G.I.-30 SEPT. 1976

GEOCRES No. 31E-157

DIST. 52 REGION

W.P. No. 438-90-00

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 60

LOCATION Replacement of Culvert 6 & 7

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

GEOCRES #31E-157

FOUNDATION INVESTIGATION REPORT
REPLACEMENT OF
CULVERT 6 - STA 13+087
CULVERT 7 - STA 13+273
W.P. 438-90-00
HIGHWAY 60, DISTRICT 52, HUNTSVILLE

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November 30, 1998

PetoMacCallum Ltd.
CONSULTING ENGINEERS

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FOUNDATION INVESTIGATION REPORT

W.P. 438-90-00, Highway 60
District 52, Huntsville
REPLACEMENT OF CULVERT NO. 6 (STA 13+087)
REPLACEMENT OF CULVERT NO. 7 (STA 13+273)
TOWN OF HUNTSVILLE, DISTRICT MUNICIPALITY OF MUSKOKA

INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the construction of concrete box culverts to replace existing CSA culverts, located at two (2) separate sites on Highway 60, about 1 km east of Muskoka Road 3, in Huntsville, Ontario. The two sites are identified as Culvert 6 - Sta 13+087 and Culvert 7 - Sta 13+273 within W.P. 438-90-00.

The report presents the factual information obtained from the subsurface investigation pertaining to the structural foundation and related earthworks for the two (2) culverts.

SITE DESCRIPTION

The project is located in the Town of Huntsville, District Municipality of Muskoka on Highway 60, approximately 1 km east of Muskoka Road 3. This area is located within the Algonquin Highlands physiographic region which exhibits the irregular rock knob or ridge topography typical of the Canadian Shield. The rock ridges/knobs are generally exposed, or veneered with a thin overburden cover. Relatively low lying areas between rock ridges have been in-filled with glacial and post glacial sediments, including clay, silt, silty sand, sand and sand and gravel. Locally in areas of relatively poor drainage, swamp environments have resulted in the development of varying thicknesses of organic accumulations. Relatively recent alluvial deposits occur in association with stream and river courses.

Culvert 6 - Sta 13+087

The water course for the existing creek is about 2 m wide and typically 2 to 3 m lower than the adjacent roads. Commercial establishments are located on properties west of the site. The new culvert will be located west of the existing culvert and lengthened to accommodate widening of Highway 60, as well as to accommodate construction of the proposed connection to Matthew Drive. A number of underground services are located on both sides of the highway. A sanitary sewer crosses the highway about 10 m west of the culvert site.

Culvert 7 - Sta 13+273

The water course for the existing creek is about 1 m wide and enters Fairy Lake about 80 to 90 m south of the culvert. A commercial establishment is located southeast of the site. The new culvert will be located immediately east of the existing culvert.

INVESTIGATION PROCEDURES

Fieldwork

The fieldwork for this investigation was carried out during the period July 20 to 22, 1998, and comprised eight (8) boreholes drilled at the locations shown on Drawing 1. In general, access to the programmed borehole locations was limited by proximity to existing stream course, roadway embankment and/or underground utilities.

The boreholes were typically drilled to depths of 5.0 to 9.6 m below existing grade. One (1) borehole was advanced to refusal on assumed bedrock at 16.5 m depth. Dynamic Cone Penetration Tests were carried out at 5 of the boreholes, to depths of 7.6 to 23.2 m below existing grade.

The boreholes were advanced using continuous flight solid and hollow steam augers, powered by a track mounted CME-55 drillrig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Representative samples of the overburden were recovered at frequent depth intervals using a conventional split spoon sampler. Standard penetration resistance tests were conducted simultaneously with sampling operations to assess the strength characteristics of the substrata. Dynamic cone penetration tests were carried out adjacent to select boreholes to further assess the relative density of the soils. Insitu field vane tests were conducted to assess the undrained shear strength of cohesive soils. The groundwater conditions in the boreholes were closely monitored during the course of the fieldwork.

The location, ground surface elevation and clearance of underground utilities at each borehole was established in the field by Peto MacCallum Ltd.

Laboratory Analysis

All of the recovered samples were returned to our laboratory for detailed visual examination and classification. The following laboratory tests were carried out:

▸ 51 Natural Moisture Contents	Log of borehole Sheets
▸ 5 Grain Size Distribution	Figures 1 to 3
▸ 2 Atterberg Limits	Log of Borehole Sheets

SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Log of Boreholes sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration "N" values, undrained shear strength based on insitu field vane tests, dynamic cone penetration tests, laboratory moisture content and Atterberg Limit test results.

The plan and locations of the boreholes as well as cross sections showing the soil profiles are presented on Drawings 1 to 4, appended. A brief description of the distribution and characteristics of the various soil types is presented below.

Culvert 6 - Sta 13+074 (Boreholes 1 to 4)

The subsurface stratigraphy revealed at boreholes 1 to 4 generally comprised surficial fill and/or silt/sand alluvium over silty sand or silt and sand. The strata encountered are summarized below:

Fill

Fill or possible fill was contacted surficially at each borehole to depths of 0.9 to 2.1 m below existing ground surface. The material comprised brown to dark brown fine sandy silt with trace clay to silty fine sand with occasional cobbles. Standard penetration resistance "N" values ranged from 2 to 12 blows/0.3 m, indicating the relative density was very loose to compact.

Alluvium

Alluvium was contacted beneath the fill at boreholes 1, 3 and 4 to depths of 2.1 to 2.9 m. The material comprised brown to dark brown fine sandy silt to silty fine sand and was generally stratified, with occasional partings of fine leafy organics. The material was saturated, with water contents of 20 to 35%. Standard penetration resistance "N" values ranged from 2 to 8 blows/0.3 m indicating the relative density was very loose to loose.

Sand

A deposit of brown to grey silty fine sand was contacted beneath the fill and/or alluvium at boreholes 1 and 2 to depths of 3.8 and 3.6 m, respectively. The material was moist to saturated with water contents of 21 to 22%. Standard penetration resistance "N" values ranged from 2 to 4 blows/0.3 m indicating the relative density was very loose.

Silt/Sand

A major deposit of brown to dark brown or grey to dark grey fine sandy silt to silty fine sand or silt and sand was encountered beneath the alluvium and/or sand at each borehole to termination at depths of 5.0 to 9.6 m. Results of grain size distribution tests carried out on two (2) select samples are shown on Figure 1. The results indicate the samples comprise 44-47% sand and 53-56% silt. Standard penetration resistance "N" values typically ranged from 1 to 9 blows/0.3 m (one "N" value of 15) and the relative density was described as very loose to loose.

Dynamic Cone Penetration Test Results

Dynamic cone penetration tests were conducted at boreholes 1 and 4 to depths of 23.2 and 18.5 m, respectively.

At borehole 1, the test results indicated the relative density of the soils was very loose to loose, becoming compact to dense below 10 m depth, and very dense below 18 m.

At borehole 4, conditions ranged from very loose to compact, becoming compact to dense below 6 m, and very dense below 16 m, with refusal at 18.5 m.

Groundwater

Upon completion of augering, free water was encountered in each of the boreholes at depths of 1.5 to 2.5 m below existing grade (elevation 282.6 to 283.8). Stabilized levels are expected to be at/close to the existing creek level. Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns.

Culvert 7 - Sta 13+273 (Boreholes 5 to 8)

The subsurface stratigraphy revealed at boreholes 5 to 8 comprised surficial alluvium or silt (possible fill) over clay/silts and clays, underlain by sand/sand and gravel. The strata encountered are summarized below:

Alluvium

Alluvium was encountered surficially at boreholes 7 and 8 to depths of 4.4 and 5.4 m, respectively. The material typically comprised dark grey fine sandy silt with organic inclusions. Moisture contents ranged from 16 to 29%. The results of grain size distribution analyses carried out on a representative sample of the material are shown on Figure 2. The results indicate the sample comprises 13% sandand 87% silt. Standard penetration resistance "N" values typically ranged from 1 to 5 blows/0.3 m indicating the relative density was very loose to loose.

Silt

A deposit of brown to grey silt, some fine sand (described as possible fill) was contacted surficially at boreholes 5 and 6 to depths of 1.4 and 1.6 m, respectively. Moisture contents were variable ranging from 11 to 33%. Standard penetration resistance "N" values ranged from 8 to 16 blows/0.3 m indicating the relative density was loose to compact.

Clay/Silts and Clays

A deposit of grey clay with thin layers of silt to layered silt and clay was contacted beneath the surficial alluvium or silt deposits at each borehole. Boreholes 5 and 7 terminated within the deposit at depths of 5.0 and 5.5 m, respectively. At boreholes 6 and 8, the unit was fully penetrated at depths of 5.5 and 12.6 m, respectively.

The results of grain size distribution analyses carried out on two (2) representative samples of the material are shown on Figure 3. The results indicate the samples comprise 1-2% sand, 63-65% silt and 34-35% clay.

Atterberg Limit tests were carried out on two (2) representative samples of the material. The plastic and liquid limits were 22 and 30, respectively with corresponding plasticity index of 8 for both samples, indicting a clay of low plasticity. Moisture contents ranged from 22 to 42%, and were wetter than the plastic limit.

