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DIST. 4 REGION

W.P. No. 152-75-05

CONT. No. 82-85

W. O. No.

STR. SITE No. 10

HWY. No. Q.E.W. & Hwy 2

LOCATION QEW North of Burlington Skiway at Hwy 2

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

CONT 82-85

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 152-75-05 DIST 4

HWY Q.E.W. STR SITE 10

Retaining Walls #1, #4, #5

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GEOCRES 30M5-130A,B,C

DATE JUL - 6 1982

FOUNDATION INVESTIGATION REPORT

For

Retaining Walls #1, #4 and #5

W. P. 152-75-05, Site 10, Q.E.W. District 4, Hamilton

INTRODUCTION:

This report summarizes the results of a foundation investigation for the above-noted retaining walls. The fieldwork was conducted during the periods from 1981 05 07-12 and 1982 05 18-19 for Retaining Wall #1; 1981 05 13-14 for Retaining Wall #4; 1981 08 24-25 for Retaining Wall #5. Continuous-flight auger machines equipped with 82 mm I.D. hollow-stem augers and BX core barrels, and a modified diamond drill equipped with NX casing were utilized in the fieldwork.

This report supersedes the previous correspondence relating to these projects.

The fieldwork is summarized in the following table:

SITE LOCATION	Sampled Boreholes with Dynamic Cone Penetration Tests	Boring Depth Range (metres)	Number of Boreholes Bedrock Coring	Coring Depth Range (metres)
A)Retaining Wall #1	7	6.1 -10.4	2	3
B)Retaining Wall #4	3	7.1 - 9.3	2	3
C)Retaining Wall #5	1	18.3	1	3

DESCRIPTION OF SITE AND GEOLOGY

The sites are located:-

- in the jurisdiction of the City of Burlington, Regional Municipality of Halton
- in the physiographic region of the Iroquois Plain, a lowland area bordering Lake Ontario.

A) Retaining Wall #1

The site is located approximately 350 metres north of the QEW-Hwy.2 interchange on the west side of the QEW S.B. lanes. The adjacent land, to the west, is a conservation area.

The topography of the site consists of a valley, approximately 5 metres below the elevation of the QEW. Indian Creek flows through the valley from north to south.

At this site, silty clay (till) overlies shaly red clay that has been derived from the underlying Queenston shale. In the valley, surface organic deposits overlie the silty clay.

B) Retaining Wall #4

The site is located directly in front of the Burlington OPP station, approximately 150 metres northeast of the QEW N.B. lanes along the exit ramp to E.B. Hwy.2. The adjacent areas have institutional developments.

The topography of the site consists of a flat plain, ranging from approximately 1 to 2 metres below the elevation of the existing exit ramp.

At this site, silty sand overlies silty clay and shale bedrock.

C) Retaining Wall #5

The site is located approximately 80 metres north of the QEW-Hwy.2 intersection on the west side of Exit Ramp S-EW. The adjacent land, to the west, is a conservation area.

The topography of the site consists of:-

- at the north end, approximately a 4 metre drop from the ramp embankment to the valley of Indian Creek,
- at the south end, approximately a 1 metre drop from the ramp embankment to the filled area over the culvert bridging Indian Creek.

A sheet pile retaining wall divides the valley and the raised fill area.

At this site the surface fill is underlain by silty clay with occasional layers containing organics, then bedrock.

SUBSURFACE CONDITIONS

For Retaining Walls #1, #4 and #5, soil boundaries, insitu and laboratory test results, and ground water levels are shown on the appended Record of Borehole Sheets. The locations and elevations of the borings, along with several estimated stratigraphical profiles based on the borehole data, are shown on Drawings No. 1527505-A (Ret.Wall #1), No. 1527505-B (Ret.Wall #4), and 1527505-C (Ret.Wall #5).

A) Retaining Wall #1

The site is underlain by shale bedrock. Silty clay till overlies the bedrock and is the surface material of the natural embankments at BH #1 and #5. Silty clay to organic silt overlies the silty clay till at BH #2, #3, #4, #10 and #11. The surface material is silty clay fill at BH #2, #4, #10 and #11. Soft undecayed organic material is at the surface of BH #3. No water was observed at BH #1, #4 and #5. The water levels at BH #2, #3, #10 and #11 was approximately at elevation 77.3.

Descriptions of the soils and bedrock encountered are presented below, sequentially from the surface to termination of the boreholes.

Fill Material

Silty clay, some sand, some gravel is the surface fill material at BH#2, #4, #10 and #11. This material ranges in thickness from 3.2 m at BH#10 (roadway embankment) to 1.2 m at BH #4 (valley). The 'N' values from the Standard Penetration Test indicate a stiff to very stiff condition.

Under the roadway fill at BH #10 and #11, the silty clay fill is underlain by silty sand fill which ranges in depth from 2.6 m (BH #10) to 0.7 m (BH #11).

Organics

This deposit is the surface layer at the location of BH #3, and has a thickness of approximately 1.5 m.

The 'N' value indicates a very soft condition.

Field inspection of the sample indicated that the organic material was undecayed and possibly fill.

Silty Clay to Organic Silt; Occ. Sand Layers

At BH #2, #3, #10 and #11, this material underlies the surface fill and extends for a thickness ranging from 1.0 to 2.5 m. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	21.5 - 34.5
Liquid Limit (%)	21.5 - 47.0
Plastic Limit (%)	14.0 - 33.5
Bulk Density (kN /m^3)	18.2 - 19.5
Undrained Shear Strength (kPa)	
Unconfined	14.3 - 43.6

The consistency of the deposit ranges from soft to stiff. Grain size distribution is shown in Figure 1, Appendix. The material has generally low plasticity, although some layers have intermediate plasticity.

Silty Clay; Some Sand, Some Gravel

This material is located immediately above the shale bedrock at all borehole locations. In the natural embankments, at BH #1 and #5 it is the surface material and ranges in depth from 5.2 to 7.0 metres. In the valley, at BH #2, #3 and #4, it lies below, from 1.2 to 4.0 metres of other overburden, and extends for a depth of from 3.4 to 5.8 metres. Below the roadway fill embankment, at BH #10 and #11 it ranges in thickness from 2.5 to 3.9 metres. At BH #11 this deposit contains irregular layers of silt to silty sand.

Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	8.5 - 20.5
Liquid Limit (%)	18.0 - 30.5
Plastic Limit (%)	13.5 - 17.0
Bulk Density (kN/m^3)	21.6 (one test)

The consistency of the deposit ranges from firm to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

B) Retaining Wall #4

At this site silty clay overlies the shale bedrock. The surface material is silty sand. All boreholes were dry.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Silty Sand; Some Clay

This deposit is the surface material at the site, ranging in thickness from 3.0 to 5.2 metres.

Natural moisture contents range from 12% to 20%.

The Standard Penetration Test 'N' values (5 to 66 blows / 0.3 m) indicate a compact to very dense condition. Grain size distribution is shown in Figure 3, Appendix.

Silty Clay; Some Sand, Some/Trace Gravel

This material is located immediately above the shale bedrock at all borehole locations, ranging in thickness from 2.5 to 3.6 metres. Its physical properties, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	11.5 - 26.5
Liquid Limit (%)	19.5 - 32.5
Plastic Limit (%)	14.0 - 16.5
Bulk Density (kN/m^3)	19.5 - 20.4
Undrained Shear Strength (kPa)	
Unconfined	61.4 - 75.6
Quick Triaxial	93.4 (one test)

The consistency of the deposit ranges from stiff to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

C) Retaining Wall #5

The site is underlain by shale bedrock. Silty clay with layers containing organics overlies the bedrock. The surficial deposit at the borehole locations is fill material. The water level was measured at a depth of 13.7 m (elev. 66.6) approximately the same level as Indian Creek.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Fill Material; Sandy Clay to Sand; Some Gravel, Some Organics

This surface fill material extends for a depth of 4.0 m. The upper 2 metres is cohesive material (with consistency ranging from firm to stiff) with low plasticity. Below this lies 2 metres of non-cohesive material with a range in denseness from loose to dense.

Silty Clay; Some Gravel; Trace/Some/With Organics

This deposit extends for 13.2 m and is located immediately above bedrock. Layers at elevations 73.3 to 71.8 and 69.6 to 52.9 contain significant amounts of organic material. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	26.0 - 40.0
Liquid Limit (%)	47.0 - 49.5
Plastic Limit (%)	24.0 - 25.0
Bulk Density (kN/m^3)	17.0 - 17.6
Undrained Shear Strength (kPa)	
Unconfined	45.6 - 74.6
Field Vane	61.4 -101.7

The consistency of the deposit ranges from firm to stiff. The material has intermediate plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations.

DISCUSSION AND RECOMMENDATIONS

Retaining walls #1, #4 and #5 are required for the proposed road designs. General foundation recommendations for all of these retaining walls are provided below, followed by specific design data for each site.

General Recommendations for Retaining Walls #1, #4 and #5

- For frost protection, a minimum cover of 1.2 m is required.
- The existing embankments should be protected during construction.
- If the excavations for spread footings or pile caps are carried out below the prevailing ground water level, a dewatering scheme may be required.

A) Retaining Wall #1 (Adjacent to QEW S.B. Collector Lanes, N.of Hwy.2)

The retaining wall can be founded on end-bearing steel 'H' piles with reinforced tips. The piles are to be driven to bedrock. Estimated tip elevations range from elevation 74.0 at Sta. 11 + 740 to elevation 69.0 at Sta. 11 + 820.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purpose of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition in which the at-rest condition applies.

The following construction procedures are recommended at Retaining Wall #1.

1) Drive protective sheeting into glacial till (or weathered shale). Estimated tip elevations are - for Sta. 11 + 740 Elev. 77.5; for Sta. 11 + 820 Elev. 74.0. The top of the sheeting should be at elev. 80.3 from which point the existing embankment behind the sheeting should be trimmed to 1.5 horizontal: 1 vertical or flatter. Protect the granular material on the exposed embankment slope against erosion with suitable polyethylene sheeting.

2) Install tiebacks, if required.

3) Excavate for footing and construct it.

4) Construct concrete retaining wall, founded on steel H-piles, as recommended.

5) Cut off sheeting at top of footing and backfill simultaneously.

In order to estimate the earth pressures on the retaining wall, the following values are recommended:

a) Granular Soil

$K_a = 0.33$

$K_o = 0.50$

Unit Weight $\gamma = 21.2$ kN/m^3

b) Cohesive Soil

$K_a = 0.45$

$K_o = 0.57$

Unit Weight $\gamma = 19.0$ kN/m^3

NOTE: Assume water level at elev. 77.3. Compute passive resistance below the bottom of the footing as $\frac{1}{3}H + 2c$ where c = 30 kPa.

The exact location of the existing 1200 mm diameter concrete pipe (sewer) should be determined by the designer. If the sewer is located less than 4 m from the footing. The piles should be pre-augered at least 2 m below the invert level.

B) Retaining Wall #4 (At Ramp S-E)

The entire wall may be supported on steel 'H' piles equipped with reinforced tips and driven to elevation 70 ±.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purposes of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition with K_o=0.5 for granular backfill.

C) Retaining Wall #5 (At Ramp N-EW)

Option 1: Standard cantilever retaining wall with spread footings on compacted granular 'A' as illustrated in Figure 1.

Option 2: Precast interlocking drywall - "Pisa Stone" as supplied by Risi Stone Ltd., Thornhill, on compacted granular 'A' as illustrated in Figure 2. Refer to W.P. 606-74-02, Contract 76-51 for further construction details. The top of wall elevations may be slightly varied to suit stone thickness. If safety barriers are required, this option may not be applicable.

For both options, the following design values are recommended:

- Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation condition with K_a=0.33 for granular backfill.

- Bearing Capacity

  Net Safe pressure 200 kPa

  and for the purposes of the O.H.B.D.C.:

  Capacity of S.L.S. Type II 200 kPa

  Factored capacity at U.L.S. 500 kPa

- Sliding at Base

  A friction co-efficient of 0.5 may be assumed to apply between the base of the footing and the underlying subsoil.

- Settlement

  Under the above loading conditions, settlements of the wall foundations will be less than 25 mm.

- Suitable weepholes should be provided to relieve any buildup of excess hydrostatic pressure.

- The groundwater level is lower than the bottom of the proposed excavation.

For the complete length of the wall (Sta. 300 to 315) the existing soil should be excavated to a sufficient depth to achieve the geometry of Fig. 4 or Fig. 5. The minimum thickness of the granular pad required is 0.6 m. It should be noted however that all existing soil above elev. 77.9 must be removed.

If required, the wall may be stepped.

MISCELLANEOUS

The fieldwork for these investigations was carried out under the supervision of Mr. D. H. Dundas, Project Foundation Engineer. The rock core was examined by Mrs. Z. Koniuszy, Geologist.

The drilling equipment was owned and operated by Atcost Soil Drilling Inc. and Master Soil Investigation Ltd.

This report was written by Mr. D. H. Dundas and reviewed by Mr. K. G. Selby, Senior Foundations Engineer.

D. H. Dundas

D. H. Dundas, P. Eng.
Project Foundations Engineer

K. G. Selby

K. G. Selby, P. Eng.
Senior Foundations Engineer

A P P E N D I X

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 303.0 E 279 518.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger, H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.5	Ground Level										
0.0	Silty clay Some sand, some gravel		1	SS	24	DRY	84				
			2	SS	57						
	Very Stiff to Hard		3	SS	69		82				0 13 50 37
			4	SS	99						
			5	SS	82						
			6	SS	104/23 cm		80				0 13 82 5
			7	SS	60/10 cm						
	with shaly layers Hard		8	SS	82/23 cm		78				
77.5											
7.0 76.7	*Shale, weathered		9	SS	50/13 cm						
7.8	End of Borehole						76				
	*Bedrock shale weathered										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 311.0 E 279 497.5 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 and 81 05 08 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.7	Ground Level										
0.0 / 77.2	Silty Clay Some sand, some gravel, Stiff (Fill Material)		1	SS	12	▼	78				
1.5 / 74.7	Silty Clay to Organic Silt Occasional sand Layers soft to firm		2	SS	4						0 4 74 22
			3	TW	PH		76			18.2	0 5 75 20
			4	TW	PH					18.3	0 9 65 26
4.0	Silty Clay some sand, some gravel hard		5	TW	PH					19.7	0 19 53 28
			6	TW	PH		74				
			7	SS	33						
	with shaly layers		8	SS	112		72				
			9	SS	115/23 cm						
70.3			10	SS	50/ 5 cm						
8.4	Bedrock shale weathered sound						70				
			11	RC BXL	100%						
							68				
66.5			12	RC BXL	98%						
12.2	End of Borehole						66				

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 340.0 E 279 471.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 08 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.8	Ground Level										
0.0	Organics very soft		1	SS	2		78				
77.3			2	SS	4						
1.5	Silty Clay to Organic Silt Occasional sand layers		3	TW	PH		76			19.5	
74.8			4	TW	PH					18.3	0 51 39 10
4.0	Silty Clay some sand, some gravel Hard with shaly layers		5	TW	PH					21.6	
			6	SS	100/20 cm		74				19 15 (66)
			7	SS	50/8 cm						
69.0							72				
68.8	Shale; weathered						70				
10.0	End of Borehole						68				

OFFICE REPORT ON SOIL EXPLORATION

+^{3}, ×^{5} : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 4

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 397.0 E 279 409.5 ORIGINATED BY D.H.D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P.P.

DATUM Geodetic DATE 81-05-12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.0	Ground Level									
0.0	Silty Clay some sand, some gravel (FILL MATERIAL) stiff hard		1	SS	11	DRY	78			0 16 72 12
			2	SS	60/15 cm					
			3	SS	98/25 cm		76			
	with shaly layers hard									
74.4										
4.6	Bedrock shale		4	RC BXL	42%		74			
	weathered sound						72			
			5	RC BXL	92%					
69.9							70			
9.1	End of Borehole						68			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 5

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 429.0 E 279 380.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.6	Ground Level										
0.0	Silty Clay some sand, some gravel hard		1	SS	46	DRY	84				
			2	SS	80				o		
			3	SS	90/23 cm		82				
			4	SS	60/15 cm				o		24 26 40 10
	with shaly layers										
79.4			5	SS	109/25 cm						
5.2	Bedrock weathered										
78.5	Shale sound		6	SS	60/3 cm						
6.1	End of Borehole						78				

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 6

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 118.5 E 297 993.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 13 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, * QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.6	Ground Level										
0.0	Silty Sand some clay compact to dense		1	SS	12		78				
			2	SS	23	DRY					
75.6			3	SS	34		76				0 62 36 2
3.0	Silty Clay some sand, trace of gravel stiff to very stiff with shaly layers hard		4	SS	19						
			5	SS	9						
			6	SS	60/15 cm						
72.5			7	SS	92/23 cm		72				
6.1	Bedrock Shale weathered		8	RC BXL	67%		70				
67.9			9	RC BXL	45%		68				
10.7	End of Borehole						66				

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 7

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 085.0 E 280 013.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 14 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
77.5	Ground Level										
0.0	Silty Sand some clay compact		1	SS	13	DRY	76				0 35 50 15
			2	SS	16						
74.5			3	SS	14						
3.0	Silty Clay Some sand, trace of gravel stiff with shaly layers		4	TW	PH		74			20.3	
			5	TW	PH					20.4	0 5 55 39
72.0	hard		6	SS	112						
5.5	Bedrock Shale weathered sound		7	RC BXL	93%		72				
							70				
66.8			8	RC BXL	100%		68				
10.7	End of Borehole						66				

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵ : Numbers refer to Sensitivity

15 20/10 S (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 8

W P 152-75-05 LOCATION RETAINING WALL #4 Co-ords. N 4 797 031.0 E 280 002.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 15 14 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.0	Ground Level										
0.0	Silty Sand some clay		1	SS	5		80				0 42 43 15
	compact to very dense		2	SS	12						
			3	SS	66		78				
			4	SS	38						0 41 43 15
			5	SS	35						
75.8			6	SS	27		76				
5.2	Silty Clay some sand, trace of gravel		7	SS	13						0 5 57 38
			8	TW	PH					19.5	0 9 (91)
			9	SS	8						
	stiff		10	SS	8		74				
	with shaly layers hard		11	SS	70						0 22 48 30
72.2											
71.7	*Shale, weathered		12	SS	77/2 cm		72				
9.3	End of Borehole										
	*Bedrock, Shale, weathered hard						70				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 9

RETAINING WALL #5

W P 152-75-05 LOCATION Co-ords. N 4 797 075 E 279 664 ORIGINATED BY D. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY O. J.

DATUM Geodetic DATE 81 08 24, 25 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
80.3	Ground Level										
0.0	Sandy Clay, some gravel, some organics firm to stiff (FILL MATERIAL)		1	SS	11		80				
			2	SS	6						
	Sand, some gravel, trace of organics, loose to dense (FILL MATERIAL)		3	SS	5		78				
76.3			4	SS	34						
4.0	Silty Clay some sand, trace of gravel, trace of organics firm to stiff		5	SS	18		76				
			6	SS	8	▼					
			7	SS	15						
			8	SS	9		74				
	some organics		9	TW	PH					17.6	
			10	SS	7		72				
			11	SS	7						
	with organics		12	TW	PH		70			17.1	
			13	SS	10		68				
			14	TW	PH					17.0	0 32 55 13
			15	SS	14		66				
	with shaly layers						64				
63.1			16	SS	15						
17.2	Bedrock shale weathered		17	SS	80/2 cm		62				
	sound		18	RC BXL	100%						
			19	RC BXL	93%		60				
59.0											
21.3	End of Borehole						58				

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 10

W P 152-75-05 LOCATION Co-ords. N 4 797 368.0; E 279 457.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 18-19 CHECKED BY D.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.7	Ground Level										
0.0	Fill Material						84				
	Silty Clay (CL) Some Sand, Some Gravel Stiff		1	SS	7						
			2	SS	6		82				
	— — —		3	SS	10						
	Silty Sand Trace of Gravel and Clay Occ. Organics		4	SS	18		80				
78.9	Loose to Compact		5	SS	7						1 64 24 11
5.8	Silty Clay to Organic Silt		6	SS	5						1 52 31 16
	Occ. Sand Layers		7	SS	8	▼	78				
76.8	Firm		8	SS	6						
7.9	Silty Clay (CL) Some Sand, Some Gravel Very Stiff (Till)		9	SS	21		76				
74.3											
10.4	Probable Bedrock End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 11

W P 152-75-05 LOCATION Co-ords. N 4 797 365.0; E 279 454.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 19 CHECKED BY D.D.

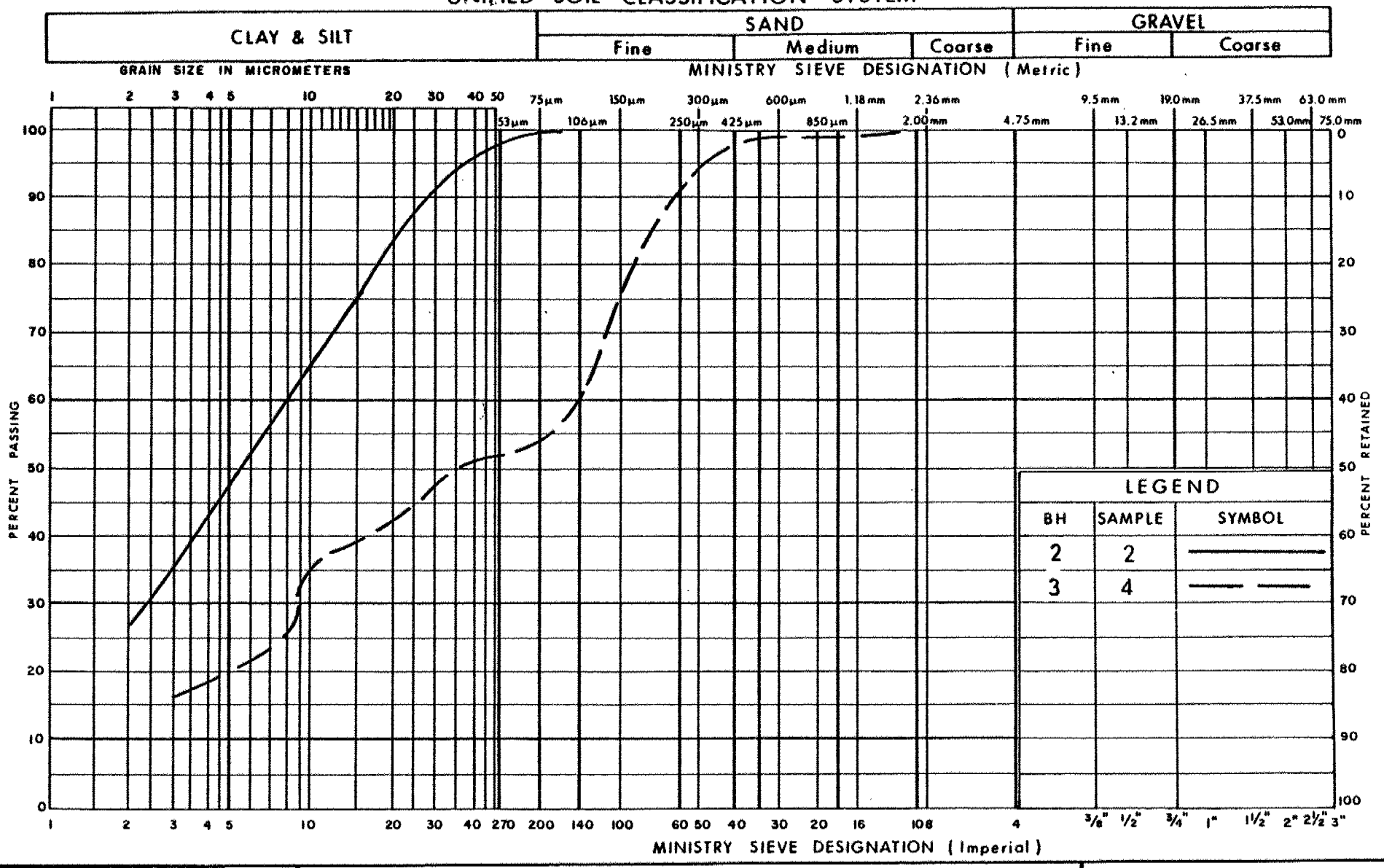
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.5	Ground Level										
0.0	Fill Material										
	Silty Clay (CL) Some Sand, Some Gravel, Occ. organics		1	SS	19						
			2	SS	27		80				
79.1	Silty Sand Compact										
2.4	Silty Clay to Organic		3	SS	13						
78.1	Silt Stiff		4	SS	11						
3.4	Silty Clay (CL) Occ. Irregular Layers of Silt to Silty Sand Occ. Organics Firm to Hard						78				
			5	SS	6	▼			WD		11 42 37 10
			6	SS	10		76		WD		12 31 42 15
74.2			7	SS	39						
7.3	Probable Bedrock End of Borehole						74				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



