

GEOCRYS No:

41K-52

---



# **FOUNDATION INVESTIGATION REPORT**

**CONTRACT NO. 2000-0241**

## TABLE OF CONTENTS

	2
	PAGE
1.0 INTRODUCTION .....	1
2.0 SITE DESCRIPTION AND PHYSIOGRAPHY .....	1
3.0 INVESTIGATION PROCEDURES .....	2
4.0 SUBSURFACE CONDITIONS .....	3
4.1 SANDY GRAVEL TO SAND (FILL) .....	3
4.2 SAND .....	3
4.3 CLAY TO SILTY CLAY .....	4
4.4 HETEROGENEOUS MIXTURE OF SAND, SILT AND GRAVEL (GLACIAL TILL) .....	5
4.5 HETEROGENEOUS MIXTURE OF CLAY, SILT AND GRAVEL (GLACIAL TILL) .....	5
4.6 GROUNDWATER CONDITIONS .....	6
5.0 CLOSURE .....	6

## FIGURES

GRAIN SIZE DISTRIBUTION CURVES	1 - 4, 11
PLASTICITY CHARTS	5 - 6, 12
FIELD VANE AND QUICK TRIAXIAL TEST RESULTS	7
CONSOLIDATION TEST RESULTS	8, 10
CONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS	9

## ENCLOSURES

BOREHOLE LOCATIONS AND SOIL STRATA	DWG. NO. 1
BOREHOLE LOG SHEETS	

41K00-052

## 1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Philips Planning & Engineering Limited to conduct a foundation investigation at the site of a proposed bridge replacement that will carry Highway 17 over Pancake River. The site is located about 61 km west of the city of Sault Ste. Marie, in the Townships of Ryan and Herrick, in MTO District 62 - Sault Ste. Marie. The proposed bridge will be an approximately 45 m long, 13.8 m wide, single span, 2-lane structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes, and based on the findings, to provide recommendations for the foundation design of the proposed structure and the approach fills.

## 2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located at the existing Highway 17 bridge crossing over Pancake River, about 5 km west of Regional Road 563. The grade along Highway 17 is generally level at Elevation 190 m, sloping gently to the west. The existing highway embankment is about 8 m in height at the abutment locations, decreasing in height to about 2 m at the immediate approaches. Pancake River flows from north to south, with the riverbed in a depression, at about Elevation 182 m  $\pm$ .

The existing bridge was originally constructed sometime in the 1940's or 1950's, and widened and rehabilitated in the 1960's. The existing bridge is a nine-span, 42 m long, 12.9 m wide structure, supported by timber piles. The bridge is in poor condition and in need of replacement. The timber piles are damaged or rotted and splited in some areas.

Rip-rap covers the western embankment side slopes, under the east abutment forward slope and along the river banks. A gabion wall supports the northwest embankment slope. Some erosion scour and embankment slope sloughing has occurred along the northeast embankment. The existing northeast ditchline is also eroding.

Based on available geological information<sup>1</sup>, the site is in an area of glaciolacustrine/lacustrine shallow deposits (sands), and modern alluvium (sand, silt, gravel and muck). Generally after the last glacial withdrawal which deposited glacial till over the bedrock surface, the area was inundated by glacial Lake Algonquin, depositing sands, silts and clays. Organic (i.e. peat) and alluvial soils were then deposited along drainage courses.

---

<sup>1</sup>Cowan, W.R. and Broster, B.E. 1988. Quaternary Geology of the Sault Ste. Marie Area, District of Algoma, Ontario; Ontario Geological Survey, Map P.3104, Geological Series-Preliminary Map, scale 1:100 000. Geology 1976.

The bedrock generally consists of the Late Precambrian (Keweenawan) mafic volcanic rocks<sup>2</sup> (i.e. basalt) of the Southern Province (a structural subdivision of the Canadian Shield).

### 3.0 INVESTIGATION PROCEDURES

The fieldwork for this project was performed during the period of September 21 to 27, 1999, and consisted of drilling and sampling six boreholes. The plan locations of the boreholes, along with stratigraphic sections are shown on Drawing No. 1.

Due to the presence of reinforced concrete approach slabs adjacent to the existing bridge, the exact proposed abutment locations were not accessible. The boreholes were therefore drilled somewhat offset from the actual proposed foundation element, as close as practicable.

The boreholes were advanced using hollow stem continuous flight augers with a truck-mounted power auger drilling rig (BOA 12M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of experienced geotechnical personnel from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Due to the presence of cobbles and boulders within the glacial till deposits, Boreholes 1, 2, 3 and 4 were either advanced by wash boring or rotary core drilling methods through the cobbles and boulders in the overburden utilizing NQ and NW size casing.

The borehole locations were established in the field by our engineering staff, in relation to the existing bridge structure. The borehole geodetic elevations and northing and easting co-ordinates were later taken by surveyors from D.S. Urso Surveying Limited.

The soil samples were shipped in sealed containers to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, Atterberg Limits tests, consolidation tests, triaxial tests and grain-size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log Sheets and also in Figure Nos. 1 to 10.

---

<sup>2</sup>Giblin, P.E. and Leahy, E.J. 1976. Sault Ste. Marie - Elliot Lake, Districts of Algoma, Manitoulin and Sudbury, Ontario. Ontario Geological Survey, Map 2419, Geological Compilation Series, scale 1:253 440.

.../...

Two standpipe piezometers were sealed in different strata in Borehole 1 to monitor the groundwater level over a prolonged period of time without interference from surface water. The boreholes were backfilled with auger cuttings mixed with a cement-bentonite mixture.

#### **4.0 SUBSURFACE CONDITIONS**

The subsurface conditions were explored at six borehole locations (Borehole Nos. 1 to 6, inclusive). The locations of the boreholes are shown on the Plan and Profile on Drawing No. 1 and indicated on the individual Record of Borehole sheets. Cross sections of inferred subsurface stratigraphy are also shown on Drawing No. 1.

In general, the boreholes shows beneath pavement fill and a thin sand layer, the presence of clay overburden. The clay extends to a depth of about 5 to 8 m  $\pm$  below existing highway grade. Underlying the cohesive soils is a cohesionless glacial till deposit. Underlying the cohesionless glacial till in Boreholes 2 and 3, at a depth of about 18 to 20 m  $\pm$ , is a cohesive glacial till deposit. The groundwater table at the time of our investigation was encountered at depths of about 1 to 3 m  $\pm$  below existing highway grade.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole sheets. The individual strata are briefly described below.

#### **4.1 SANDY GRAVEL TO SAND (FILL)**

The boreholes were drilled through the Highway 17 embankment, and encountered 50 to 200 mm of asphaltic concrete, underlain by 0.2 to 0.5 m of sandy gravel fill. The granular base material is underlain by a mixture of sand with gravel fill to depths ranging from 0.8 to 2.0 m. One grain size distribution analysis was conducted on a sample of each of the two types of fill and the results are presented in Figure No. 1. The results indicate 0 and 54% gravel, 96 and 42% sand and 4% silt and clay size particles.

Measured 'N'-values within the fill materials generally range from 6 to 65 blows/0.3 m, indicating a loose to very dense condition, but generally compact to dense.

Measured natural moisture contents range from 4 to 20%.

In our experience the thickness of fill frequently varies in between and beyond the borehole locations.

#### **4.2 SAND**

Underlying the fill in Boreholes 1, 2, 3, 4 and 5, is a sand layer ranging in thickness from 0.2 to 0.6 m. A 50 mm thick organic layer was encountered overlying the sand in Borehole 3. 'N'-values of 6 and 7 blows/0.3 m were measured within this layer, indicating a loose condition. Two grain size distribution analyses were conducted on samples of the sand layer and the results are presented

.../...

in Figure No. 2. The results indicate 1% gravel, 97 to 98% sand and 1 to 2% silt and clay size particles. Measured moisture contents range from 24 to 62%.

