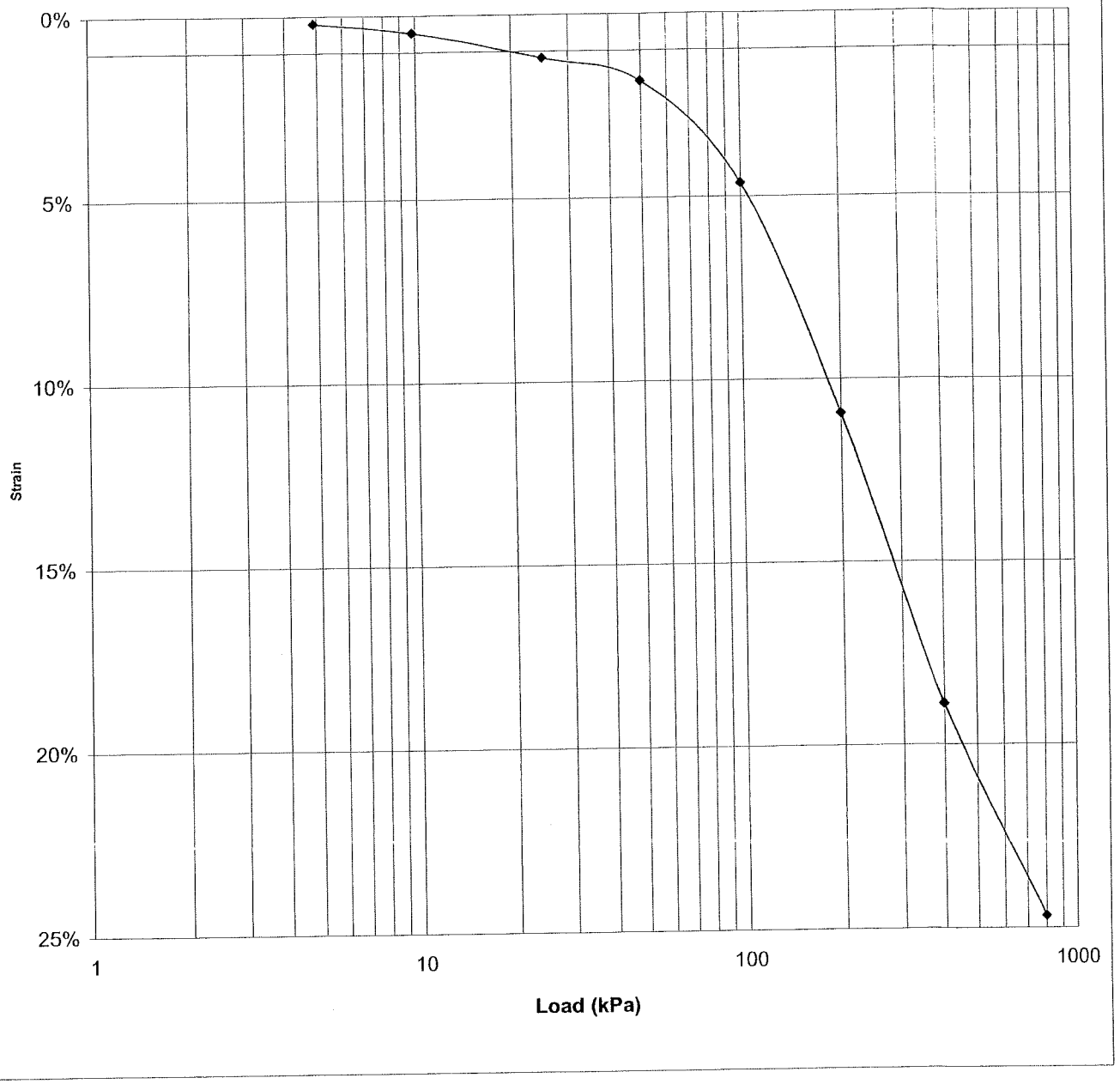


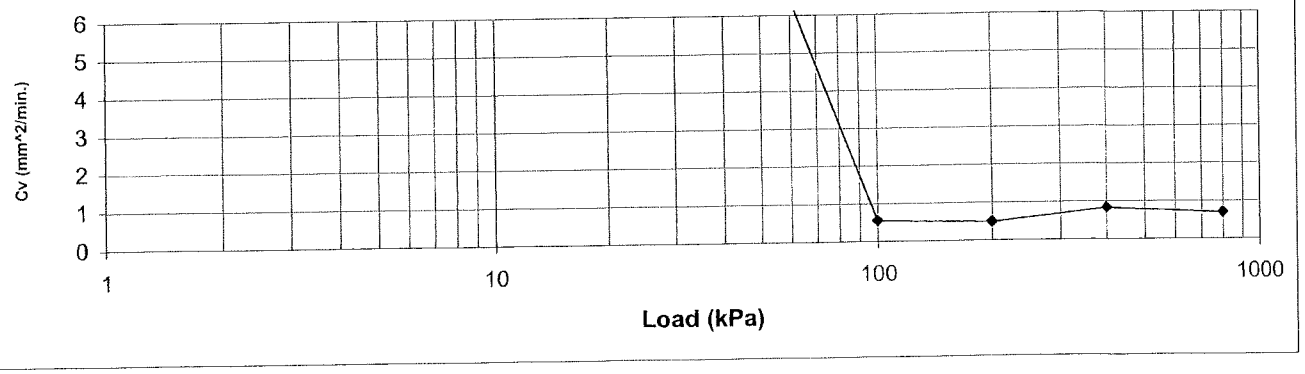
CONSOLIDATION TEST
Calstock

Borehole 3 Depth: 5.18 m Lab No. 06-310

Project No.: 05-101

Enclosure No.7





CONSOLIDATION TEST
Calstock

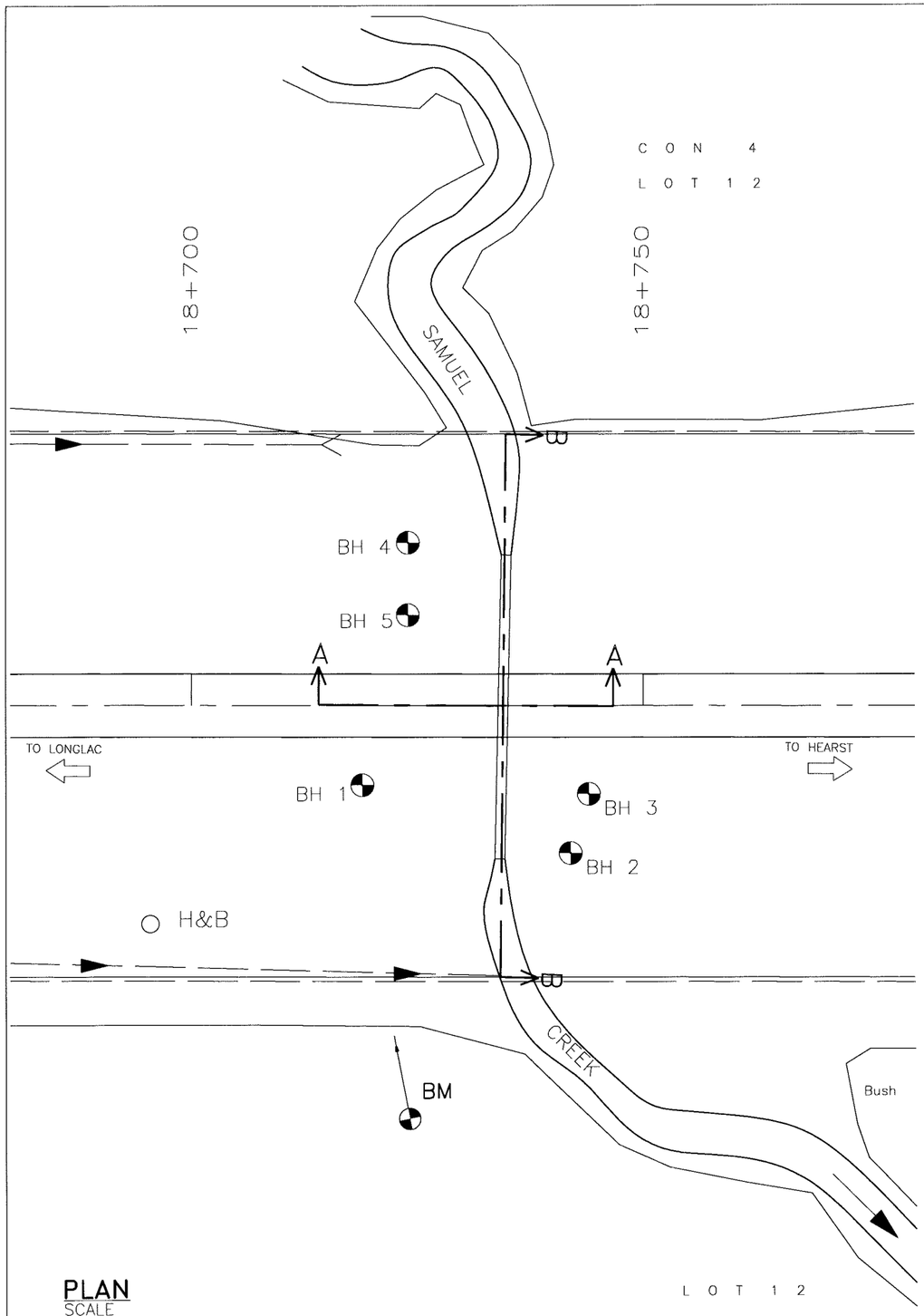
Project No.: 05-101

Borehole 3 Depth: 5.18 m Lab No.: 06-310

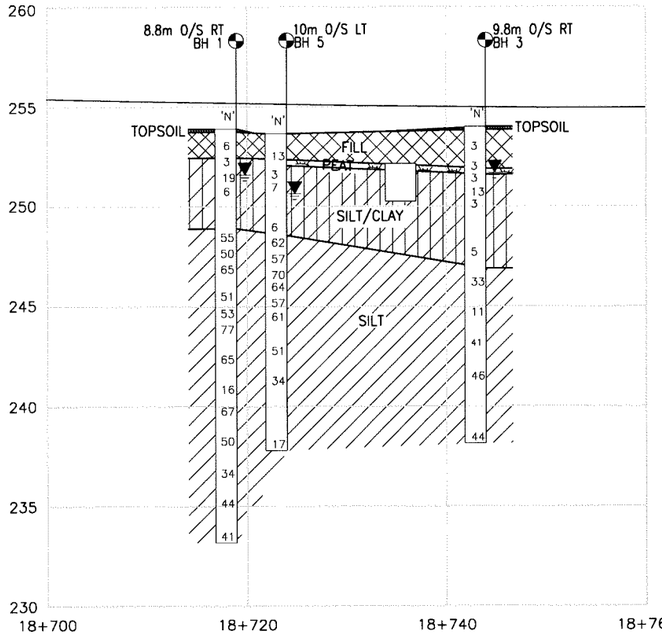
Enclosure No.8

APPENDIX C

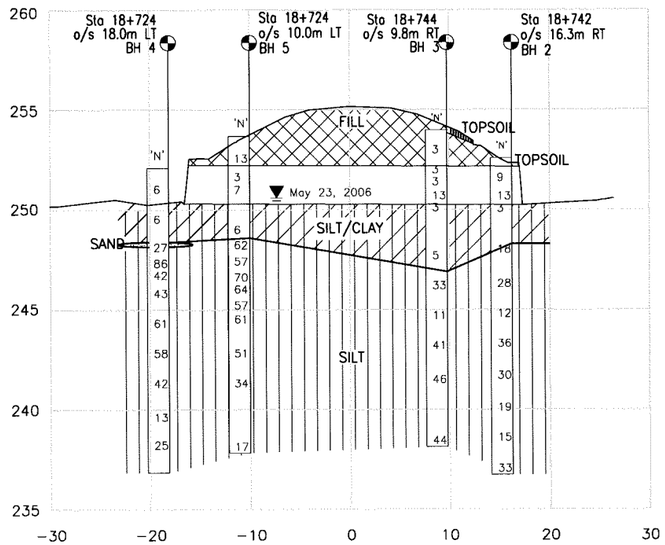
DRAWINGS AND FIGURES



PLAN
SCALE
0 2 4 6 8 10 20m



PROFILE A–A
SCALE
HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m



SECTION B–B
SCALE
HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m

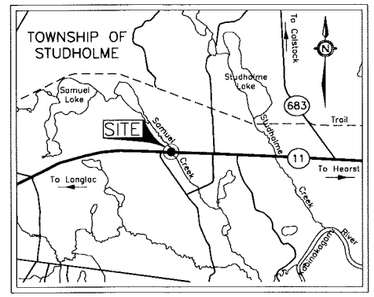
SECTION B–B REFERENCED FROM ENL SAMUEL–SECTIONS–MAY 23–2006.dwg.
PLAN & PROFILE REFERENCED FROM FILE 08470011018.jpg MAY 1988.

CONT No
GWP NO 146–98–00

SAMUEL CREEK CULVERT
HWY 11, 25km WEST OF HEARST
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
.

TBT ENGINEERING



KEY PLAN
1.0 km 0 1.0 km
SCALE 1:50,000

SOIL STRATA SYMBOLS
- TOPSOIL
- SILT
- PEAT
- FILL
- SILT/CLAY

LEGEND
- Borehole
- 'N' Std Pen Test (Blows/0.3m)
- WL at time of investigation April 2006

No	ELEVATION	STATION	OFFSET
1	253.9	18+719	8.8m RT
2	252.6	18+742	16.3m RT
3	254.0	18+744	9.8m RT
4	252.1	18+724	18.0m LT
5	253.7	18+724	10.0m LT

Borehole Elevations referenced from:

BM 252.764
TOP OF "T" RAIL
Sta 18+722.4, o/s 36.5RT
Elev. 252.764m Geodetic

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

REVISIONS

HWY 11 SAMUEL CREEK			DIST SUDHOLME
SUBM'D WH	CHECKED	DATE MAY 2006	SITE
DRAWN T.B	CHECKED	APPROVED	DWG