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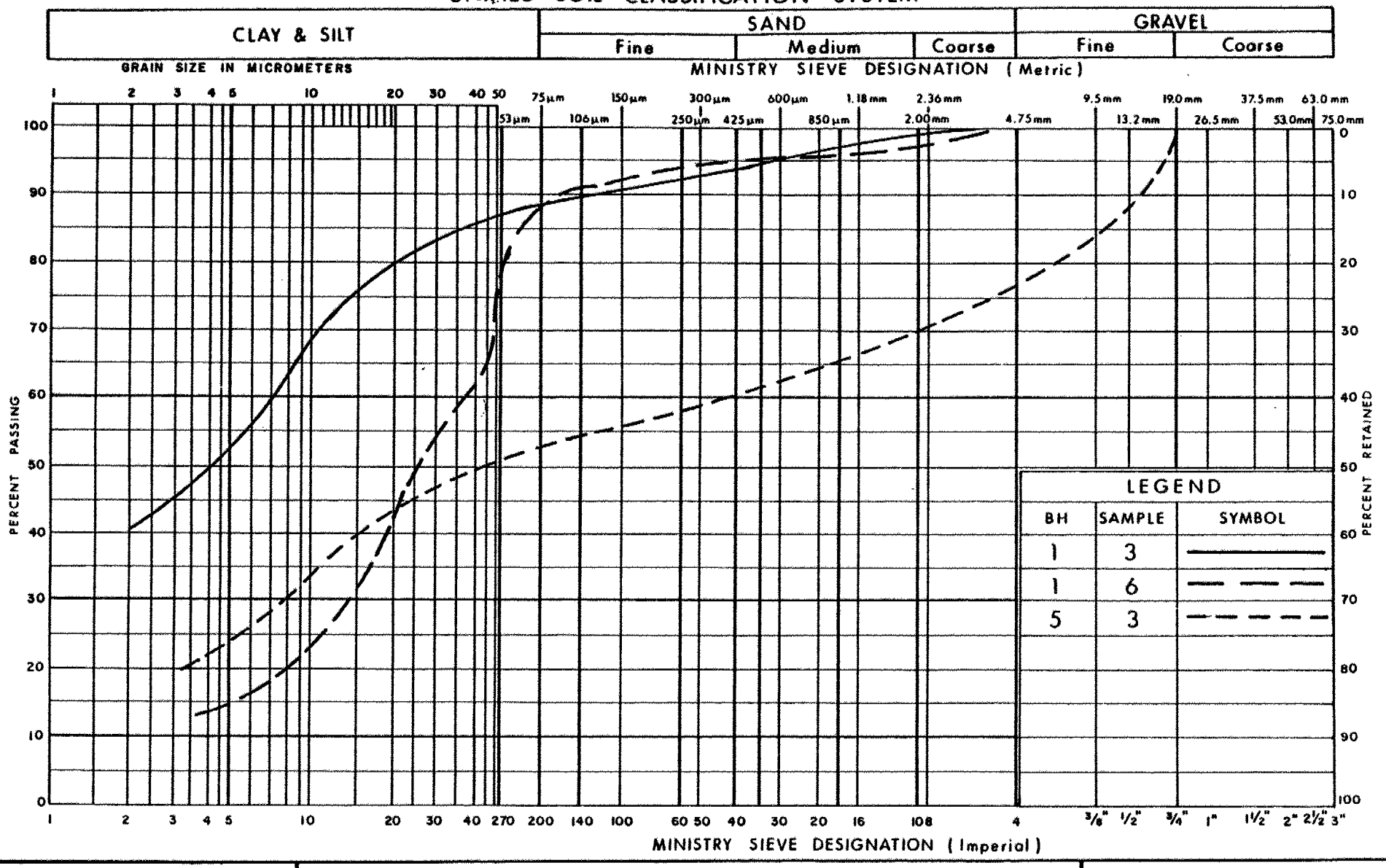
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY
TO ORGANIC SILT

FIG No 1
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM

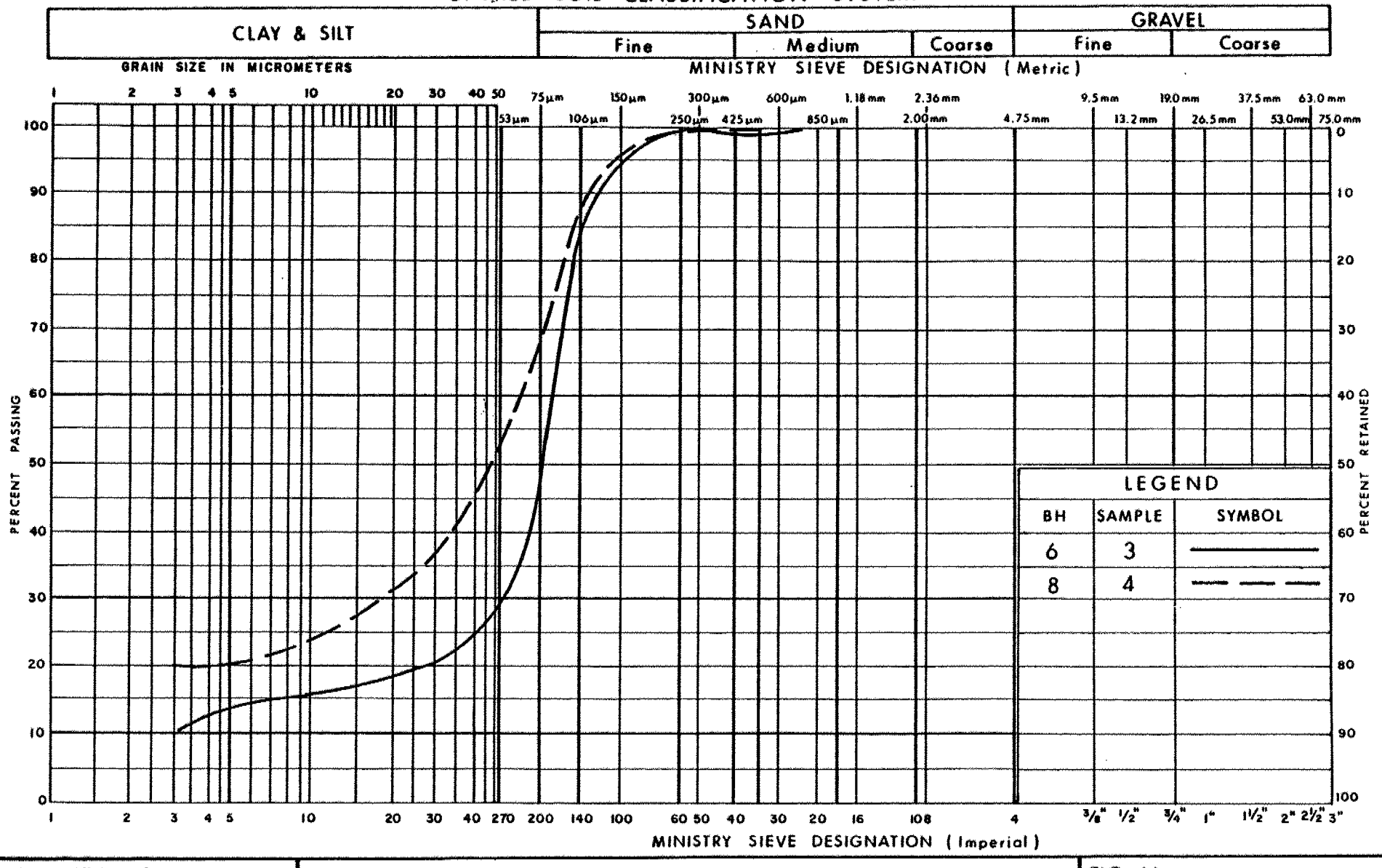


Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY
SOME SAND SOME GRAVEL

FIG No 2
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND
SOME CLAY

FIG No 3
W P 152-75-05

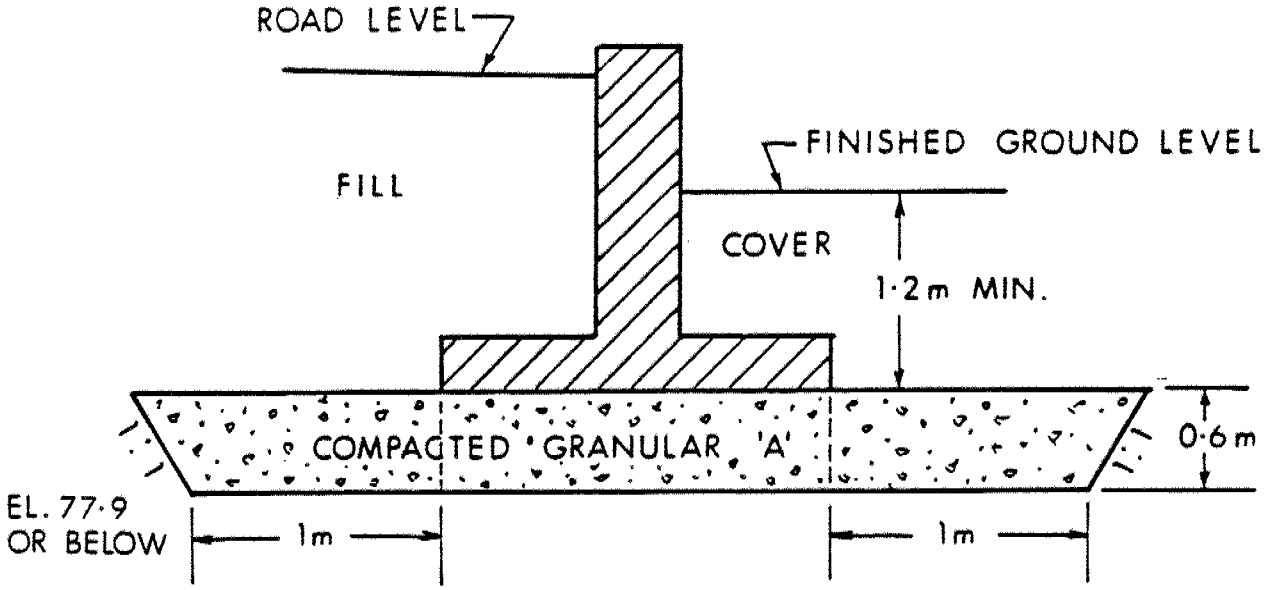
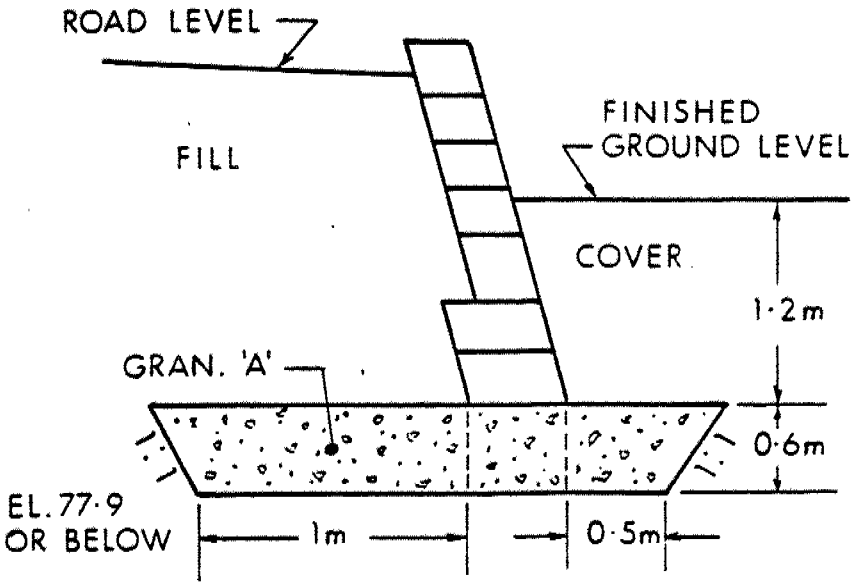


FIG. 4

RETAINING WALL ON SPREAD FOOTING

STA 0+300 TO STA 0+315

COMPLETE LENGTH OF WALL



PISA WALL FIG. 5

STA 0+300 TO STA 0+315

COMPLATE LENGTH OF WALL

RETAINING WALL No 5

W. P. 152-75-05

Ministry of Transportation and Communications
Ontario

TABLE 1

DIAMOND DRILL RECORD

HOLE NO. _____ SHEET NO. _____

DIP

PROPERTY: WP 152-75-05
LOCATION: QEW Skyway - Burlington
LATITUDE:
DEPARTURE:
BEARING:
TOTAL FOOTAGE:

ELEV. COLLAR:
DATUM:
DATE STARTED:
DATE COMPLETED:
DRILLED BY:
LOGGED BY:

FOOTAGE FROM	FOOTAGE TO	FORMATION	SAMPLE NUMBER			REMARKS
		B.H.1-2 = B.H. #2				
30'	40'	Red and green shale, medium hard.				90% recovery
		B.H.1-4 = B.H. #4				
15'	20'	Red and green shale, medium hard with few sections of shaly silty limestone.				Core broken and ground 25% recovery
20'	25'	Core missing.				
25'	30'	Red and green shale, medium hard with sections of shaly, silty limestone.				
		B.H. 4-1 = B.H. #6				
25'	35'	Red and green shale, medium hard.				65% recovery
		B.H. 4-2 = B.H. #7				
25'	35'	Red and green shale, medium hard with few sections of silty shaly limestone.				90% recovery

DATE OF EXAMINATION: July 2, 1981

Z. Koniuszy

OB-MT-113

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:

R Q D (%)	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

METRIC

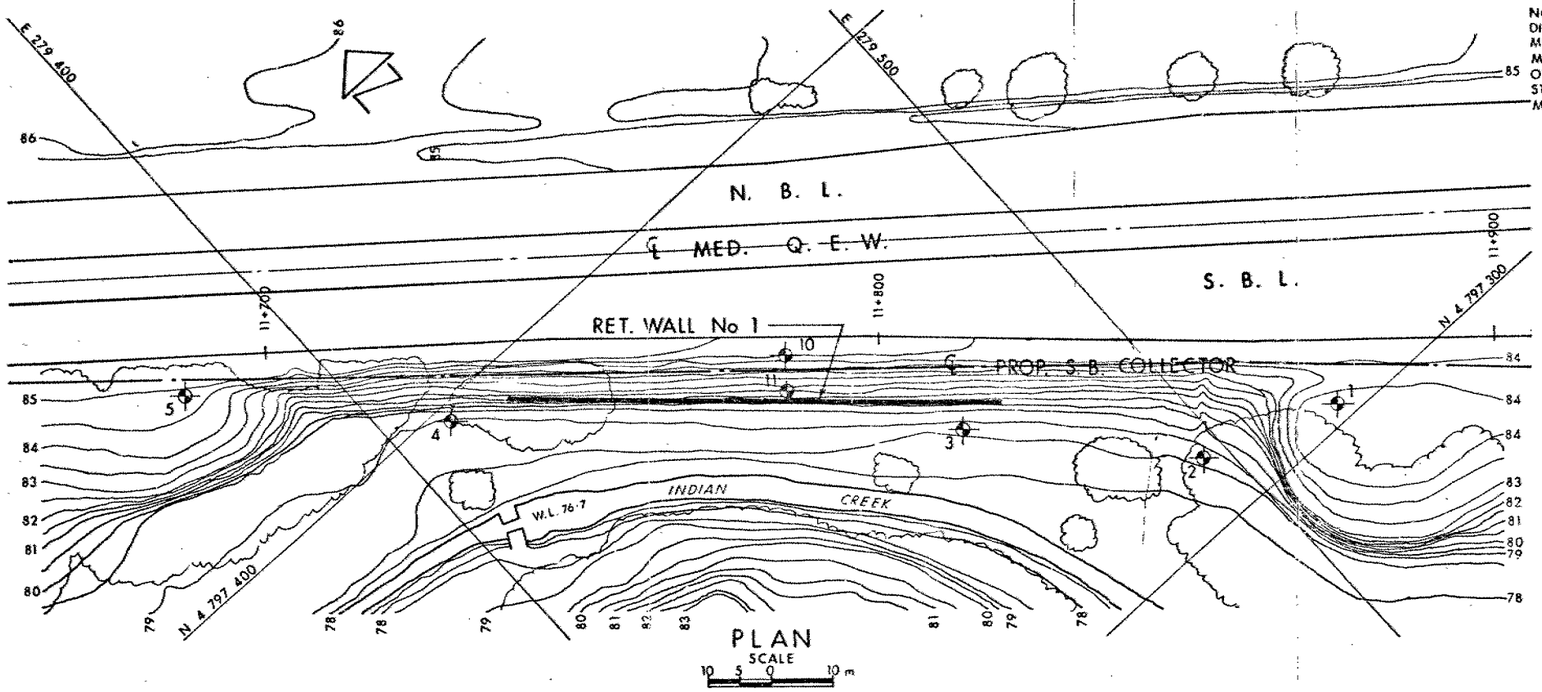
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
STATIONS IN KILOMETRES + METRES

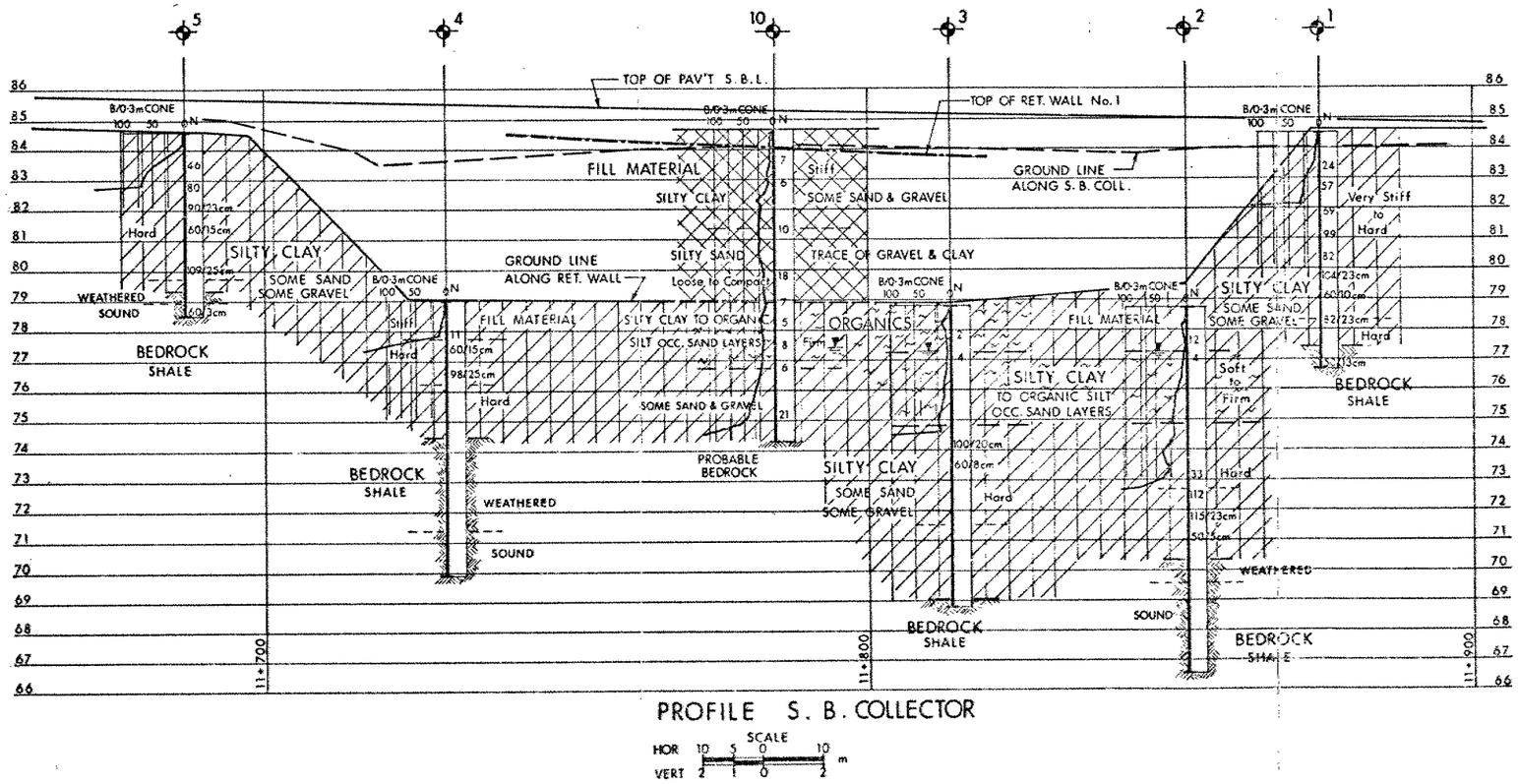
CONT No
WP No 152-75-05

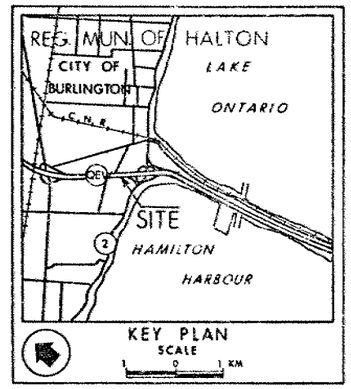
RETAINING WALL No 1

BORE HOLE LOCATIONS & SOIL STRATA

SHEET







LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- WL at time of investigation 81 05 08
  NO WL Established in BH 1, 4, 5

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	84·5	4 797 303·0	279 518·0
2	78·7	4 797 311·0	279 497·5
3	78·8	4 797 340·0	279 471·0
4	79·0	4 797 397·0	279 409·5
5	84·6	4 797 429·0	279 380·0
10	84·7	4 797 368·0	279 457·0
11	81·5	4 797 365·0	279 454·0

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

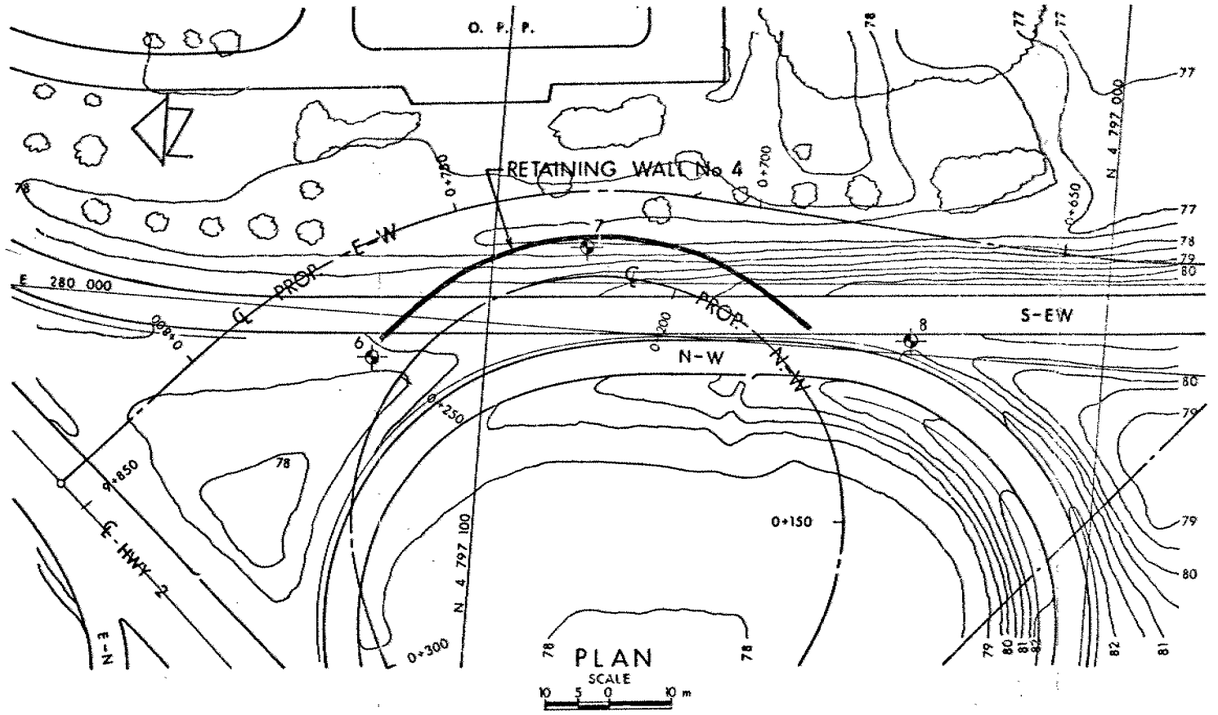
D. H. BRONDAS
REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

