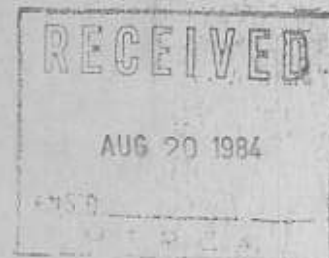




**GEO-CANADA LTD.**  
CONSULTING GEOTECHNICAL ENGINEERS

90 NOLAN CRT., UNIT 21  
MARKHAM, ONT.  
L3R 4L9  
(416) 474-9255

GEOTECHNICAL INVESTIGATION  
PROPOSED DYKING  
DUFFIN CREEK  
PICKERING, ONTARIO



Ref. No. G-84.0709  
August 1984

Prepared for:

Metro Toronto Region Conservation Authority  
c/o Simcoe Engineering Limited  
Consulting Engineers  
345 Kingston Road  
Pickering, Ontario  
L1V 1A1

Distribution

5 copies - Simcoe Engineering Limited  
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August 15, 1984

Ref. No. G-84.0709

Metro Toronto Region Conservation Authority  
c/o Simcoe Engineering Limited  
Consulting Engineers  
345 Kingston Road  
Pickering, Ontario  
L1V 1A1

Attention: Mr. L. Smith, P.Eng.

Re: Geotechnical Investigation  
Proposed Dyking  
Duffin Creek  
Pickering, Ontario

Dear Sirs:

At your request, we have investigated the subsurface and foundation conditions at the site of the proposed dyke near the intersection of Duffin Creek and Church Street in Pickering, Ontario. Under cover of this letter, we are pleased to submit to you our report on our findings and recommendations.

Should you, after the review of the report, have any questions or should you feel that we can be of further assistance, we shall be pleased to be at your service.

Sincerely yours,

GEO-CANADA LTD.

*Ivan P. Lieszkowsky*  
Ivan P. Lieszkowsky, P.Eng.

IPL:esp





Ref. No. G-84.0709

#### EXECUTIVE SUMMARY

Three exploratory boreholes drilled on the line of the proposed dyke indicate that the typical subsurface profile consists of about 0.3 m topsoil, underlain by very loose to loose organic silt to a depth of 2.6 to 3 m, and compact silty sand and gravel. The groundwater level at the time of the investigation ranged between 77 and 76.5 m.

Although the foundation conditions are marginal, our analysis indicates that under a 3 m high dyke, constructed with 2:1 side slopes, the safety factor against general foundation failure is about 2, which is considered to be adequate. Settlements are estimated to be of the order of 0.1 m.

Although the theoretical safety factor against "piping" (subsurface erosion) and uplift on the downstream or dry side of the dyke is less than unity due to the short duration that the water is at flood levels and the time lag required for critical piping and uplift conditions to develop, in our opinion design measures to prevent these will not be required.

Consequently, the dyke can be constructed as proposed, but the cross section of the dyke should be verified after a suitable borrow material has been identified and tested.







Ref. No. G-84.0709

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A P P E N D I X

STATEMENT OF LIMITATION.....	Appendix "A"
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E N C L O S U R E S

BOREHOLE LOCATION PLAN.....	Enclosure 1
BOREHOLE LOGS.....	Enclosures 2-4 inclusive
GRAIN SIZE DISTRIBUTION CURVES.....	Figures 1 & 2







1.0 INTRODUCTION

The Metro Toronto Region Conservation Authority has retained through their Consulting Engineers, Simcoe Engineering Limited, the services of Geo-Canada Ltd. to investigate the subsurface and foundation conditions at the site of a proposed flood control dyke near the intersection of Duffin Creek and Church Street in Pickering, Ontario. Verbal authorization to carry out the investigation was received from Mr. L. Smith, P.Eng., on August 1, 1984, and the terms of reference and the scope of the work were discussed with the Consulting Engineers during a meeting at their office on June 13, 1984.

Accordingly, the purpose of the geotechnical investigation and study was to establish the subsurface conditions at three points along the dyke; to evaluate the foundation conditions and the stability of the dyke; to evaluate the seepage conditions under the dyke; to assess the suitability of earth materials available from borrow areas to be selected by the client for the construction of the dyke; to recommend design cross sections for the dyke; and to make suggestions for the geotechnical related aspects of the contract specifications.

