GEOTECHNICAL REPORT

SLUDGE DEWATERING BUILDING

NORTH END WATER POLLUTION CONTROL CENTRE

PREPARED FOR

WARDROP ENGINEERING INC.

and

THE CITY OF WINNIPEG

December 17, 1987

Project No. 87482

1.0 INTRODUCTION

This report summarizes the results of a geotechnical investigation undertaken by Dyregrov and Burgess at the site of the proposed sludge dewatering facility at the City of Winnipeg's North End Water Pollution Control Centre. The work was done at the request of Wardrop Engineering Inc.

2.0 DESCRIPTION OF THE FIELDWORK

A total of six, 4 0 mm diameter boreholes were put down on October 15, 1987 at the locations shown on the site plan, Figure 1. A truck mounted power auger supplied by Subterranean (Winnipeg) Ltd. was used. Borings 1 and 2 were extended to auger refusal and the remainder were terminated at 4.3 to 4.6 metre depths. The soil profile was examined and logged on a continuous basis as drilling progressed. Disturbed and relatively undisturbed soil samples were recovered at regular intervals for on-site classification and for laboratory testing purposes.

In situ testing with the flat dilatometer was done near test hole 6 on November 4, 1987 using drilling equipment supplied by Paddock Drilling Ltd. of Brandon. The dilatometer consists of a flat steel blade that is about 250 mm long, 100 mm wide and 14 mm thick. An expandable, 50 mm diameter metal diaphragm is enclosed on one surface of the blade and a control system enables the operator to record pressure-deformation data at each test depth. The blade is attached to AW drill rods and is pushed to each desired test depth with a drill rig. Tests were done at 300 mm depth intervals within the lacustrine deposits to the 13.8 metre depth. The test cannot be done in coarse granular or bouldery soils such as gravel or glacial till common to Winnipeg. The test yields strength and compressibility data in addition to information related to the degree of overconsolidation of the soil types encountered and Ko, the ratio of lateral to vertical stresses within a soil mass. Soil is classified as silt, sand, clay or a variation of these basic types by the test at each depth interval. Software is available for the processing of the field data and the results are given in tabular and graphic form, as shown in Figures 11 and 12.

3.0 THE SOIL PROFILE

The soil profile is similar to that encountered at other locations in the vicinity of the NEWPCC and consists essentially of a thick deposit of lacustrine clays that are underlain by glacial till and bedrock. The upper 4 metres of the profile contains varying amounts of silty clay fill and tan, saturated silt. The silt deposits are natural and these are commonly encountered within the surficial several metres of the soil profile throughout Winnipeg. The fill is thickest at borings 2 and 5, on the west side of the site and this may be related to previous construction.

The Agassiz clays are stiff to very stiff in terms of their relative consistency, with undrained shear strengths in the range of about 40 to 90 kPa. The strength data from unconfined compression, Torvane and pocket penetrometer tests are shown in Figure 10. The clays are highly plastic and the moisture content profiles suggest that moisture depletion is significant in clays within about the upper 4 metres of the profile.

Glacial silt till was encountered at depths of 18.5 and 18.9 metres at borings 1 and 2. The till is a mixture of sand, gravel and boulder sized materials within a predominantly silt matrix that has a low but variable clay content. The till was classified as medium dense, dense or very dense on the basis of a visual examination of auger cuttings. Moisture contents of the till samples are also indicative of its relative density. Moisture contents in the 5 to 10 percent range are typical of dense to very dense material. Auger refusal occurred at depths of 22.5 and 21.8 metres at boreholes 1 and 2 respectively. The rapid inflow of water at the refusal depths suggests that refusal may have occurred in close proximity to the bedrock surface. The actual depth to bedrock, however, was not confirmed.

The soil profile and the results of field and laboratory tests are described in detail on the borehole logs, Figures 2 - 9.

4.0 RECOMMENDATIONS

4.1 Foundations

We understand that unfactored design loads at column locations could be in the range of about 1200 to 4500 kN. The most economical foundation system and is likely to consist of prestressed, precast concrete piles that are driven to practical refusal. These can be assigned allowable loads of 445, 625 and 800 kN for 300, 350 and 400 mm diameter pile sizes respectively. A driving energy of at least 40 kilojoules must be used and the piles must be driven to practical refusal which can be defined as final penetration resistance values of 5, 8 and 12 blows per 25 mm. Pile groups will be necessary and, because this pile type derives nearly all of its capacity in end bearing, no reduction for group action is necessary. Pile heave is likely to occur and the top elevation of all piles must be monitored as driving is done. All piles in groups must be restruck, to counter the effects of heave. Heave monitoring should be done during restriking as well. Double restriking may be necessary at some locations, in view of the pile lengths that will be required and the relatively deep penetration of the glacial till that is likely to occur. Pile spacing should not be closer than 2.5 diameters, centre to centre. Preboring should be done at all driven pile locations, to minimize the potential for heave, to enhance pile plumbness and to minimize the effects of vibration during driving. Preboring to a depth of at least 9 metres should be specified.

Cast in place concrete friction piles are a foundation alternative for relatively light loads. These can be designed on the basis of an allowable skin friction of 18 kPa. Skin friction should be ignored within fill and silt deposits and within 3 metres of the basement floor elevation. Groups of friction piles are not recommended for major column locations and friction pile spacing should not be closer than 3 diameters. A reduction in pile capacity for group action applies to friction pile groups containing three or more piles. The use of a mixture of friction piles and driven concrete piles for structural support of the building or its components should be reviewed by the geotechnical engineer. The use of both types is acceptable in some cases but can lead to undesirable performance in others.