#### 4.3 CLAY TO SILTY CLAY

Underlying the sand layer or fill in the boreholes is a massive, reddish-brown clay to silty clay deposit. The deposit extends to depths ranging from 4.8 to 8.3 m (or Elevation 185.2 to 181.7 m), or to the termination depths of Boreholes 5 and 6. The cohesive deposit contains frequent grey silt pockets or layers, and occasional gravel inclusions. These silt layers range from 10 to 150 mm in thickness. In Boreholes 2 and 3, interbedded between the massive clay deposit, is a varved stratum less than 1 m in thickness. The red clay varves are about 1 to 2 mm in thickness, whereas the grey silt varves are generally 10 mm in thickness.

Measured 'N'-values range from 1 to 5 blows/0.3 m. The in-situ shear strength of the clay was measured at frequent intervals of depth by the field vane shear test. Measured shear strengths range from 36 to 88 kPa, indicating a firm to stiff consistency.

Seven grain size analyses were conducted on samples from this deposit, resulting in the following grain size measurements.

Gravel:	0 to 1%
Sand:	0 to 14%
Silt:	23 to 40%
Clay:	34 to 73%

The grain size analyses results are presented in Figure No. 3.

Twelve Atterberg Limits tests, six quick triaxial tests and two consolidation tests were conducted on samples from the massive clays, varved clays and silt varves. The following results were obtained:

	MASSIVE CLAY TO SILTY CLAY RANGE	VARVED CLAY	SILT VARVES/LAYERS
Plastic Limit (%)	15 to 20	-	18 to 19
Liquid Limit (%)	41 to 48	-	22 to 26
Plasticity Index (%)	24 to 30	-	4 to 7
Moisture Content (%)	24 to 66	33	24 to 27
Unit Weight (kN/m <sup>3</sup> )	15.8 to 22.4	18.9	-
Shear Strength			
Field Vane (kPa)	36 to 88	44 to 68	-
Laboratory Vane (kPa)	10 to 34	-	-
Unconfined Compressive Strength (kPa)	38 to 64	-	-
Compression Index (C <sub>c</sub> )	0.06 to 0.23	-	-
Recompression index (C <sub>r</sub> )	0.02 to 0.04	-	-
Coefficient of consolidation (C <sub>v</sub> )	0.025 to 0.08	-	-

.../...

These Atterberg Limits values are characteristic of clayey soils of intermediate to high plasticity (Figure No. 5). Its moisture content exceeds the liquid limit at some locations, indicating that portions of the clays are highly compressible. Based on the field vane and unconfined compressive strength results, the clays are generally firm to stiff in consistency, with occasional soft zones. The laboratory vane results are very low and are likely due to sample disturbance. The results of all field vane and of the quick triaxial compression tests are summarized in Figure No. 7. The results of a consolidation test performed on a sample of this massive clay to silty clay is presented in Figure No. 8. Consolidated undrained triaxial compression tests with pore water pressure measurements were performed on two samples of the massive clay giving an angle of internal friction  $\phi'$  of  $28^\circ$  and a cohesion  $c'$  of 8 kPa (Figure No. 9).

The values for the grey silt varves are characteristic of plastic inorganic silt to clayey silt (Figure No. 6). The results of a consolidation test performed on a sample from a massive clay with pockets of silt are presented in Figure No. 10.

#### 4.4 HETEROGENEOUS MIXTURE OF SAND, SILT AND GRAVEL (GLACIAL TILL)

Below the clay deposits in Boreholes 1, 2, 3 and 4, a cohesionless glacial till deposit was encountered. This deposit consists of a heterogeneous mixture of sand, silt and gravel, with frequent cobbles and boulders. The till extends to the remaining depth of Boreholes 1 and 4 (14.2 and 9.4 m or Elevation 175.8 and 180.6 m, respectively). In Boreholes 2 and 3, the till extends to depths of 20.1 and 17.7 m (or Elevations 169.9 and 172.3 m), respectively. Due to the frequent cobbles and boulders (a boulder 1.0 m in thickness was cored in Borehole 1), auger refusal was encountered within the till at depths ranging from 6.7 to 10.6 m. In order to by-pass the obstructions, rock coring and wash boring were conducted. Measured 'N'-values range from 36 to greater than 50 blows/0.3 m indicating a compact to very dense condition, but generally very dense. Measured natural moisture contents range from 6 to 20%. Measured unit weights range from 20.4 to 24.3 kN/m<sup>3</sup>, or an average of about 23.1 kN/m<sup>3</sup>.

Seven grain size distribution analyses were conducted on samples from this deposit and the results are presented in Figure No. 11. The results indicate 9 to 41% gravel, 22 to 60% sand, 23 to 54% silt and 2 to 10% clay size particles. Measured moisture contents range from 6 to 20%.

#### 4.5 HETEROGENEOUS MIXTURE OF CLAY, SILT AND GRAVEL (GLACIAL TILL)

Underlying the above cohesionless glacial till, Boreholes 2 and 3 encountered a reddish brown, cohesive glacial till deposit. This glacial till deposit is composed of a heterogeneous mixture of clay, silt and gravel size particles. Due to difficulties in obtaining a sample below the bouldery cohesionless till, no sample of this cohesive till was obtained from Borehole 3, aside from washed samples. A measured 'N'-value of 150 blows/0.09 m was obtained in this deposit in Borehole 2, indicating a hard consistency. An Atterberg Limits test was conducted on the sample obtained and is presented in Figure No. 12. The laboratory test results are presented below:

Liquid Limit:	19%
Plastic Limit:	15%
Plasticity Index:	4
Moisture Content:	12%
Unit Weight:	23.1 kN/m <sup>3</sup>

.../...

#### 4.6 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. To enable us to measure water levels at the site over a prolonged period of time without interference from surface water, two standpipe piezometers were installed within different strata in Borehole 1.


The recorded values are shown on the individual Record of Borehole sheets. Based on the recorded values in the piezometers installed and moisture contents of recovered samples, the groundwater levels at the time of the investigation generally ranged from 1 to 3 +\_m below the ground surface (approximately Elevation 189 to 187 m). It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to heavy rains. Also, a perched water table may be encountered in the pervious fill and sand deposits overlying the relatively impermeable clay deposits.

#### 5.0 CLOSURE

It should be noted that AGRA guarantees the results only at the borehole locations. The findings in this report must only be used for this specific project.

Sincerely,

  
Andrew Drevininkas, P. Eng.

   
G. S. W. Chow, P. Eng.  
ATO Designated Contact.

AD

.../...