.../...





Presented in this report are the results and findings of the subsurface investigation together with our interpretation of the data and recommendations for the items indicated above, however, as at the time when this report was prepared a borrow site had not been selected, the borrow material will be evaluated later.

2.0 THE PROJECT

We understand that the purpose of the dyke is to reduce the frequency and the risk of flooding in a low lying area located on the west side of Church Street, just north of Highway 401, on the east bank of the Duffin Creek. The dyke will be about 330 m long and the crest of the dyke will be at Elevation 81.3 m. The high water level during design flood levels will be at the same elevation. The crest of the dyke will be 4 m wide and, tentatively, 2 horizontal in 1 vertical side slopes are proposed by the consultant. It is understood that the duration of the flood water levels will be short and will not exceed twelve hours and possibly will be much shorter. The recommendations made in this report will be based on this information.

.../...





3.0 METHOD OF INVESTIGATION

The field work was carried out on August 3, 1984 under the supervision of a geotechnical engineer. Three exploratory boreholes were drilled at the locations shown on the attached Plan (Enclosure 1). The boreholes were advanced with a power auger machine and soil samples were recovered by the standard penetration test method at 0.75 m intervals from the ground surface to a depth of 3.5 m. The recovered soil samples were visually identified and classified in the field and were forwarded to our laboratory for further examination and testing. The testing programme consisted of grain size analyses (sieve and hydrometer tests), Atterberg limit tests, and the measurement of the natural moisture contents. The results of the field and laboratory tests are presented on the Borehole Logs and on Figures 1 and 2.

Elevations were referred to temporary local benchmarks established at the site by the consultants. The elevations, in metres, are referred to the geodetic datum.

Groundwater conditions were observed during drilling and the boreholes were left open until the completion of the field work, at which time the water levels were again recorded.

.../...







4.0 SUBSURFACE CONDITIONS

The borings, records of which are presented on Enclosures 2, 3 and 4, indicate that the subsurface conditions at the site are reasonably uniform. The borings have identified four main strata:

- Topsoil.
- Very loose to loose organic silt.
- Compact silty sand and gravel.
- Dense sandy silt till (Borehole 3 only).

The thickness and the surface elevation of the individual strata, however, varies somewhat across the site and the dense sandy silt till was encountered only in Borehole 3.

As details of the subsurface conditions are shown on the individual borehole logs, in the following paragraphs only the main characteristics of the various soil strata will be discussed briefly.

The present grade along the line of the proposed dyke is at about Elevation 78.5 m. The boreholes encountered an approximately 0.3 m layer of dark organic topsoil. Below

.../...





this, the natural subsoil is a greenish brown to grey coloured organic silt. This stratum extends to a depth of 2.6 m in Boreholes 2 and 3, and 3.2 m in Borehole 1. A grain size analysis of a sample recovered from Borehole 2 indicates that the deposit consists of about 30% fine sand and 70% soil fines (Figure 1). An Atterberg test performed on the soil fines gave a liquid limit of 31%, a plastic limit of 24%, and a plasticity index of 7. Based on this, the material is classified as an organic silt. Embedded in the fine textured matrix of the soil are shells, pieces of wood, etc. Penetration resistances in this material ranged from 3 to 8 blows per 0.3 m, indicating that the material is very loose to loose. The natural moisture content of the stratum is about 27% and a tactile examination of the soil samples indicated that the deposit is rather compressible. The coefficient of permeability of the deposit is estimated to be low, of the order of or slightly less than  $10^{-5}$  cm/second.

The organic silt is underlain by a well graded mixture of sand and gravel with some silt. The thickness of this stratum varies from 0.5 m in Borehole 3 to over 1 m in Borehole 2. The result of a grading analysis is shown on Figure 2, indicating 20% gravel, 69% sand and 11% silt.

.../...





Penetration resistances in the sand and gravel range from 15 to 25 blows per 0.3 m, indicating a compact relative density. The coefficient of permeability of this material is estimated to be of the order of  $5 \times 10^{-3}$  cm/second.

In Borehole 3, the sand and gravel are underlain by a very dense cemented sandy silt till. The permeability of the till is estimated to be very low.