Conditions are not suitable for the economical use of belled caissons in glacial till. The alternative to driven, precast concrete piles for the support of major building loads consists of rock socketted caissons. Rock socketted caissons, however, because of the relatively low column loads, are likely to not be economically attractive in comparison to precast concrete piles.

The sludge dewatering facility will house large centrifuge units and these will impart horizontal and vertical forces on a transient basis during start-up. The critical speeds are 231 and 163 C.P.M. for maximum vertical and horizontal dynamic loads respectively. The dynamic forces are 75.6 kN vertical and 20 kN horizontal, per isolator, at the critical speeds. Each unit is supported on four isolators. The dynamic loads which would be added to static forces at operating speeds are not nearly as significant as those that occur at the critical speeds.

We understand that the horizontal forces are likely to be transferred to the foundations through a system of shear walls or beams such that the loads are applied simultaneously to a series of piles or pile groups that support a line of columns. The loads are transient and, on a per pile basis, we understand that they are low, perhaps comparable to those produced by wind, for example. No special design considerations are considered necessary with respect to the lateral loading applied to the foundation system. Well compacted 20 mm crushed gravel backfill should be specified around all pile caps, however, to increase the lateral resistance of the groups.

Soil strength and deformation parameters that are applicable to foundation design are given in the results of the dilatometer testing, Figures 11 and 12. These include values for Young's modulus, constrained modulus and undrained shear strength, on which basis an analysis of the performance of the foundation system can be done if required.

4.2 Main Floor and Basement

The facility will contain a partial, L-shaped basement that will likely be 3 to 4 metres below the existing grade. The basement and the main floors should be structurally supported and be independent of the subgrade by a subfloor void of at least 150 mm. The basement walls should be designed to resist lateral earth pressures that can be calculated on the following basis:

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

Where: P = Lateral earth pressure at depth H (kPa)

K = Earth pressure coefficient (0.5)

γ = Backfill unit weight (silty clay at 19.6 kN/cu.metre)

H = Backfill depth (metres)

Q = Live load surcharge within distance H of top of basement wall (kPa)

The complete basement should contain a perimeter weeping tile drainage system connected to an interior sump. The weeping tile can consist of 150 mm diameter perforated drain pipe that is enclosed or wrapped in filter cloth and embedded in pea gravel. The basement is likely to be constructed within a sloped excavation and the invert of the perimeter weeping tile should be maintained everywhere at least 150 mm below the elevation of the basement excavation.

The on-site soils, including the existing clay fill, can be used as backfill against the basement walls. Granular backfill should be used if winter construction is planned. The backfill should be placed in thin lifts and compacted throughout. Grading should ensure that run off is directed away from the building at gradients of at least 2 percent in landscaped areas.

Concrete in contact with the soils at this location should be of high quality and be made with sulphate resistant cement.

The silt deposits within the upper 4 metres of the soil profile were saturated at the time of our fieldwork. These are likely to be the primary source of seepage during construction and they constitute a perched water table within the soil profile. For design purposes, this water table should be presumed to be at the ground surface. Seepage into the basement excavation during construction should not be of significance and easily handled with perimeter ditches and temporary sumps, on the basis of observations that were made during test hole drilling for this investigation. The excavation slopes will tend to slough, due to the saturated condition of the silt, unless relatively flat slope gradients are used. Temporary slopes of 3:1 (H:V) are recommended. Flatter slopes may be necessary along the west boundary, depending on groundwater conditions at the time of construction and the condition of the fill that appears to be thickest along this side of the site.

4.3 Geotechnical Inspection

We recommend that pile inspection be done at least at the start of foundation construction, to determine that the work is done in accordance with recommendations in this report and to determine that subsoil and foundation conditions are consistent with those encountered at the boreholes that were put down for this investigation. Full time pile inspection by geotechnical personnel should be done at the start of pile installation. Part time inspection can be done thereafter, as warranted. Heave monitoring will be necessary during all pile driving.