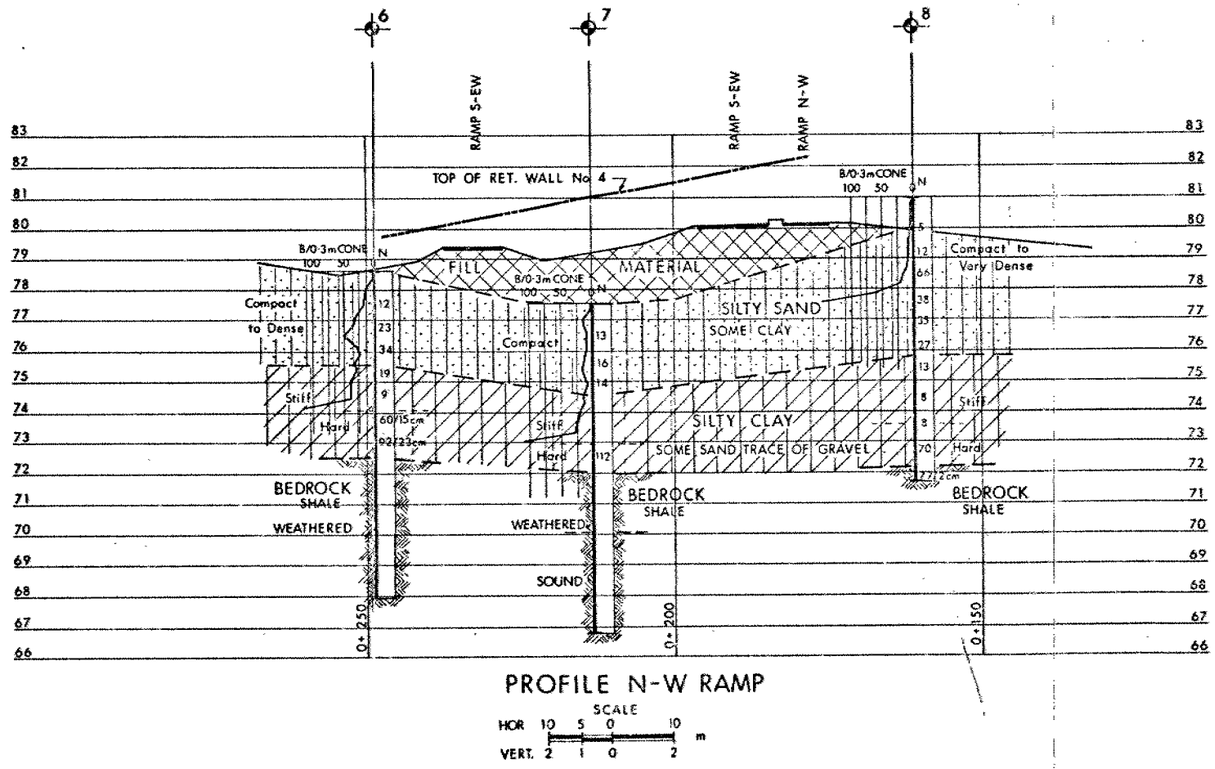
REVISIONS		
DATE	BY	DESCRIPTION

Geocres No 30M15-130A

HWY No	G E W		DIST 4
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN GL T	CHECKED	APPROVED	DWG 1527505-A

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-308M 6-78





PROFILE N-W RAMP

SCALE
HOR 10 5 0 10 m
VERT. 2 1 0 2

METRIC

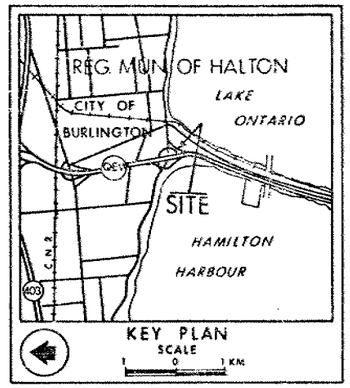
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

RETAINING WALL No 4

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation
  NO WL Established

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
6	78·6	4 797 118·5	297 993·0
7	77·5	4 797 085·0	280 013·0
8	81·0	4 797 031·0	280 002·0

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

REVISIONS

DATE	BY	DESCRIPTION

Geocres No 30M5-1308

HWY No Q E W		DIST 4	
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN Q L J	CHECKED	APPROVED	DWG 527505-B

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-30RM 8-76

METRIC

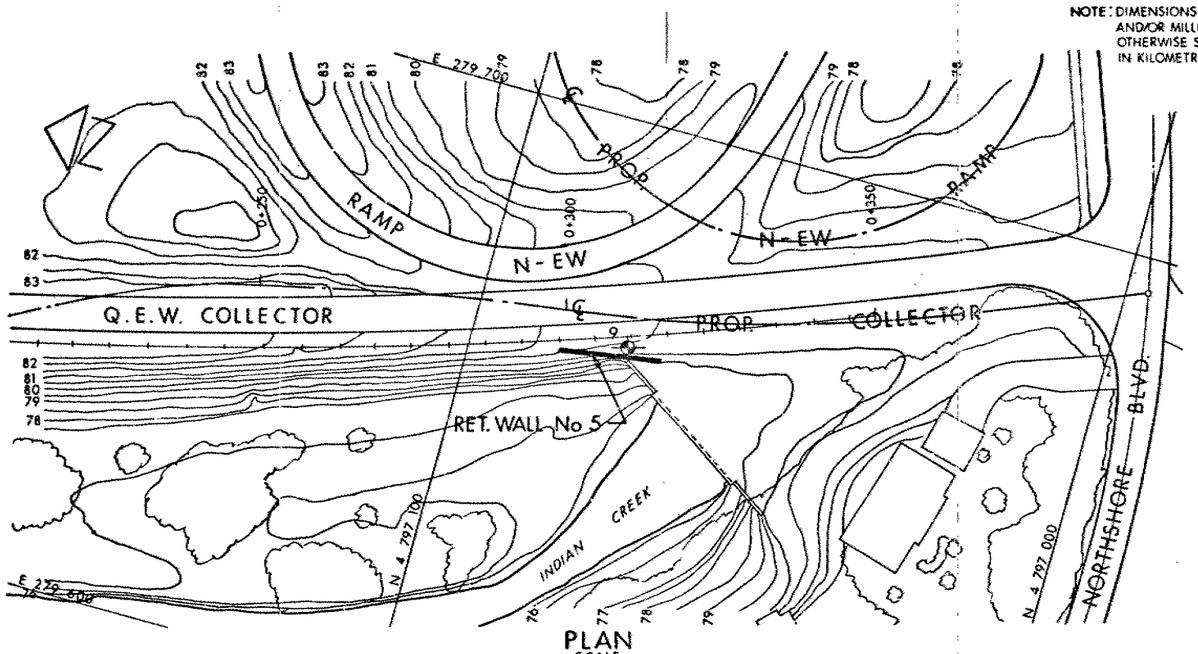
NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

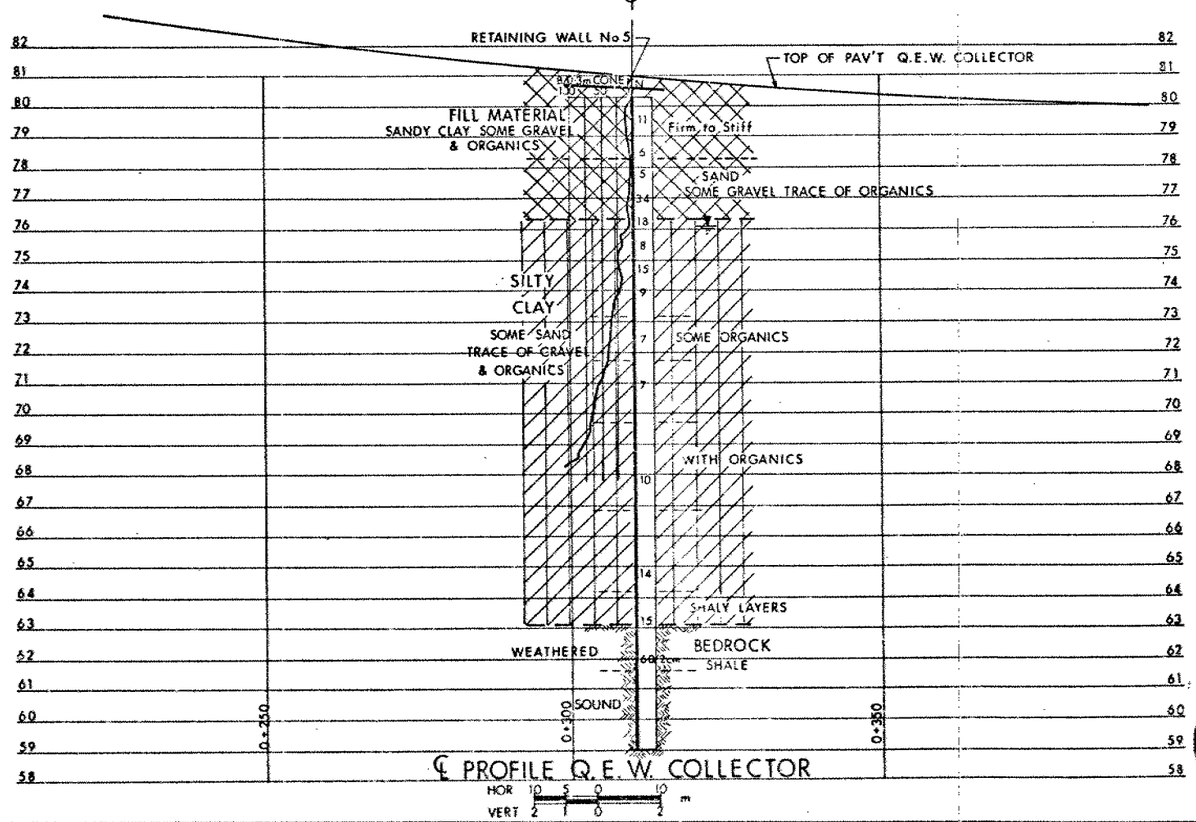
RETAINING WALL No. 5

BORE HOLE LOCATIONS & SOIL STRATA

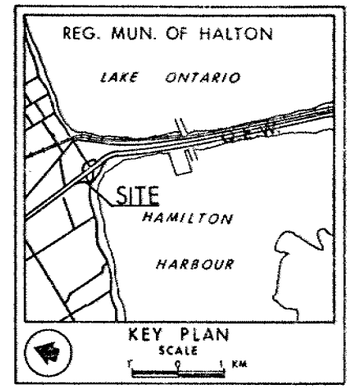
SHEET



PLAN
SCALE 10 5 0 10 m



℄ PROFILE Q.E.W. COLLECTOR
HOR 10 5 0 10 m
VERT 2 1 0 2



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation 81 08 24

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
9	80·3	4 797 075	279 664

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

REVISIONS

DATE	BY	DESCRIPTION

D H DUNCAS

Geocres No 30M5-130C

HWY No	Q. E. W.		DIST 4
SUBMD D. D	CHECKED	DATE 82 01 22	SITE
DRAWN O. J	CHECKED	APPROVED	DWG 1527505-C

Ontario

Ministry of
Transportation and
Communications

Pavement & Foundation Design Section,
Engineering Materials Office,
Room 315, Central Building,
1201 Wilson Avenue,
Downsview, Ontario
M3M 1J8

Telephone: (416) 248-3282

January 27, 1982

DelCan,
2315 Riverside Drive,
Billings Bridge Plaza,
Box 8004,
Ottawa, Ontario
K1G 3H6

ATTENTION: Mr. G. S. Saunders, Project Manager

Re: M. T. C. W. P. 152-75-05, Site 10
Retaining Walls #1, #4, #5
Q. E. W. and Highway 2

Your "Layout and Details" drawings for the above-noted retaining walls, received, along with your letter of January 21, 1982, have been reviewed by this Section. There is no comment at this time.

D. H. Dundas, P. Eng,
Project Foundations Engineer

DHD/bd

cc: M. D. Bendayan
W. Lin

Ontario

Ministry of
Transportation and
Communications

WP 152-75-05
RET WALL # 1

Engineering Materials Office,
Pavement & Foundation Design Section,
Room 315, Central Building,
1201 Wilson Avenue,
Downsview, Ontario

Telephone: (416) 248-3282

January 21, 1982

Delcan,
2315 Riverside Drive,
Ottawa, Ontario
K1G 3H6

Mr. G. Saunders,
Associate Chief Structural Engineer

Dear Sir:

Further to our memo of June 16, 1981, the following construction procedures are recommended between Sta. 11+740 and Sta. 11+820.

1. Drive sheeting into glacial till (or weathered shale). Estimated tip elevations at Sta. 11+740: El. 77.5 and Sta. 11+820: El. 74.0.

2. Install tiebacks

3. Excavate for footing and construct it

4. Construct concrete wall

5. Cut off sheeting at top of footing and backfill simultaneously.

In order to estimate the earth pressures on the retaining wall, the following values are recommended:

(a) GRANULAR BACKFILL TO RETAINING WALL

K_A = 0.33
K_O = 0.50
Unit Weight γ = 21.2 kN/m^3

(b) EXISTING EMBANKMENT FILL MATERIAL

K_A = 0.33
K_O = 0.50
Unit Weight γ = 21.2 kN/m^3

(c) EXISTING COHESIVE SOIL BELOW EL. 79.3

K_A = 0.45
K_O = 0.57
~~K_p = 2.46~~
Unit Weight γ = 19.0 kN/m^3

NOTE: Assume W. L. at el. 77.3. Compute passive resistance below bottom of footing as H+2C where C = 30 kPa.

The exact location of the existing 1200 mm Ø concrete pipe (storm sewer) should be determined by the designer. If the storm sewer is located less than 4 m from the footing, the piles should be pre-augered.

For your information, the Record of Borehole Sheets are attached.

Yours truly,

P. Payer

P. Payer,
Foundations Engineer

For:

K. G. Selby,
Senior Foundations Engineer

PP/bd

cc: W. L. Lin
M. D. Bendayan

memorandum

Ontario

To: Mr. G. C. E. Burkhardt,
Head, Structural Section,
Central Region

Date: 81 08 28

From: Pavement & Foundation Design Section,
Room 315, Central Building,
Downsview, Ontario

ATTENTION: Mr. M. D. Bendayan

Re: Retaining Wall #5,
Q. E. W. and Highway 2,
W. P. 152-75-05; Site 10,
District 4, Hamilton

Our field investigation for the above-noted retaining wall was recently completed.

The materials encountered are descirbed (in sequence from surface, down) as below:

Depth (m)	Elevation (m)	Description
0 - 1.5 (1.5m)	80.2 - 78.7	Sandy clay with organics firm to stiff ML - CL
1.5 - 4.0 (2.5m)	78.7 - 76.2	Sand, some fine gravel trace of organics loose to dense SW - SM
4.0 - 18.3 (14.3m)	76.2 - 61.9	Silty clay, some organic material and fine sand, some layers of organic silty clay firm to stiff CL to (CL - OL)
18.3 - 21.3 (3m)	61.9 - 58.9	Bedrock Red shale

The groundwater level is estimated to be at 4.2 m depth (elevation 76 m) - i. e., 0.5 m above water level in Indian Creek.

Our recommendations for Retaining Wall #5 are as follows:

Option 1: Standard cantilever retaining wall with spread footings on compacted granular 'A' as illustrated in figure 1.

Option 2: Precast interlocking drywall - "Pisa Stone" as supplied by Risi Stone Ltd., Thornhill, on compacted granular 'A' as illustrated in figure 2. Refer to W. P. 606-74-02, Contract 76-51 for further construction details. The top of wall elevations may be slightly varied to suit stone thickness. If safety barriers are required, this option may not be applicable.

For both options, the following design values are recommended:

- Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C.

- Bearing Capacity

Net Safe pressure	200 kPa
Capacity of S.L.S. Type II	200 kPa
Factored capacity at U.L.S.	500 kPa

- Sliding at Base
A friction co-efficient of 0.5 may be assumed to apply between the base of the footing and the underlying subsoil.

- Settlement
Under the above loading conditions, settlements of the wall foundations will be less than 25 mm.

- Suitable weepholes should be provided to relieve any buildup of excess hydrostatic pressure.

- The groundwater level is lower than the bottom of the proposed excavation.

- Cover should be 1.2 m to provide for frost protection.

- Foundation elevations
From STA: 0 + 310 to STA: 0+315, the existing material should be excavated to an elevation of 77.9 m. Following the design illustrated in figures 1 and 2, 0.6 m of compacted granular 'A' should be placed to an elevation of 78.5.

From STA: 0+300 to 0+310, the foundation elevation should parallel the contour of the existing surface.

If required, the wall may be stepped.

Our complete foundation investigation report will be submitted in the near future.

Should further information be required, please contact our office.

D. H. Dundas

D. H. Dundas,
Project Foundations Engineer

for:

K. G. Selby,
Senior Foundations Engineer

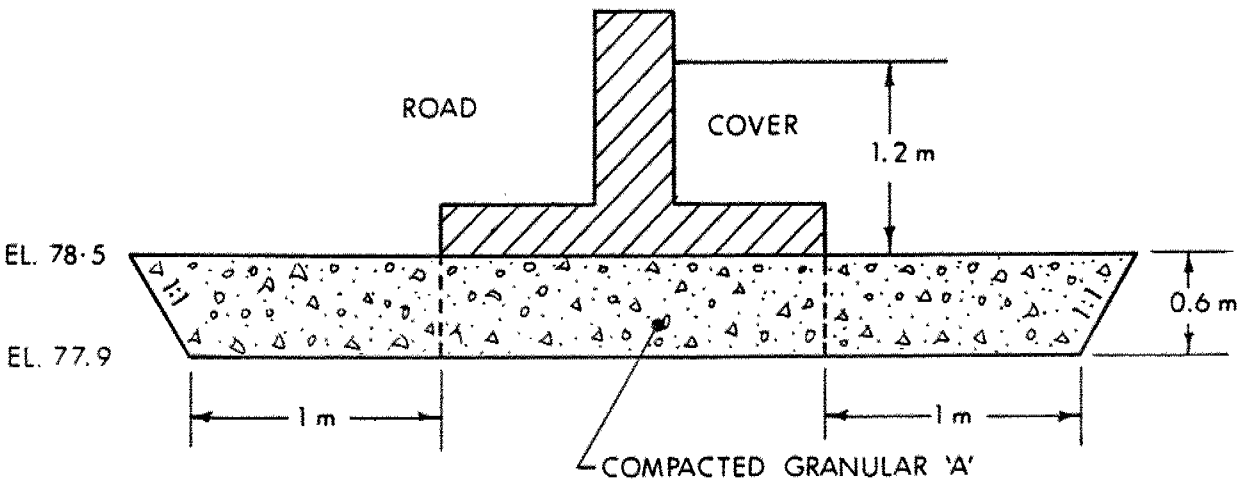


FIG. 1 - RETAINING WALL ON SPREAD FOOTING (sta. 0+310 to sta. 0+315)

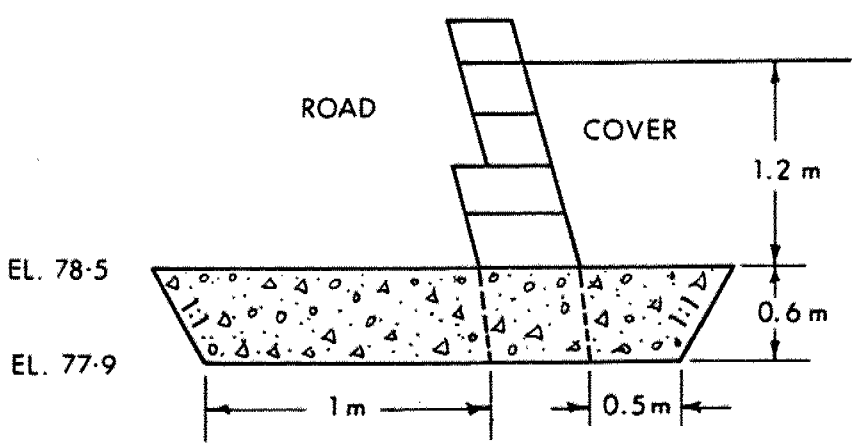


FIG. 2 - PISA WALL (sta. 0+310 to sta. 0+315)

memorandum

Ontario

To: Mr. K.G. Selby,
Senior Foundation Engineer,
Pavement and Foundation
Design Section,
Central Building, Room #313,
Downsview, Ontario.

Date: 1981-08-06

Central Region

Attention: Mr. P. Payer,
Foundation Engineer

RE: Retaining Walls #1,4 and 5 at the
Q.E.W./Highway 2 Interchange,
W.P. 152-75-05, Site 10
District 4, Hamilton

Thank you for your memo of 81-06-16 given foundation recommendations re. the above retaining walls #1 and #4.

At the time of our report, the need for retaining wall #5 (15 m long) had not been established. Having now been informed by the Consultants that this structural element is required, would you kindly arrange to have same also included in your report.

The attached two prints of site plan 306-31, showing in plan and profile details of Ret. Wall #5, will assist you in the necessary investigations.

According to our telephone conversation of today, we are proceeding with the design of such wall, based on a spread footing type of foundation.

Details of same will be submitted for your comments, in the near future.

MDB:rb
Attach.

M. D. Bendayan,
Senior Structural Engineer,
for:
G.C.E. Burkhardt,
Head, Structural Section.

c.c. Mr. R. Fitzgibbon
Mr. N. Sen

memorandum

Ontario

To: Mr. G.C.E. Burkhardt
Head, Structural
Central Region

Date: 81 06 16

From: Pavement & Foundation Design Section
Central Building, Room 313
Downsview, Ontario

Attention: M.D. Bendayan

Re: Retaining Walls #1 & #4
Q.E.W. & Hwy. 2
W.P. 152-75-05; Site 10
District #4, Hamilton

In response to your verbal request our recommendations concerning the foundations of these retaining walls are as follows:

Retaining Wall #1 (Adjacent to Q.E.W., S.B. Collector Lanes)

Due to the irregular depths of the competent foundation subsoil, this wall should be built in independent segments. The following foundation types are recommended along the proposed retaining wall.

Sta: 11 + 686 (North End) - Sta: 11 + 700
Spread footings on compacted granular 'A'

Sta: 11 + 700 - Sta: 11 + 715
Spread footings on weathered shale, between elevation 80.5 ± and elevation 77.5 ±

Sta: 11 + 715 - Sta: 11 + 740
Spread footings on compacted granular 'A'

Sta: 11 + 740 - Sta: 11 + 870 (South End)
End bearing Steel 'H' piles with reinforced tips. Estimated tip elevations: elevation 71 ± to elevation 78 ±. Interpolate between stations as follows:
The following design values are recommended:

a) Spread footings on compacted granular 'A'

Net safe pressure	290 kPa
Capacity at S.L.S. Type II	290 kPa
Factored capacity at U.L.S.	435 kPa

11+683 11+730 +814' 11+820
el. 78.0 el.74.0 el.69.0 el.62.0
Piles will be driven to bedrock.
WALL IS 11+740 to 11+820

KG Bailey 91-12-02

b) Spread footings on weathered shale

Net safe pressure	580 kPa
Capacity at S.L.S. Type II	580 kPa
Factored capacity at U.L.S.	870 kPa

c) Steel 'H' piles

Pile Type	Safe Capacity	Capacity at S.L.S. Type II	Factored Capacity At U.L.S.
310HP110	1150 KN	1150 KN	1600 KN
310HP79	760 KN	760 KN	1060 KN

Retaining Wall #4 (At Ramp W-Q.E.W., N.B. Collector)

The entire wall may be supported on Steel 'H' piles equipped with reinforced tips and driven to elevation 70 ±. Recommended design values: similar to those given (C), Steel 'H' piles).

Other Considerations

The frost protection requirement in this area is 1.2 m of earth cover.

Earth pressures should be computed as per subsection 6.6.1.2.2. of the O.H.B.D.C.

It is recommended that the surface of the weathered shale ~~be~~ protected by a layer (3 cm) of lean concrete immediately upon exposure.

The width of the granular 'A' pad should extend for a minimum distance of 1 m horizontally on each side of the footing and vertically for about 2 m. The slope of this granular pad should not be less than 1:1.

The existing embankments should be protected during construction.

~~The pile driving should be controlled on the field by MTC Standards SS103-11 or SS103-10.~~ It is recommended that the driving energy should not be less than 50 000 joules per blow. Piles should be driven to bedrock

At locations where the piles are closer than 4 m to buried utilities (in this case a storm sewer) the piles should be pre-augered at least 2 m below the invert level.

If the excavations for spread footings or pile caps are carried out below the prevailing water level a dewatering schem may be required.

Our complete foundation investigation report will be submitted in the near future.

Should further information be required please contact our office.

P. Payer
Foundations Engineer

For

K. G. Selby
Senior Foundations Engineer

memorandum

Ontario

To: Mr. N. Sen
Project Manager
Planning & Design Section
Central Region

Date: 1981 05 05

From: Pavement & Foundation Design Section
Room 313, Central Building
Downsview

Re: Q.E.W. Southbound Collector Embankment South of Hwy. 2
Sta. 12+280 to Sta. 12+540, W.P. 152-75-05,
District 4, Hamilton

We have now completed the foundation investigation and analysis for the above mentioned embankment location. This memo will summarize the subsoil conditions encountered and detail our final recommendations with regards to embankment design and construction as per our discussions at the DeLCan progress meeting dated 81 04 14.

No further report will be issued for this project except for the documents required for contract purposes, which will be prepared upon receipt of the final grading drawings.

Subsurface Conditions

Overlying the site and encountered for depths ranging from 1.0 to 3.4 metres is a surficial fill material consisting of a brown sand and gravel, generally compact in denseness. This fill material is underlain by 1 to 4.2 metres of a grey alluvial silty sand which becomes interbedded with alternating layers of silty clay, increasing in bedding frequency towards the bottom of this stratum. Standard Penetration Test 'N' values indicate a very loose to compact denseness, but generally can be described as loose for the silty sand stratum.

Underlying the natural granular deposit and encountered for a maximum depth of 12.5 metres is a greenish-grey highly compressible organic clay (OH) with random seams, lenses and inclusions of black organics. This material oxidized very rapidly to a char-coal colour. Included organic material ranged from decayed wood fibre and leaves to small shells.