At the time of the investigation, the groundwater level was between Elevation 77.1 m at Borehole 3 and 76.5 m at Borehole 1, indicating a small gradient from north to south.

## 5.0 DISCUSSION OF THE RESULTS

### 5.1 General

The investigation has indicated that the line of the proposed dyke is underlain by about 0.3 m of topsoil, followed by very loose to loose organic silt to a depth of about 2.6 to 3.2 m, which in turn is underlain by compact silty sand and gravel.

From the design point of view, the loose organic silt deposit is the significant and controlling soil deposit. The silt

.../...







has a relatively low shear strength, is compressible, and has a generally low permeability. For design, the following parameters are suggested: Unit weight of silt - 17.5 kN per cubic metre; angle of shearing resistance - 27 degrees; coefficient of permeability -  $10^{-5}$  cm/second.

As at the time when this report was prepared the source of borrow material had not been identified, the analysis will be based on the assumption that the borrow material will be a well graded glacial till consisting of particles ranging from sand to clay size, and that the material will have a permeability equal to or less than  $10^{-5}$  cm/second. These assumptions should be verified and the design should be modified if necessary.

## 5.2 Foundations

We have analyzed the bearing capacity of the subsoil to carry the weight of a 3 m high dyke constructed with 2:1 side slopes and found that the minimum safety factor against general shear failure of the foundation stratum is 2. This is considered to be adequate.





5.3 Settlement

Based on our analysis, we estimate that the settlement under the 3 m high embankment will most likely be about 0.1 m, and it is unlikely that it will exceed 0.2 m. To allow for this settlement, it is therefore recommended that the crest elevation of the dyke be raised from 81.3 m to 81.4 or possibly 81.5 m. The settlement will be time dependent, but the majority of the settlement, about 80%, should be completed by the end of the first year.

5.4 Subsurface Erosion

Assuming that the the high water level on the upstream side of the dyke is maintained at Elevation 83.1 m for a sufficiently long time period, theoretically the dyke could fail by "piping", that is by subsurface erosion through the silty foundation material. It is estimated, however, that for these steady seepage conditions to develop, the high water level will have to be maintained for a period in excess of a month. Since it is our understanding that the flood water will rise, peak and drop again within a period of a few hours, in our opinion there is an adequate safety factor against piping.

.../...





### 5.5 Uplift

Theoretically, the ground on the downstream (dry side) of the dyke could be threatened by uplift due to the water pressure in the sand and gravel stratum. Assuming that the sand and gravel stratum is hydraulically connected to the creek, during flood conditions the water head in the sand and gravel stratum would be 2.9 m above the ground surface. As the overlying silt is considerably less pervious, this pressure would not be relieved by seepage through the silt. Consequently, the water pressure would tend to lift up the overlying silt stratum. This uplift pressure is resisted only by the weight of the silt. Assuming that the thickness of the silt stratum is 2.6 m throughout and that the bulk unit weight of the silt is 17 kN per cubic metre, the maximum resisting force that can be mobilized is 44 kN per square metre. The maximum uplift pressure at the interface of the silt and the underlying sand and gravel is equal to 5.5 m of water head, i.e. about 55 kN per square metre. The safety factor against uplift is, therefore, only 0.8. The critical head, for a safety factor of 1.0, is Elevation 80.3 m.

However, the water pressure in the sand and gravel deposit will not rise immediately with the water level in the creek,

.../...







but will follow it with some time lag. This time lag will be a function of the distance from the creek. Assuming that the minimum distance between the dyke and the creek is 60 m, and that the dyke at its base is 15 m, we estimate that at this distance the time lag required for the water pressure to respond will probably be of the order of 1 or 2 days. As the duration of the flood level is expected to be considerably shorter, a blow-out condition on the dry side of the dyke is unlikely to develop. It would be prudent, however, to carefully observe the ground conditions for signs of an imminent blow-out (boils, tension cracks, etc.) during the first few floods following the construction of the dyke.

In view of the low probability of a blow-out occurring and that the consequences of a blow-out would not be too serious (i.e. no threat to life or serious damage to real property), at this time we do not consider it to be necessary to incorporate in the design remedial measures to prevent uplift.