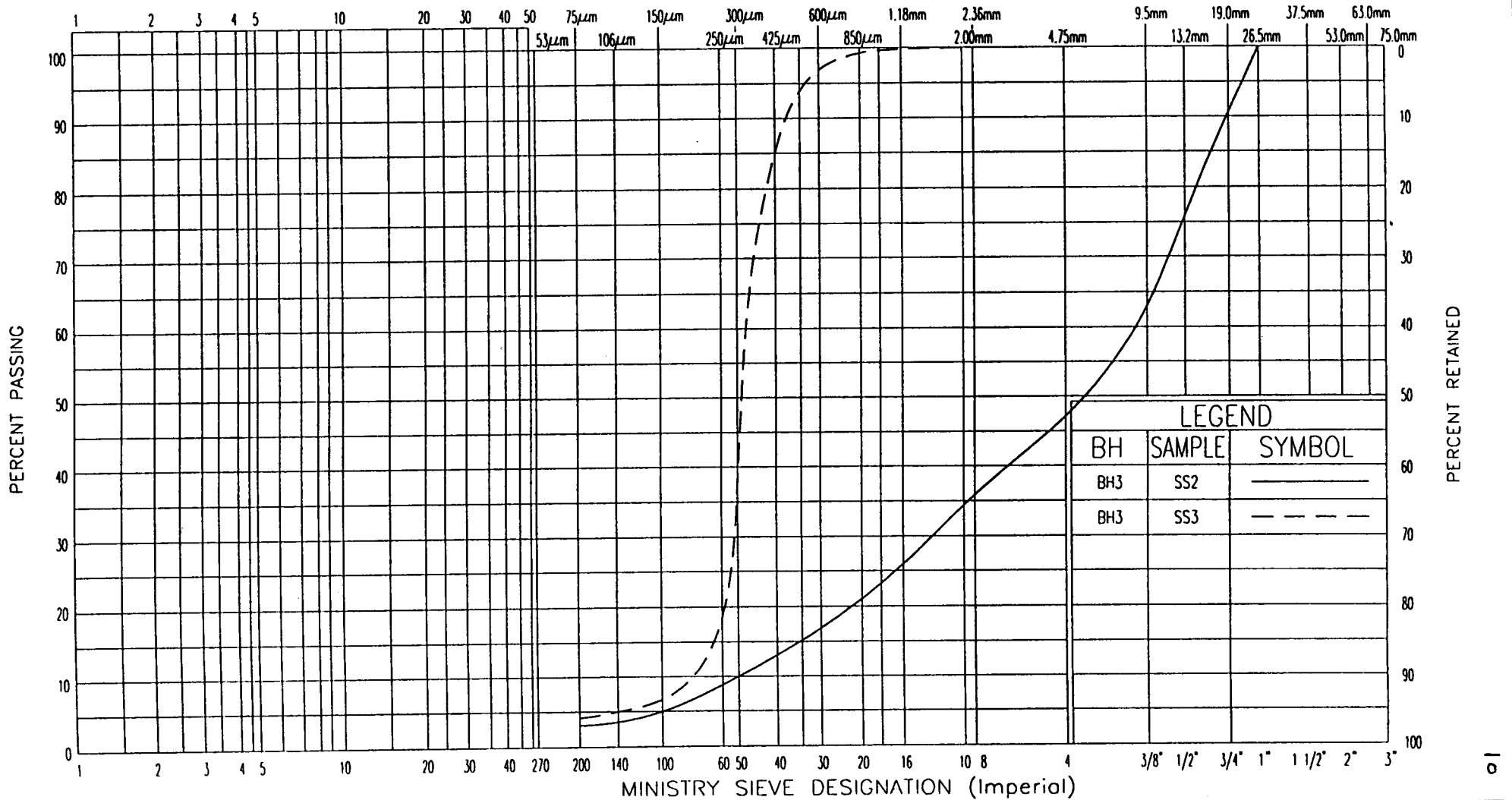
## FIGURES

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)

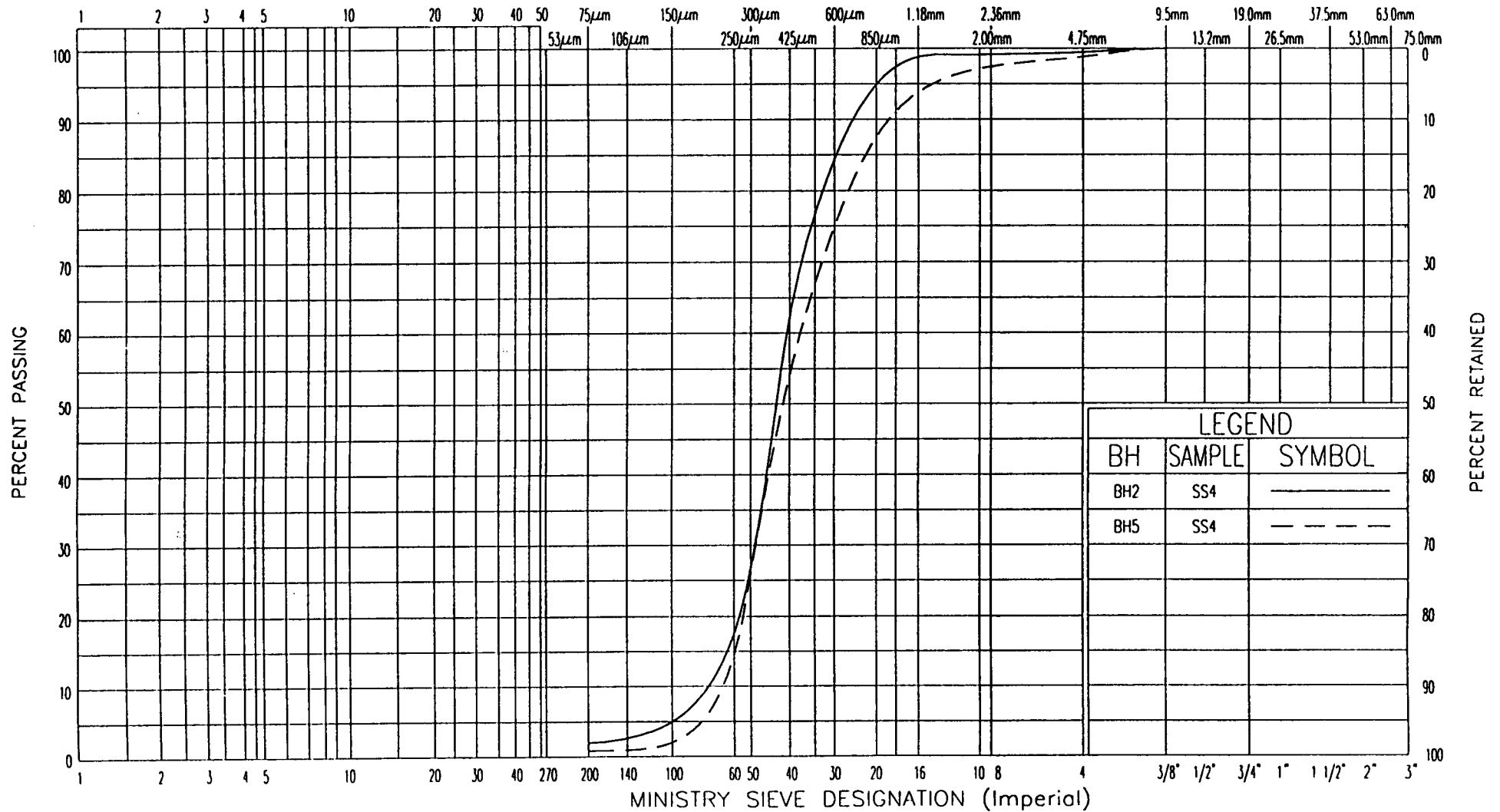


# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND		
BH	SAMPLE	SYMBOL
BH2	SS4	————
BH5	SS4	- - - - -



GRAIN SIZE DISTRIBUTION  
SAND

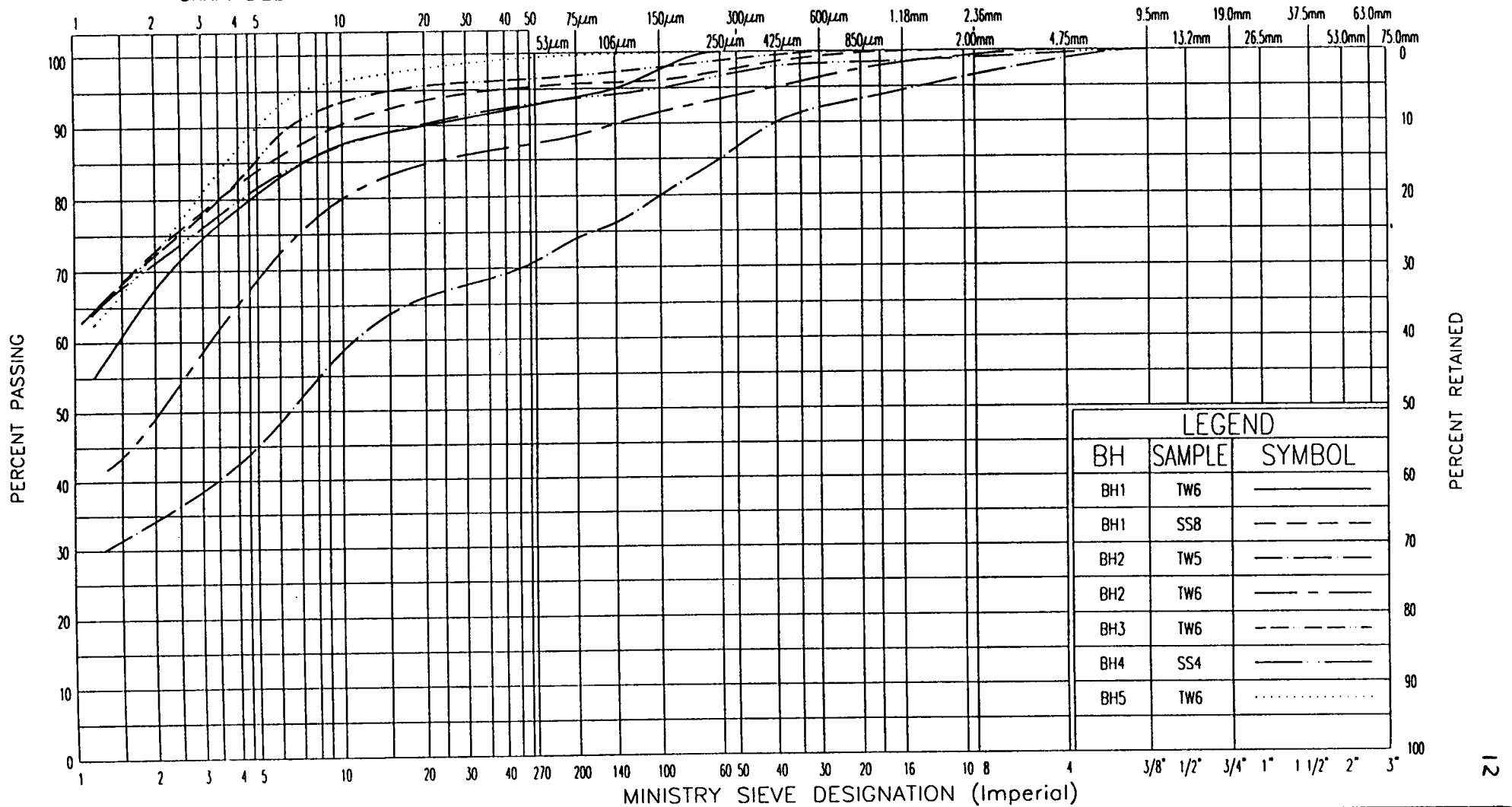
FIG. No 2  
W. P. 108-99-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION  
CLAY