Results of laboratory testing on representative samples from this deposit are summarized below.

continued...../2

		Range	Average
Liquid Limit	(w_L)%	61 - 114	86
Plastic Limit	(w_p)%	32 - 90	57
Plasticity Index	(I_p)%	21 - 29	25
Water Content	(w)%	57 - 149	92
Unit Weight	(γ) kN/m^3	12.1 - 15.8	14.1
Organic Content	(Om)%	6.9 - 24.8	13.7

Shear strength testing consisting of in-situ field vane, unconfined compression and quick triaxial lab tests indicate the organic clay deposit to have a firm to stiff consistency, with the upper 6.5 metres described as firm, in the 22 to 40 kPa range.

The organic clay stratum is underlain by a thin veneer of red silty clay till which is known to overlie shale bedrock in the area.

Groundwater levels across the site were found to reflect creek water levels at the time of investigation.

Discussion and Recommendations

Present planning calls for the construction of approach embankments between the existing Q.E.W. embankment and Indian Creek for the southbound collector overpass at Hwy. 2.

In consideration of the proposed height of fill, proximity of embankment toe to creek channel slopes, and the firm, highly compressible nature of the underlying organic clays concern was expressed with regards to the integrity of the proposed embankment.

Numerous stability analyses in terms of total stresses were carried out for representative embankment cross sections based on various alternative profile grade arrangements. After much discussion it was agreed that profile 3 incorporting a lowering of the S.B. collector bridge profile by some .77 metres be adopted thus eliminating costly subexcavation and replacement schemes.

Our comments with regards to embankments constructed to profile 3 are as follows:

- In order to insure the stability of fills constructed with 2:1 slopes to the proposed profile grade, all embankment fill material should consist of lightweight fill (i.e. air cooled slag) with a maximum in place compacted unit weight of 14.1 kN/m^3 (i.e. 90 p.c.f.). Embankments should be constructed with this lightweight fill between stations 12+280 and 12+540 within the full plan limits of the embankment.

$\phi = 35°$

continued...../3

- The embankment should be constructed in stages with the initial 5 metres of lightweight fill being placed and allowed to consolidate for 6 months. Then each successive 1 metre lift should be placed at 1 month intervals. By using stage construction techniques the stability of the embankment is increased and a majority of the consolidation settlements are allowed to occur prior to paving operations thus decreasing long term maintenance costs.

We trust the information provided is sufficient for your present requirements. Please feel free to contact this Section if further discussion is required.

T.J. Kazmierowski
Foundations Engineer

TJK:ea

cc: M. Bendayan
P. Weber
A. Teoh (DeLCan)

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M5-130A, B, C

DIST. 4 REGION

W.P. No. 152-75-05

CONT. No. 82-85

W. O. No.

STR. SITE No. 10

HWY. No. Q.E.W. & Hwy 2

LOCATION QEW North of Burlington Skiway at Hwy 2

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ontario

Ministry of
Transportation and
Communications

FILE No. WP 152-75-05 **DATE**

REMARKS slope stability STA: 11+800

CONT 82-85

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 152-75-05 DIST 4

HWY Q.E.W. STR SITE 10

Retaining Walls #1, #4, #5

DISTRIBUTION

G.C.E. Burkhardt (3)
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K. Bassi
B.J. Giroux

R. Hore

R. Fitzgibbon (Cover Only)
T.J. Kovich (Cover Only)

Files

GEOCRES 30M5-130A,B,C

DATE JUL - 6 1982

FOUNDATION INVESTIGATION REPORT

For

Retaining Walls #1, #4 and #5

W. P. 152-75-05, Site 10, Q.E.W. District 4, Hamilton

INTRODUCTION:

This report summarizes the results of a foundation investigation for the above-noted retaining walls. The fieldwork was conducted during the periods from 1981 05 07-12 and 1982 05 18-19 for Retaining Wall #1; 1981 05 13-14 for Retaining Wall #4; 1981 08 24-25 for Retaining Wall #5. Continuous-flight auger machines equipped with 82 mm I.D. hollow-stem augers and BX core barrels, and a modified diamond drill equipped with NX casing were utilized in the fieldwork.

This report supersedes the previous correspondence relating to these projects.

The fieldwork is summarized in the following table:

SITE LOCATION	Sampled Boreholes with Dynamic Cone Penetration Tests	Boring Depth Range (metres)	Number of Boreholes Bedrock Coring	Coring Depth Range (metres)
A)Retaining Wall #1	7	6.1 -10.4	2	3
B)Retaining Wall #4	3	7.1 - 9.3	2	3
C)Retaining Wall #5	1	18.3	1	3

DESCRIPTION OF SITE AND GEOLOGY

The sites are located:-

- in the jurisdiction of the City of Burlington, Regional Municipality of Halton
- in the physiographic region of the Iroquois Plain, a lowland area bordering Lake Ontario.

A) Retaining Wall #1

The site is located approximately 350 metres north of the QEW-Hwy.2 interchange on the west side of the QEW S.B. lanes. The adjacent land, to the west, is a conservation area.

The topography of the site consists of a valley, approximately 5 metres below the elevation of the QEW. Indian Creek flows through the valley from north to south.

At this site, silty clay (till) overlies shaly red clay that has been derived from the underlying Queenston shale. In the valley, surface organic deposits overlie the silty clay.

B) Retaining Wall #4

The site is located directly in front of the Burlington OPP station, approximately 150 metres northeast of the QEW N.B. lanes along the exit ramp to E.B. Hwy.2. The adjacent areas have institutional developments.

The topography of the site consists of a flat plain, ranging from approximately 1 to 2 metres below the elevation of the existing exit ramp.

At this site, silty sand overlies silty clay and shale bedrock.

C) Retaining Wall #5

The site is located approximately 80 metres north of the QEW-Hwy.2 intersection on the west side of Exit Ramp S-EW. The adjacent land, to the west, is a conservation area.

The topography of the site consists of:-

- at the north end, approximately a 4 metre drop from the ramp embankment to the valley of Indian Creek,
- at the south end, approximately a 1 metre drop from the ramp embankment to the filled area over the culvert bridging Indian Creek.

A sheet pile retaining wall divides the valley and the raised fill area.

At this site the surface fill is underlain by silty clay with occasional layers containing organics, then bedrock.

SUBSURFACE CONDITIONS

For Retaining Walls #1, #4 and #5, soil boundaries, insitu and laboratory test results, and ground water levels are shown on the appended Record of Borehole Sheets. The locations and elevations of the borings, along with several estimated stratigraphical profiles based on the borehole data, are shown on Drawings No. 1527505-A (Ret.Wall #1), No. 1527505-B (Ret.Wall #4), and 1527505-C (Ret.Wall #5).

A) Retaining Wall #1

The site is underlain by shale bedrock. Silty clay till overlies the bedrock and is the surface material of the natural embankments at BH #1 and #5. Silty clay to organic silt overlies the silty clay till at BH #2, #3, #4, #10 and #11. The surface material is silty clay fill at BH #2, #4, #10 and #11. Soft undecayed organic material is at the surface of BH #3. No water was observed at BH #1, #4 and #5. The water levels at BH #2, #3, #10 and #11 was approximately at elevation 77.3.

Descriptions of the soils and bedrock encountered are presented below, sequentially from the surface to termination of the boreholes.

Fill Material

Silty clay, some sand, some gravel is the surface fill material at BH#2, #4, #10 and #11. This material ranges in thickness from 3.2 m at BH#10 (roadway embankment) to 1.2 m at BH #4 (valley). The 'N' values from the Standard Penetration Test indicate a stiff to very stiff condition.

Under the roadway fill at BH #10 and #11, the silty clay fill is underlain by silty sand fill which ranges in depth from 2.6 m (BH #10) to 0.7 m (BH #11).

Organics

This deposit is the surface layer at the location of BH #3, and has a thickness of approximately 1.5 m.

The 'N' value indicates a very soft condition.

Field inspection of the sample indicated that the organic material was undecayed and possibly fill.

Silty Clay to Organic Silt; Occ. Sand Layers

At BH #2, #3, #10 and #11, this material underlies the surface fill and extends for a thickness ranging from 1.0 to 2.5 m. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	21.5 - 34.5
Liquid Limit (%)	21.5 - 47.0
Plastic Limit (%)	14.0 - 33.5
Bulk Density (kN /m^3)	18.2 - 19.5
Undrained Shear Strength (kPa)	
Unconfined	14.3 - 43.6

The consistency of the deposit ranges from soft to stiff. Grain size distribution is shown in Figure 1, Appendix. The material has generally low plasticity, although some layers have intermediate plasticity.

Silty Clay; Some Sand, Some Gravel

This material is located immediately above the shale bedrock at all borehole locations. In the natural embankments, at BH #1 and #5 it is the surface material and ranges in depth from 5.2 to 7.0 metres. In the valley, at BH #2, #3 and #4, it lies below, from 1.2 to 4.0 metres of other overburden, and extends for a depth of from 3.4 to 5.8 metres. Below the roadway fill embankment, at BH #10 and #11 it ranges in thickness from 2.5 to 3.9 metres. At BH #11 this deposit contains irregular layers of silt to silty sand.

Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	8.5 - 20.5
Liquid Limit (%)	18.0 - 30.5
Plastic Limit (%)	13.5 - 17.0
Bulk Density (kN/m^3)	21.6 (one test)

The consistency of the deposit ranges from firm to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

B) Retaining Wall #4

At this site silty clay overlies the shale bedrock. The surface material is silty sand. All boreholes were dry.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Silty Sand; Some Clay

This deposit is the surface material at the site, ranging in thickness from 3.0 to 5.2 metres.

Natural moisture contents range from 12% to 20%.

The Standard Penetration Test 'N' values (5 to 66 blows / 0.3 m) indicate a compact to very dense condition. Grain size distribution is shown in Figure 3, Appendix.

Silty Clay; Some Sand, Some/Trace Gravel

This material is located immediately above the shale bedrock at all borehole locations, ranging in thickness from 2.5 to 3.6 metres. Its physical properties, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	11.5 - 26.5
Liquid Limit (%)	19.5 - 32.5
Plastic Limit (%)	14.0 - 16.5
Bulk Density (kN/m^3)	19.5 - 20.4
Undrained Shear Strength (kPa)	
Unconfined	61.4 - 75.6
Quick Triaxial	93.4 (one test)

The consistency of the deposit ranges from stiff to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

C) Retaining Wall #5

The site is underlain by shale bedrock. Silty clay with layers containing organics overlies the bedrock. The surficial deposit at the borehole locations is fill material. The water level was measured at a depth of 13.7 m (elev. 66.6) approximately the same level as Indian Creek.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Fill Material; Sandy Clay to Sand; Some Gravel, Some Organics

This surface fill material extends for a depth of 4.0 m. The upper 2 metres is cohesive material (with consistency ranging from firm to stiff) with low plasticity. Below this lies 2 metres of non-cohesive material with a range in denseness from loose to dense.

Silty Clay; Some Gravel; Trace/Some/With Organics

This deposit extends for 13.2 m and is located immediately above bedrock. Layers at elevations 73.3 to 71.8 and 69.6 to 52.9 contain significant amounts of organic material. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	26.0 - 40.0
Liquid Limit (%)	47.0 - 49.5
Plastic Limit (%)	24.0 - 25.0
Bulk Density (kN/m^3)	17.0 - 17.6
Undrained Shear Strength (kPa)	
Unconfined	45.6 - 74.6
Field Vane	61.4 -101.7

The consistency of the deposit ranges from firm to stiff. The material has intermediate plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations.

DISCUSSION AND RECOMMENDATIONS

Retaining walls #1, #4 and #5 are required for the proposed road designs. General foundation recommendations for all of these retaining walls are provided below, followed by specific design data for each site.

General Recommendations for Retaining Walls #1, #4 and #5

- For frost protection, a minimum cover of 1.2 m is required.
- The existing embankments should be protected during construction.
- If the excavations for spread footings or pile caps are carried out below the prevailing ground water level, a dewatering scheme may be required.

A) Retaining Wall #1 (Adjacent to QEW S.B. Collector Lanes, N.of Hwy.2)

The retaining wall can be founded on end-bearing steel 'H' piles with reinforced tips. The piles are to be driven to bedrock. Estimated tip elevations range from elevation 74.0 at Sta. 11 + 740 to elevation 69.0 at Sta. 11 + 820.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purpose of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition in which the at-rest condition applies.

The following construction procedures are recommended at Retaining Wall #1.

1) Drive protective sheeting into glacial till (or weathered shale). Estimated tip elevations are - for Sta. 11 + 740 Elev. 77.5; for Sta. 11 + 820 Elev. 74.0. The top of the sheeting should be at elev. 80.3 from which point the existing embankment behind the sheeting should be trimmed to 1.5 horizontal: 1 vertical or flatter. Protect the granular material on the exposed embankment slope against erosion with suitable polyethylene sheeting.

2) Install tiebacks, if required.

3) Excavate for footing and construct it.

4) Construct concrete retaining wall, founded on steel H-piles, as recommended.

5) Cut off sheeting at top of footing and backfill simultaneously.

In order to estimate the earth pressures on the retaining wall, the following values are recommended:

a) Granular Soil

$K_a = 0.33$

$K_o = 0.50$

Unit Weight $\gamma = 21.2$ kN/m^3

b) Cohesive Soil

$K_a = 0.45$

$K_o = 0.57$

Unit Weight $\gamma = 19.0$ kN/m^3

NOTE: Assume water level at elev. 77.3. Compute passive resistance below the bottom of the footing as $\frac{1}{3}H + 2c$ where c = 30 kPa.

The exact location of the existing 1200 mm diameter concrete pipe (sewer) should be determined by the designer. If the sewer is located less than 4 m from the footing. The piles should be pre-augered at least 2 m below the invert level.

B) Retaining Wall #4 (At Ramp S-E)

The entire wall may be supported on steel 'H' piles equipped with reinforced tips and driven to elevation 70 ±.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purposes of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition with K_o=0.5 for granular backfill.

C) Retaining Wall #5 (At Ramp N-EW)

Option 1: Standard cantilever retaining wall with spread footings on compacted granular 'A' as illustrated in Figure 1.

Option 2: Precast interlocking drywall - "Pisa Stone" as supplied by Risi Stone Ltd., Thornhill, on compacted granular 'A' as illustrated in Figure 2. Refer to W.P. 606-74-02, Contract 76-51 for further construction details. The top of wall elevations may be slightly varied to suit stone thickness. If safety barriers are required, this option may not be applicable.

For both options, the following design values are recommended:

- Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation condition with K_a=0.33 for granular backfill.

- Bearing Capacity

  Net Safe pressure 200 kPa

  and for the purposes of the O.H.B.D.C.:

  Capacity of S.L.S. Type II 200 kPa

  Factored capacity at U.L.S. 500 kPa

- Sliding at Base

  A friction co-efficient of 0.5 may be assumed to apply between the base of the footing and the underlying subsoil.

- Settlement

  Under the above loading conditions, settlements of the wall foundations will be less than 25 mm.

- Suitable weepholes should be provided to relieve any buildup of excess hydrostatic pressure.

- The groundwater level is lower than the bottom of the proposed excavation.

For the complete length of the wall (Sta. 300 to 315) the existing soil should be excavated to a sufficient depth to achieve the geometry of Fig. 4 or Fig. 5. The minimum thickness of the granular pad required is 0.6 m. It should be noted however that all existing soil above elev. 77.9 must be removed.

If required, the wall may be stepped.

MISCELLANEOUS

The fieldwork for these investigations was carried out under the supervision of Mr. D. H. Dundas, Project Foundation Engineer. The rock core was examined by Mrs. Z. Koniuszy, Geologist.

The drilling equipment was owned and operated by Atcost Soil Drilling Inc. and Master Soil Investigation Ltd.

This report was written by Mr. D. H. Dundas and reviewed by Mr. K. G. Selby, Senior Foundations Engineer.

D. H. Dundas

D. H. Dundas, P. Eng.
Project Foundations Engineer

K. G. Selby

K. G. Selby, P. Eng.
Senior Foundations Engineer

A P P E N D I X

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 303.0 E 279 518.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger, H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.5	Ground Level										
0.0	Silty clay Some sand, some gravel		1	SS	24	DRY	84				
			2	SS	57						
	Very Stiff to Hard		3	SS	69		82				0 13 50 37
			4	SS	99						
			5	SS	82						
			6	SS	104/23 cm		80				0 13 82 5
			7	SS	60/10 cm						
	with shaly layers Hard		8	SS	82/23 cm		78				
77.5											
7.0 76.7	*Shale, weathered		9	SS	50/13 cm						
7.8	End of Borehole						76				
	*Bedrock shale weathered										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
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RECORD OF BOREHOLE No 2

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 311.0 E 279 497.5 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 and 81 05 08 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.7	Ground Level										
0.0 / 77.2	Silty Clay Some sand, some gravel, Stiff (Fill Material)		1	SS	12	▼	78				
1.5 / 74.7	Silty Clay to Organic Silt Occasional sand Layers soft to firm		2	SS	4						0 4 74 22
			3	TW	PH		76			18.2	0 5 75 20
			4	TW	PH					18.3	0 9 65 26
4.0	Silty Clay some sand, some gravel hard		5	TW	PH					19.7	0 19 53 28
			6	TW	PH		74				
			7	SS	33						
	with shaly layers		8	SS	112		72				
			9	SS	115/23 cm						
70.3			10	SS	50/ 5 cm						
8.4	Bedrock shale weathered sound						70				
			11	RC BXL	100%						
							68				
66.5			12	RC BXL	98%						
12.2	End of Borehole						66				

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 340.0 E 279 471.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 08 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.8	Ground Level										
0.0	Organics very soft		1	SS	2		78				
77.3			2	SS	4						
1.5	Silty Clay to Organic Silt Occasional sand layers		3	TW	PH		76			19.5	
74.8			4	TW	PH					18.3	0 51 39 10
4.0	Silty Clay some sand, some gravel Hard with shaly layers		5	TW	PH					21.6	
			6	SS	100/20 cm		74				19 15 (66)
			7	SS	50/8 cm						
69.0							72				
68.8	Shale; weathered						70				
10.0	End of Borehole						68				

OFFICE REPORT ON SOIL EXPLORATION

+^{3}, ×^{5} : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 4

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 397.0 E 279 409.5 ORIGINATED BY D.H.D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P.P.

DATUM Geodetic DATE 81-05-12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.0	Ground Level									
0.0	Silty Clay some sand, some gravel (FILL MATERIAL) stiff hard		1	SS	11	DRY	78			0 16 72 12
			2	SS	60/15 cm					
			3	SS	98/25 cm		76			
	with shaly layers hard									
74.4										
4.6	Bedrock shale		4	RC BXL	42%		74			
	weathered sound						72			
			5	RC BXL	92%					
69.9							70			
9.1	End of Borehole						68			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 5

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 429.0 E 279 380.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.6	Ground Level										
0.0	Silty Clay some sand, some gravel hard		1	SS	46	DRY	84				
			2	SS	80				o		
			3	SS	90/23 cm		82				
			4	SS	60/15 cm				o		24 26 40 10
	with shaly layers										
79.4			5	SS	109/25 cm						
5.2	Bedrock weathered										
78.5	Shale sound		6	SS	60/3 cm						
6.1	End of Borehole						78				

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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Ontario

RECORD OF BOREHOLE No 6

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 118.5 E 297 993.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 13 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, * QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.6	Ground Level										
0.0	Silty Sand some clay compact to dense		1	SS	12		78				
			2	SS	23	DRY					
75.6			3	SS	34		76				0 62 36 2
3.0	Silty Clay some sand, trace of gravel stiff to very stiff with shaly layers hard		4	SS	19						
			5	SS	9						
			6	SS	60/15 cm						
72.5			7	SS	92/23 cm		72				
6.1	Bedrock Shale weathered		8	RC BXL	67%		70				
67.9			9	RC BXL	45%		68				
10.7	End of Borehole						66				

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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Ontario

RECORD OF BOREHOLE No 7

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 085.0 E 280 013.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 14 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
77.5	Ground Level										
0.0	Silty Sand some clay compact		1	SS	13	DRY	76				0 35 50 15
			2	SS	16						
74.5			3	SS	14						
3.0	Silty Clay Some sand, trace of gravel stiff with shaly layers		4	TW	PH		74			20.3	
			5	TW	PH					20.4	0 5 55 39
72.0	hard		6	SS	112						
5.5	Bedrock Shale weathered sound		7	RC BXL	93%		72				
							70				
66.8			8	RC BXL	100%		68				
10.7	End of Borehole						66				

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵ : Numbers refer to Sensitivity

15 20/10 S (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 8

W P 152-75-05 LOCATION RETAINING WALL #4 Co-ords. N 4 797 031.0 E 280 002.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 15 14 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.0	Ground Level										
0.0	Silty Sand some clay		1	SS	5		80				0 42 43 15
	compact to very dense		2	SS	12						
			3	SS	66		78				
			4	SS	38						0 41 43 15
			5	SS	35						
75.8			6	SS	27		76				
5.2	Silty Clay some sand, trace of gravel		7	SS	13						0 5 57 38
			8	TW	PH					19.5	0 9 (91)
			9	SS	8						
	stiff		10	SS	8		74				
	with shaly layers hard		11	SS	70						0 22 48 30
72.2											
71.7	*Shale, weathered		12	SS	77/2 cm		72				
9.3	End of Borehole										
	*Bedrock, Shale, weathered hard						70				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 9

RETAINING WALL #5

W P 152-75-05 LOCATION Co-ords. N 4 797 075 E 279 664 ORIGINATED BY D. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY O. J.

DATUM Geodetic DATE 81 08 24, 25 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
80.3	Ground Level										
0.0	Sandy Clay, some gravel, some organics firm to stiff (FILL MATERIAL)		1	SS	11		80				
			2	SS	6						
	Sand, some gravel, trace of organics, loose to dense (FILL MATERIAL)		3	SS	5		78				
76.3			4	SS	34						
4.0	Silty Clay some sand, trace of gravel, trace of organics firm to stiff		5	SS	18		76				
			6	SS	8	▼					
			7	SS	15						
			8	SS	9		74				
	some organics		9	TW	PH					17.6	
			10	SS	7		72				
			11	SS	7						
	with organics		12	TW	PH		70			17.1	
			13	SS	10		68				
			14	TW	PH					17.0	0 32 55 13
			15	SS	14		66				
	with shaly layers						64				
63.1			16	SS	15						
17.2	Bedrock shale weathered		17	SS	80/2 cm		62				
	sound		18	RC BXL	100%						
			19	RC BXL	93%		60				
59.0											
21.3	End of Borehole						58				

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 10

W P 152-75-05 LOCATION Co-ords. N 4 797 368.0; E 279 457.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 18-19 CHECKED BY D.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.7	Ground Level										
0.0	Fill Material						84				
	Silty Clay (CL) Some Sand, Some Gravel Stiff		1	SS	7						
			2	SS	6		82				
	— — —		3	SS	10						
	Silty Sand Trace of Gravel and Clay Occ. Organics		4	SS	18		80				
78.9	Loose to Compact		5	SS	7						1 64 24 11
5.8	Silty Clay to Organic Silt		6	SS	5						1 52 31 16
	Occ. Sand Layers		7	SS	8	▼	78				
76.8	Firm		8	SS	6						
7.9	Silty Clay (CL) Some Sand, Some Gravel Very Stiff (Till)		9	SS	21		76				
74.3											
10.4	Probable Bedrock End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 11

W P 152-75-05 LOCATION Co-ords. N 4 797 365.0; E 279 454.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 19 CHECKED BY D.D.