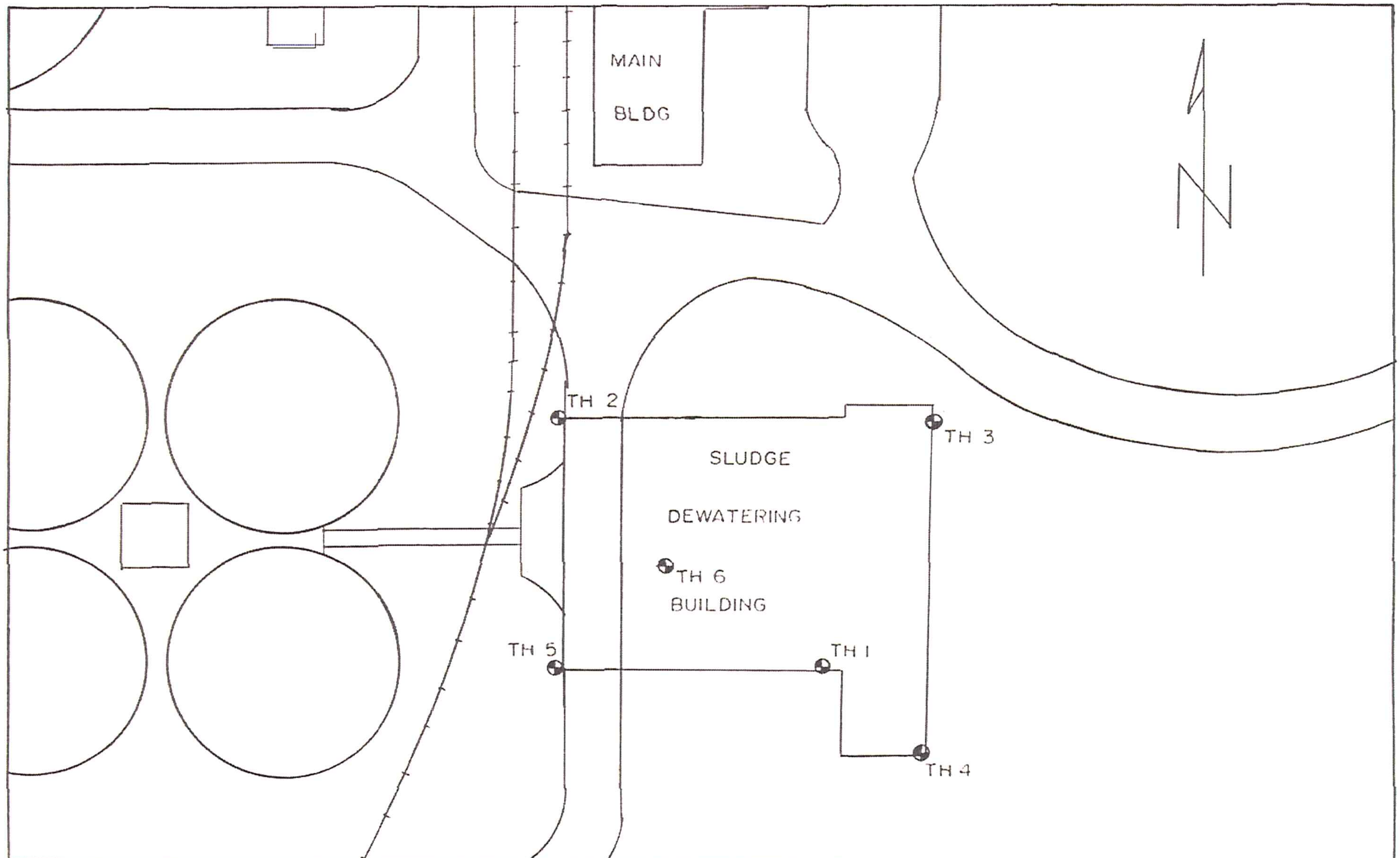
Respectfully submitted,

DYREGROV & BURGESS

Per: NCBurgess

N.C. Burgess, P.Eng.

NCB/pf



DYREGROV & BURGESS
CONSULTING GEOTECHNICAL ENGINEERS

TESTHOLE LOCATION PLAN
SLUDGE DEWATERING BUILDING
N E W P C C

SCALE 1:600	DATE 6/07/97	MADE SDG	CHKD HCB	JOB 87482	FIGURE 1

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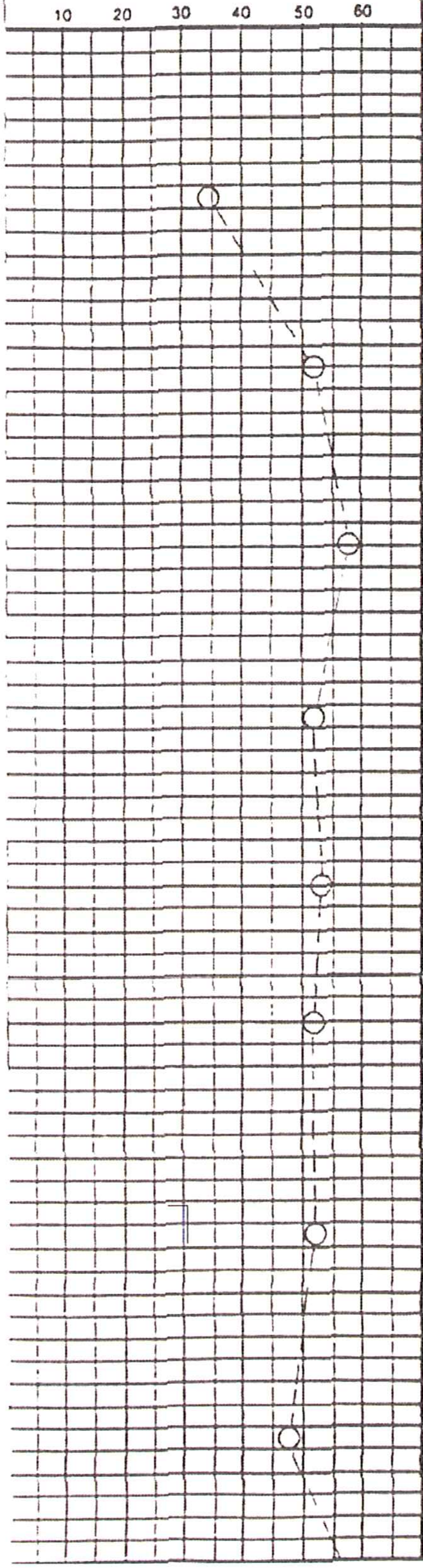
BOREHOLE LOG