#### 5.6 Dyke Cross Section

Based on the foregoing analysis and making the previously discussed assumptions regarding the nature of the borrow

.../...





material, we recommend that the following dyke cross section be adopted:

Crest Elevation 81.4 m  
Crest Width 4.0 m  
Side Slopes 2:1 (H:V)

#### 5.7 Construction

We recommend that the topsoil (approximately 0.3 m) be stripped throughout the full width of the dyke. The topsoil could be stock piled and reused after construction for the top dressing of the dyke.

The surface of the silt subgrade should be left rough so that the first lift of the fill material blends in and forms a homogeneous mixture with the subgrade. Depending on the dyke material used, other methods may be required to achieve this.

The material used for dyke construction should be placed in uniform lifts throughout the full width of the dyke. The maximum thickness of the lifts should not exceed 0.2 m and each lift should be compacted to not less than 95% of its standard Proctor maximum dry density. The degree of

.../...





compaction should be checked with frequent in-situ density tests.

6.0 STATEMENT OF LIMITATION

The Statement of Limitation, as quoted in Appendix "A", is an integral part of this report.

GEO-CANADA LTD.

Ivan P. Lieszkowszky, P.Eng.

IPL:esp







A P P E N D I X





APPENDIX  
"A"  
Statement of Limitation

The conclusions and recommendations in this report are based on information determined at the borehole locations. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the boreholes. In cases where these recommendations are not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the design engineer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.