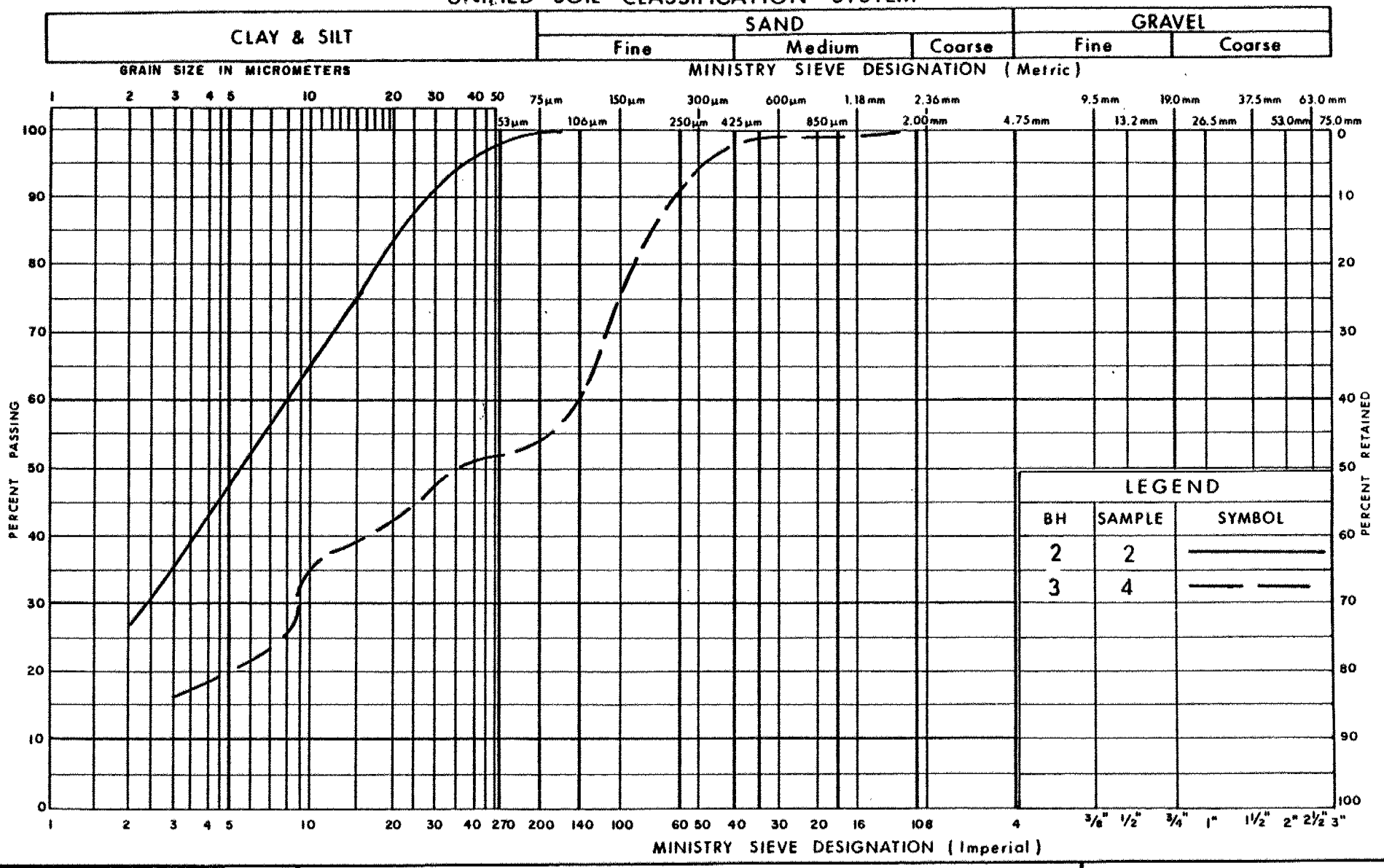
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.5	Ground Level										
0.0	Fill Material										
	Silty Clay (CL) Some Sand, Some Gravel, Occ. organics		1	SS	19						
			2	SS	27		80				
79.1	Silty Sand Compact										
2.4	Silty Clay to Organic		3	SS	13						
78.1	Silt Stiff		4	SS	11						
3.4	Silty Clay (CL) Occ. Irregular Layers of Silt to Silty Sand Occ. Organics Firm to Hard						78				
			5	SS	6	▼			WD		11 42 37 10
			6	SS	10		76		WD		12 31 42 15
74.2			7	SS	39						
7.3	Probable Bedrock End of Borehole						74				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



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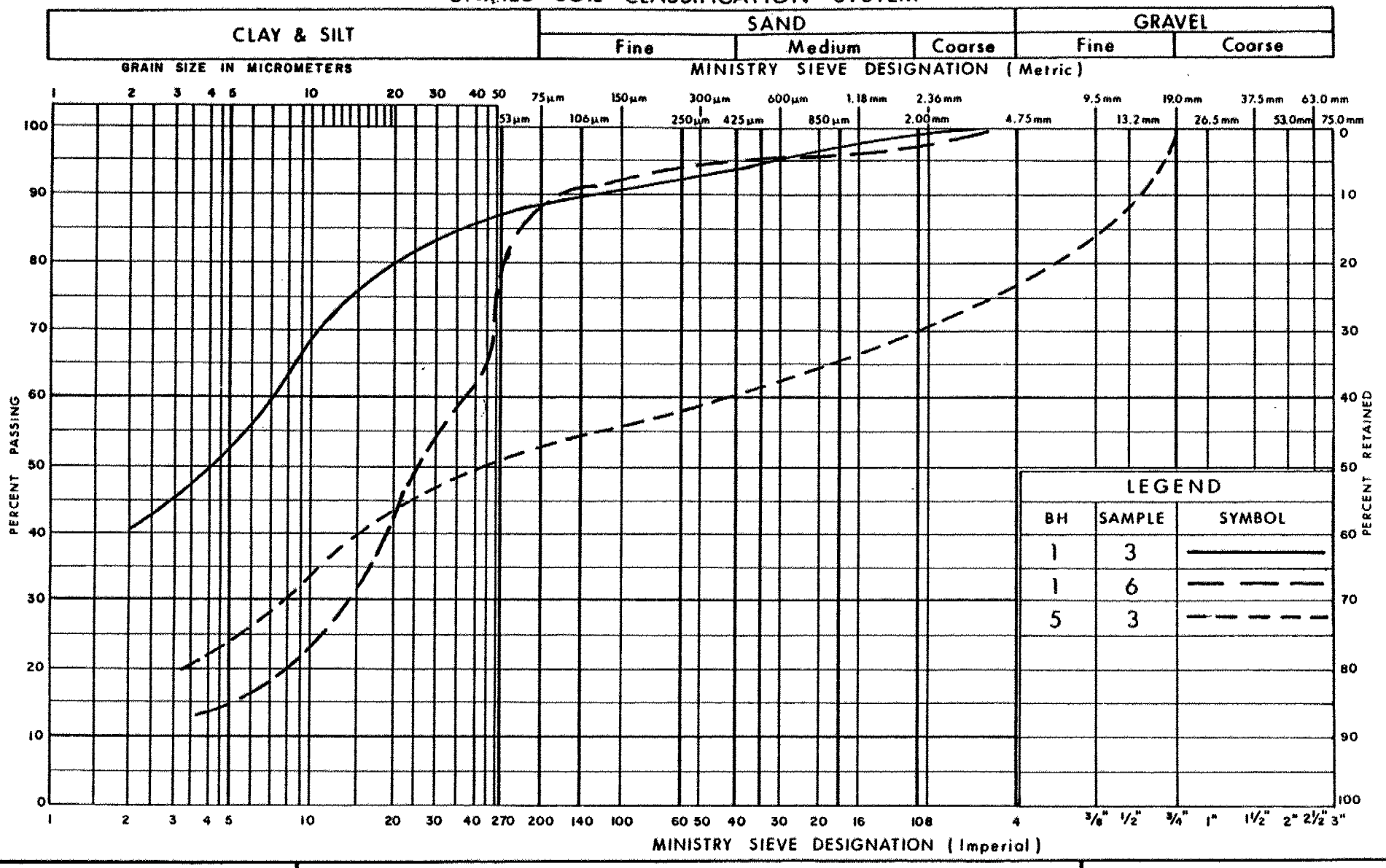
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY
TO ORGANIC SILT

FIG No 1
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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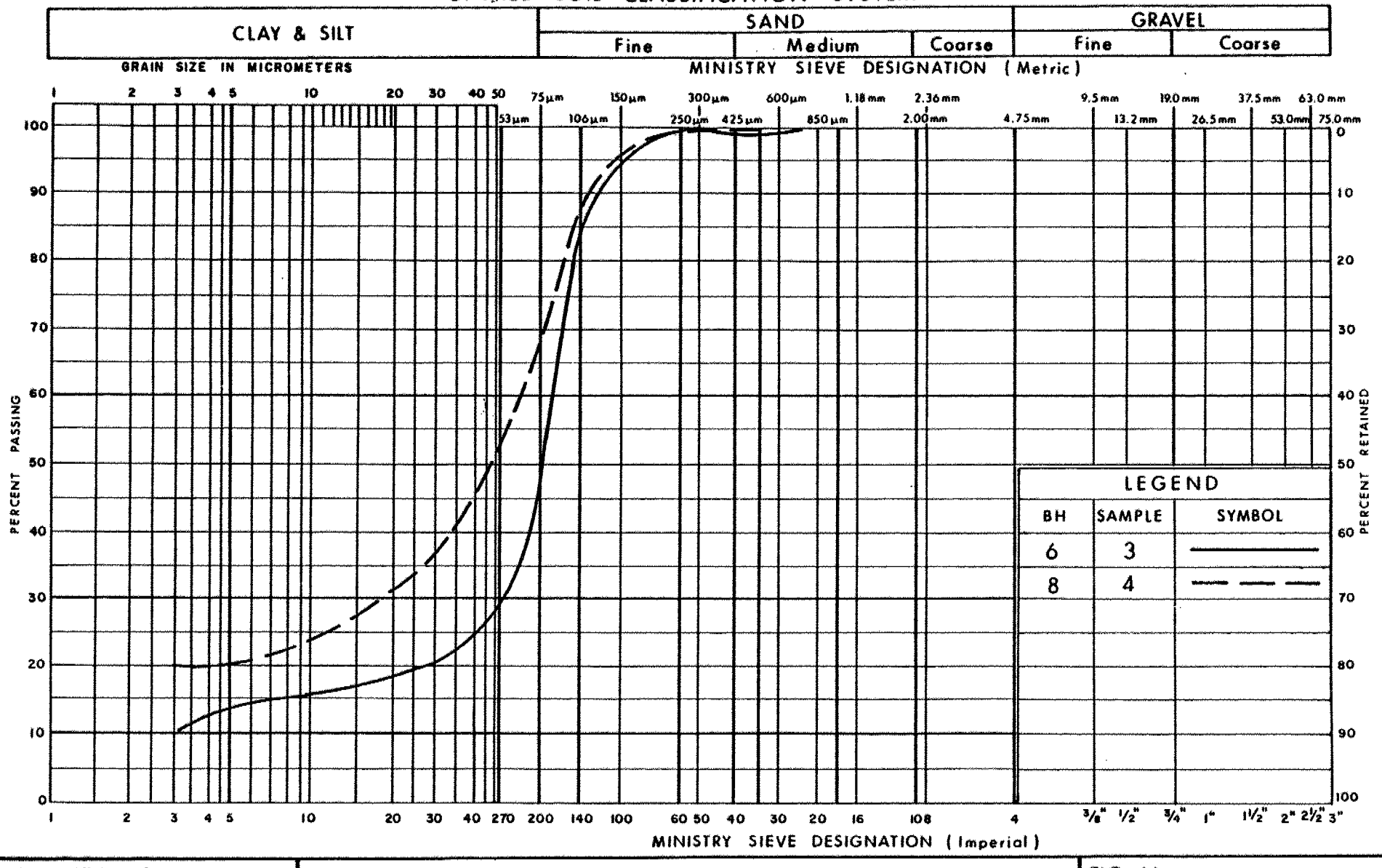
GRAIN SIZE DISTRIBUTION
SILTY CLAY
SOME SAND SOME GRAVEL

FIG No 2
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND
SOME CLAY

FIG No 3
W P 152-75-05

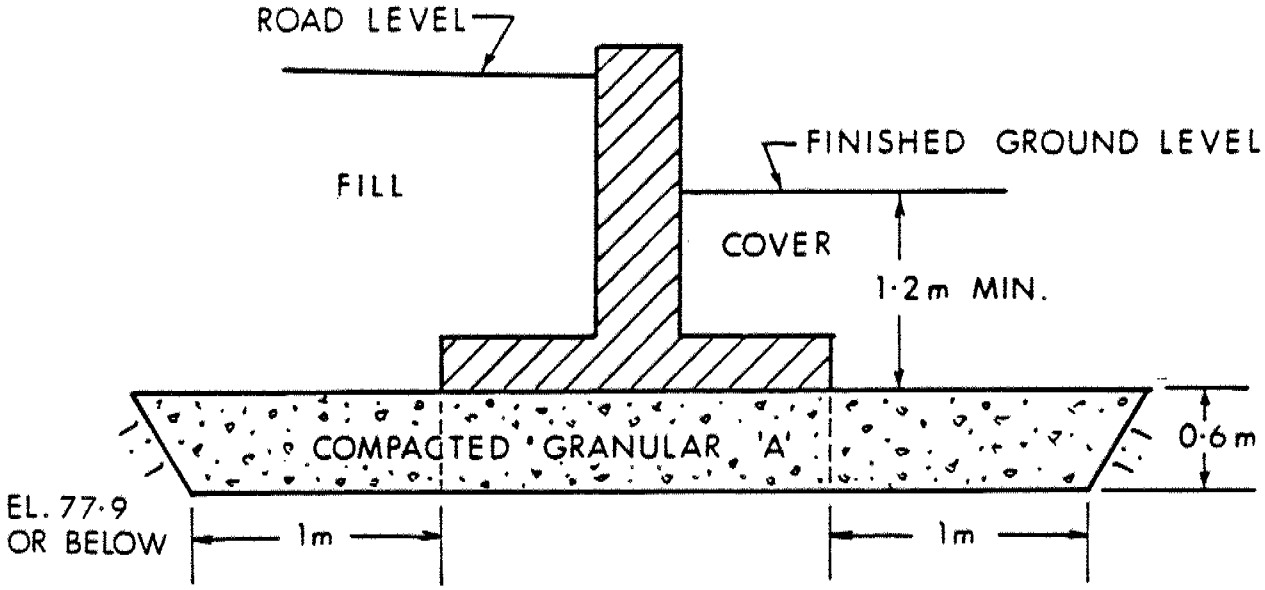
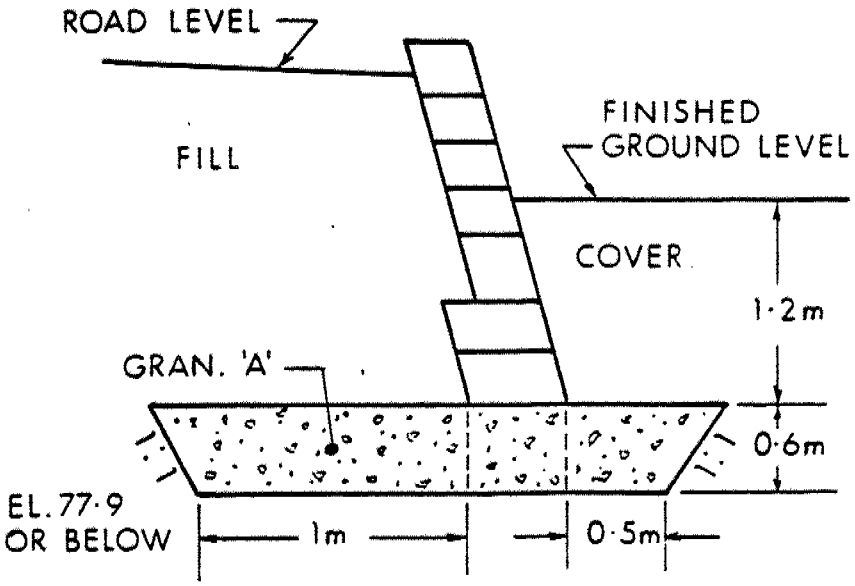


FIG. 4

RETAINING WALL ON SPREAD FOOTING

STA 0+300 TO STA 0+315

COMPLETE LENGTH OF WALL



PISA WALL FIG. 5

STA 0+300 TO STA 0+315

COMPLATE LENGTH OF WALL

RETAINING WALL No 5

W. P. 152-75-05

Ministry of Transportation and Communications
Ontario

TABLE 1

DIAMOND DRILL RECORD

HOLE NO. _____ SHEET NO. _____

DIP

PROPERTY: WP 152-75-05
LOCATION: QEW Skyway - Burlington
LATITUDE:
DEPARTURE:
BEARING:
TOTAL FOOTAGE:

ELEV. COLLAR:
DATUM:
DATE STARTED:
DATE COMPLETED:
DRILLED BY:
LOGGED BY:

FOOTAGE FROM	FOOTAGE TO	FORMATION	SAMPLE NUMBER			REMARKS
		B.H.1-2 = B.H. #2				
30'	40'	Red and green shale, medium hard.				90% recovery
		B.H.1-4 = B.H. #4				
15'	20'	Red and green shale, medium hard with few sections of shaly silty limestone.				Core broken and ground 25% recovery
20'	25'	Core missing.				
25'	30'	Red and green shale, medium hard with sections of shaly, silty limestone.				
		B.H. 4-1 = B.H. #6				
25'	35'	Red and green shale, medium hard.				65% recovery
		B.H. 4-2 = B.H. #7				
25'	35'	Red and green shale, medium hard with few sections of silty shaly limestone.				90% recovery

DATE OF EXAMINATION: July 2, 1981

Z. Koniuszy

OB-MT-113

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:

R Q D (%)	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

METRIC

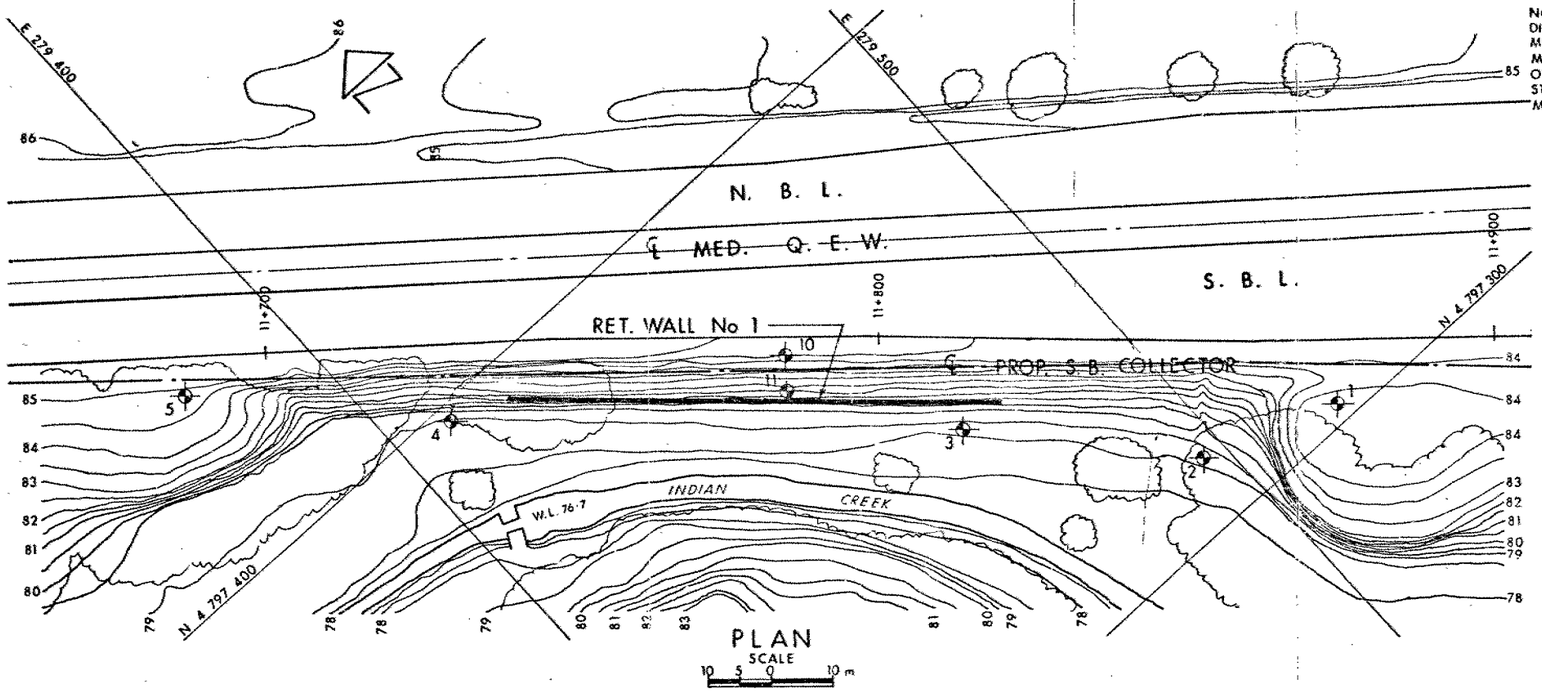
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
STATIONS IN KILOMETRES + METRES

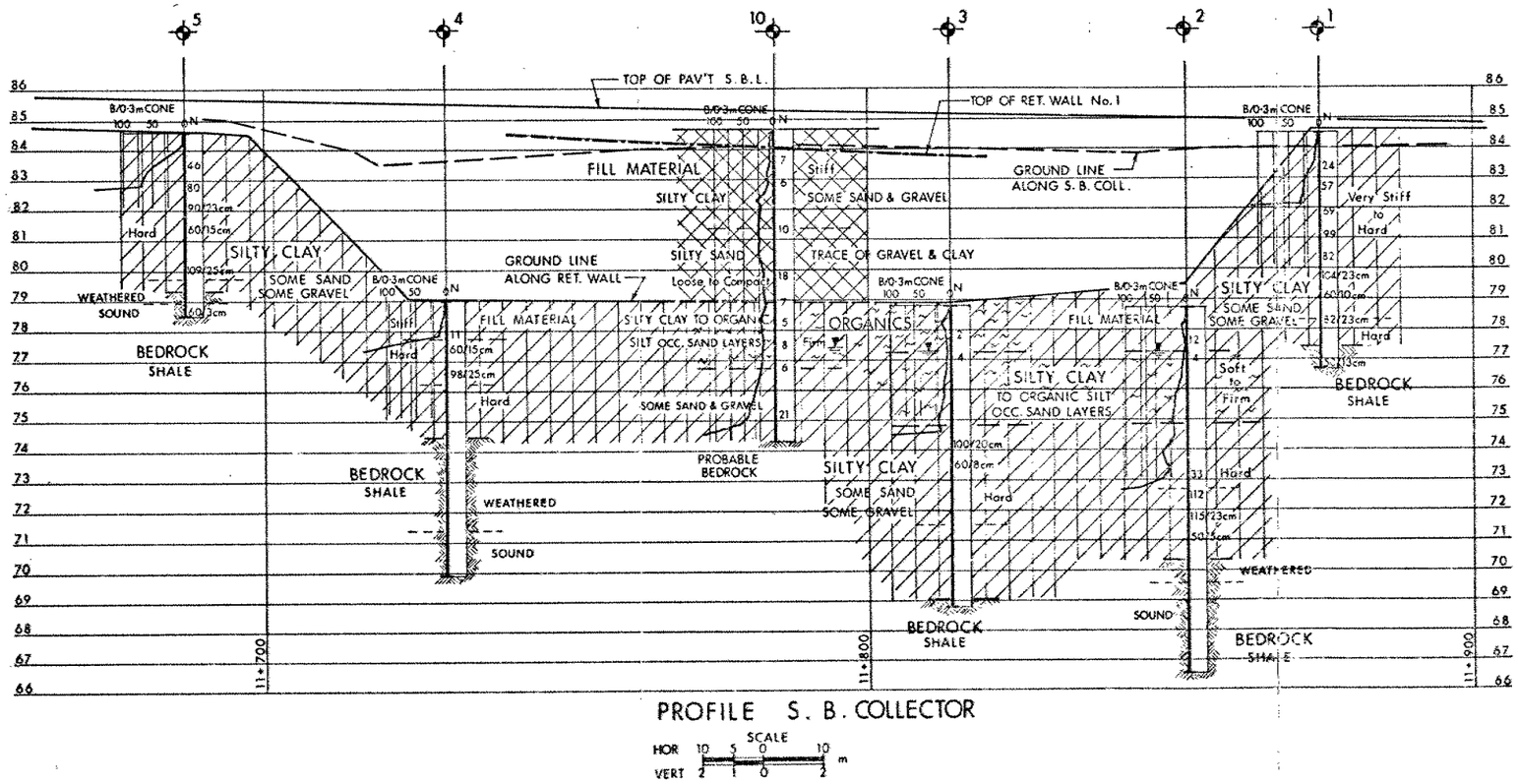
CONT No
WP No 152-75-05

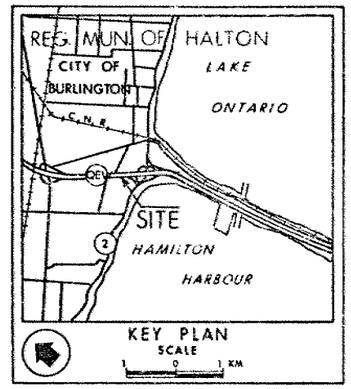
RETAINING WALL No 1

BORE HOLE LOCATIONS & SOIL STRATA

SHEET







LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- WL at time of investigation 81 05 08
  NO WL Established in BH 1, 4, 5

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	84·5	4 797 303·0	279 518·0
2	78·7	4 797 311·0	279 497·5
3	78·8	4 797 340·0	279 471·0
4	79·0	4 797 397·0	279 409·5
5	84·6	4 797 429·0	279 380·0
10	84·7	4 797 368·0	279 457·0
11	81·5	4 797 365·0	279 454·0