PROJECT: NEWPCC Sludge Dewatering Building

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	15/10/87	87482	1

DRILL TYPE: 450 mm Auger

WATER CONTENT — Wp - □ W - ○ WL - Δ. PERCENT % (10 20 30 40 50 60)



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE CONDITION	TYPE	PENETRATION RESISTANCE	OTHER TESTS
0	SS	Topsoil				
0–2		Clay -silty -brown -stiff ----silt lenses				
2–3		Silt -tan -moist				
3		Clay -mottled brown -highly plastic -stiff to firm		U		qu=77.39kpa γ_w=16.27kg/m^3 pp=125.4kpa Tv=82.3kpa
6		-----grey		U		qu=113.2kpa γ_w=16.29kg/m^3 pp=105.3kpa Tv=69.9kpa
9				U		qu=111.0kpa γ_w=16.79kg/m^3 pp=93.4kpa Tv=57.5kpa
12				U		Tv=52.2kpa qu=105.5kpa γ_w=16.55kg/m^3 pp=82.6kpa
13						

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BOREHOLE LOG

PROJECT: NEWPCC Sludge Dewatering Building

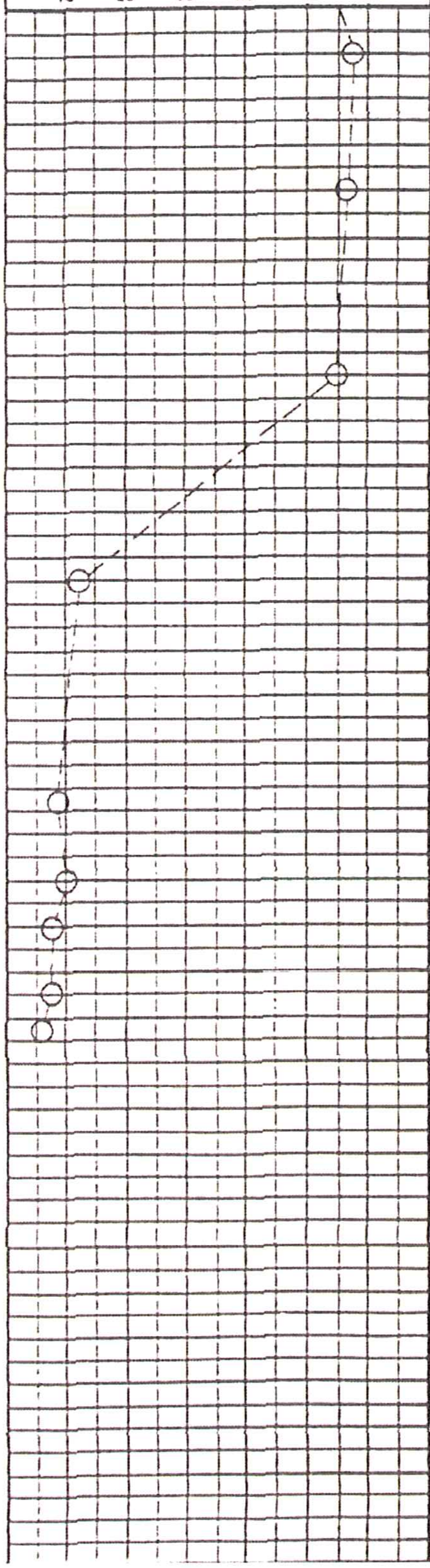
LOGGED/DWN. SDG	CKD. NCB	DATE OF INVEST. 20/10/87	JOB NO. 87482	HOLE NO. 1

WATER CONTENT

W_P - □ W - ○ W_L - △

PERCENT %

10 20 30 40 50 60



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE CONDITION	TYPE	PENETRATION RESISTANCE	DRILL TYPE: 450 mm Auger / OTHER TESTS
14		Clay (Cont'd)				
15				U		qu=92.5kpa γ_w=16.62kg/m^3 pp=86.2kpa Tv=44.0kpa
16						
17						
18						
19		Glacial Till -silty, sandy, gravelly -tan, medium dense -bouldery below 19.2 m				
20						
21		----dense to very dense below 21.3 m				
22						
23		Notes: 1.Auger refusal at 22.5 m. 2.Water level at 20.1 m in about 10 minutes after completion of drilling.				