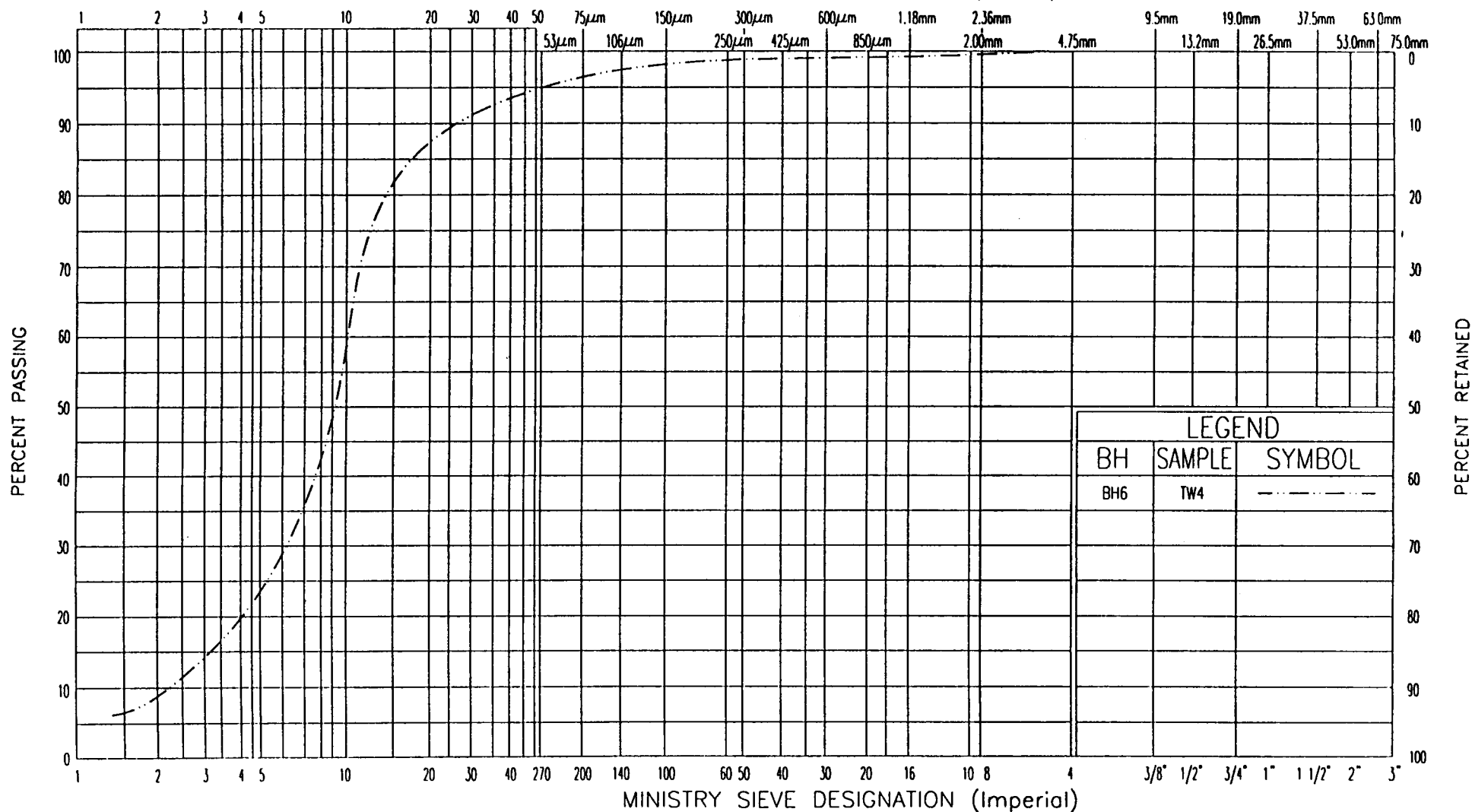
FIG. No 3  
W. P. 108-99-00

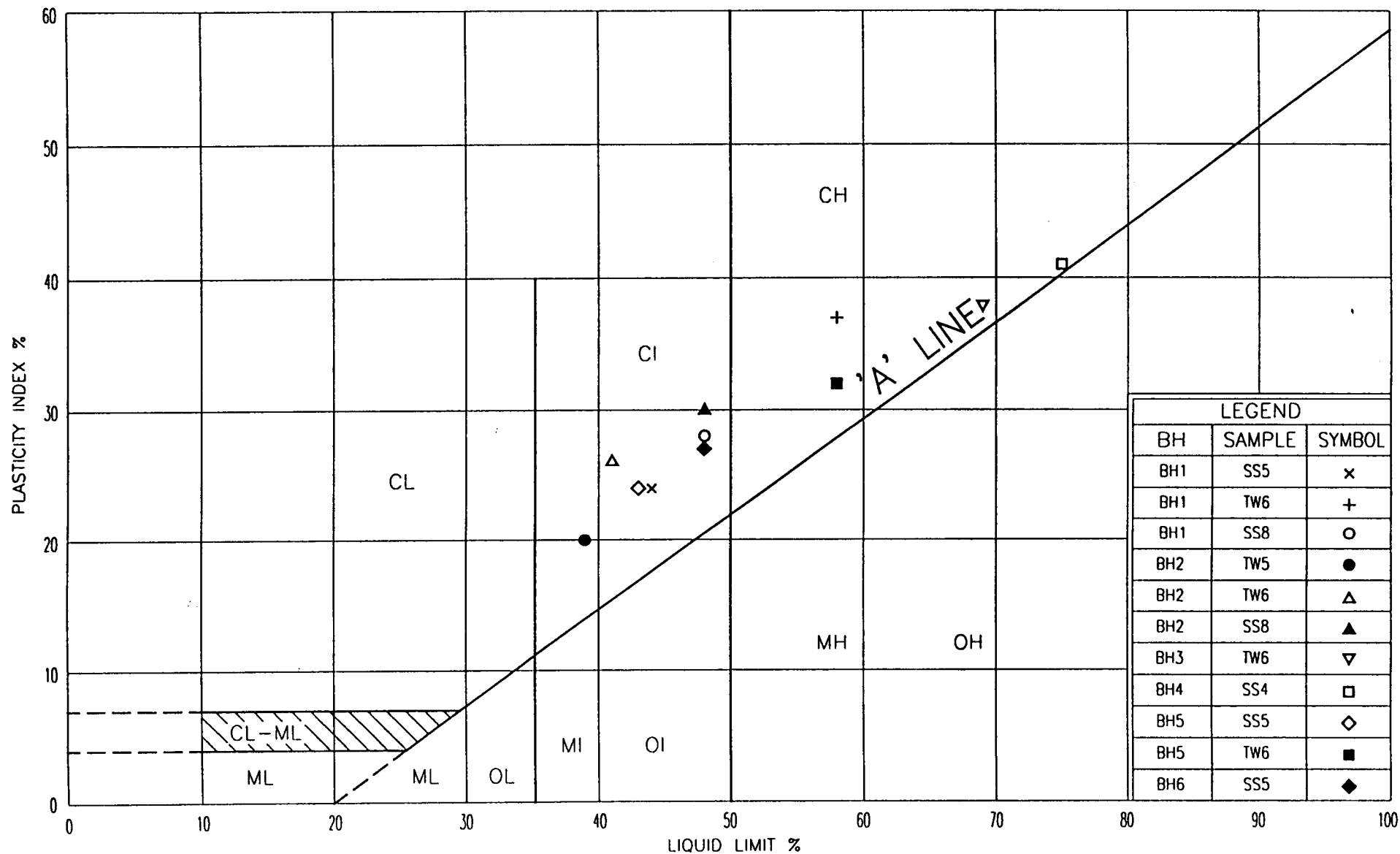
# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)