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

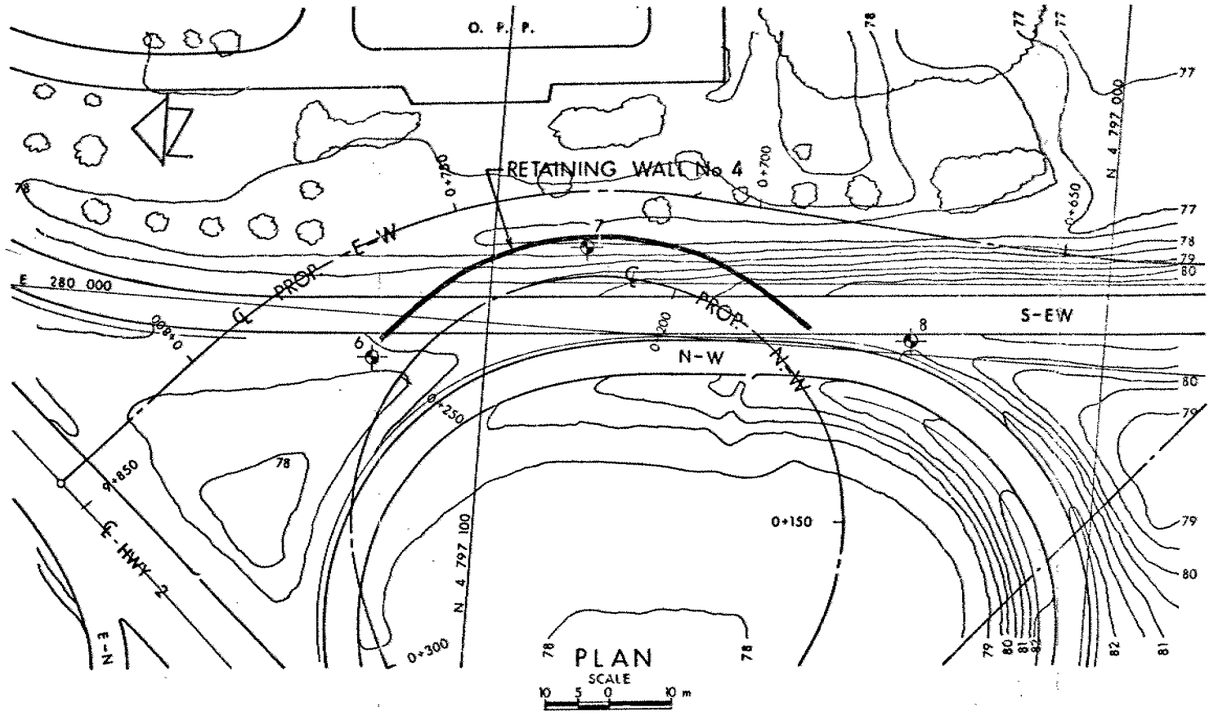
D. H. BRONDAS
REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

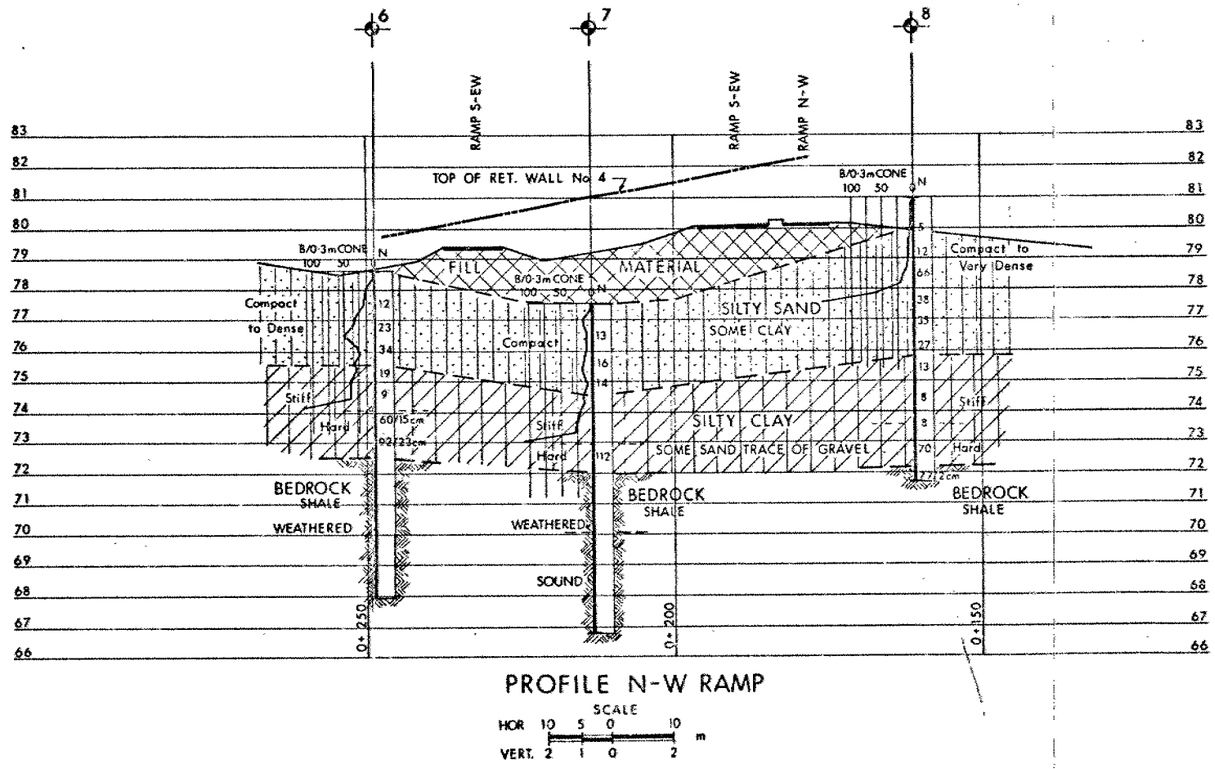
REVISIONS		
DATE	BY	DESCRIPTION

Geocres No 30M15-130A

HWY No	G E W		DIST 4
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN GL T	CHECKED	APPROVED	DWG 1527505-A

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-308M 6-78





PROFILE N-W RAMP

SCALE
HOR 10 5 0 10 m
VERT. 2 1 0 2

METRIC

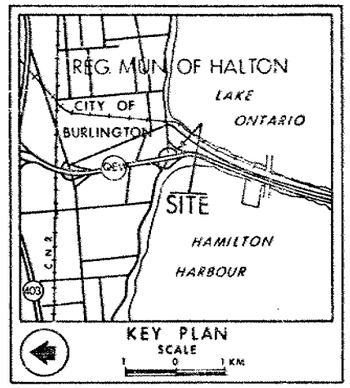
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

RETAINING WALL No 4

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation
  NO WL Established

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
6	78·6	4 797 118·5	297 993·0
7	77·5	4 797 085·0	280 013·0
8	81·0	4 797 031·0	280 002·0

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

REVISIONS

DATE	BY	DESCRIPTION

Geocres No 30M5-1308

HWY No Q E W		DIST 4	
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN Q L J	CHECKED	APPROVED	DWG 527505-B

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-30RM 8-76

METRIC

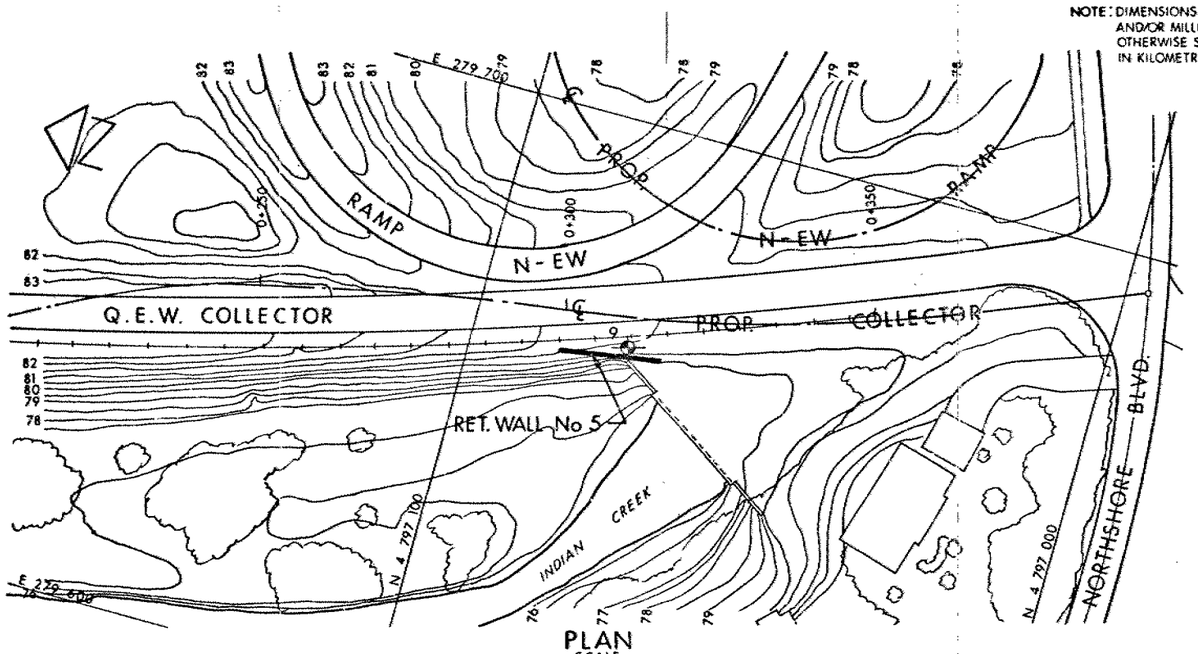
NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

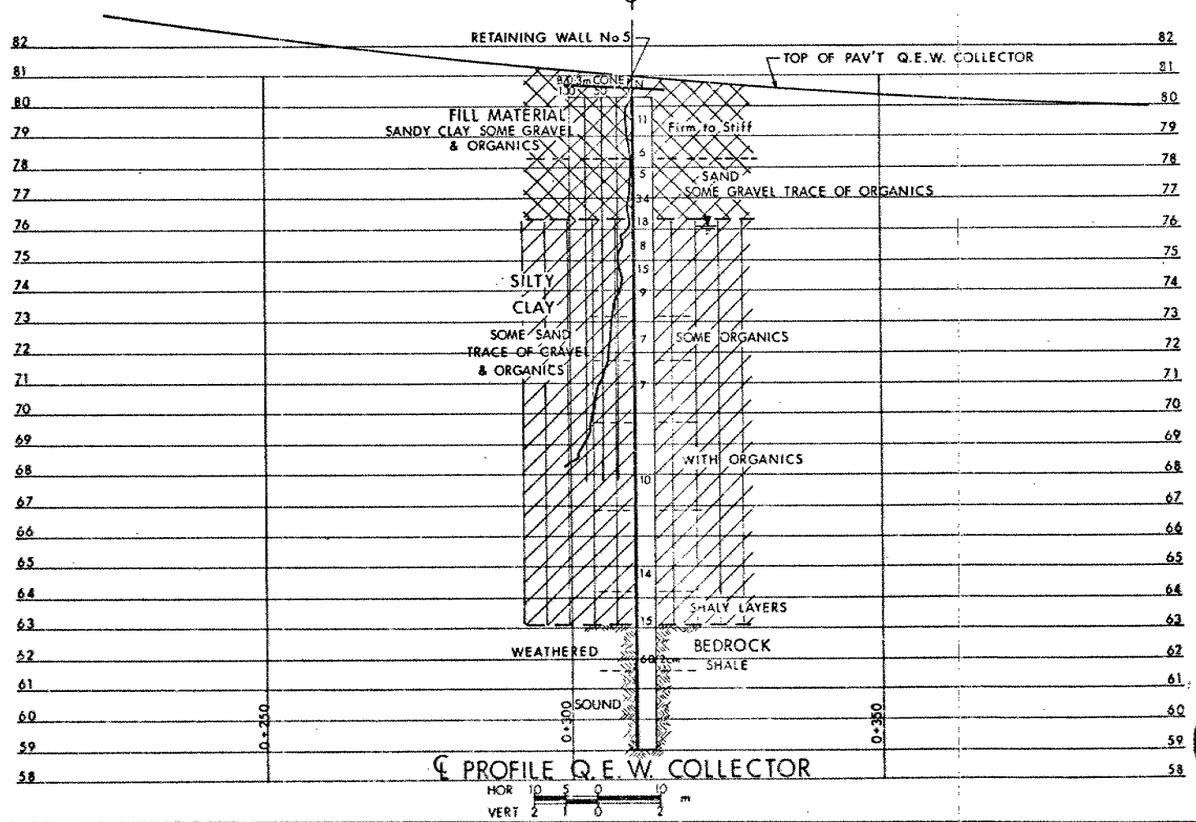
RETAINING WALL No. 5

BORE HOLE LOCATIONS & SOIL STRATA

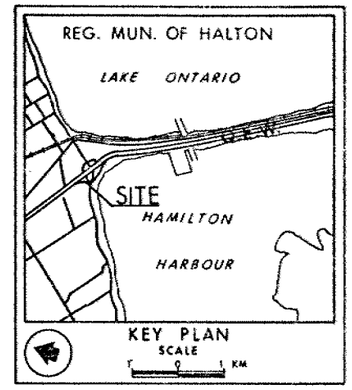
SHEET



PLAN
SCALE 10 5 0 10 m



℄ PROFILE Q.E.W. COLLECTOR
HOR 10 5 0 10 m
VERT 2 1 0 2



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation 81 08 24

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
9	80·3	4 797 075	279 664

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

REVISIONS

DATE	BY	DESCRIPTION

D H DUNCAS

Geocres No 30M5-130C

HWY No	Q. E. W.		DIST 4
SUBMD D. D	CHECKED	DATE 82 01 22	SITE
DRAWN O. J	CHECKED	APPROVED	DWG 1527505-C

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M5-130A, B, C

DIST. 4 REGION

W.P. No. 152-75-05

CONT. No. 82-85

W. O. No.

STR. SITE No. 10

HWY. No. Q.E.W. & Hwy 2

LOCATION QEW North of Burlington Skiway at Hwy 2

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

CONT 82-85

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 152-75-05 DIST 4

HWY Q.E.W. STR SITE 10

Retaining Walls #1, #4, #5

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GEOCRES 30M5-130A,B,C

DATE JUL - 6 1982

FOUNDATION INVESTIGATION REPORT

For

Retaining Walls #1, #4 and #5

W. P. 152-75-05, Site 10, Q.E.W. District 4, Hamilton

INTRODUCTION:

This report summarizes the results of a foundation investigation for the above-noted retaining walls. The fieldwork was conducted during the periods from 1981 05 07-12 and 1982 05 18-19 for Retaining Wall #1; 1981 05 13-14 for Retaining Wall #4; 1981 08 24-25 for Retaining Wall #5. Continuous-flight auger machines equipped with 82 mm I.D. hollow-stem augers and BX core barrels, and a modified diamond drill equipped with NX casing were utilized in the fieldwork.

This report supersedes the previous correspondence relating to these projects.

The fieldwork is summarized in the following table:

SITE LOCATION	Sampled Boreholes with Dynamic Cone Penetration Tests	Boring Depth Range (metres)	Number of Boreholes Bedrock Coring	Coring Depth Range (metres)
A)Retaining Wall #1	7	6.1 -10.4	2	3
B)Retaining Wall #4	3	7.1 - 9.3	2	3
C)Retaining Wall #5	1	18.3	1	3

DESCRIPTION OF SITE AND GEOLOGY

The sites are located:-

- in the jurisdiction of the City of Burlington, Regional Municipality of Halton
- in the physiographic region of the Iroquois Plain, a lowland area bordering Lake Ontario.

A) Retaining Wall #1

The site is located approximately 350 metres north of the QEW-Hwy.2 interchange on the west side of the QEW S.B. lanes. The adjacent land, to the west, is a conservation area.

The topography of the site consists of a valley, approximately 5 metres below the elevation of the QEW. Indian Creek flows through the valley from north to south.

At this site, silty clay (till) overlies shaly red clay that has been derived from the underlying Queenston shale. In the valley, surface organic deposits overlie the silty clay.

B) Retaining Wall #4

The site is located directly in front of the Burlington OPP station, approximately 150 metres northeast of the QEW N.B. lanes along the exit ramp to E.B. Hwy.2. The adjacent areas have institutional developments.

The topography of the site consists of a flat plain, ranging from approximately 1 to 2 metres below the elevation of the existing exit ramp.

At this site, silty sand overlies silty clay and shale bedrock.

C) Retaining Wall #5

The site is located approximately 80 metres north of the QEW-Hwy.2 intersection on the west side of Exit Ramp S-EW. The adjacent land, to the west, is a conservation area.

The topography of the site consists of:-

- at the north end, approximately a 4 metre drop from the ramp embankment to the valley of Indian Creek,
- at the south end, approximately a 1 metre drop from the ramp embankment to the filled area over the culvert bridging Indian Creek.

A sheet pile retaining wall divides the valley and the raised fill area.

At this site the surface fill is underlain by silty clay with occasional layers containing organics, then bedrock.

SUBSURFACE CONDITIONS

For Retaining Walls #1, #4 and #5, soil boundaries, insitu and laboratory test results, and ground water levels are shown on the appended Record of Borehole Sheets. The locations and elevations of the borings, along with several estimated stratigraphical profiles based on the borehole data, are shown on Drawings No. 1527505-A (Ret.Wall #1), No. 1527505-B (Ret.Wall #4), and 1527505-C (Ret.Wall #5).

A) Retaining Wall #1

The site is underlain by shale bedrock. Silty clay till overlies the bedrock and is the surface material of the natural embankments at BH #1 and #5. Silty clay to organic silt overlies the silty clay till at BH #2, #3, #4, #10 and #11. The surface material is silty clay fill at BH #2, #4, #10 and #11. Soft undecayed organic material is at the surface of BH #3. No water was observed at BH #1, #4 and #5. The water levels at BH #2, #3, #10 and #11 was approximately at elevation 77.3.

Descriptions of the soils and bedrock encountered are presented below, sequentially from the surface to termination of the boreholes.

Fill Material

Silty clay, some sand, some gravel is the surface fill material at BH#2, #4, #10 and #11. This material ranges in thickness from 3.2 m at BH#10 (roadway embankment) to 1.2 m at BH #4 (valley). The 'N' values from the Standard Penetration Test indicate a stiff to very stiff condition.

Under the roadway fill at BH #10 and #11, the silty clay fill is underlain by silty sand fill which ranges in depth from 2.6 m (BH #10) to 0.7 m (BH #11).

Organics

This deposit is the surface layer at the location of BH #3, and has a thickness of approximately 1.5 m.

The 'N' value indicates a very soft condition.

Field inspection of the sample indicated that the organic material was undecayed and possibly fill.

Silty Clay to Organic Silt; Occ. Sand Layers

At BH #2, #3, #10 and #11, this material underlies the surface fill and extends for a thickness ranging from 1.0 to 2.5 m. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	21.5 - 34.5
Liquid Limit (%)	21.5 - 47.0
Plastic Limit (%)	14.0 - 33.5
Bulk Density (kN /m^3)	18.2 - 19.5
Undrained Shear Strength (kPa)	
Unconfined	14.3 - 43.6

The consistency of the deposit ranges from soft to stiff. Grain size distribution is shown in Figure 1, Appendix. The material has generally low plasticity, although some layers have intermediate plasticity.

Silty Clay; Some Sand, Some Gravel

This material is located immediately above the shale bedrock at all borehole locations. In the natural embankments, at BH #1 and #5 it is the surface material and ranges in depth from 5.2 to 7.0 metres. In the valley, at BH #2, #3 and #4, it lies below, from 1.2 to 4.0 metres of other overburden, and extends for a depth of from 3.4 to 5.8 metres. Below the roadway fill embankment, at BH #10 and #11 it ranges in thickness from 2.5 to 3.9 metres. At BH #11 this deposit contains irregular layers of silt to silty sand.

Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	8.5 - 20.5
Liquid Limit (%)	18.0 - 30.5
Plastic Limit (%)	13.5 - 17.0
Bulk Density (kN/m^3)	21.6 (one test)

The consistency of the deposit ranges from firm to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

B) Retaining Wall #4

At this site silty clay overlies the shale bedrock. The surface material is silty sand. All boreholes were dry.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Silty Sand; Some Clay

This deposit is the surface material at the site, ranging in thickness from 3.0 to 5.2 metres.

Natural moisture contents range from 12% to 20%.

The Standard Penetration Test 'N' values (5 to 66 blows / 0.3 m) indicate a compact to very dense condition. Grain size distribution is shown in Figure 3, Appendix.

Silty Clay; Some Sand, Some/Trace Gravel

This material is located immediately above the shale bedrock at all borehole locations, ranging in thickness from 2.5 to 3.6 metres. Its physical properties, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	11.5 - 26.5
Liquid Limit (%)	19.5 - 32.5
Plastic Limit (%)	14.0 - 16.5
Bulk Density (kN/m^3)	19.5 - 20.4
Undrained Shear Strength (kPa)	
Unconfined	61.4 - 75.6
Quick Triaxial	93.4 (one test)

The consistency of the deposit ranges from stiff to hard, increasing with depth as the material grades into weathered shale. Grain size distribution is shown in Figure 2, Appendix. The material has low plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations, and the Appendix, Table 1, for the geologist's description of the core.

C) Retaining Wall #5

The site is underlain by shale bedrock. Silty clay with layers containing organics overlies the bedrock. The surficial deposit at the borehole locations is fill material. The water level was measured at a depth of 13.7 m (elev. 66.6) approximately the same level as Indian Creek.

Description of the soils and bedrock encountered are presented below, sequentially from surface to borehole termination.

Fill Material; Sandy Clay to Sand; Some Gravel, Some Organics

This surface fill material extends for a depth of 4.0 m. The upper 2 metres is cohesive material (with consistency ranging from firm to stiff) with low plasticity. Below this lies 2 metres of non-cohesive material with a range in denseness from loose to dense.

Silty Clay; Some Gravel; Trace/Some/With Organics

This deposit extends for 13.2 m and is located immediately above bedrock. Layers at elevations 73.3 to 71.8 and 69.6 to 52.9 contain significant amounts of organic material. Physical properties of the deposit, as determined by field and laboratory tests are summarized below:

	Range
Natural Moisture Content (%)	26.0 - 40.0
Liquid Limit (%)	47.0 - 49.5
Plastic Limit (%)	24.0 - 25.0
Bulk Density (kN/m^3)	17.0 - 17.6
Undrained Shear Strength (kPa)	
Unconfined	45.6 - 74.6
Field Vane	61.4 -101.7

The consistency of the deposit ranges from firm to stiff. The material has intermediate plasticity.

Bedrock

The bedrock at this site is medium hard, red and green shale with occasional layers of shaly, silty limestone. It is overlain by transitional zones grading from silty clay with shaly layers to weathered shale. Refer to the borehole log sheets for bedrock elevations.

DISCUSSION AND RECOMMENDATIONS

Retaining walls #1, #4 and #5 are required for the proposed road designs. General foundation recommendations for all of these retaining walls are provided below, followed by specific design data for each site.

General Recommendations for Retaining Walls #1, #4 and #5

- For frost protection, a minimum cover of 1.2 m is required.
- The existing embankments should be protected during construction.
- If the excavations for spread footings or pile caps are carried out below the prevailing ground water level, a dewatering scheme may be required.

A) Retaining Wall #1 (Adjacent to QEW S.B. Collector Lanes, N.of Hwy.2)

The retaining wall can be founded on end-bearing steel 'H' piles with reinforced tips. The piles are to be driven to bedrock. Estimated tip elevations range from elevation 74.0 at Sta. 11 + 740 to elevation 69.0 at Sta. 11 + 820.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purpose of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition in which the at-rest condition applies.

The following construction procedures are recommended at Retaining Wall #1.

1) Drive protective sheeting into glacial till (or weathered shale). Estimated tip elevations are - for Sta. 11 + 740 Elev. 77.5; for Sta. 11 + 820 Elev. 74.0. The top of the sheeting should be at elev. 80.3 from which point the existing embankment behind the sheeting should be trimmed to 1.5 horizontal: 1 vertical or flatter. Protect the granular material on the exposed embankment slope against erosion with suitable polyethylene sheeting.

2) Install tiebacks, if required.

3) Excavate for footing and construct it.

4) Construct concrete retaining wall, founded on steel H-piles, as recommended.

5) Cut off sheeting at top of footing and backfill simultaneously.

In order to estimate the earth pressures on the retaining wall, the following values are recommended:

a) Granular Soil

$K_a = 0.33$

$K_o = 0.50$

Unit Weight $\gamma = 21.2$ kN/m^3

b) Cohesive Soil

$K_a = 0.45$

$K_o = 0.57$

Unit Weight $\gamma = 19.0$ kN/m^3

NOTE: Assume water level at elev. 77.3. Compute passive resistance below the bottom of the footing as $\frac{1}{3}H + 2c$ where c = 30 kPa.

The exact location of the existing 1200 mm diameter concrete pipe (sewer) should be determined by the designer. If the sewer is located less than 4 m from the footing. The piles should be pre-augered at least 2 m below the invert level.

B) Retaining Wall #4 (At Ramp S-E)

The entire wall may be supported on steel 'H' piles equipped with reinforced tips and driven to elevation 70 ±.

The following design values are recommended:

Pile Type	Safe Capacity
310 HP 110	1150 kN
310 HP 79	820 kN

and for the purposes of the O.H.B.D.C.:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
310 HP 110	1600 kN	1150 kN
310 HP 79	1150 kN	820 kN

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation condition with K_o=0.5 for granular backfill.

C) Retaining Wall #5 (At Ramp N-EW)

Option 1: Standard cantilever retaining wall with spread footings on compacted granular 'A' as illustrated in Figure 1.