Standard penetration resistance "N" values typically ranged between 2 and 6 blows/0.3 m. Based on the results of insitu field vane tests, the undrained shear strength of the material ranges from 40 to 100 kPa (undisturbed values) and 15 to 60 kPa (remould value) with sensitivity of 2 to 4 indicating the consistency is firm to stiff.

Sand/Sand and Gravel

At boreholes 6 and 8, a deposit of brown to grey silty fine to coarse sand with some gravel to fine to medium sand and gravel, trace silt was contacted beneath the clay/silts and clays to termination of the boreholes at depths of 9.5 and 16.5 m, respectively. The material was saturated, with water contents of 8 to 15%. Standard penetration resistance "N" values ranged from 17 to 48 blows/0.3 m indicating the relative density was compact to dense.

Dynamic Cone Penetration Test Results

Dynamic cone penetration tests were conducted at boreholes 5, 6 and 8 to respective depths of 7.6, 9.3 and 16.0 m. At each borehole, the soils were very loose to loose, becoming compact below 5 to 6 m depth. At boreholes 6 and 8, the soil became dense to very dense below depths of 8 and 14 m, respectively.

Groundwater

Upon completion of augering, free water was observed in each of the boreholes at depths of 0.9 to 2.0 m below existing grade (elevation 281.6 to 283.4). Stabilized levels are expected to be at/close to the existing creek level. Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns.

CLOSURE

The fieldwork for this project was carried out under the supervision of Mr. M. Rapsey. The equipment used was supplied and operated by Master Soil Investigation Ltd. This report was prepared by Mr. J. F. Wright, B.Sc., reviewed by Mr. T. Lee-Bun, P.Eng., and approved by Mr. B. R. Gray, P.Eng.

Sincerely

PETO MacCALLUM LTD.

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Turney Lee-Bun, P.Eng.
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JFW/TLB/BRG:ga

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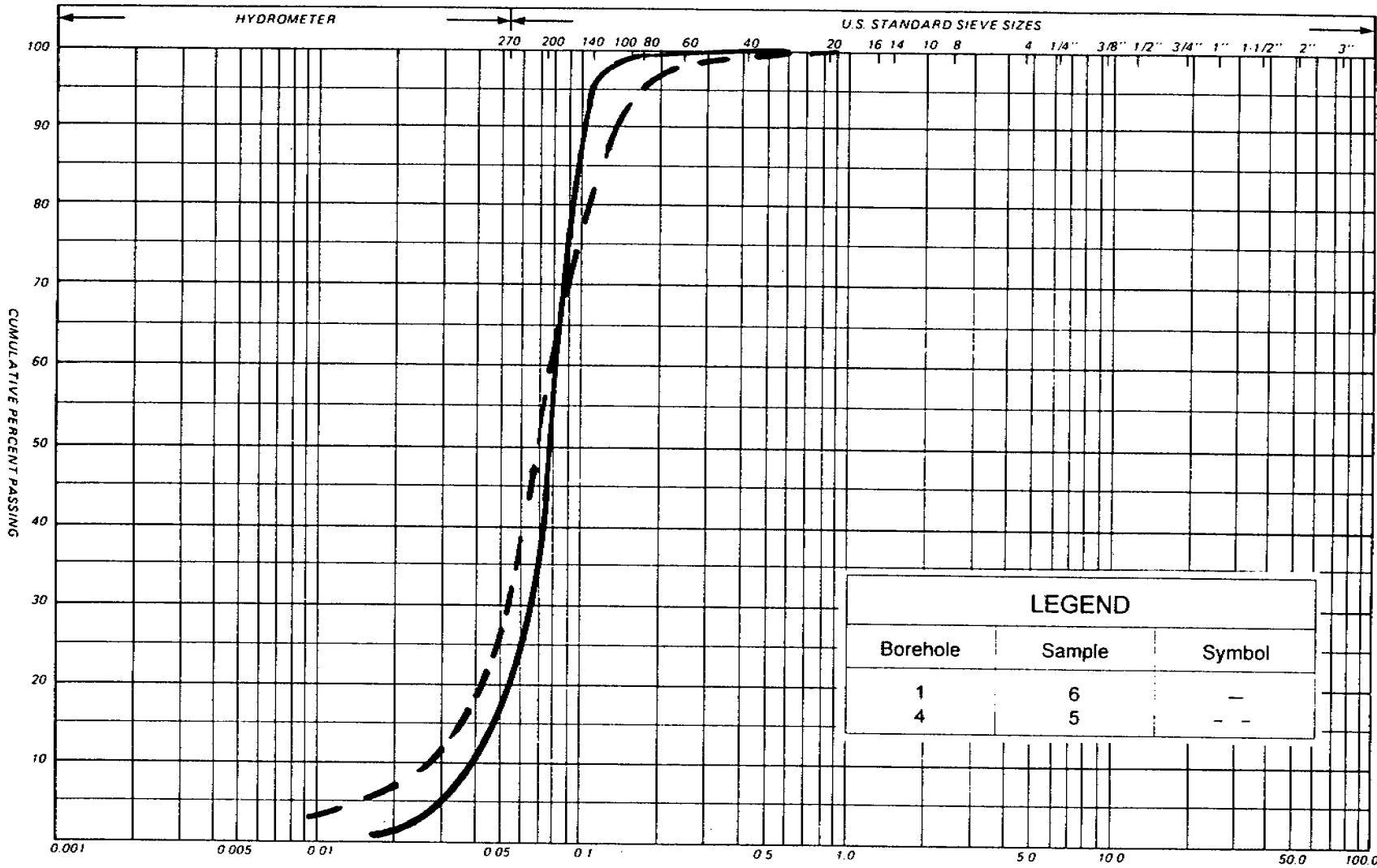
PARTICLE SIZE DISTRIBUTION CHART

FIGURE 1
W.P. 438-90-00
OUR PROJECT NO. 97 BF 027



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

REMARKS SILT AND SAND

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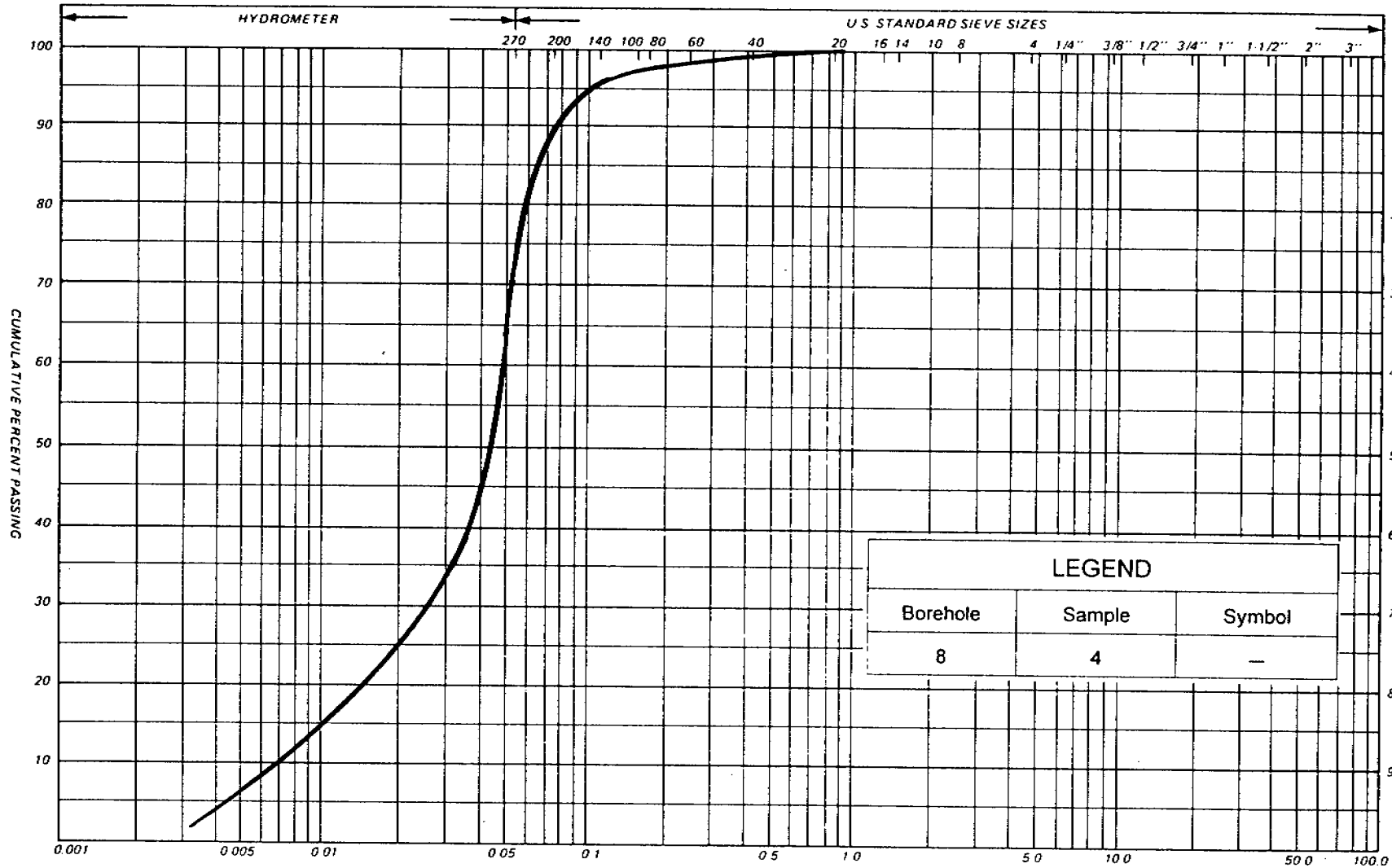
PARTICLE SIZE DISTRIBUTION CHART