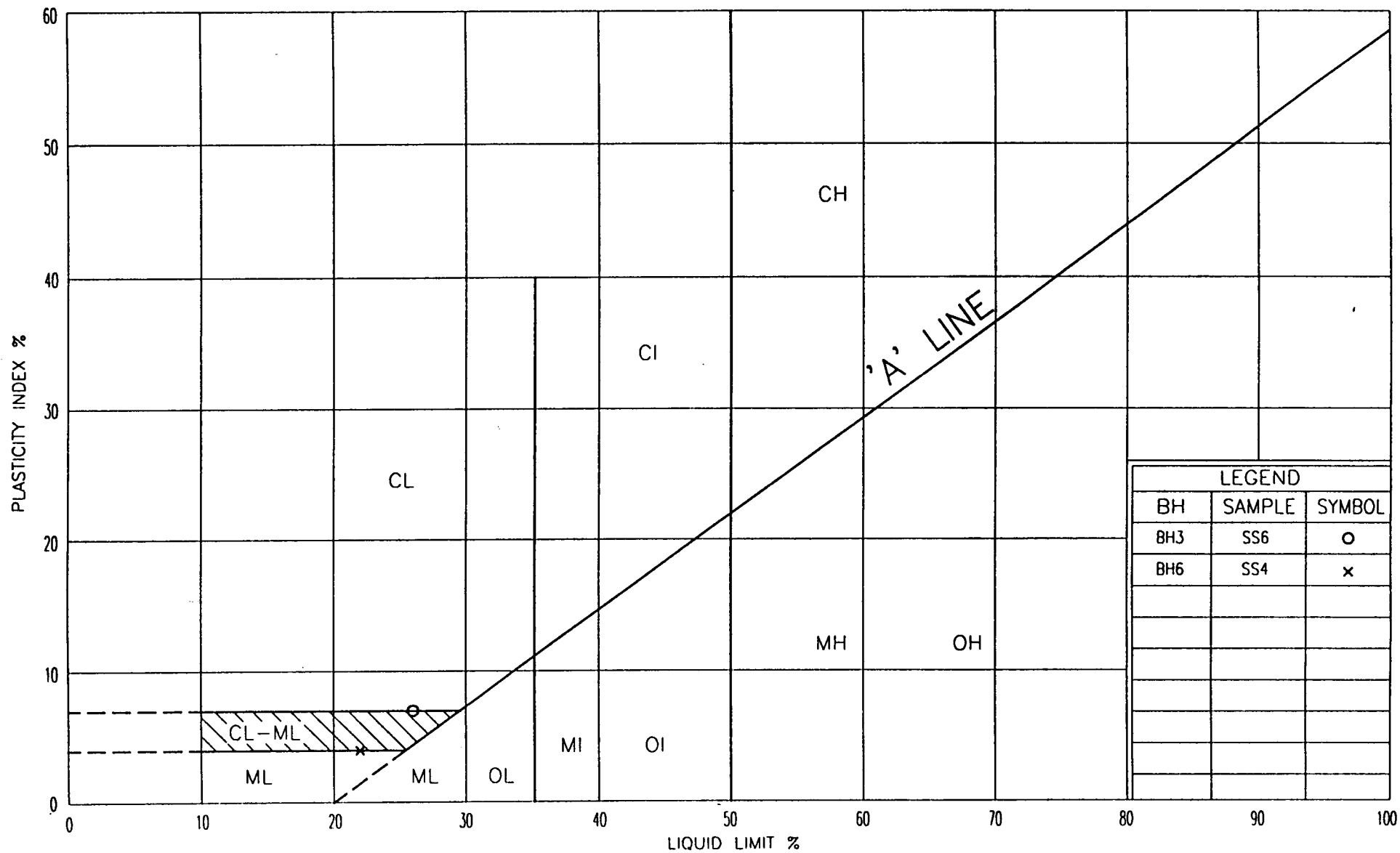
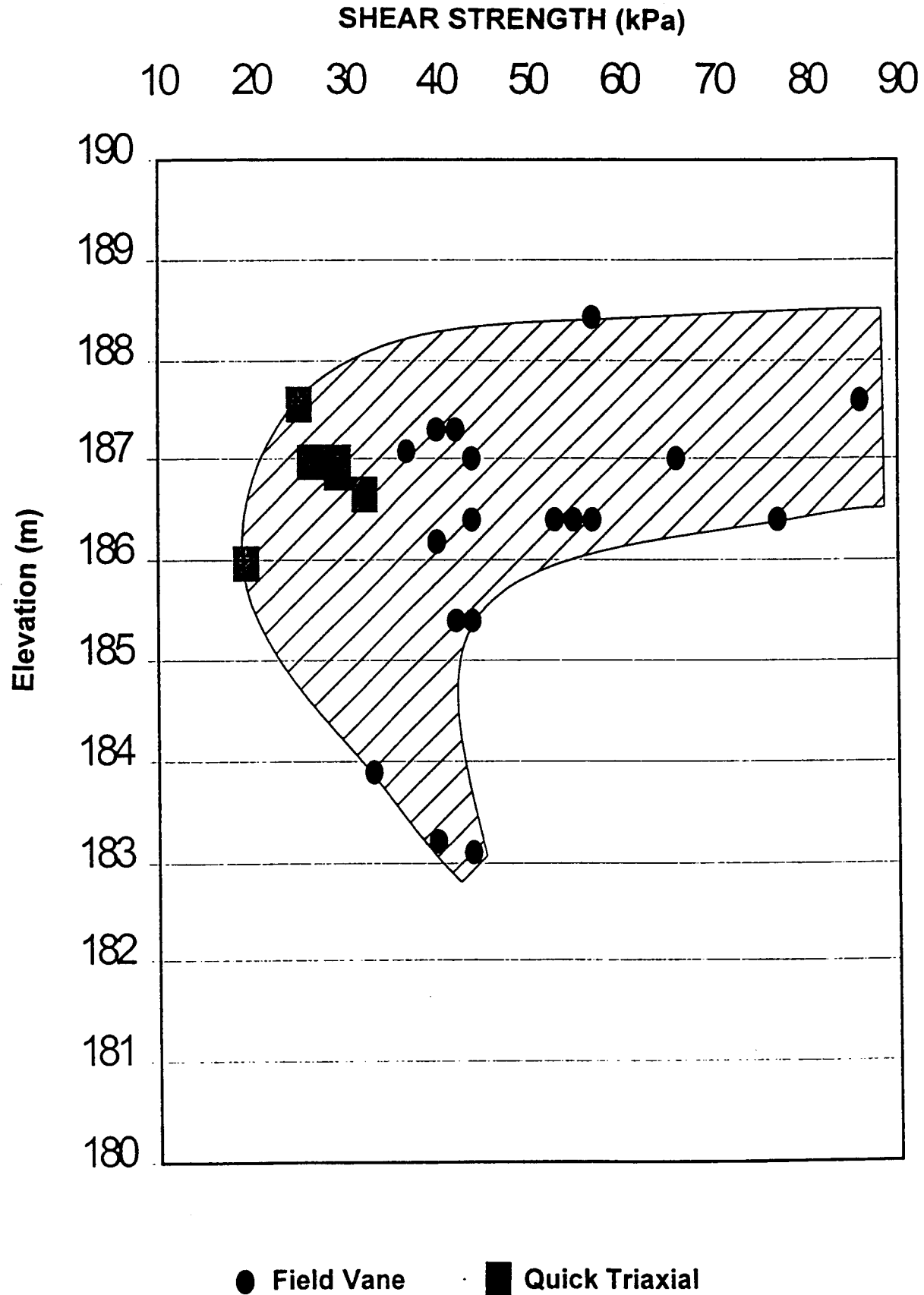