Option 2: Precast interlocking drywall - "Pisa Stone" as supplied by Risi Stone Ltd., Thornhill, on compacted granular 'A' as illustrated in Figure 2. Refer to W.P. 606-74-02, Contract 76-51 for further construction details. The top of wall elevations may be slightly varied to suit stone thickness. If safety barriers are required, this option may not be applicable.

For both options, the following design values are recommended:

- Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation condition with K_a=0.33 for granular backfill.

- Bearing Capacity

  Net Safe pressure 200 kPa

  and for the purposes of the O.H.B.D.C.:

  Capacity of S.L.S. Type II 200 kPa

  Factored capacity at U.L.S. 500 kPa

- Sliding at Base

  A friction co-efficient of 0.5 may be assumed to apply between the base of the footing and the underlying subsoil.

- Settlement

  Under the above loading conditions, settlements of the wall foundations will be less than 25 mm.

- Suitable weepholes should be provided to relieve any buildup of excess hydrostatic pressure.

- The groundwater level is lower than the bottom of the proposed excavation.

For the complete length of the wall (Sta. 300 to 315) the existing soil should be excavated to a sufficient depth to achieve the geometry of Fig. 4 or Fig. 5. The minimum thickness of the granular pad required is 0.6 m. It should be noted however that all existing soil above elev. 77.9 must be removed.

If required, the wall may be stepped.

MISCELLANEOUS

The fieldwork for these investigations was carried out under the supervision of Mr. D. H. Dundas, Project Foundation Engineer. The rock core was examined by Mrs. Z. Koniuszy, Geologist.

The drilling equipment was owned and operated by Atcost Soil Drilling Inc. and Master Soil Investigation Ltd.

This report was written by Mr. D. H. Dundas and reviewed by Mr. K. G. Selby, Senior Foundations Engineer.

D. H. Dundas

D. H. Dundas, P. Eng.
Project Foundations Engineer

K. G. Selby

K. G. Selby, P. Eng.
Senior Foundations Engineer

A P P E N D I X

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 303.0 E 279 518.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger, H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.5	Ground Level										
0.0	Silty clay Some sand, some gravel		1	SS	24	DRY	84				
			2	SS	57						
	Very Stiff to Hard		3	SS	69		82				0 13 50 37
			4	SS	99						
			5	SS	82						
			6	SS	104/23 cm		80				0 13 82 5
			7	SS	60/10 cm						
	with shaly layers Hard		8	SS	82/23 cm		78				
77.5											
7.0 76.7	*Shale, weathered		9	SS	50/13 cm						
7.8	End of Borehole						76				
	*Bedrock shale weathered										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
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RECORD OF BOREHOLE No 2

RETAINING WALL # 1

W P 152-75-05 LOCATION Co-ords. N 4 797 311.0 E 279 497.5 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 07 and 81 05 08 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.7	Ground Level										
0.0 / 77.2	Silty Clay Some sand, some gravel, Stiff (Fill Material)		1	SS	12	▼	78				
1.5 / 74.7	Silty Clay to Organic Silt Occasional sand Layers soft to firm		2	SS	4						0 4 74 22
			3	TW	PH		76			18.2	0 5 75 20
			4	TW	PH					18.3	0 9 65 26
4.0	Silty Clay some sand, some gravel hard		5	TW	PH					19.7	0 19 53 28
			6	TW	PH		74				
			7	SS	33						
	with shaly layers		8	SS	112		72				
			9	SS	115/23 cm						
70.3			10	SS	50/ 5 cm						
8.4	Bedrock shale weathered sound						70				
			11	RC BXL	100%						
							68				
66.5			12	RC BXL	98%						
12.2	End of Borehole						66				

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 3

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 340.0 E 279 471.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 08 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.8	Ground Level										
0.0	Organics very soft		1	SS	2		78				
77.3			2	SS	4						
1.5	Silty Clay to Organic Silt Occasional sand layers		3	TW	PH		76			19.5	
74.8			4	TW	PH					18.3	0 51 39 10
4.0	Silty Clay some sand, some gravel Hard with shaly layers		5	TW	PH					21.6	
			6	SS	100/20 cm		74				19 15 (66)
			7	SS	50/8 cm						
69.0							72				
68.8	Shale; weathered						70				
10.0	End of Borehole						68				

OFFICE REPORT ON SOIL EXPLORATION

+^{3}, ×^{5} : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 4

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 397.0 E 279 409.5 ORIGINATED BY D.H.D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P.P.

DATUM Geodetic DATE 81-05-12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.0	Ground Level									
0.0	Silty Clay some sand, some gravel (FILL MATERIAL) stiff hard		1	SS	11	DRY	78			0 16 72 12
			2	SS	60/15 cm					
			3	SS	98/25 cm		76			
	with shaly layers hard									
74.4										
4.6	Bedrock shale		4	RC BXL	42%		74			
	weathered sound						72			
			5	RC BXL	92%					
69.9							70			
9.1	End of Borehole						68			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 5

RETAINING WALL #1

W P 152-75-05 LOCATION Co-ords. N 4 797 429.0 E 279 380.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 12 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.6	Ground Level										
0.0	Silty Clay some sand, some gravel hard		1	SS	46	DRY	84				
			2	SS	80				o		
			3	SS	90/23 cm		82				
			4	SS	60/15 cm				o		24 26 40 10
	with shaly layers										
79.4			5	SS	109/25 cm						
5.2	Bedrock weathered										
78.5	Shale sound		6	SS	60/3 cm						
6.1	End of Borehole						78				

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 6

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 118.5 E 297 993.0 ORIGINATED BY D. H. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Cont. Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 05 13 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, * QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
78.6	Ground Level										
0.0	Silty Sand some clay compact to dense		1	SS	12		78				
			2	SS	23	DRY					
75.6			3	SS	34		76				0 62 36 2
3.0	Silty Clay some sand, trace of gravel stiff to very stiff with shaly layers hard		4	SS	19						
			5	SS	9						
			6	SS	60/15 cm						
72.5			7	SS	92/23 cm		72				
6.1	Bedrock Shale weathered		8	RC BXL	67%		70				
67.9			9	RC BXL	45%		68				
10.7	End of Borehole						66				

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 7

RETAINING WALL #4

W P 152-75-05 LOCATION Co-ords. N 4 797 085.0 E 280 013.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger COMPILED BY P. P.

DATUM Geodetic DATE 81 05 14 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
77.5	Ground Level										
0.0	Silty Sand some clay compact		1	SS	13	DRY	76				0 35 50 15
			2	SS	16						
74.5			3	SS	14						
3.0	Silty Clay Some sand, trace of gravel stiff with shaly layers		4	TW	PH		74			20.3	
			5	TW	PH					20.4	0 5 55 39
72.0	hard		6	SS	112						
5.5	Bedrock Shale weathered sound		7	RC BXL	93%		72				
							70				
66.8			8	RC BXL	100%		68				
10.7	End of Borehole						66				

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵ : Numbers refer to Sensitivity

15 20/10 S (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 8

W P 152-75-05 LOCATION RETAINING WALL #4 Co-ords. N 4 797 031.0 E 280 002.0 ORIGINATED BY O. J.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Continuous Flight Auger; H. S. COMPILED BY P. P.

DATUM Geodetic DATE 81 15 14 CHECKED BY D.H.D.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.0	Ground Level										
0.0	Silty Sand some clay		1	SS	5		80				0 42 43 15
	compact to very dense		2	SS	12						
			3	SS	66		78				
			4	SS	38						0 41 43 15
			5	SS	35						
75.8			6	SS	27		76				
5.2	Silty Clay some sand, trace of gravel		7	SS	13						0 5 57 38
			8	TW	PH					19.5	0 9 (91)
			9	SS	8						
	stiff		10	SS	8		74				
	with shaly layers hard		11	SS	70						0 22 48 30
72.2											
71.7	*Shale, weathered		12	SS	77/2 cm		72				
9.3	End of Borehole										
	*Bedrock, Shale, weathered hard						70				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 9

RETAINING WALL #5

W P 152-75-05 LOCATION Co-ords. N 4 797 075 E 279 664 ORIGINATED BY D. D.

DIST 4 HWY Q. E. W. BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY O. J.

DATUM Geodetic DATE 81 08 24, 25 CHECKED BY D.H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
80.3	Ground Level										
0.0	Sandy Clay, some gravel, some organics firm to stiff (FILL MATERIAL)		1	SS	11		80				
			2	SS	6						
	Sand, some gravel, trace of organics, loose to dense (FILL MATERIAL)		3	SS	5		78				
76.3			4	SS	34						
4.0	Silty Clay some sand, trace of gravel, trace of organics firm to stiff		5	SS	18		76				
			6	SS	8	▼					
			7	SS	15						
			8	SS	9		74				
	some organics		9	TW	PH					17.6	
			10	SS	7		72				
			11	SS	7						
	with organics		12	TW	PH		70			17.1	
			13	SS	10		68				
			14	TW	PH					17.0	0 32 55 13
			15	SS	14		66				
	with shaly layers						64				
63.1			16	SS	15						
17.2	Bedrock shale weathered		17	SS	80/2 cm		62				
	sound		18	RC BXL	100%						
			19	RC BXL	93%		60				
59.0											
21.3	End of Borehole						58				

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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Ontario

RECORD OF BOREHOLE No 10

W P 152-75-05 LOCATION Co-ords. N 4 797 368.0; E 279 457.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 18-19 CHECKED BY D.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.7	Ground Level										
0.0	Fill Material						84				
	Silty Clay (CL) Some Sand, Some Gravel Stiff		1	SS	7						
			2	SS	6		82				
	— — —		3	SS	10						
	Silty Sand Trace of Gravel and Clay Occ. Organics		4	SS	18		80				
78.9	Loose to Compact		5	SS	7						1 64 24 11
5.8	Silty Clay to Organic Silt		6	SS	5						1 52 31 16
	Occ. Sand Layers		7	SS	8	▼	78				
76.8	Firm		8	SS	6						
7.9	Silty Clay (CL) Some Sand, Some Gravel Very Stiff (Till)		9	SS	21		76				
74.3											
10.4	Probable Bedrock End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 11

W P 152-75-05 LOCATION Co-ords. N 4 797 365.0; E 279 454.0 ORIGINATED BY D.D.
DIST 4 HWY O.E.W. BOREHOLE TYPE NX Casing COMPILED BY O.J.
DATUM Geodetic DATE 82 05 19 CHECKED BY D.D.

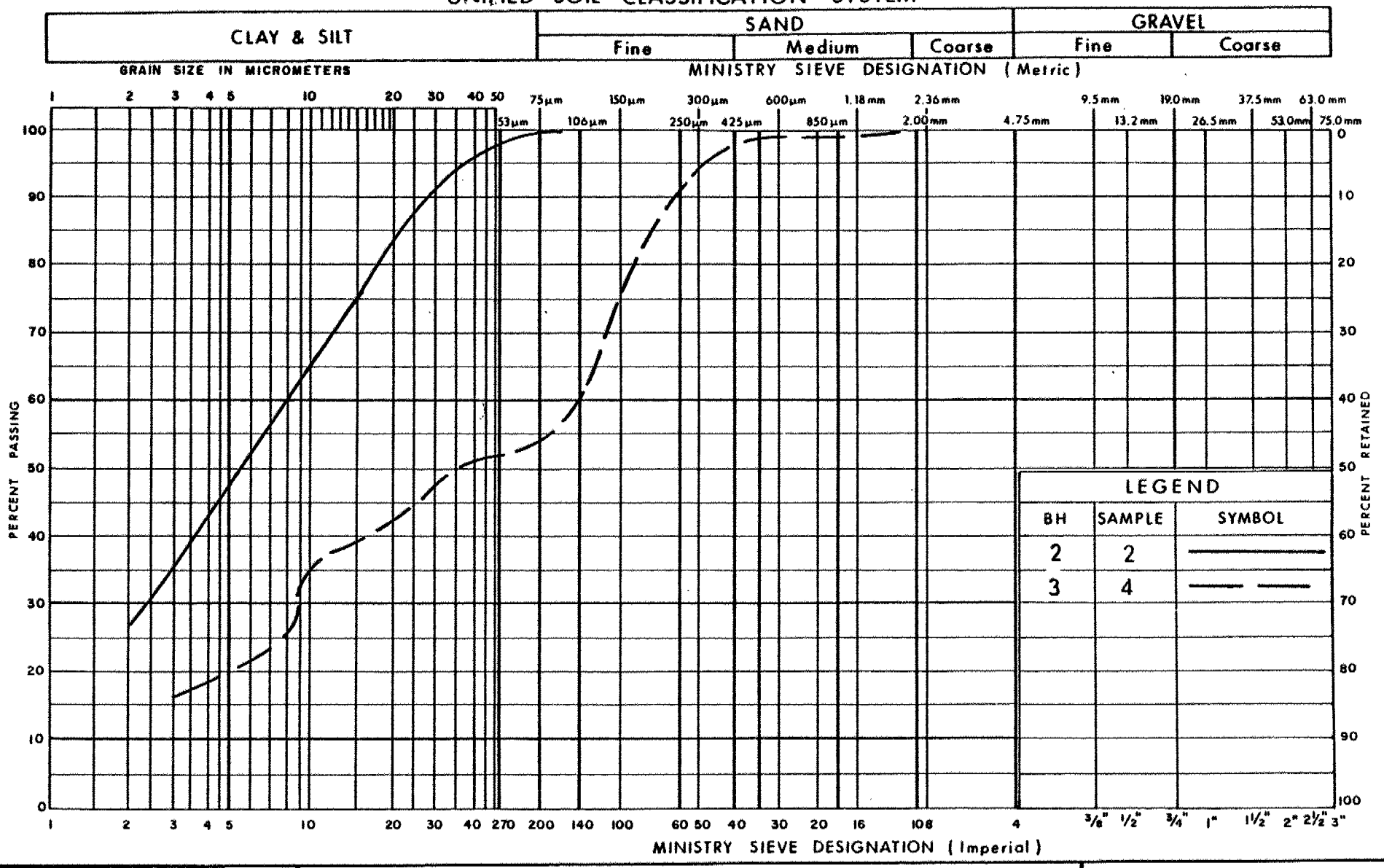
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.5	Ground Level										
0.0	Fill Material										
	Silty Clay (CL) Some Sand, Some Gravel, Occ. organics		1	SS	19						
			2	SS	27		80				
79.1	Silty Sand Compact										
2.4	Silty Clay to Organic		3	SS	13						
78.1	Silt Stiff		4	SS	11						
3.4	Silty Clay (CL) Occ. Irregular Layers of Silt to Silty Sand Occ. Organics Firm to Hard						78				
			5	SS	6	▼			WD		11 42 37 10
			6	SS	10		76		WD		12 31 42 15
74.2			7	SS	39						
7.3	Probable Bedrock End of Borehole						74				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



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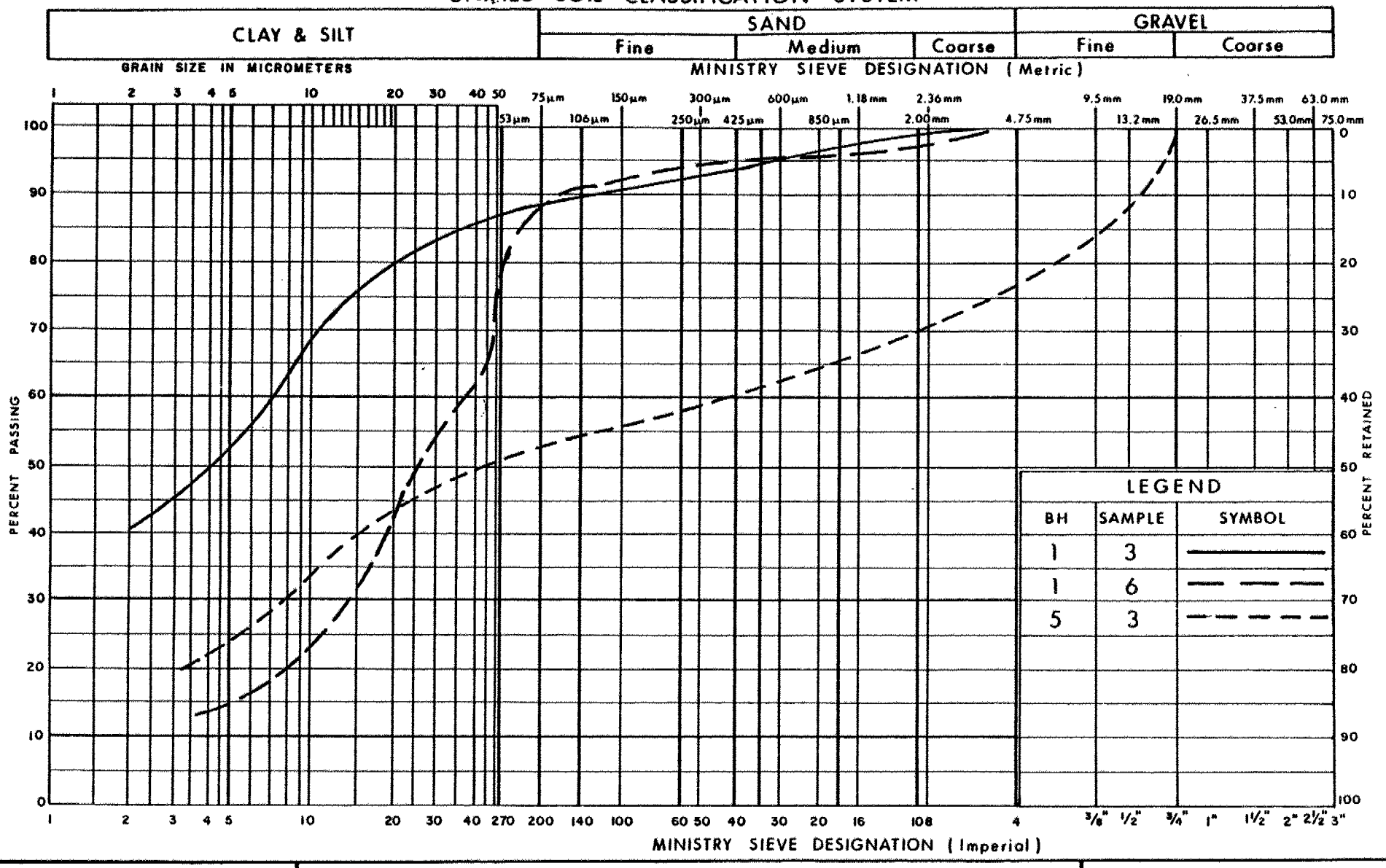
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY
TO ORGANIC SILT

FIG No 1
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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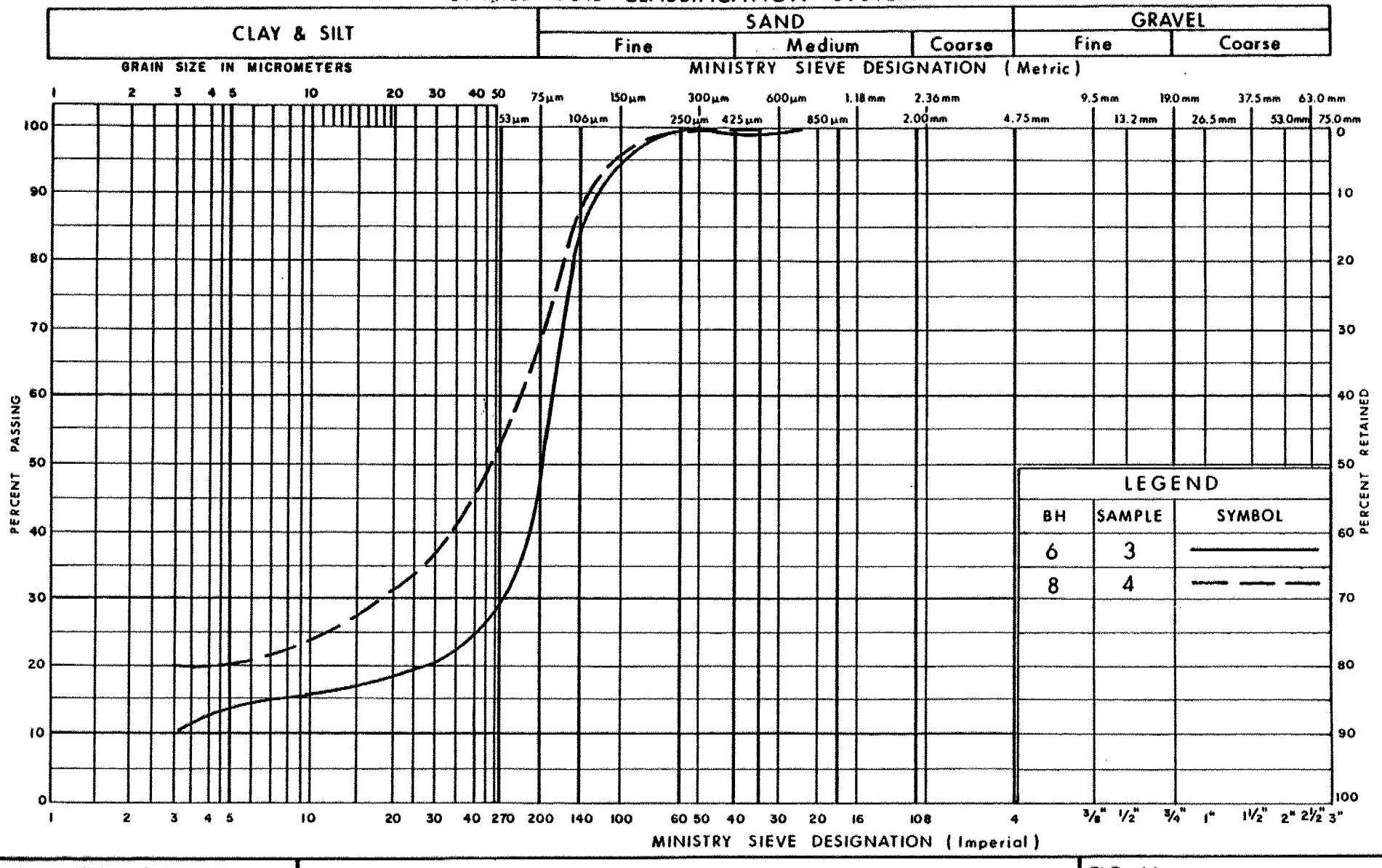
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY
SOME SAND SOME GRAVEL

FIG No 2
W P 152-75-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND
SOME CLAY

FIG No 3
W P 152-75-05

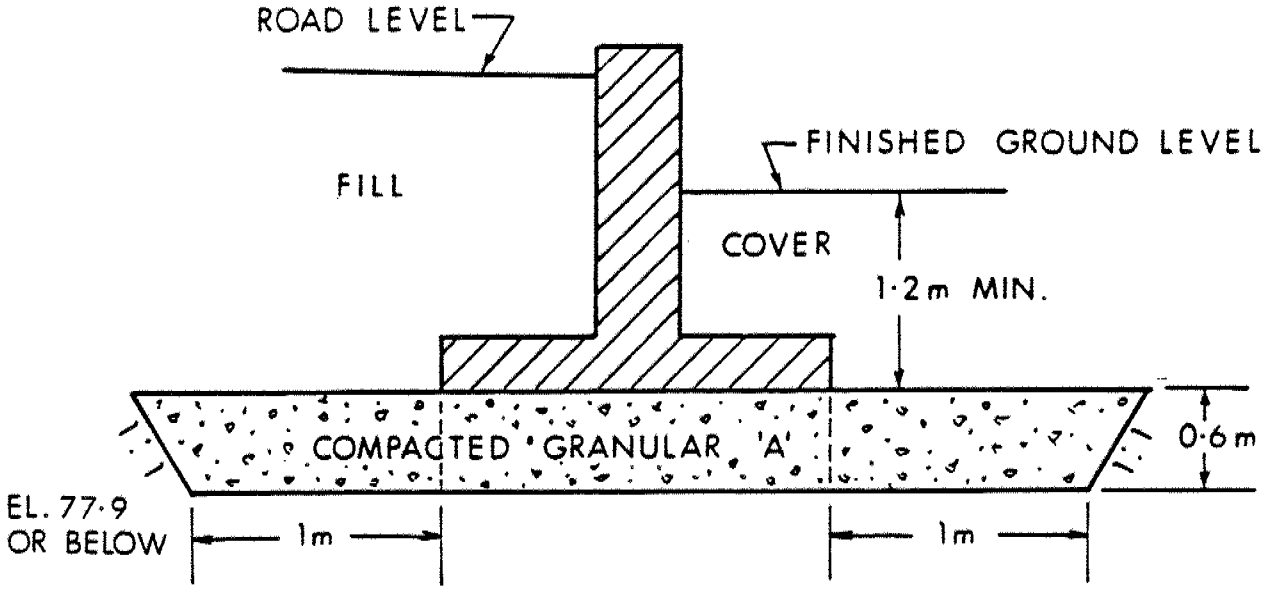
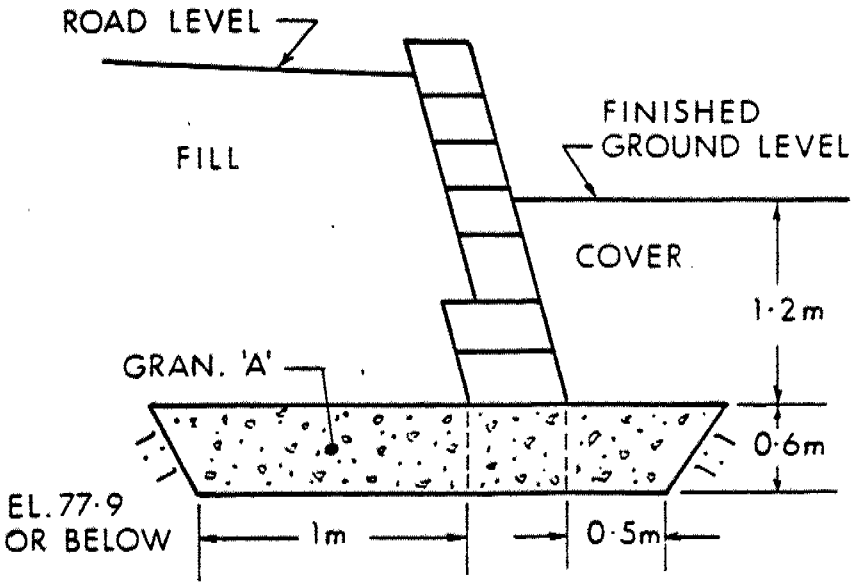