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BOREHOLE LOG

PROJECT NEWPCC Sludge Dewatering Building

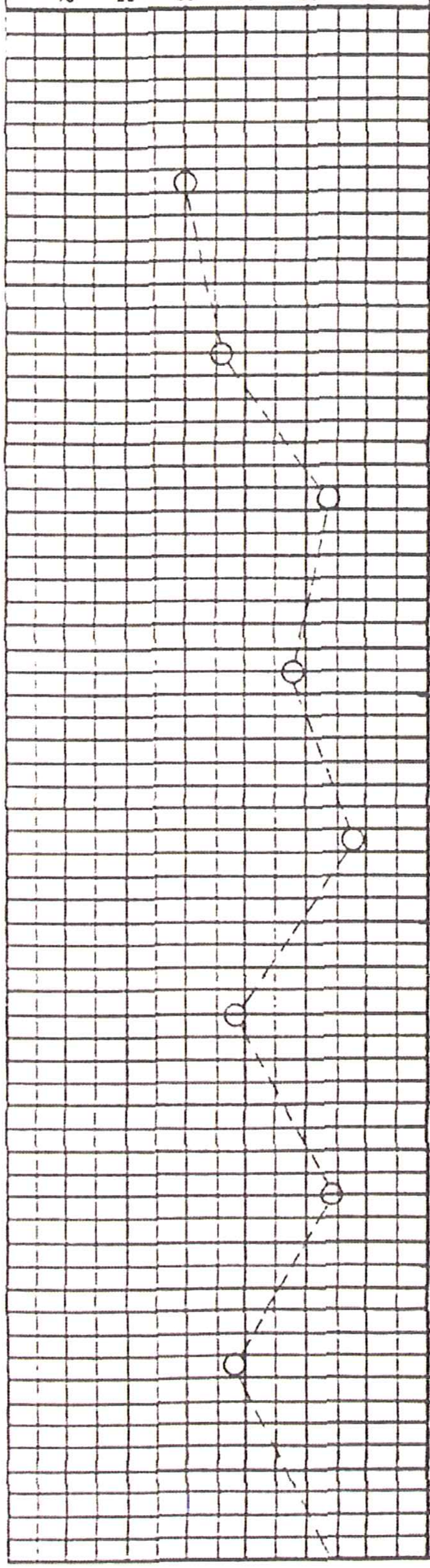
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	20/10/87	87482	2

WATER CONTENT

Wp - □ W - ○ W_L - △.

PERCENT %

10 20 30 40 50 60



DEPTH (M)

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE

DRILL TYPE: 450 mm Auger

OTHER TESTS

Depth (M)	Soil Description	Sample Type	Other Tests
0	Fill -clay -silt -topsoil		
1	Clay -silty -brown -stiff		
2	Silt -tan -wet to saturated		
3	Clay -mottled brown -highly plastic -stiff to firm		
4		U	qu=118.7kpa γ_w=16.63kg/m^3 pp=160.4kpa Tv=88.1kpa
5			
6			
	- - - grey		
7		U	qu=117.4kpa γ_w=16.12kg/m^3 pp=125.4kpa Tv=68.9kpa
8			
9			
10		U	qu=131.8kpa γ_w=16.70kg/m^3 pp=93.8kpa Tv=55.5kpa
11			
12			
13			

Plate 4

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BOREHOLE LOG

PROJECT: NEWPCC Sludge Dewatering Building

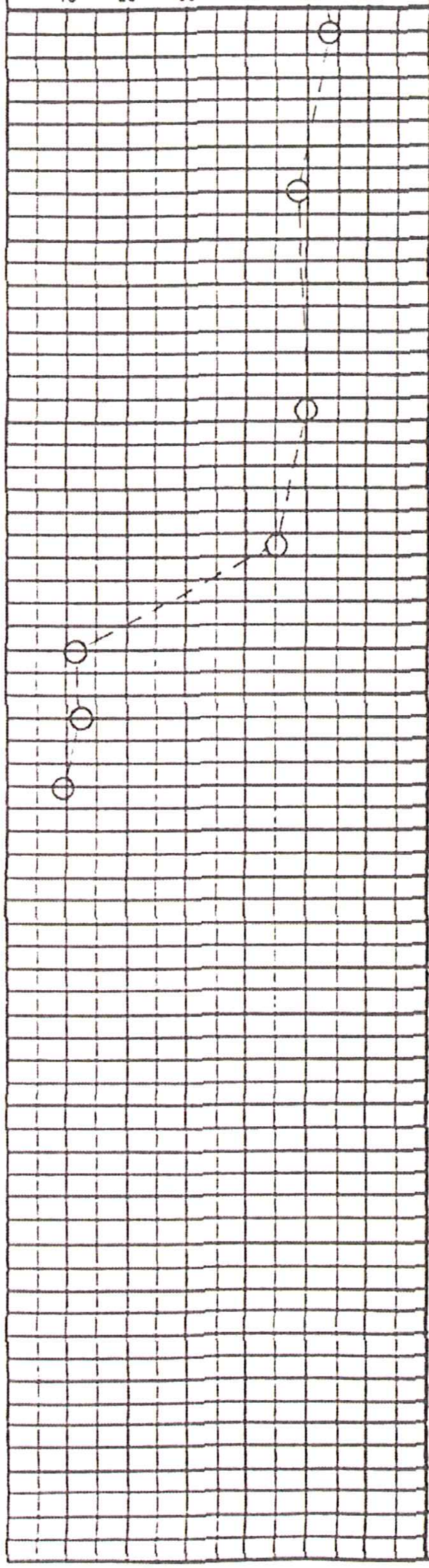
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	20/10/87	87482	2

DRILL TYPE: 450 mm Auger

DATUM

SURFACE ELEVATION

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT %



DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	TYPE	PENETRATION RESISTANCE	OTHER TESTS
14	Clay (Cont'd)		U		qu=108.9kpa γ_w=16.95kg/m^3 pp=95.8kpa Tv=54.1kpa
15					
16					
17			U		qu=106.5kpa γ_w=17.20kg/m^3 pp=86.2kpa Tv=53.1kpa
18					
19	Glacial Till -silty, sandy, gravelly -tan, medium dense -clay seams to 19.8 m				
20					
21					
22	Notes: 1.Auger refusal at 21.8 m. 2.Water level at 17.7 m about 5 minutes after completion of drilling.				