FIGURE 2
W.P. 438-90-00
OUR PROJECT NO. 97 BF 027



REMARKS SILT WITH SAND

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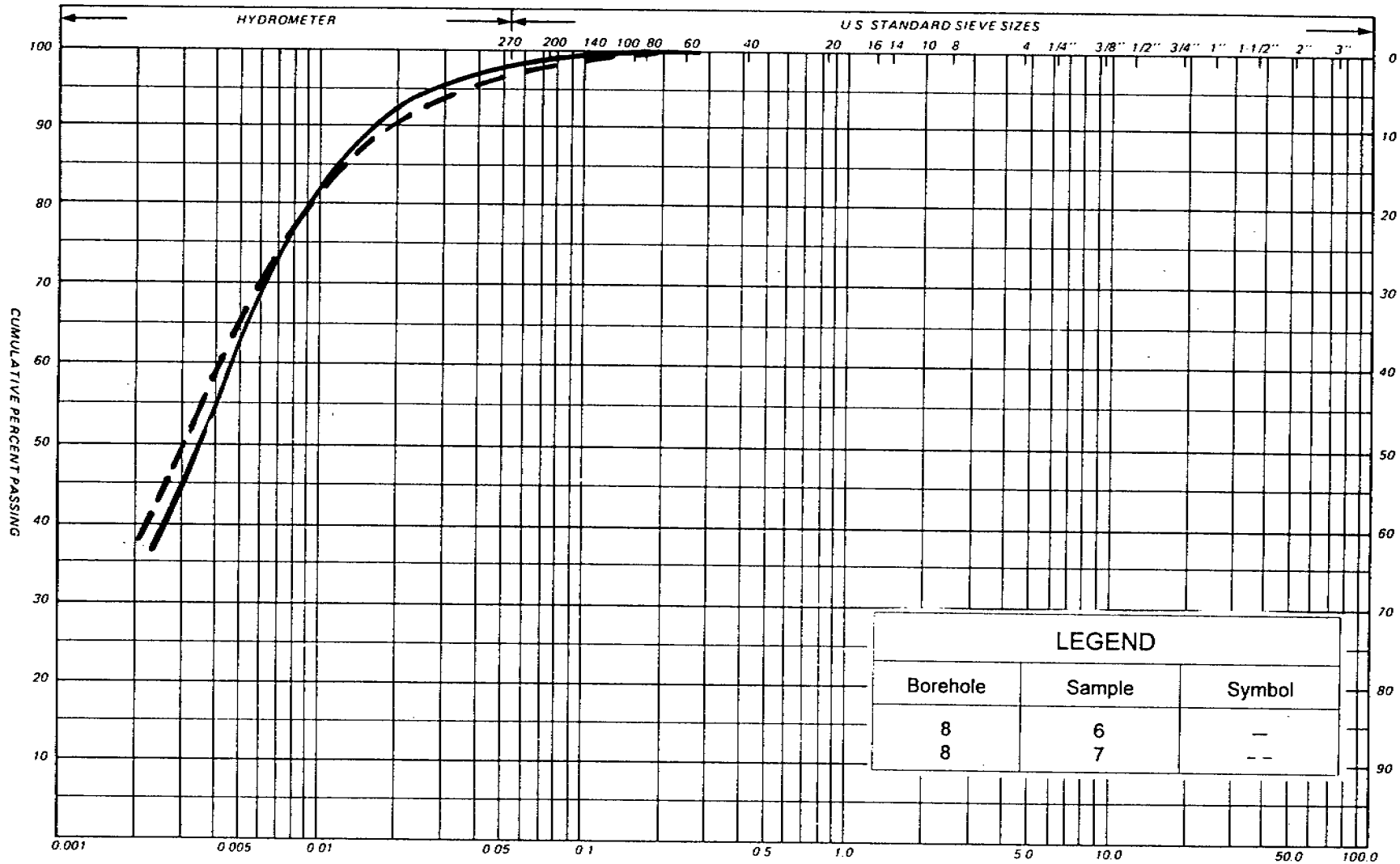
PARTICLE SIZE DISTRIBUTION CHART

FIGURE 3
W.P. 438-90-00
OUR PROJECT NO. 97 BF 027



REMARKS SILTY CLAY

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LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N'. - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 0.3m INTO THE SUBSOIL. DRIVEN BY MEANS OF A 63.5kg HAMMER FALLING FREELY A DISTANCE OF 0.76m.

DYNAMIC PENETRATION RESISTANCE: - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 51mm, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS. 0.3m INTO THE SUBSOIL. THE DRIVING ENERGY BEING 475J PER BLOW.

DESCRIPTION OF SOIL

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

CONSISTENCY	'N' BLOWS/0.3m	c kPa
VERY SOFT	0 - 2	0 - 12
SOFT	2 - 4	12 - 25
FIRM	4 - 8	25 - 50
STIFF	8 - 15	50 - 100
VERY STIFF	15 - 30	100 - 200
HARD	> 30	> 200

DENSENESS	'N' BLOWS/0.3m
VERY LOOSE	0 - 4
LOOSE	4 - 10
COMPACT	10 - 30
DENSE	30 - 50
VERY DENSE	> 50

W.T.P.L. WETTER THAN PLASTIC LIMIT
D.T.P.L. DRIER THAN PLASTIC LIMIT
A.P.L. ABOUT PLASTIC LIMIT

TYPE OF SAMPLE

S.S. SPLIT SPOON
W.S. WASHED SAMPLE
S.B. SCRAPER BUCKET SAMPLE
A.S. AUGER SAMPLE
C.S. CHUNK SAMPLE
S.T. SLOTTED TUBE SAMPLE
T.W. THINWALL OPEN
T.P. THINWALL PISTON
O.S. OESTERBERG SAMPLE
F.S. FOIL SAMPLE
R.C. ROCK CORE
P.H. SAMPLE ADVANCED HYDRAULICALLY
P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

Qu UNCONFINED COMPRESSION
Q UNDRAINED TRIAXIAL
Qcu CONSOLIDATED UNDRAINED TRIAXIAL
Qd DRAINED TRIAXIAL
L.V. LABORATORY VANE
F.V. FIELD VANE
C CONSOLIDATION

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LOG OF BOREHOLE NO. 1 (1 of 2)

PROJECT W.P.438-90-00, Highway 60, District 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 6, Highway 60, Huntsville, Ontario
LOCATION Station 13+074, 23.4 Rt. — ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 285.40				
	SILT FILL: Very loose brown fine sandy silt, trace clay, damp	285			
0.90					
	SILT/SAND ALLUVIUM: Loose brown to dark brown fine sandy silt to silty fine sand, damp to saturated	284	1	SS	3
1.5			2	SS	5
2.10					
	SAND: Very loose, brown to grey silty fine sand, saturated	283	3	SS	2
3.0					
		282	4	SS	2
3.80					
	SILT/SAND: Loose to very loose dark brown to dark grey fine sandy silt to silty fine sand, saturated	281			
4.5			5	SS	6
		280			
6.0					
		279	6	SS	3
7.5		278			
			7	SS	5
		277			
9.0					
		276	8	SS	2
9.60					
	BOREHOLE TERMINATED AT 9.60 m (2.1 m sand heave inside augers)	275			
10.5					
		274			
12.0					
		273			
13.5		272			
		271			
15.0					
15.00	(continued on next page)				

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M: 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT %: 10 20 30

INVERT EL. 282.7±

GROUNDWATER OBSERVATIONS AND REMARKS

* Upon completion of augering free water and cave at 1.60 m

NOTES

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CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 1 (2 of 2)

PROJECT W.P. 438-90-00, Highway 60, district 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 6, Highway 60, Huntsville, Ontario
LOCATION Station 13+074, 23.4 Rt. — ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N-VALUES	SHEAR STRENGTH C_u ▲ / DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ○ BLOWS/0.3M (20 40 60 80)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P W W_L) WATER CONTENT % (10 20 30)	GROUNDWATER OBSERVATIONS AND REMARKS
	GROUND ELEVATION 285.40								
	(continued from previous page)		270						
16.5			269						
			268						
18.0			267						
			266						
19.5			265						
21.0			264						
			263						
22.5									
	23.20						DYNAMIC CONE PENETRATION TEST TERMINATED AT 23.20 m		
24.0									
25.5									
27.0									