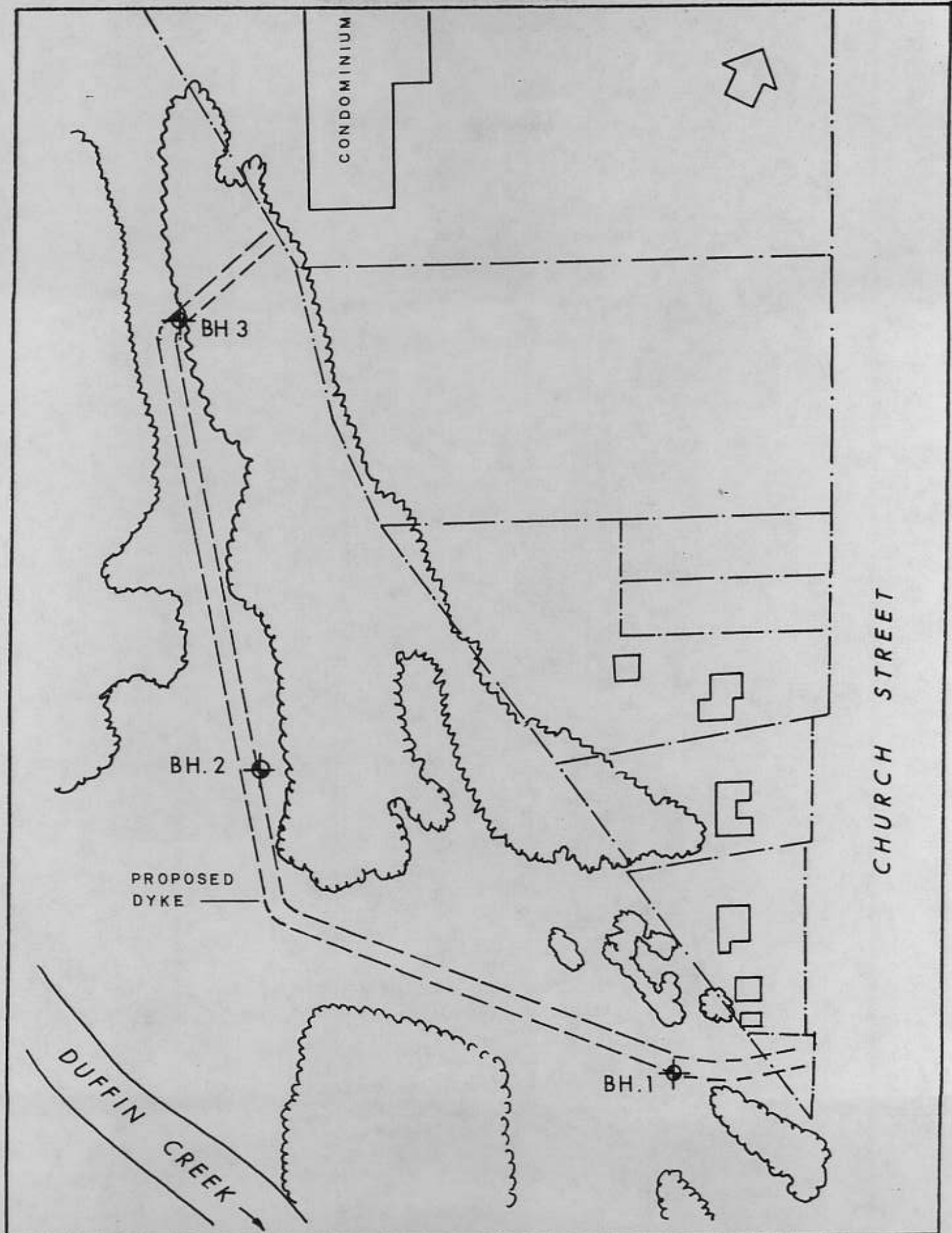




ENCLOSURES







BOREHOLE LOCATION PLAN

G-84.0709

ENCL. 1



# LOG OF BOREHOLE ..1.....

Our Reference No. C-84.0709

Enclosure No. 2

CLIENT: SIMCOE ENGINEERING LTD.  
 PROJECT: DUFFIN CREEK DYKE  
 LOCATION: PICKERING, ONTARIO  
 DATUM ELEVATION: GEODETIC

**DRILLING DATA**

Method: AUGERING  
 Diameter: 125 mm  
 Date: August 3, 1984

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>l</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH m	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	70	40	60	80						100	SHEAR STRENGTH
											○ UNCONFINED      * FIELD VANE ● QUICK TRIAXIAL    x LAB VANE			WATER CONTENT (%)				
78.6	Ground Surface																	
0.0	TOPSOIL																	
78.3			1	SS	24													
0.3	SILT Organic Some Sand, Shells, Very Slightly Plastic Very Loose to Loose																	
			2	SS	7													
		Moist Wet																
			3	SS	4													
		Brown Grey																
	Sandy		4	SS	3													
75.4		Wood																
3.2	Silty SAND & GRAVEL		5	SS	25													
75.1	Compact	Wet																
3.5	END OF BOREHOLE																	



# LOG OF BOREHOLE ..2.....

Our Reference No. G-84.0709

Enclosure No. 3

CLIENT: SIMCOE ENGINEERING LTD.  
 PROJECT: DUFFIN CREEK DYKE  
 LOCATION: PICKERING, ONTARIO  
 DATUM ELEVATION: GEODETIC

**DRILLING DATA**

Method: AUGERING  
 Diameter: 125 mm  
 Date: August 3, 1984

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH m	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W		
78.4	Ground Surface															
0.0	TOPSOIL		1	SS	4											
78.1																
0.3	Brown SILT Organic Some Sand, Shells		2	SS	8										-1, 30, 70	
	Moist Wet															
	Slightly Plastic Loose		3	SS	5											
75.8			4	SS	6										20, 65, 11, -	
2.6	Grey Silty SAND & GRAVEL Some Organic Matter Compact															
	Wet															
			5	SS	16											
74.9																
3.5	END OF BOREHOLE															





# LOG OF BOREHOLE .3.....

Our Reference No. G-84.0709

Enclosure No. 4

CLIENT: SIMCOE ENGINEERING LTD.  
 PROJECT: DUFFIN CREEK DYKE  
 LOCATION: PICKERING, ONTARIO  
 DATUM ELEVATION: GEODETIC