FIG. 4

RETAINING WALL ON SPREAD FOOTING

STA 0+300 TO STA 0+315

COMPLETE LENGTH OF WALL



PISA WALL FIG. 5

STA 0+300 TO STA 0+315

COMPLATE LENGTH OF WALL

RETAINING WALL No 5

W. P. 152-75-05

Ministry of Transportation and Communications
Ontario

TABLE 1

DIAMOND DRILL RECORD

HOLE NO. _____ SHEET NO. _____

DIP

PROPERTY: WP 152-75-05
LOCATION: QEW Skyway - Burlington
LATITUDE:
DEPARTURE:
BEARING:
TOTAL FOOTAGE:

ELEV. COLLAR:
DATUM:
DATE STARTED:
DATE COMPLETED:
DRILLED BY:
LOGGED BY:

FOOTAGE FROM	FOOTAGE TO	FORMATION	SAMPLE NUMBER			REMARKS
		B.H.1-2 = B.H. #2				
30'	40'	Red and green shale, medium hard.				90% recovery
		B.H.1-4 = B.H. #4				
15'	20'	Red and green shale, medium hard with few sections of shaly silty limestone.				Core broken and ground 25% recovery
20'	25'	Core missing.				
25'	30'	Red and green shale, medium hard with sections of shaly, silty limestone.				
		B.H. 4-1 = B.H. #6				
25'	35'	Red and green shale, medium hard.				65% recovery
		B.H. 4-2 = B.H. #7				
25'	35'	Red and green shale, medium hard with few sections of silty shaly limestone.				90% recovery

DATE OF EXAMINATION: July 2, 1981

Z. Koniuszy

OB-MT-113

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:

R Q D (%)	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

METRIC

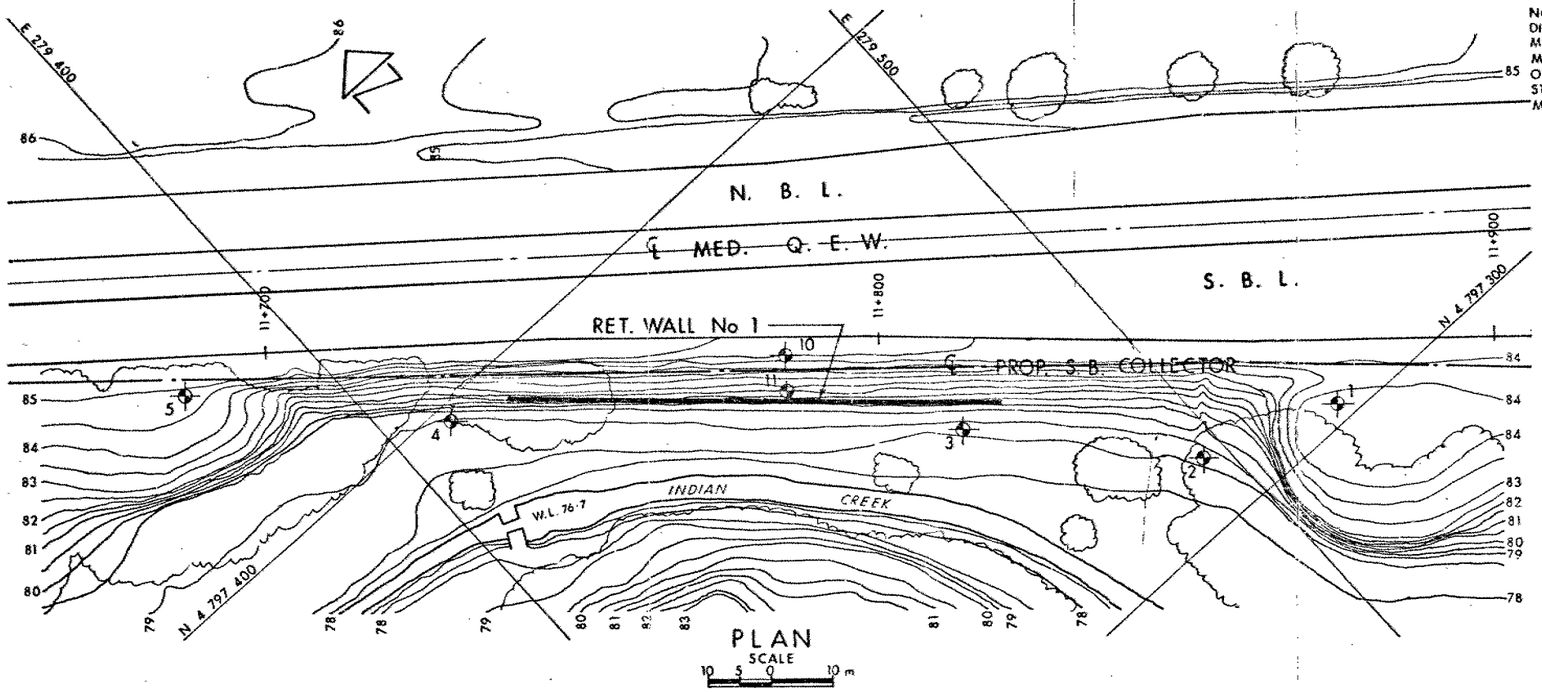
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
STATIONS IN KILOMETRES + METRES

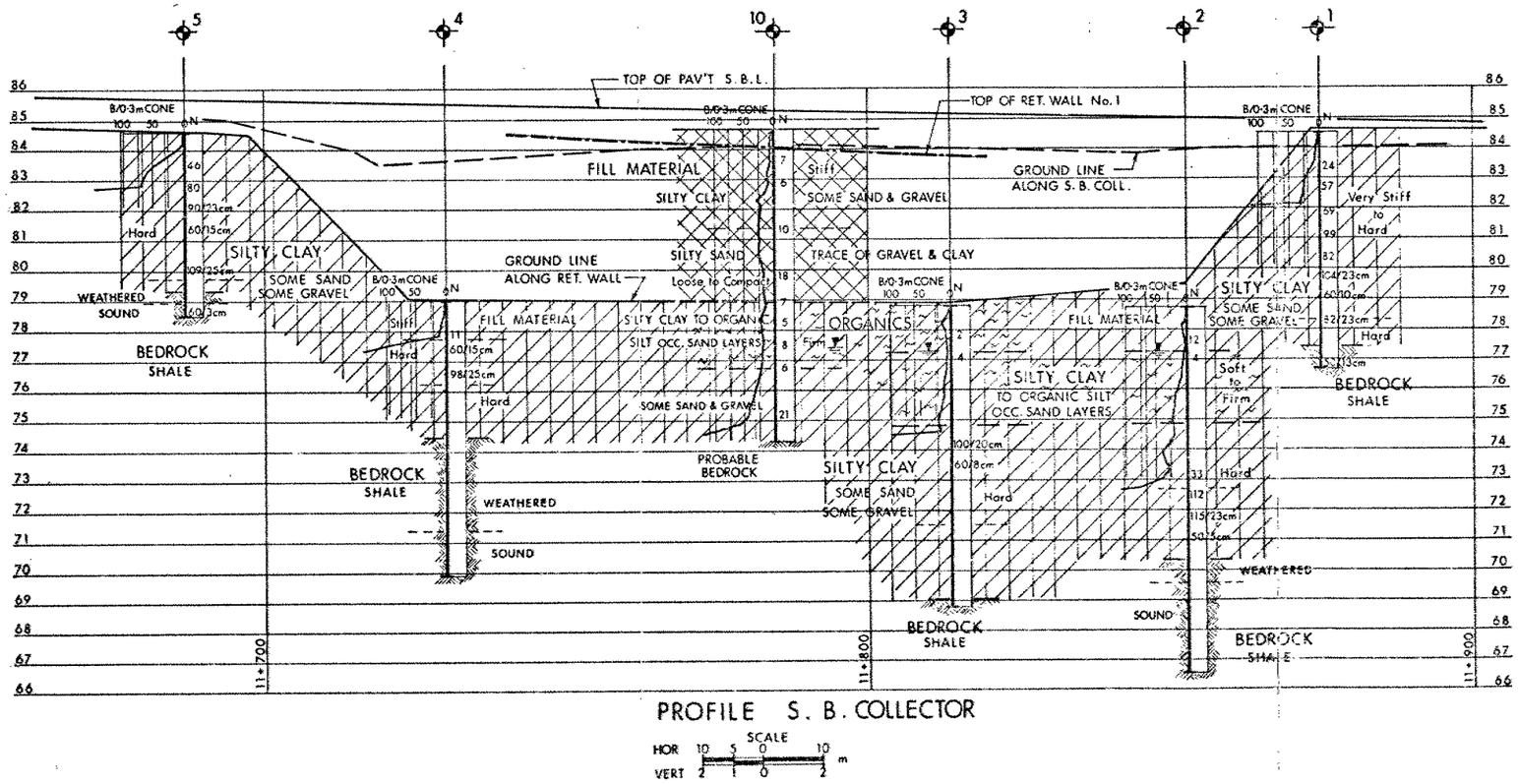
CONT No
WP No 152-75-05

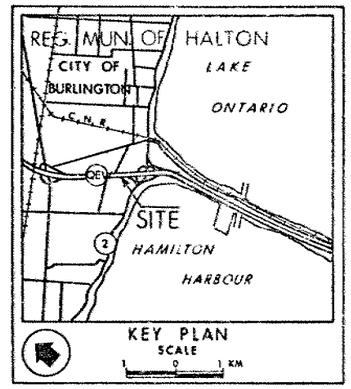
RETAINING WALL No 1

BORE HOLE LOCATIONS & SOIL STRATA

SHEET







LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- WL at time of investigation 81 05 08
  NO WL Established in BH 1, 4, 5

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	84·5	4 797 303·0	279 518·0
2	78·7	4 797 311·0	279 497·5
3	78·8	4 797 340·0	279 471·0
4	79·0	4 797 397·0	279 409·5
5	84·6	4 797 429·0	279 380·0
10	84·7	4 797 368·0	279 457·0
11	81·5	4 797 365·0	279 454·0

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

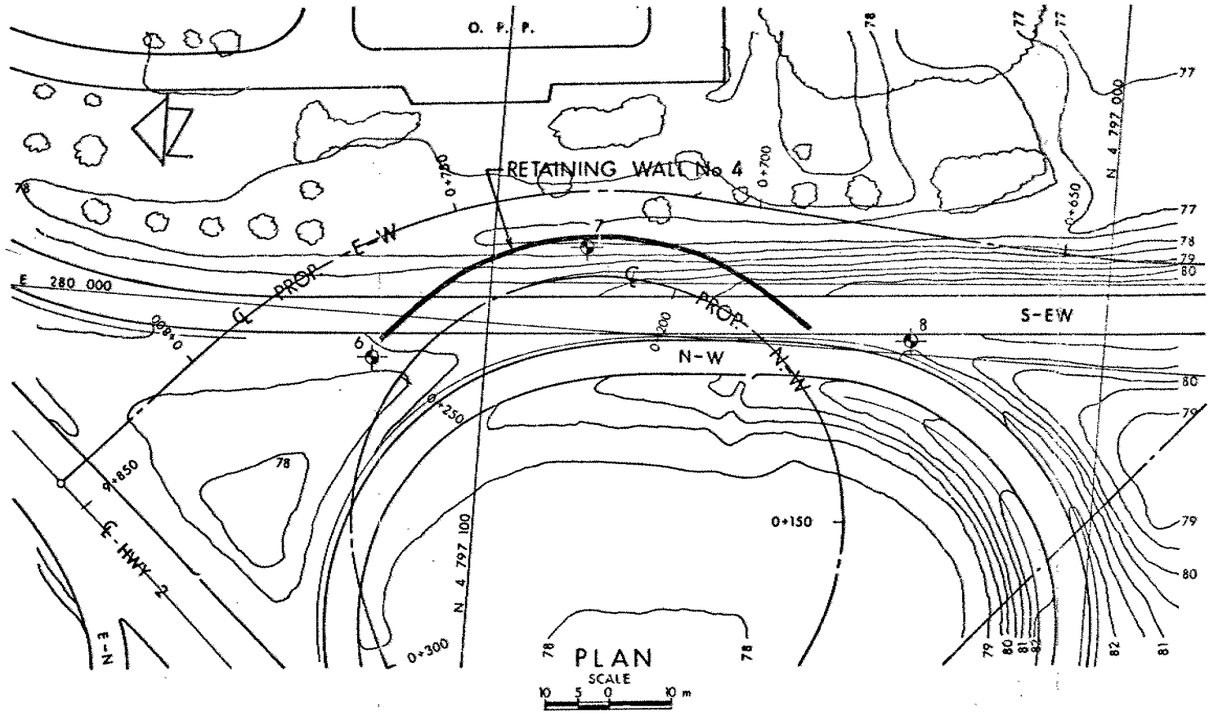
D. H. BRONDAS
REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

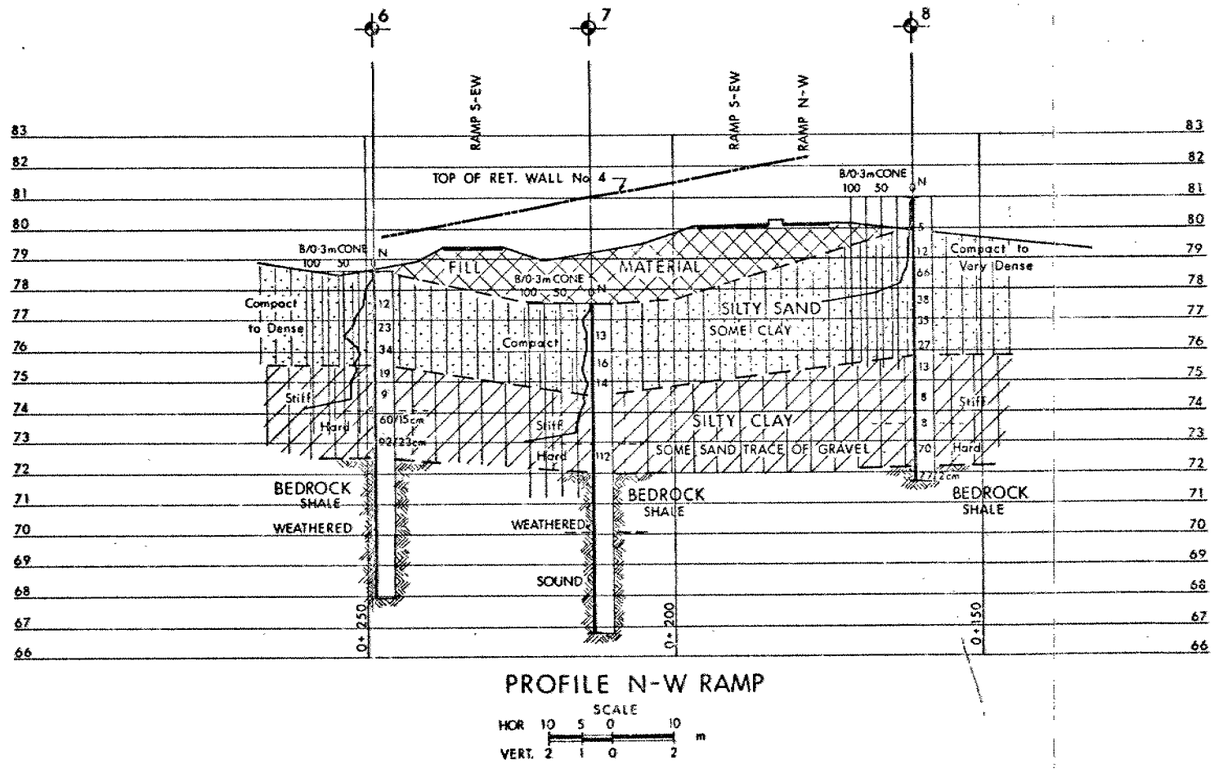
REVISIONS		
DATE	BY	DESCRIPTION

Geocres No 30M15-130A

HWY No	G E W		DIST 4
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN GL T	CHECKED	APPROVED	DWG 1527505-A

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-308M 6-78





PROFILE N-W RAMP

SCALE
HOR 10 5 0 10 m
VERT. 2 1 0 2

METRIC

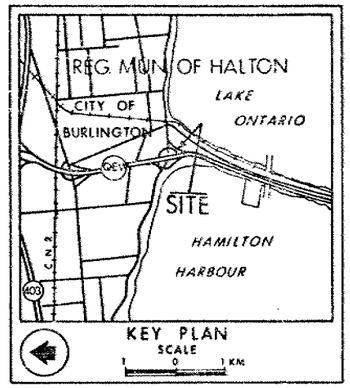
NOTE:
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

RETAINING WALL No 4

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation
  NO WL Established

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
6	78·6	4 797 118·5	297 993·0
7	77·5	4 797 085·0	280 013·0
8	81·0	4 797 031·0	280 002·0

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

REVISIONS

DATE	BY	DESCRIPTION

Geocres No 30M5-1308

HWY No Q E W		DIST 4	
SUBM'D P P	CHECKED	DATE 81 06 26	SITE 10
DRAWN Q L J	CHECKED	APPROVED	DWG 527505-B

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 08-MT-30RM 8-76

METRIC

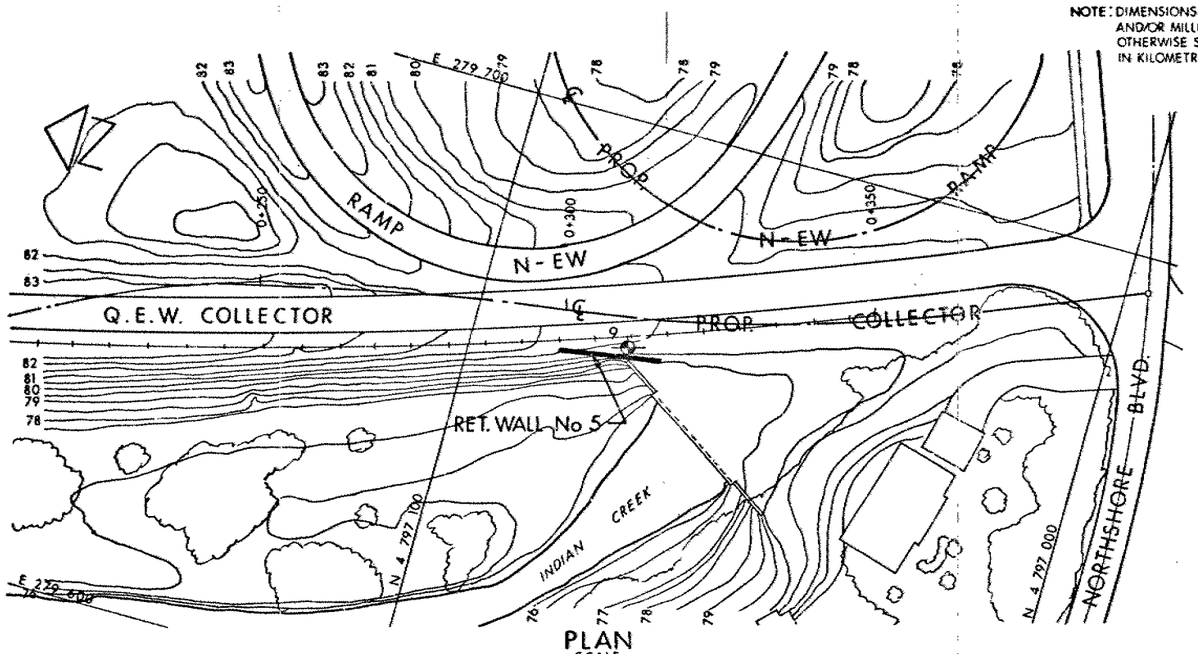
NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 152-75-05

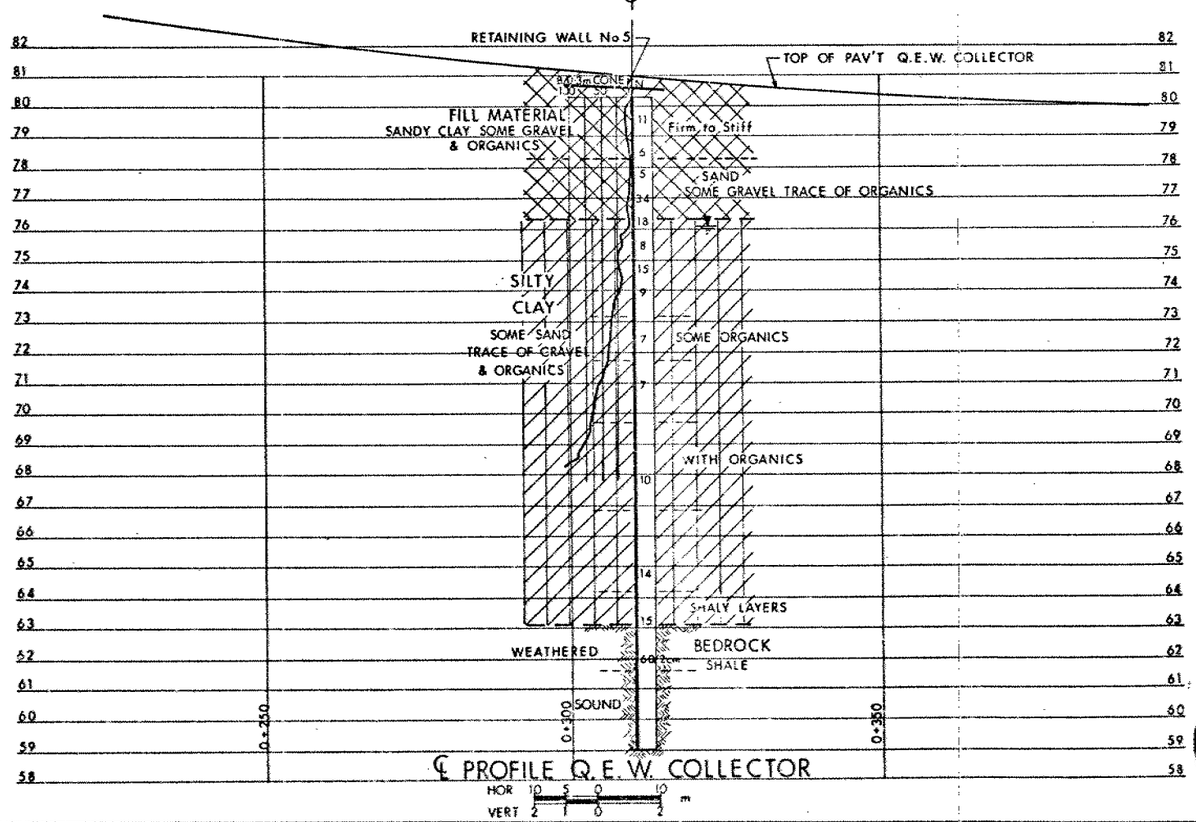
RETAINING WALL No. 5

BORE HOLE LOCATIONS & SOIL STRATA

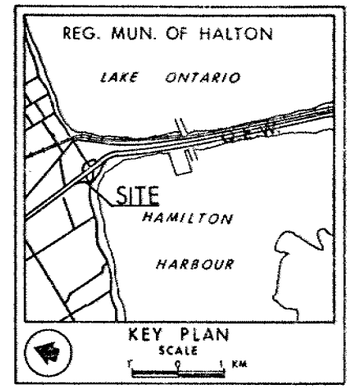
SHEET



PLAN
SCALE 10 5 0 10 m



℄ PROFILE Q.E.W. COLLECTOR
HOR 10 5 0 10 m
VERT 2 1 0 2



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation 81 08 24

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
9	80·3	4 797 075	279 664

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

REVISIONS

DATE	BY	DESCRIPTION

D H DUNCAS

Geocres No 30M5-130C

HWY No	Q. E. W.		DIST 4
SUBMD D. D	CHECKED	DATE 82 01 22	SITE
DRAWN O. J	CHECKED	APPROVED	DWG 1527505-C