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LOG OF BOREHOLE NO. 2

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 6, Highway 60, Huntsville, Ontario
LOCATION Station 13+083, 28.0 Rt. — ENGINEER TLB
BORING METHOD Continuous Flight Solid Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 285.40					
	SAND: Loose, brown silty fine sand, occasional cobbles, damp (possible fill)		285			
				1	SS	8
1.5	1.65		284			
	SAND: Loose to very loose, brown to grey, silty fine sand, moist to saturated			2	SS	5
			283	3	SS	4
3.0				4	SS	3
	3.60		282			
	SILT/SAND: Very loose to loose, grey fine sandy silt, saturated			5	SS	2
4.5			281	6	SS	4
	5.00					
	BOREHOLE TERMINATED AT 5.00 m		280			
6.0			279			
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT % 10 20 30

INVERT EL. 282.7 ±

GROUNDWATER OBSERVATIONS AND REMARKS

▼* 2.40

* Upon completion of augering free water and cave at 2.40 m

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LOG OF BOREHOLE NO. 3

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 6, Highway 60, Huntsville, Ontario
LOCATION Station 13+082, 13.1 Lt. — ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 284.50				
	SAND FILL: Very loose, brown silty fine sand, moist	284			
			1	SS	2
1.5		283	2	SS	12
2.10	SAND ALLUVIUM: Loose, brown silty fine sand, stratified, saturated, with occasional partings of fine leafy organics	282	3	SS	8
2.90			4	SS	3
3.0	SILT/SAND: Very loose, dark grey fine sand, some silt, saturated	281	5	SS	4
4.5		280	6	SS	2
6.0		279	7	SS	1
7.5		278			
9.0		277			
9.10	BOREHOLE TERMINATED AT 9.10 m (2.7 m heave inside augers)	276			
10.5		275			
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M
20 40 60 80

(no recovery)
INVERT EL. 282.8±

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

▼*

* Upon completion of augering free water at 1.5 m

NOTES

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CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 4

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville
SITE Culvert No. 6, Highway 60, Huntsville, Ontario
OUR PROJECT NO. 98 BF 027
LOCATION Station 13+092, 14.4 Lt.
ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE July 20/22, 1998
TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 285.0					
	SAND FILL: Loose, dark brown silty fine sand, moist		284	1	SS	4
1.40						
1.5	SILT ALLUVIUM: Very loose sandy silt, wet		283	2	SS	2
				3	SS	2
2.90			282			
3.0	SILT/SAND: Loose to compact, brown silty fine sand, trace gravel, to silt and sand saturated			4	SS	9
			281	5	SS	15
4.5				6	SS	7
5.00			280			
	BOREHOLE TERMINATED AT 5.00m (suspect close to existing sewer)					
6.0			279			
			278			
7.5			277			
			276			
9.0						
			275			
10.5			274			
			273			
12.0						
			272			
13.5			271			
			270			
15.0						
			269			
18.0			268			

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M 20 40 60 80

(no recovery)
(no recovery)
INVERT EL. 282.8 ±

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT % 10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

* Upon completion of augering free water at 2.45 m

Dynamic Cone Penetration Test Terminated at 18.47 m

NOTES

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CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 5

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 7, Highway 60, Huntsville, Ontario
LOCATION Station 13+275, 23.5 Rt. — ENGINEER TLB
BORING METHOD Continuous Flight Solid Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 284.70				
	SILT: Compact brown silt, some fine sand, mottled dark brown (possible fill)	284	1	SS	16
1.40					
1.5	SILTS AND CLAYS: Layers of very loose to loose greyish brown silt, non-plastic and greyish brown to grey clay, W.T.P.L.	283	2	SS	11
		282	3	SS	3
3.0	3.20				
	becoming silt with clay layers		4	SS	2
		281	5	SS	5
4.5		280	6	SS	9
	5.00				
	BOREHOLE TERMINATED AT 5.00 m	279			
6.0		278			
7.5	7.60	277			
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT % 10 20 30

INVERT EL.282.8 ±

Dynamic Cone Penetration Test Terminated At 7.60 m

GROUNDWATER OBSERVATIONS AND REMARKS

▼* Upon completion of augering free water and cave at 2.00 m

NOTES

CHECKED BY

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 6

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 7, Highway 60, Huntsville, Ontario
LOCATION Station 13+263, 21.0 Rt. — ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 284.10					
	SILT: Loose grey silt some fine sand, trace clay, mottled brown		283	1	SS	8
1.60				2	SS	1
	SILTS AND CLAYS: Layers of very loose to loose grey silt, non-plastic, dilatent, wet, and soft grey clay, W.T.P.L.		282	3	SS	5
3.0			281	4	SS	4
4.5			280	5	SS	4
5.50				6	SS	4
	SAND: Compact, grey silty fine to coarse sand, some gravel, saturated		279			
6.0			278	7	SS	17
7.5			277	8	SS	24
9.0			276			
9.50			275	9	SS	86/200mm and bouncing
	BOREHOLE TERMINATED AT 9.50 m upon practical refusal to auger at 9.50 m		274			
10.5			273			
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ○
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT % 10 20 30

INVERT EL. 282.8±

100/125 mm

Dynamic Cone Penetration Test Terminated at 9.30 m

GROUNDWATER OBSERVATIONS AND REMARKS

* Upon completion of augering free water at 2.50 m cove at 3.0 m

NOTES

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CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 7

PROJECT W.P. 438-90-00, Highway 60, District 52, Huntsville
OUR PROJECT NO. 98 BF 027
SITE Culvert No. 7, Highway 60, Huntsville, Ontario
LOCATION Station 13+275, 14.5 Lt.
ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE July 20/22, 1998
TECHNICIAN MR

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES	SHEAR STRENGTH C_u kPa ▲ 25 50 75 100; DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ○ BLOWS/0.3M 20 40 60 80	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; W_P W W_L; WATER CONTENT % 10 20 30	GROUNDWATER OBSERVATIONS AND REMARKS
	GROUND ELEVATION 284.25								
	SILT ALLUVIUM: Very Loose dark grey fine sandy silt, moist, low organic		284						
			283	1	SS	2			▼ *
1.5				2	SS	1	INVERT EL.282.8±		
			282						
				3	SS	2			
3.0			281	4	SS	1	(no recovery)		
			280	5	SS	3	(no recovery)		
4.40									
4.5	CLAY: Firm, grey clay, W.T.P.L.			6	SS	5			
5.50			279		FV		△ ▲		
	BOREHOLE TERMINATED AT 5.50 m								* Upon completion of augering free water at 0.85 m
6.0									
7.5									
9.0									
10.5									
12.0									
13.5									
15.0									
16.5									

NOTES ▲/△ = Undisturbed/remoulded undrained shear strength based on insitu vane tests.

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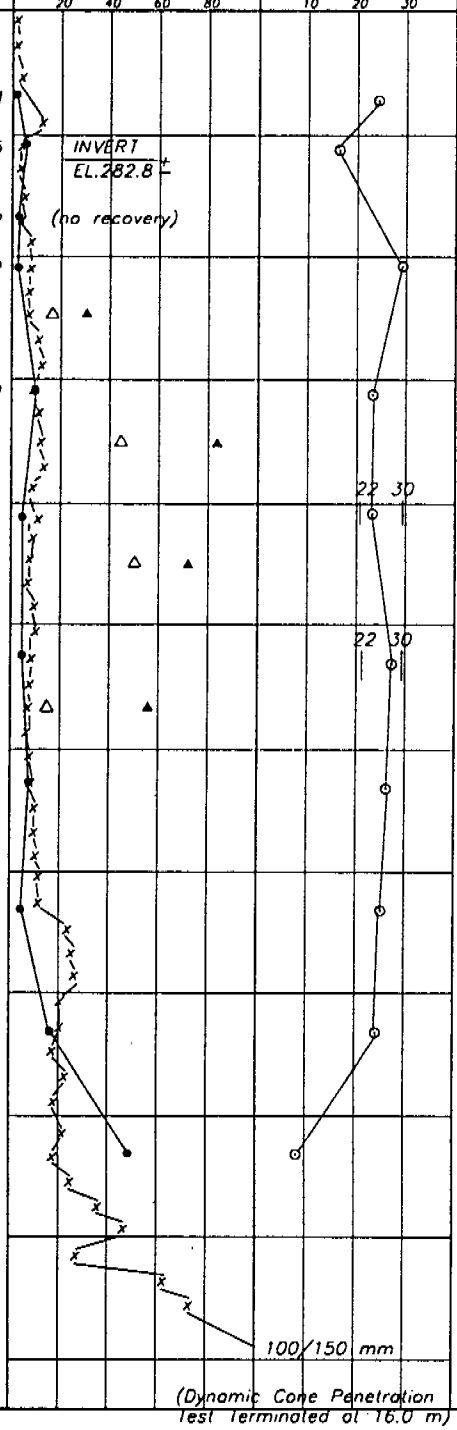
LOG OF BOREHOLE NO. 8