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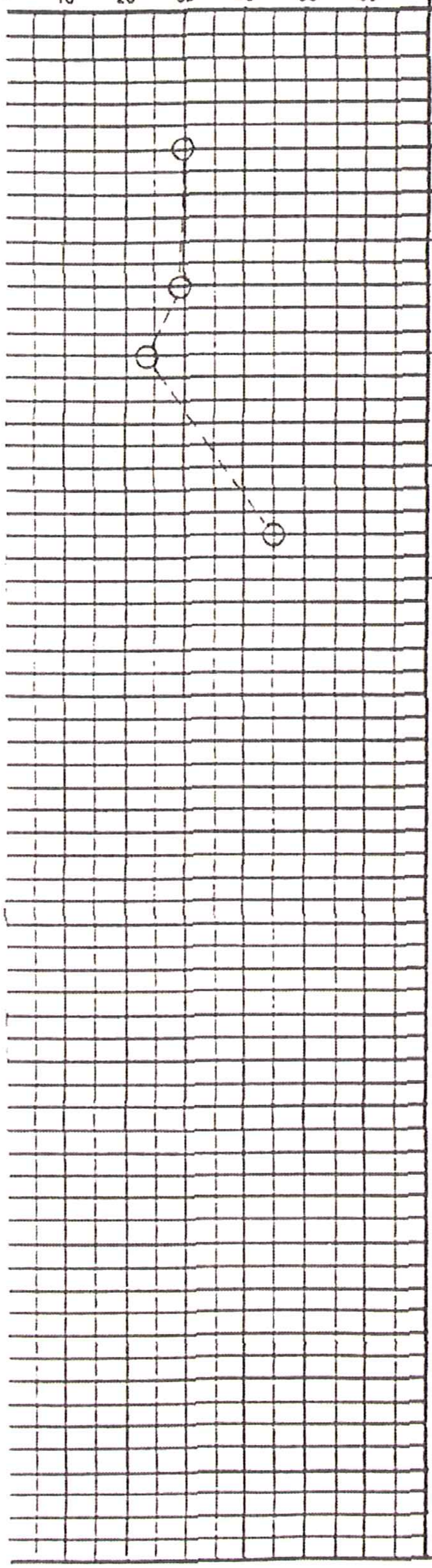
BOREHOLE LOG

PROJECT
NEWPCC Sludge Dewatering Building

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	20/10/87	87482	3

DRILL TYPE
450 mm
Auger

WATER CONTENT
Wp - □   w - ○ W_L - △.
PERCENT %
10 20 30 40 50 60



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	TYPE	PENETRATION RESISTANCE	OTHER TESTS
0		Fill -clay, silt				
1		Clay -silty, brown -stiff - - - mottled brown -silt lenses throughout				
2						
3		Silt -tan -wet to saturated				
4		Clay -mottled brown -highly plastic -stiff				
5		Hole terminated at 4.6 m.				

Plate 6

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BOREHOLE LOG

PROJECT: NEWPCC Sludge Dewatering Building

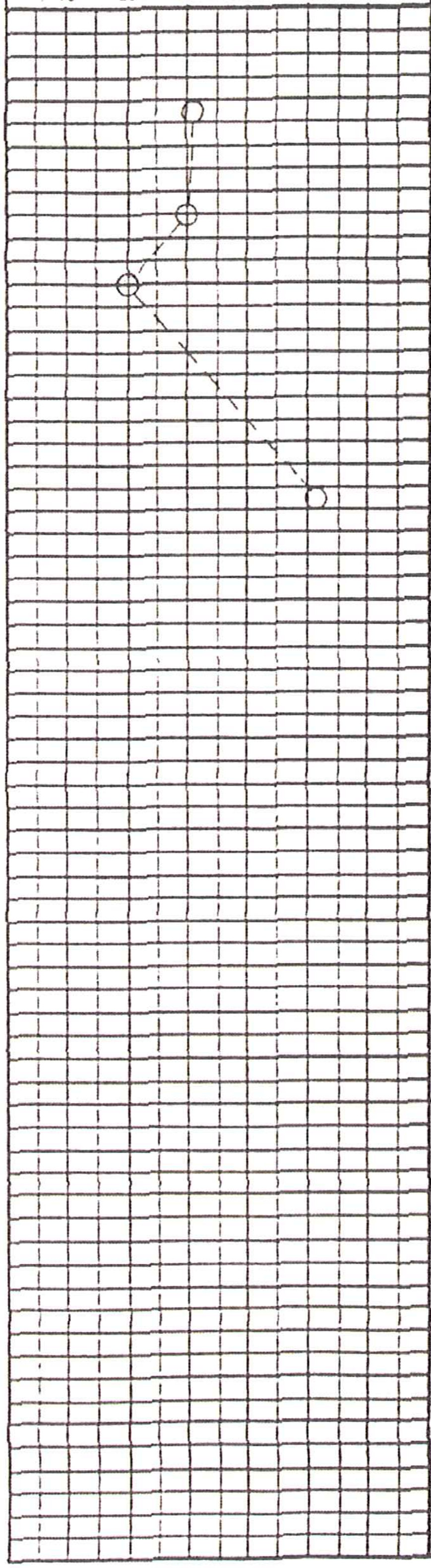
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	20/10/87	87482	4

WATER CONTENT

Wp - □ W - ○ W_L - △.