FIGURE NO. 7: FIELD VANE AND  
QUICK TRIAXIAL TEST RESULTS





Ring # : 1 Ring Height (in) = 0.71 Wt of dry filter paper (g) = 0.66 17

Wet soil + Ring Wt (g) = 122.57 Wt of ring (g) = 59.09

Wet soil + Wet Paper + Ring (g) = 120.31 Wet Paper (g) = 1.85

Dry Soil + Dry Paper + Ring (g) = 107.91 Ring Dia (in) = 1.900

Initial moisture Content (%) = 31.811 Final moisture Content (%) = 23.277

Area of Ring (in<sup>2</sup>) = 2.835 Initial Volume (in<sup>3</sup>) = 2.0131

Initial Bulk Density (kg/m<sup>3</sup>) = 1924 Initial Dry Density (kg/m<sup>3</sup>) = 1460

Specific Gravity of Soil = 2.7 Equiv. Thick. of solids (mm) = 9.751

Final gauge reading for Load 1 =

Gauge reading for last Loading =

Trial #	1	2	3	4	5	6	7
Load (tsf)	0	0.125	0.25	0.5	1.0	2.0	4.0
Gauge Reading (in)	0.2597	0.2523	0.24775	0.24165	0.2311	0.20855	0.1789
(H-Hs) mm	8.283	8.095	7.979	7.824	7.556	6.984	6.230
Voids ratio	0.849	0.830	0.818	0.802	0.775	0.716	0.639
t <sub>90</sub> (min)			2.56	3.80	3.42	3.24	3.24
C <sub>v</sub> (ft <sup>2</sup> /day)			0.406	0.269	0.292	0.294	0.271
k (tsf)		11.993	19.505	29.098	33.649	31.486	47.892
M <sub>v</sub> (ft <sup>2</sup> / ton)		0.0834	0.0513	0.0344	0.0297	0.0318	0.0209

Trial #	8	9	10	11	12	13	14
Load (tsf)	8.0	16.0		4.0		1.0	
Gauge Reading (in)	0.1532	0.1208		0.1267		0.1352	
(H-Hs) mm	5.576	4.755		4.905		5.120	
Voids ratio	0.572	0.488		0.503		0.525	
t <sub>90</sub> (min)	3.8025	1.32					
C <sub>v</sub> (ft <sup>2</sup> /day)	0.212	0.553					
k (tsf)	110.291	175.580		1444.068		250.588	
M <sub>v</sub> (ft <sup>2</sup> / ton)	0.0091	0.0057		0.0007		0.0040	

Trial #	15	16
Load (tsf)	0.25	0.125
Gauge Reading (in)	0.1455	0.1520
(H-Hs) mm	5.382	5.547
Voids ratio	0.552	0.569
t <sub>90</sub> (min)		
C <sub>v</sub> (ft <sup>2</sup> /day)		
k (tsf)	51.699	13.654
M <sub>v</sub> (ft <sup>2</sup> / ton)	0.0193	0.0732