PROJECT W.P. 438-90-00, Highway 60, district 52, Huntsville — OUR PROJECT NO. 98 BF 027
SITE Culvert No. 7, Highway 60, Huntsville, Ontario
LOCATION Station 13_266, 13.5 Lt. — ENGINEER TLB
BORING METHOD Continuous Flight Hollow Stem Augers — BORING DATE July 20/22, 1998 — TECHNICIAN MR

GROUND ELEVATION 284.35

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	SILT ALLUVIUM: Very loose to loose dark grey, fine sandy silt, moist, low organic	284			
		283	1	SS	1
1.80	layer of very loose, brown silty fine to medium sand, saturated		2	SS	5
		282	3	SS	2
2.85		281	4	SS	2
				FV	
		280	5	SS	9
5.10	CLAY: Firm grey clay, W.T.P.L.	279		FV	
		278	6	SS	4
				FV	
		277			
			7	SS	4
8.70	with occasional thin lenses of silt	276		FV	
		275	8	SS	6
10.20	with numerous thin layers of silt	274			
		273	9	SS	4
11.70	becoming predominately silt, compact	272	10	SS	16
12.65	SAND AND GRAVEL: Dense brown fine to medium sand and sub-angular gravel, trace of silt, saturated	271			
		270	11	SS	48
	cobbles/boulders	269			
16.46	BOREHOLE TERMINATED UPON PRACTICAL REFUSAL TO AUGER AT 16.46 m	268			

SHEAR STRENGTH C_u kPa ▲ (25, 50, 75, 100)
DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ○
BLOWS/0.3M (20, 40, 60, 80)



LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT % (10, 20, 30)

(Dynamic Cone Penetration Test terminated at 16.0 m)

GROUNDWATER OBSERVATIONS AND REMARKS

* Upon completion of augering free water at 1.2 m

NOTES ▲/△ = Undisturbed/remoulded undrained sheor strength as determined by insitu vane tests.

CHECKED BY

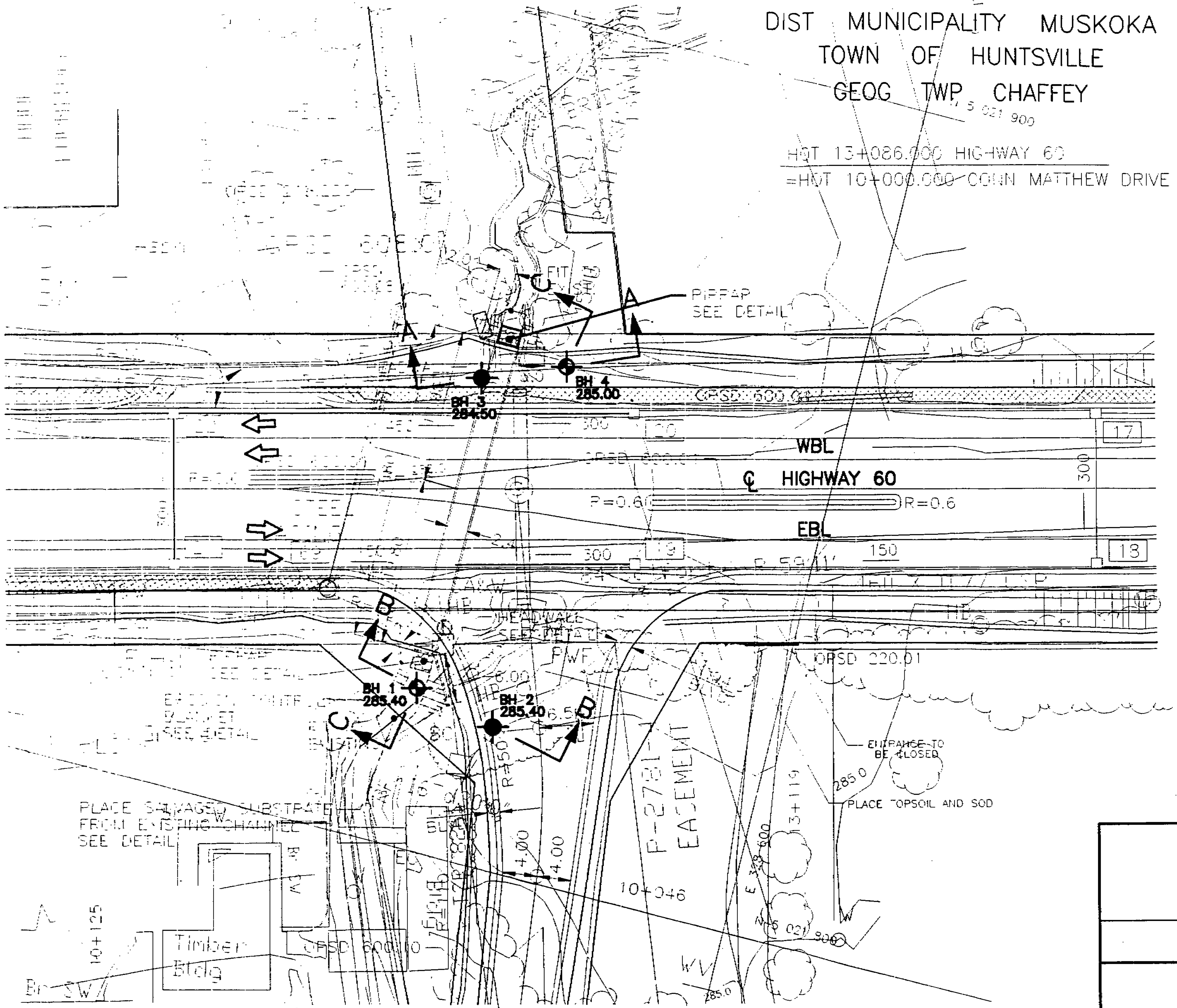
DIST MUNICIPALITY MUSKOKA
TOWN OF HUNTSVILLE
GEOG TWP CHAFFEY

METRIC

PLATE No
CONT No
WP No 438-90-00

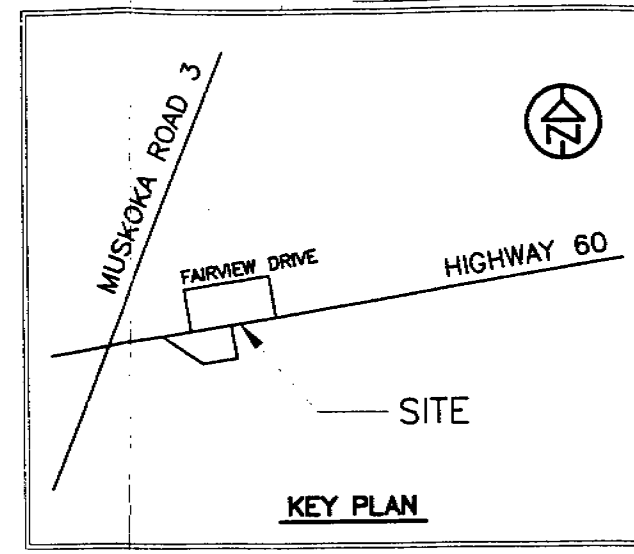
NEW CONSTRUCTION
STA TO STA
Survey SURVEYED Revised REVISED

SHEET



BOREHOLE LOCATION PLAN

SCALE 1:500



KEY PLAN

LEGEND

- BOREHOLE
- BOREHOLE & DYNAMIC CONE PENETRATION TEST

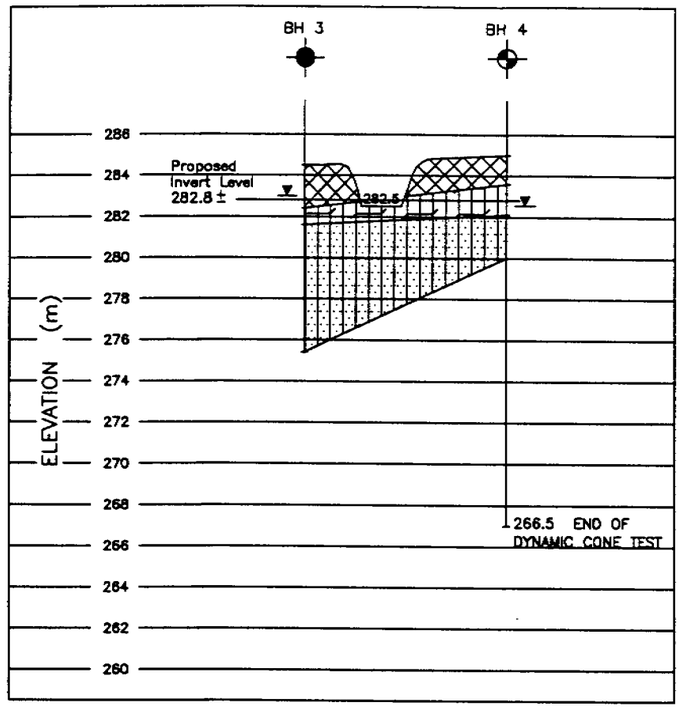
BOREHOLE	LOCATION		ELEVATION
BH 1	13+074	23.4 m Rt	285.40
BH 2	13+083	28.0 m Rt	285.40
BH 3	13+082	13.1 m Lt	284.50
BH 4	13+092	14.4 m Lt.	285.00