PERCENT %

10 20 30 40 50 60



DRILL TYPE: 450 mm Auger

OTHER TESTS

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION
0	SS	Topsoil
1		Clay -silty -brown -stiff ---mottled brown -silt lenses throughout
2		
3		Silt -tan, moist to wet
		Clay -mottled brown -highly plastic -stiff
4		
		Hole terminated at 4.3 m.
5		

Plate 7

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BOREHOLE LOG

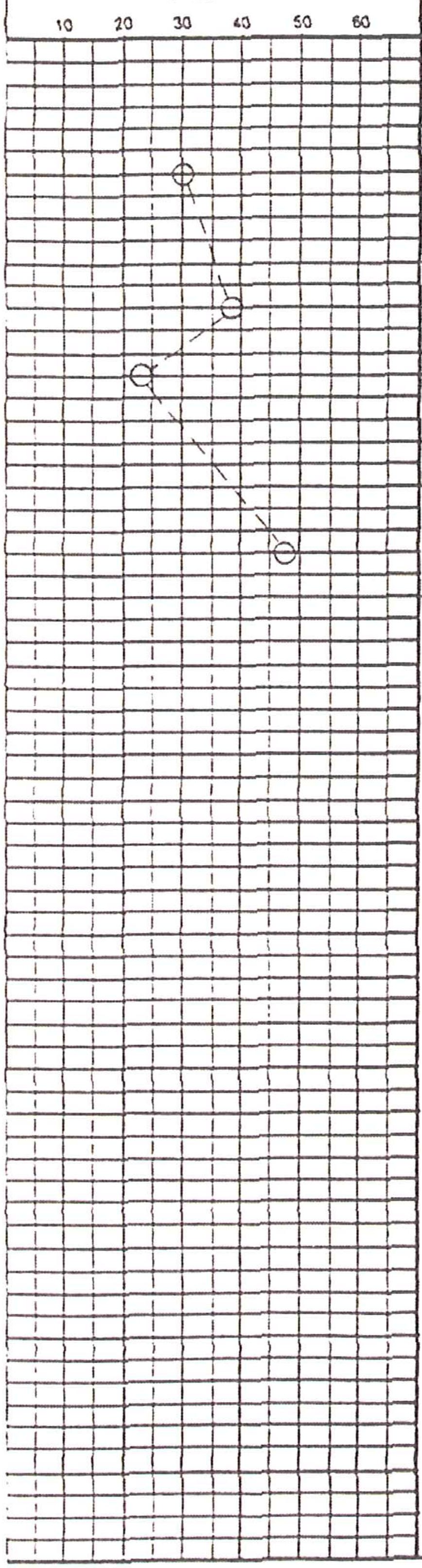
PROJECT: NEWPCC Sludge Dewatering Building

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	20/10/87	87482	5

WATER CONTENT

Wp - □ w - ○ W_L - △.

PERCENT %



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	TYPE	PENETRATION RESISTANCE
0 – 2		Fill -silt -clay -topsoil -firm			
		Clay -silty, brown			
3		Silt -tan -wet to saturated			
4		Clay -mottled brown -highly plastic -stiff			
5		Hole terminated at 4.6 m.			

DRILL TYPE: 450 mm Auger

OTHER TESTS

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BOREHOLE LOG

PROJECT NEWPCC Sludge Dewatering Building

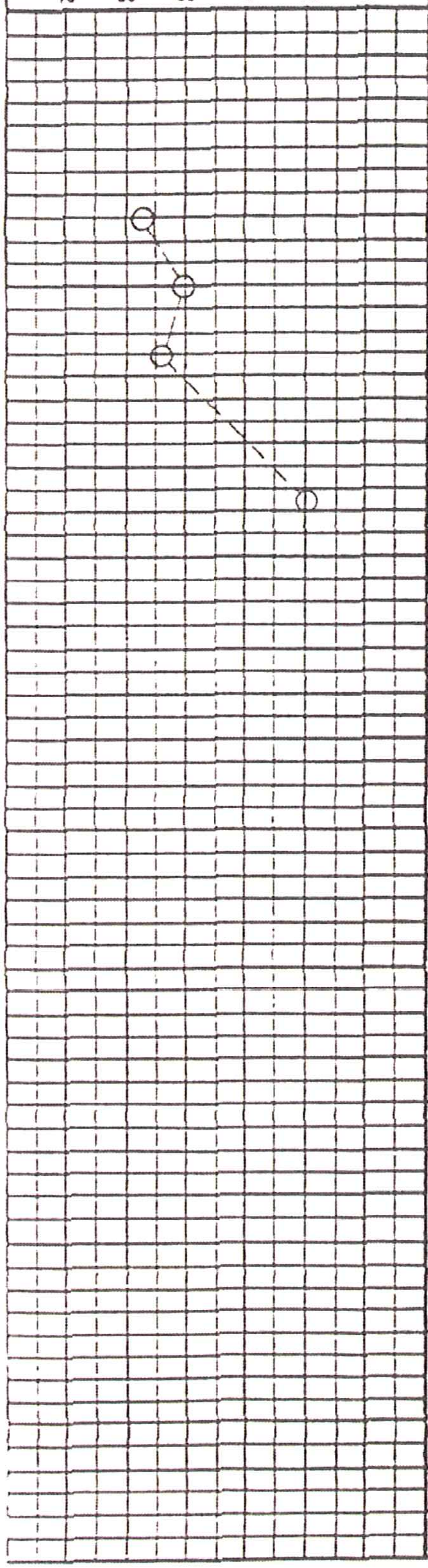
LOGGED/DWN. SDG	CKD. NCB	DATE OF INVEST. 20/10/87	JOB NO. 87482	HOLE NO. 6