# AGRA EARTH AND ENVIRONMENTAL LIMITED

November, 1999

Borehole 2

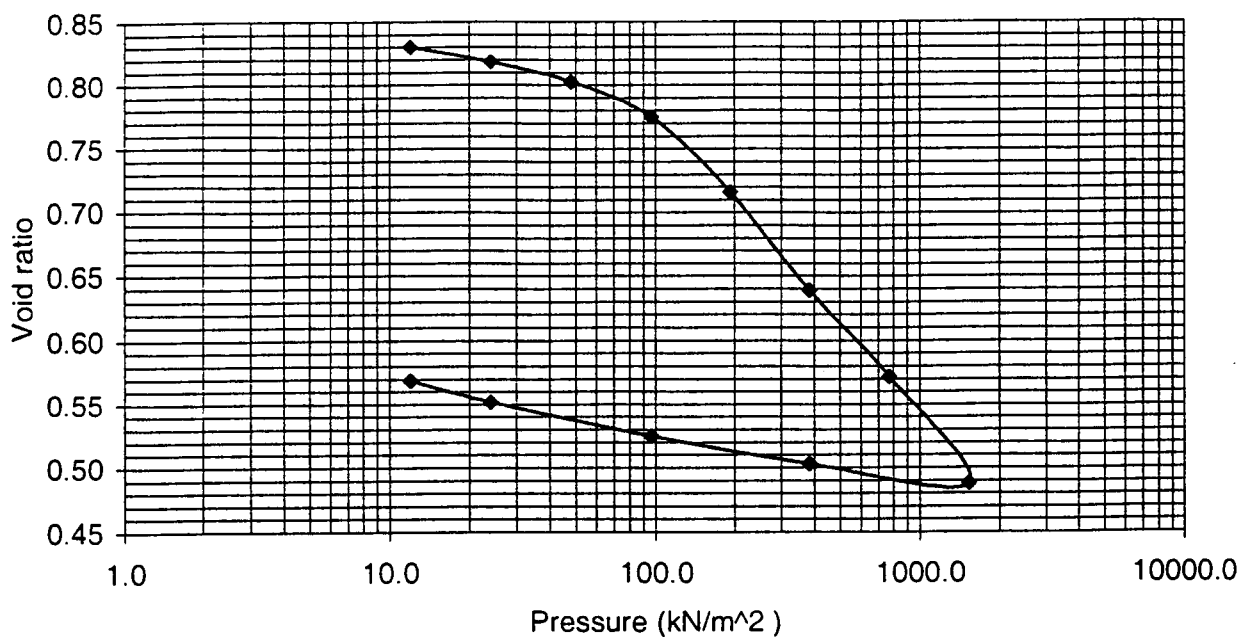
TW 5

## CONSOLIDATION TEST RESULTS

Ref. No. TT 99853

CLAY TO SILTY CLAY

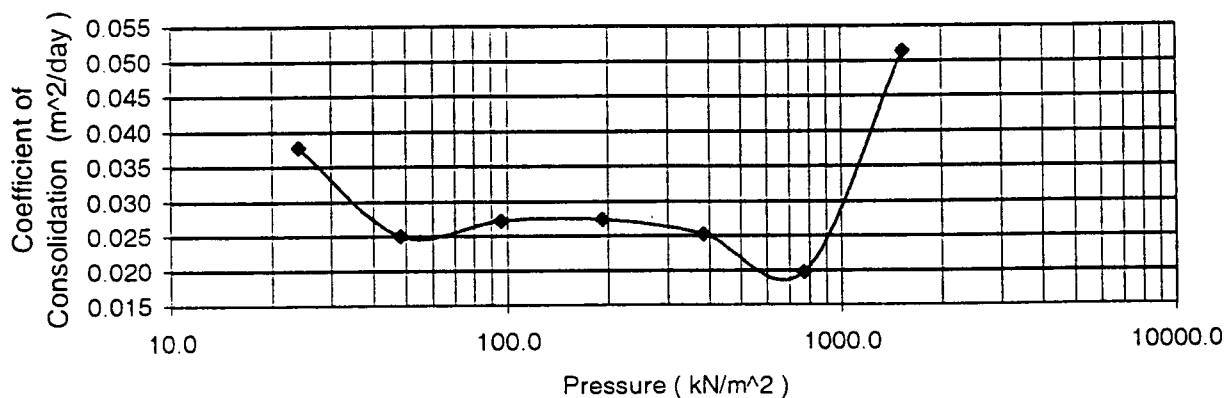
Figure No. 8



$$\sigma_o' = 60 \text{ kPa} \quad \sigma_c' = 90 \text{ kPa}$$

$$C_c = 0.23 \quad C_r = 0.04$$

### Coefficient of Consolidation Vs Pressure



**AGRA EARTH AND ENVIRONMENTAL LIMITED**

November, 1999

Borehole 2

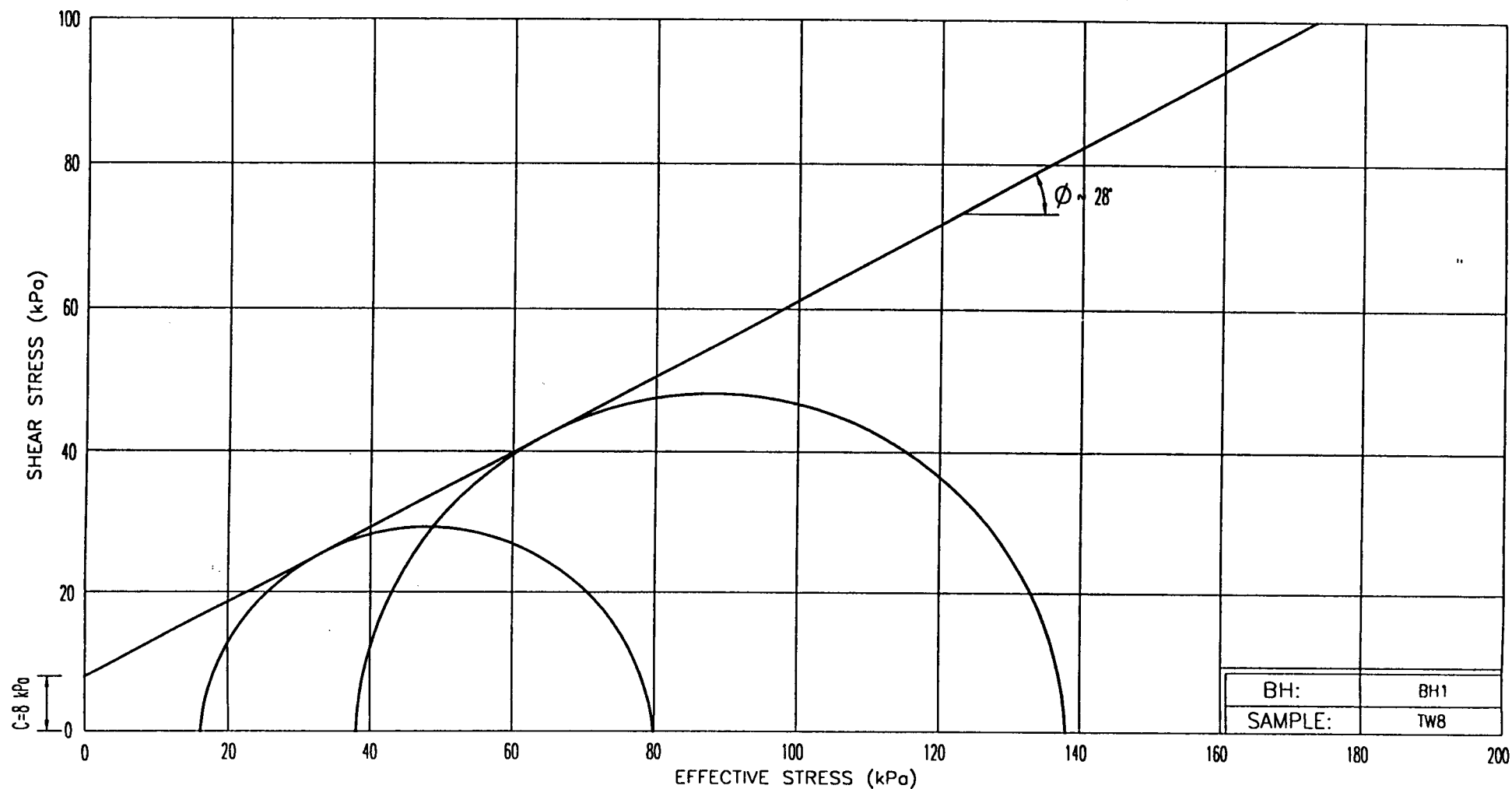
TW 5

**CONSOLIDATION TEST RESULTS**

Ref. No. TT 99853

CLAY TO SILTY CLAY

Figure No. 8



AGRA

EFFECTIVE STRESS TRIAXIAL COMPRESSION  
CONSOLIDATED UNDRAINED

FIG No 9

W.P. 108-99-00

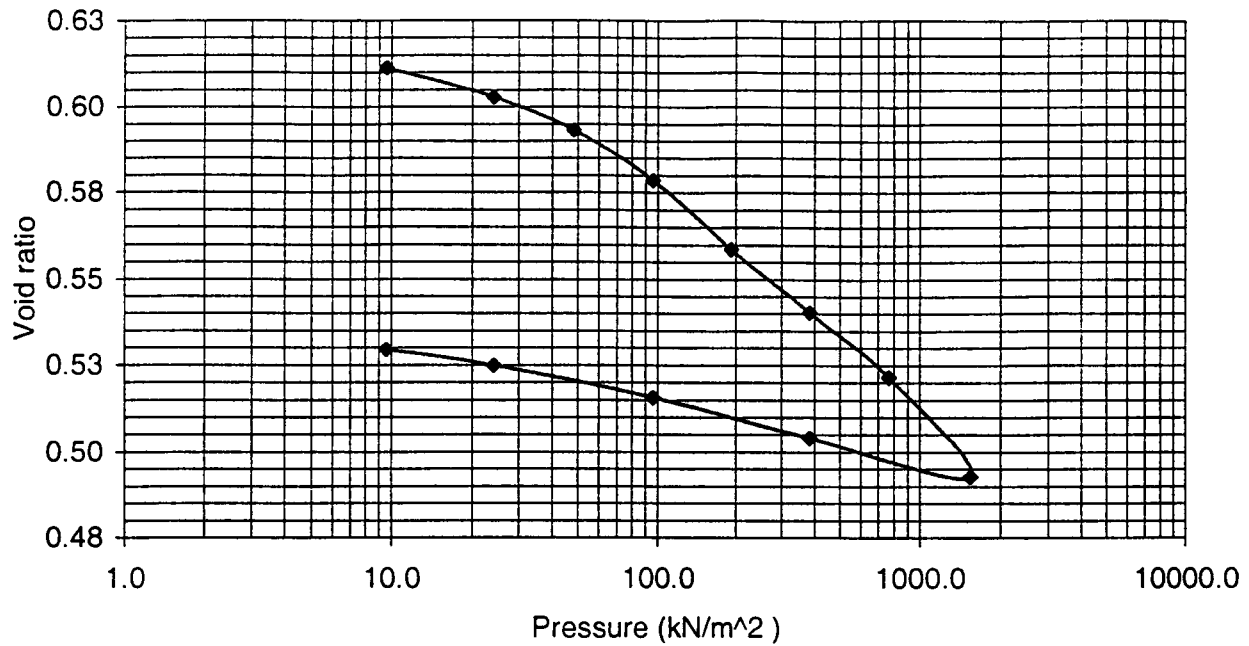
Ring # : 5      Ring Height (in) = 0.76      Wt of dry filter paper (g) = 0.66      20  
 Wet soil + Ring Wt (g) = 128.31      Wt of ring (g) = 56.83  
 Wet soil + Wet Paper + Ring (g) = 127.83      Wet Paper (g) = 1.94  
 Dry Soil + Dry Paper + Ring (g) = 114.96      Ring Dia (in) = 1.895  
 Initial moisture Content (%) = 24.378      Final moisture Content (%) = 20.167  
 Area of Ring (in<sup>2</sup>) = 2.820      Initial Volume (in<sup>3</sup>) = 2.1435  
 Initial Bulk Density (kg/m<sup>3</sup>) = 2035      Initial Dry Density (kg/m<sup>3</sup>) = 1636  
 Specific Gravity of Soil = 2.7      Eqiv. Thick. of solids (mm) = 11.698  
 Final gauge reading for Load 1 = 0.3159      Gauge reading for last Loading = 0.2434