W. P. 438-90-00, HIGHWAY 60
DISTRICT 52, HUNTSVILLE
CULVERT NO. 6, HIGHWAY 60
HUNTSVILLE, ONTARIO

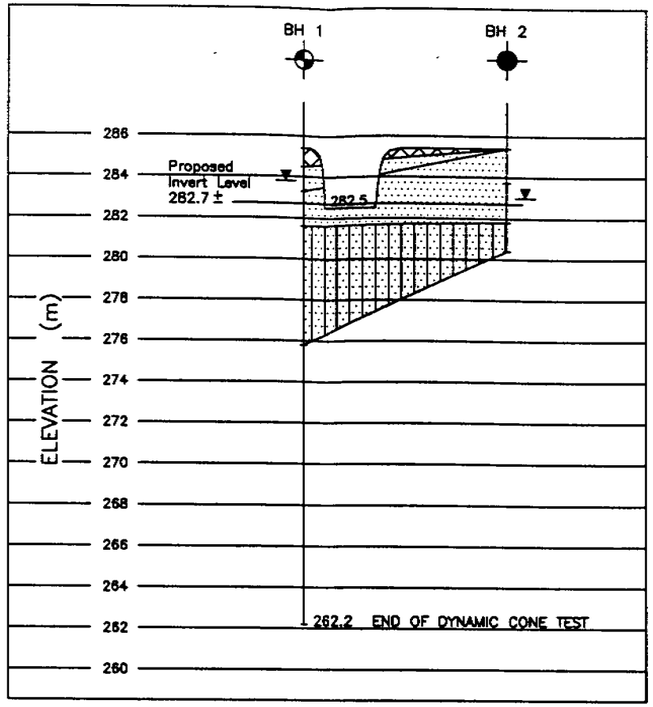
BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED	TLB	NOV. 24/98	1:500	98BF027	1
APPROVED	BRG				



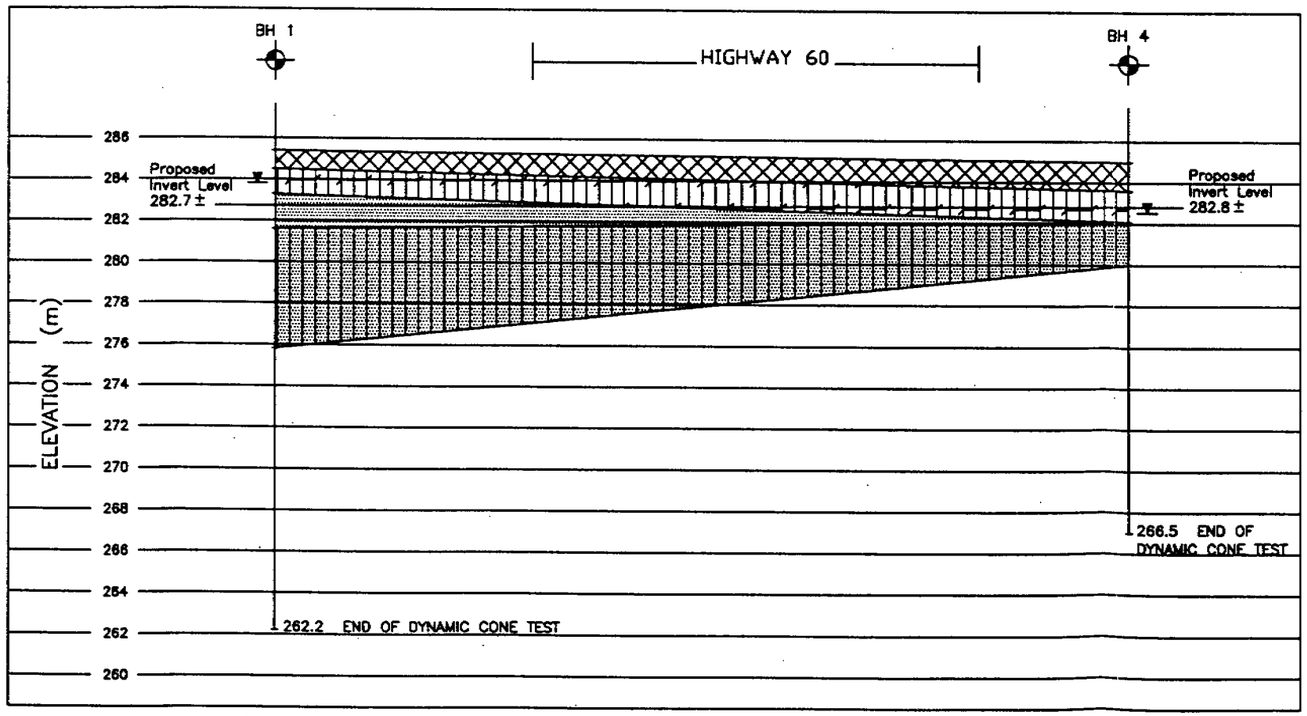
SECTION A–A



SECTION B–B

LEGEND

- BOREHOLE
- BOREHOLE & DYNAMIC CONE TEST
- FILL
- SILT ; SILT/SAND
- SILTS AND CLAYS
- SILT ALLUVIUM
- CLAY
- SAND
- SAND AND GRAVEL
- WATER LEVEL (UPON COMPLETION OF AUGERING IN BOREHOLES)



SECTION C–C

NOTES

1. REFER TO LOG OF BOREHOLE SHEETS FOR DETAILED SUBSURFACE CONDITIONS.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES, THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.

W. P. 438–90–00 HIGHWAY 60
DISTRICT 52, HUNTSVILLE
CULVERT NO. 6, HIGHWAY 60, HUNTSVILLE, ONTARIO

SECTIONS A–A B–B C–C

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED	TLB	NOV. 24/98	1:300	98BF027	2
APPROVED	BRG				