WATER CONTENT

W_p - □ w - ○ W_L - △

PERCENT %

10 20 30 40 50 60

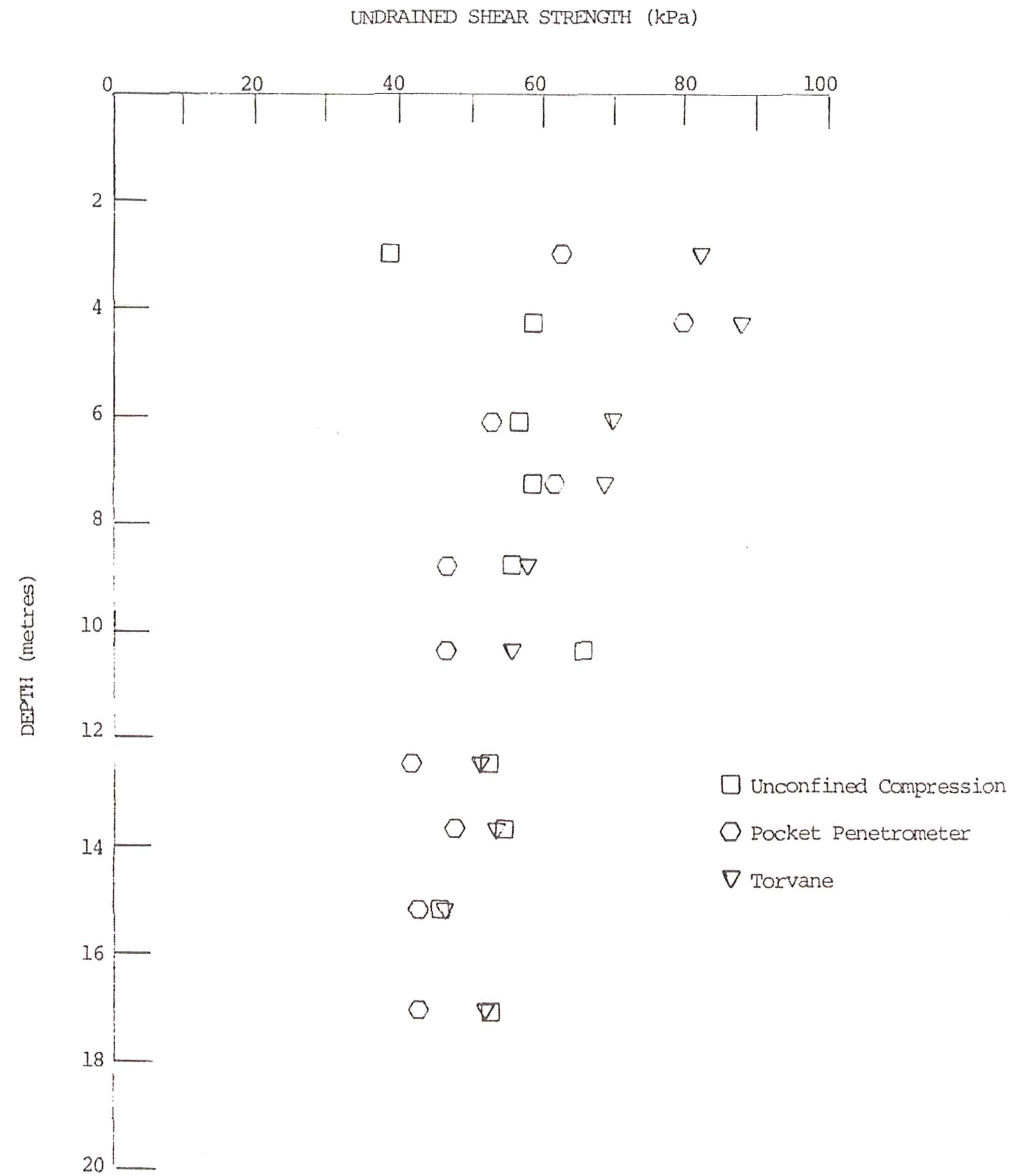


DEPTH (M)	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	CONDITION	TYPE	PENETRATION RESISTANCE
0	Fill -clay, some gravel			
1	Clay -silty -brown			
2	Silt -tan, saturated			
	Clay -mottled brown -stiff			
3	Silt -tan -saturated			
4	Clay -mottled brown -highly plastic -stiff			
5	Hole terminated at 4.6 m.			

DRILL TYPE

450 mm Auger

OTHER TESTS



DYRεGROV & BURGESS CONSULTING GEOTECHNICAL ENGINEERS	SHEAR STRENGTH DATA

SCALE	DATE	MADE	CHKD	JOB 87482	FIGURE 10