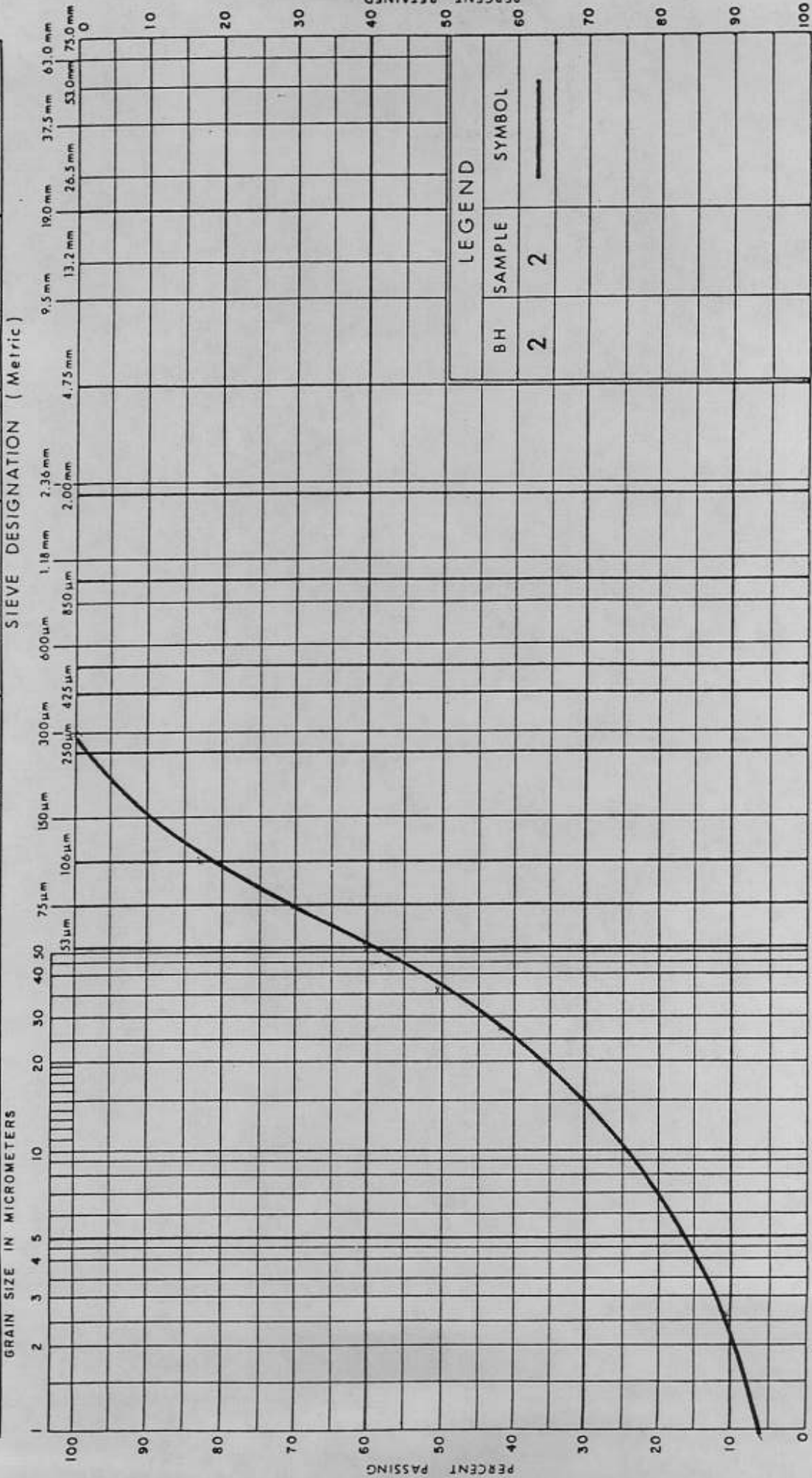
**DRILLING DATA**  
 Method: AUGERING  
 Diameter: 125 mm  
 Date: August 3, 1984

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH m	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	W		
78.6	Ground Surface															
0.0	TOPSOIL		1	SS	7											
78.3																
0.3	Brown SILT Organic Some Sand, Shells Slightly Plastic Loose		2	SS	7											
			3	SS	4											
76.0			4	SS	15											
2.6	Grey, Compact wet Silty SAND & GRAVEL															
75.5																
3.1	Grey, Dense Sandy Silt TILL		5	SS	30											
75.1																
3.5	END OF BOREHOLE															



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
Grain Size in Micrometers		Fine	Medium	Coarse	Fine	Coarse	Coarse
Sieve Designation (Metric)		Sieve Designation (Metric)			Sieve Designation (Metric)		