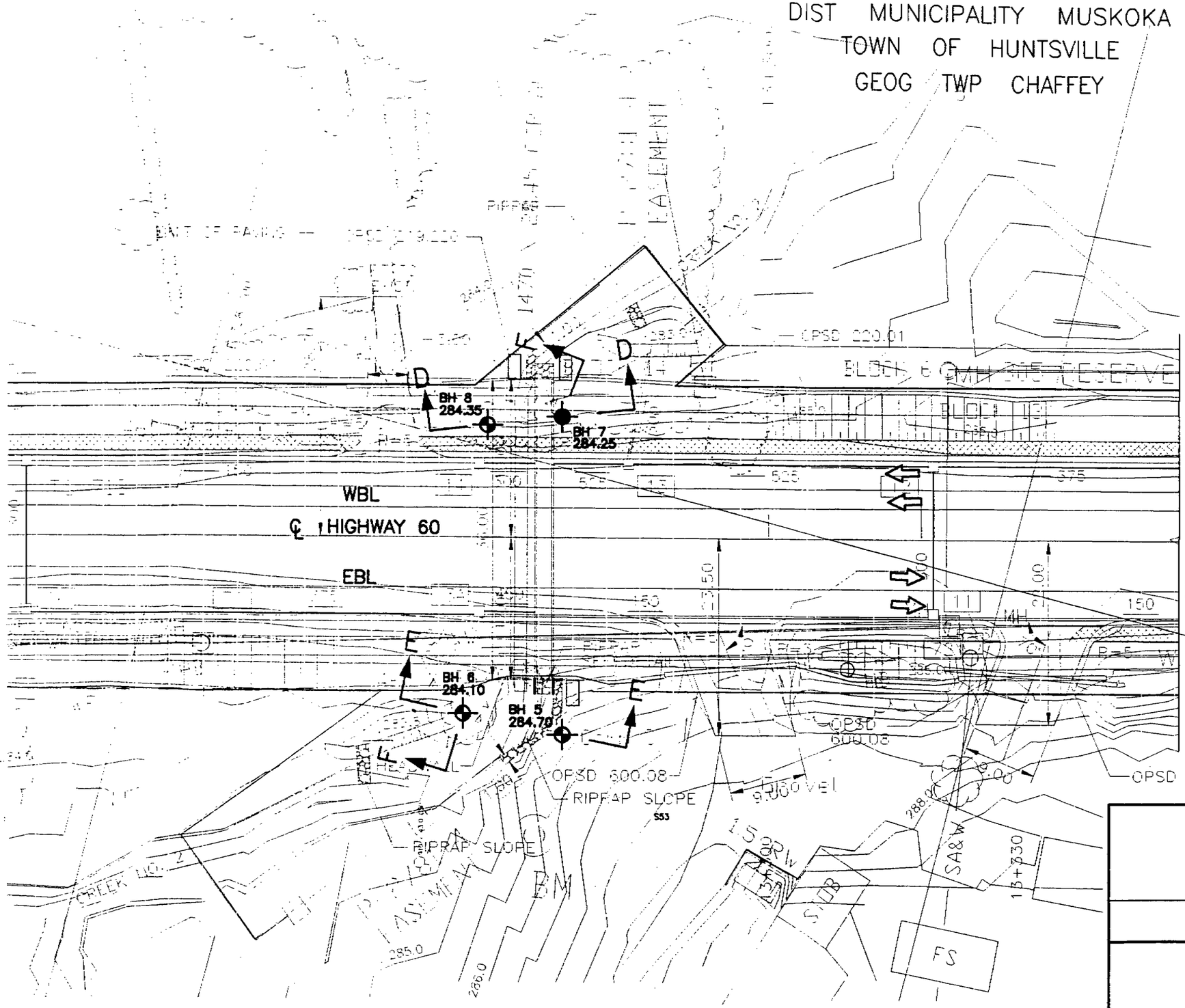
DIST MUNICIPALITY MUSKOKA
TOWN OF HUNTSVILLE
GEOG TWP CHAFFEY

METRIC

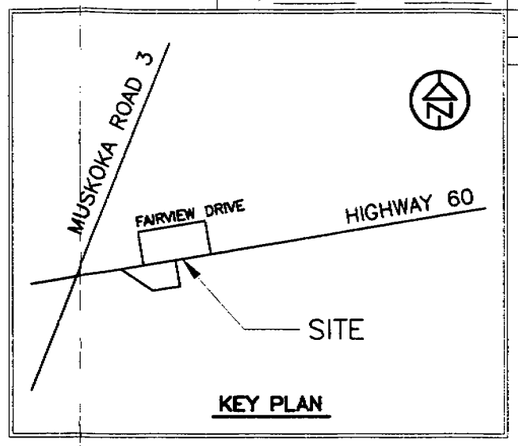
PLATE No
CONT No
WP No 438-90-00

NEW CONSTRUCTION
STA TO STA
Survey SURVEYED Revised REVISED

SHEET



BOREHOLE LOCATION PLAN
SCALE 1:500



KEY PLAN

LEGEND

- BOREHOLE
- BOREHOLE & DYNAMIC CONE PENETRATION TEST

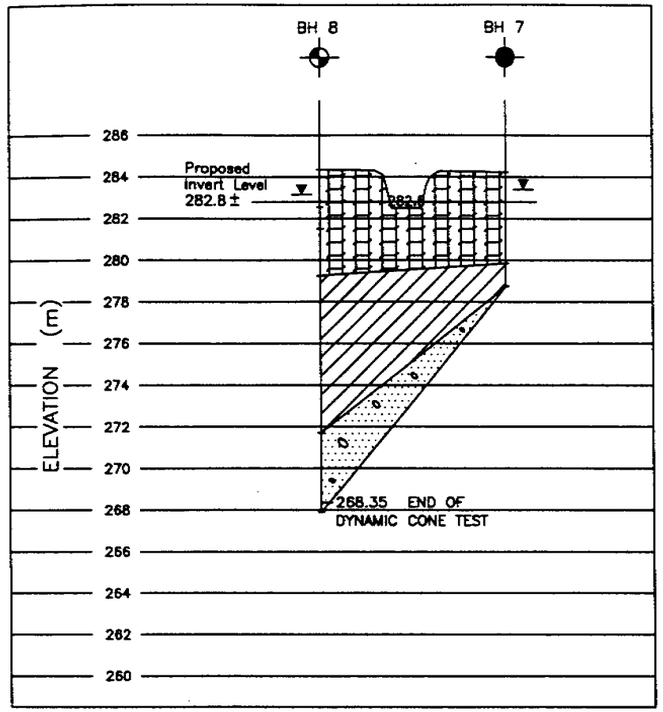
BOREHOLE	LOCATION		ELEVATION
BH 5	13+275	23.5 m Rt	284.70
BH 6	13+263	21.0 m Rt	284.10
BH 7	13+275	14.5 m Lt	284.25
BH 8	13+266	13.5 m Lt	284.35

W. P. 438-90-00, HIGHWAY 60
DISTRICT 52, HUNTSVILLE
CULVERT NO. 7, HIGHWAY 60
HUNTSVILLE, ONTARIO

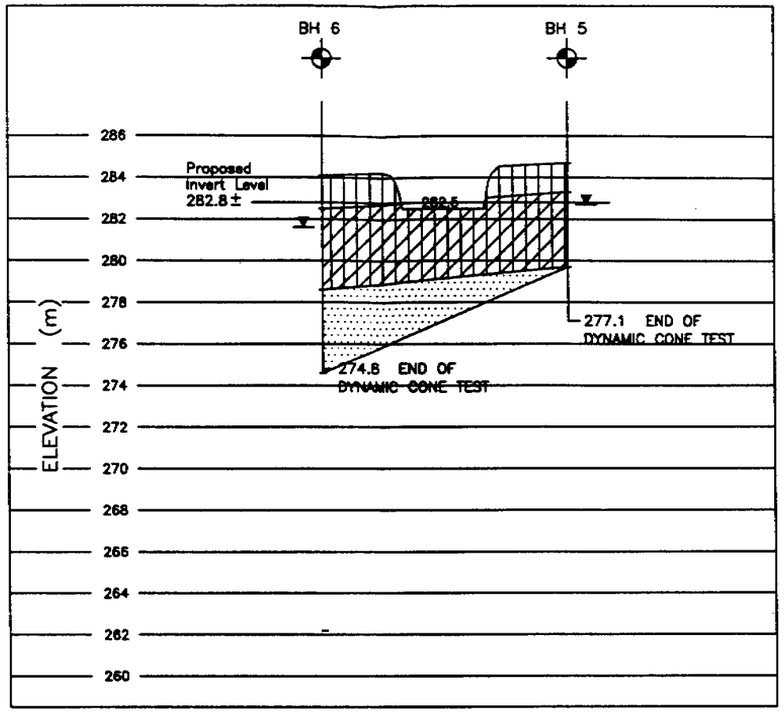
BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

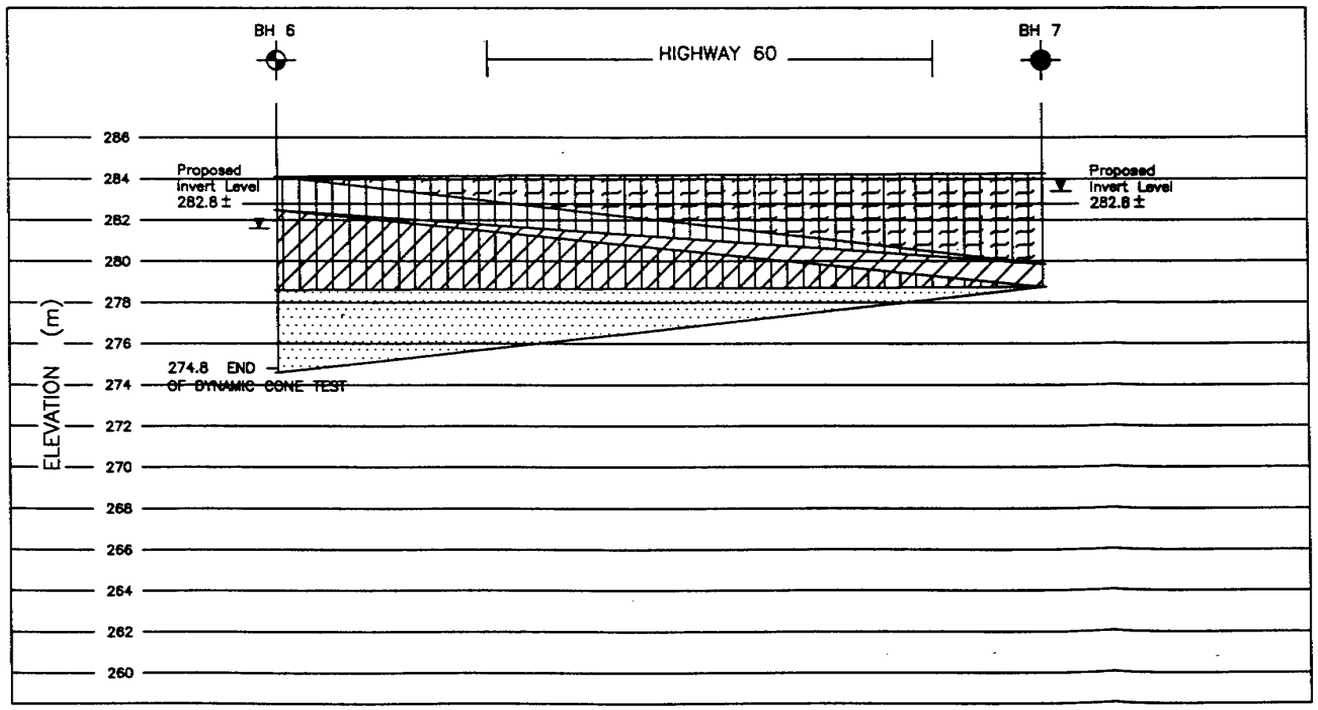
		DATE	SCALE	JOB NO.	DRAWING NO.
DRAWN	CB	NOV. 24/98	1:500	98BF027	3
CHECKED	TLB				
APPROVED	BRG				



SECTION D–D



SECTION E–E



SECTION F–F

LEGEND

- BOREHOLE
- BOREHOLE & DYNAMIC CONE TEST
- FILL
- SILT
- SILTS AND CLAYS
- SILT ALLUVIUM
- CLAY
- SAND
- SAND AND GRAVEL
- WATER LEVEL (UPON COMPLETION OF AUGERING IN BOREHOLES)

NOTES
1. REFER TO LOG OF BOREHOLE SHEETS FOR DETAILED SUBSURFACE CONDITIONS.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES, THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.

W. P. 438–90–00 HIGHWAY 60
DISTRICT 52, HUNTSVILLE
CULVERT NO. 7, HIGHWAY 60, HUNTSVILLE, ONTARIO

SECTIONS D–D E–E F–F

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED	TLB	NOV. 24/98	1:300	98BF027	4

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION DESIGN REPORT
REPLACEMENT OF
CULVERT 6 - STA 13+087
CULVERT 7 - STA 13+273
W.P. 438-90-00
HIGHWAY 60, DISTRICT 52, HUNTSVILLE

DISTRIBUTION:

2 cc: McCormick Rankin Corporation
1 cc: PML Barrie
1 cc: PML Toronto

PML REF: 98 BF 027

November 30, 1998

PetoMacCallum Ltd.
CONSULTING ENGINEERS

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FOUNDATION DESIGN REPORT

W.P. 438-90-00, Highway 60
District 52, Huntsville
REPLACEMENT OF CULVERT 6 - STA 13+087
REPLACEMENT OF CULVERT 7- STA 13+273
TOWN OF HUNTSVILLE, DISTRICT MUNICIPALITY OF MUSKOKA

INTRODUCTION

This report provides geotechnical comments and recommendations regarding design of foundations and earthworks required for the proposed replacement of the noted culverts. The recommendations are based on factual information presented in the Foundation Investigation Report for the project, presented under separate cover.

Culvert 6 - Sta 13+087 will comprise a 37 m long 1.8 by 2.4 m concrete box structure with head/wing walls up to 3.0 m high required at both the inlet and outlet. The invert of the culvert will be about elevation 282.7, some 3.8 m below proposed final grade.

The subsurface stratigraphy revealed at boreholes 1 to 4, in the vicinity of Culvert 6, typically comprised surficial fill and/or silt/sand alluvium over silty sand or silt and sand to termination at depths of 5.0 to 9.6 m. The relative density of these soils was typically very loose to loose. Dynamic cone penetration tests indicated the soil becomes compact to dense below depths of 6 to 10 m and very dense below depths of 16 to 18 m.

Culvert 7 - Sta 13+273 will comprise a 35 m long 1.2 by 1.8 m concrete box structure with 3 m high head wall required at the outlet. The invert of the culvert will be about elevation 282.8, some 4.0 m below proposed final grade.

The subsurface stratigraphy revealed at boreholes 5 to 8, in the vicinity of Culvert 7, typically comprised surficial alluvium or silt (possible fill) over clay/silts and clays underlain by sand/sand and gravel. Dynamic cone penetration tests indicated the soils were very loose to loose becoming compact below 5 to 6 m depth and very dense below 8 to 14 m depth.

FOUNDATIONS

Spread Footings

At both sites, very loose soil conditions in combination with the groundwater table at/above the proposed founding level were encountered at shallow depth. We do not recommend the use of conventional spread footings, for the following reasons:

- soil strength parameters are less than minimum required for rational design;
- there is a potential for settlements to exceed 25 mm even under very low loads;
- difficulties associated with establishing and maintaining a stable subgrade during construction.

Piles

Based on the borehole information, it is considered feasible to support the box culverts and associated head walls/wing walls on a deep foundation system involving pipe piles. Two alternate schemes are presented for your consideration.

Low to Medium Resistance Piles

The piles should be driven to an adequate set, at least 1.5 m into the very dense soil anticipated at/below the following elevations:

Location	Top of Very Dense Soil (Elevation)	Pile Length * (m)
Culvert 6		
South End	267	14.7
North End	269	12.7
Culvert 7		
South End	275	6.7
North End	268	13.7

* Assumes top of pile is at elevation 281.7, about 1 m below invert level.

Factored pile resistance at the ultimate limit state for selected pile sections are presented below. These values were obtained by determining the ultimate geotechnical resistance based on static analysis, and applying a resistance factor of 0.4. The geotechnical resistance at serviceability limit states allows for 25 mm of compression of the pile founding medium. Design will be governed by SLS.

Pipe Pile Section	Factored Resistance at ULS (kN)	SLS (kN)
273 x 9.5	216	180
324 x 9.5	297	247
356 x 9.5	366	305

The piles should be driven closed ended. Based on the conditions at the boreholes, driving shoes should not be required.

The required set should be determined when pile size and type of driving equipment have been selected.

High Resistance Piles

The piles should be driven to practical refusal in the very dense sand and gravel, or on bedrock which is anticipated at/below the following elevations:

Location	Inferred Bedrock (Elevation)	Pile Length * (m)
Culvert 6		
South End	262	19.7
North End	266	15.7
Culvert 7		
South End	274	7.7
North End	268	13.7

* Assumes top of pile is at elevation 281.7, about 1 m below invert level.

If this alternative is considered to be a feasible option, additional drilling, involving coring should be carried out to confirm the bedrock elevation and quality.

Factored pile resistance at the ultimate limit state for selected pile sections are presented below. The values were obtained by applying a geotechnical resistance factor of 0.55 to ultimate structural resistance of the pile section. A yield strength of 300 Mpa is assumed for the steel.

Based on previous experience, the ultimate geotechnical resistance exceeds the structural resistance of the pile section under consideration when driven to practical refusal on bedrock in this area. The geotechnical resistance factor depends on the method of analysis and confidence level and ranges from 0.4 to 0.6 for deep foundations in axial compression. For this case, for piles driven to bedrock, a higher end value is considered appropriate, subject to the results of bedrock coring.

Pipe Pile Section	Factored Capacity at ULS (kN)
273 x 9.5	1300
324 x 9.5	1550
356 x 9.5	1700

The capacity at serviceability states normally allows for 25 mm of compression of the pile founding medium. Considering the bedrock to be non-yielding, the design is not expected to be governed by settlement since the loading required to produce deformation of the pile will be much larger than the factored capacity at ULS.

The installation operations should be inspected on a full-time basis by qualified geotechnical personnel to confirm the toe elevation, driving resistance, alignments, plumbness, uniformity of set, and quality of splices.

Pile caps should be provided with the normal 1.6 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

RETAINING WALLS

The head walls and wing walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral pressure, p, may be computed using the equivalent fluid pressures presented in Section 6-7.4.4 of the Ontario Highway Bridge Design Code, 3rd Editions, 1991 (OHBDC) or employing the following equation, assuming a triangular pressure distribution:

$$P = K(\gamma H + q)$$

Where K = coefficient of lateral earth pressure

γ = unit weight of free draining granular material

H = depth below final grade (m)

q = surcharge load (kPa), if present

Free draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	Granular 'A'	Granular 'B'
Angle of Internal Friction	35	32
Unit Weight (kN/m^3)	22.8	21.2
Active Earth Pressure (Ka)	0.27	0.31
At Rest Earth Pressure Coefficient (K_0)	0.43	0.47
Passive Earth Pressure Coefficient (K_p)	3.69	3.25

A weeping tile system and/or weeping hole should be installed to minimise the build up of hydrostatic pressure behind the wall. The weeping tile should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on positive grade and lead to a frost free outlet.

EXCAVATION AND GROUNDWATER CONTROL

Excavation for construction of pile caps, is expected to be carried out primarily within sand or silt fill, sand/silt alluvium or native sand. Excavation of these materials should be relatively straightforward using conventional equipment.

The in situ materials are classified as Type 3 soils according to the Occupational Health and Safety Act criteria. Temporary cut slopes inclined at 1 horizontal to 1 vertical should be stable above the groundwater level.

Free water was observed in the sand overburden at elevations at/above the proposed invert level at both sites. It is noteworthy that this is the water level observed at the time of drilling; seasonal/weather dependent fluctuations must be considered. If excavation extends below the groundwater level, positive groundwater control measures (sumps, well points) and/or flattening of the side slopes will be required due to the potential for "running sands".

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

BACKFILL

The box culverts should be backfilled in accordance with OPSD 803.01 and 803.02. Backfill should comprise OPSS Granular 'A' or Granular 'B' Type II. The depth of frost treatment is 1.6 m.

CLOSURE

This report was prepared by Mr. J. F. Wright, B.Sc., reviewed by Mr. T. Lee-Bun, P.Eng., and approved by Mr. Brian R. Gray, P.Eng.

Sincerely

PETO MacCALLUM LTD.

John F. Wright, B.Sc.,
Senior Geologist

Turney Lee-Bun, P.Eng.
Manager, Geotechnical Engineering

REGISTERED PROFESSIONAL ENGINEER
T. LEE-BUN
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JFW/TLB/BRG:ga