LEGEND

BH	SAMPLE	SYMBOL
2	2	—

GRAIN SIZE DISTRIBUTION

SILT, sandy, organic

FIG No 1

REF. No G-84.0709

DATE AUG. 1984

GEO-CANADA

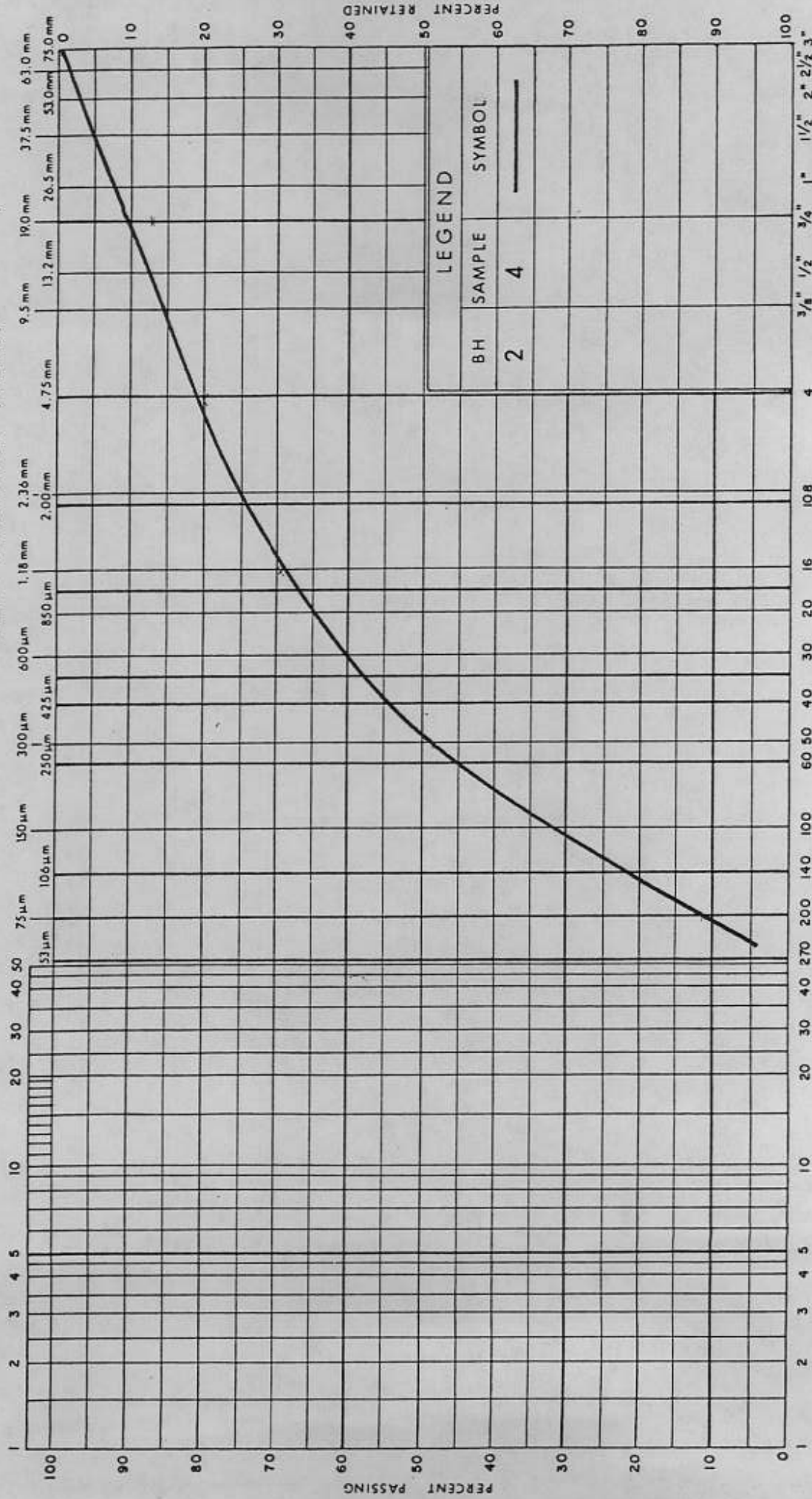


UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
Fine		Medium	Coarse	Fine	Coarse	

SIEVE DESIGNATION (Metric)

GRAIN SIZE IN MICROMETERS



LEGEND

BH	SAMPLE	SYMBOL
2	4	—

SIEVE DESIGNATION (Imperial)

GRAIN SIZE DISTRIBUTION  
SILTY SAND & GRAVEL

FIG No 2

GEO-CANADA

REF. No G-84.0709

DATE AUG. 1984