Trial #	1	2	3	4	5	6	7
Load (tsf)	0	0.1	0.25	0.75	1.0	2.0	4.0
Gauge Reading (in)	0.3159	0.298	0.2941	0.28965	0.28295	0.2738	0.2653
(H-Hs) mm	7.606	7.152	7.053	6.940	6.769	6.537	6.321
Voids ratio	0.650	0.611	0.603	0.593	0.579	0.559	0.540
t <sub>90</sub> (min)			1.44	1.21	1.00	1.44	3.61
Cv (ft <sup>2</sup> /day)			0.807	0.949	1.131	0.768	0.299
k (tsf)		4.246	29.231	85.393	28.358	83.060	178.824
Mv (ft <sup>2</sup> / ton)		0.2355	0.0342	0.0117	0.0353	0.0120	0.0056

Trial #	8	9	10	11	12	13	14
Load (tsf)	8.0	16.0	8.0	4.0	2.0	1.0	0.5
Gauge Reading (in)	0.2567	0.2434		0.2486		0.2540	
(H-Hs) mm	6.101	5.765		5.897		6.033	
Voids ratio	0.522	0.493		0.504		0.516	
t <sub>90</sub> (min)	1.96	1.44					
Cv (ft <sup>2</sup> /day)	0.538	0.709					
k (tsf)	351.445	458.868		1753.846		426.168	
Mv (ft <sup>2</sup> / ton)	0.0028	0.0022		0.0006		0.0023	

Trial #	15	16
Load (tsf)	0.25	0.10
Gauge Reading (in)	0.2582	0.2603
(H-Hs) mm	6.141	6.194
Voids ratio	0.525	0.530
t <sub>90</sub> (min)		
Cv (ft <sup>2</sup> /day)		
k (tsf)	134.118	54.286
Mv (ft <sup>2</sup> / ton)	0.0075	0.0184

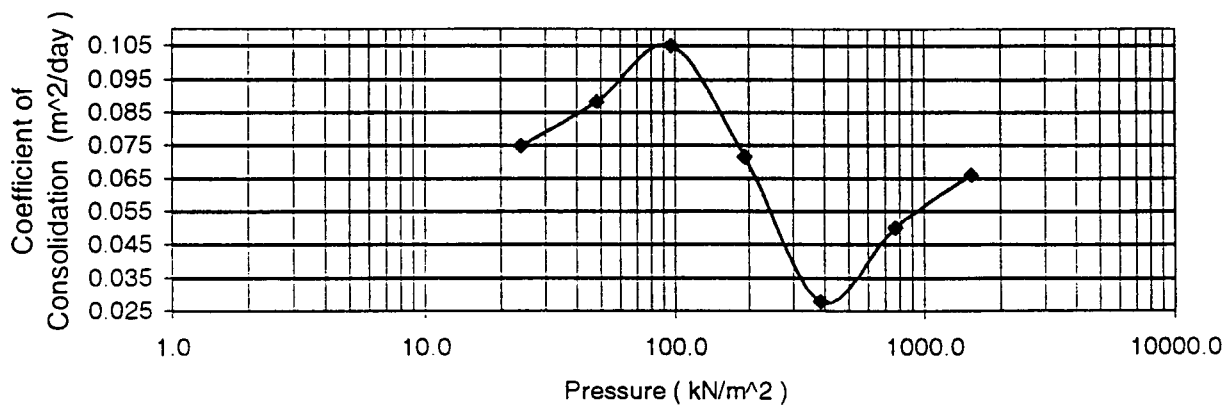
AGRA EARTH AND ENVIRONMENTAL LIMITED		
December, 1999		Borehole 6
		TW 4
CONSOLIDATION TEST RESULTS		
Ref. No. TT 99853	SILTY CLAY WITH SILT	Figure No. 10



$$\sigma_o' = 35 \text{ kPa} \quad \sigma_c' = 55 \text{ kPa}$$

$$C_c = 0.06 \quad C_r = 0.02$$

### Coefficient of Consolidation Vs Pressure



**AGRA EARTH AND ENVIRONMENTAL LIMITED**

December, 1999

Borehole 6

TW 4

### CONSOLIDATION TEST RESULTS

Ref. No. TT 99853

SILTY CLAY WITH SILT

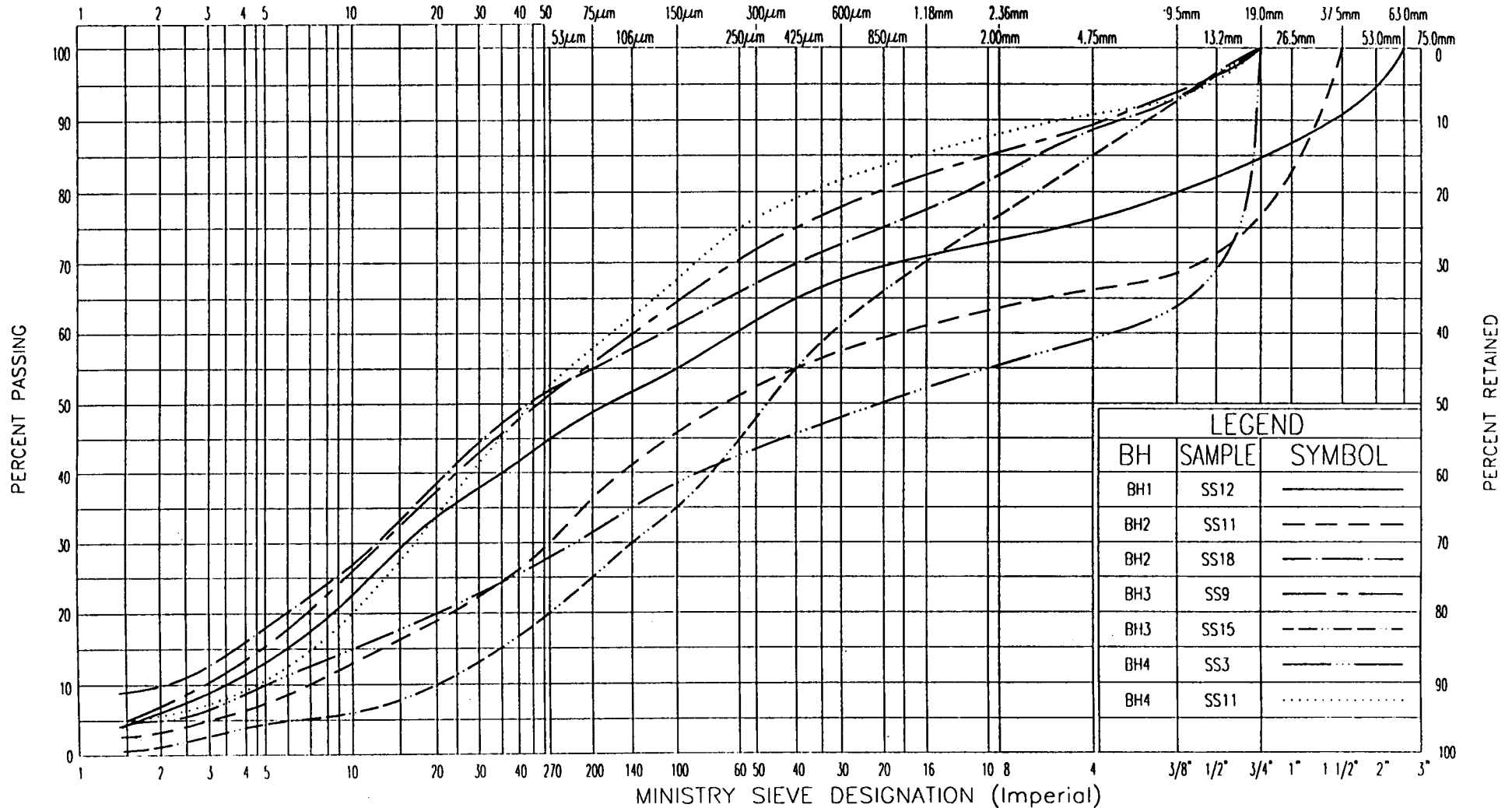
Figure No. 10

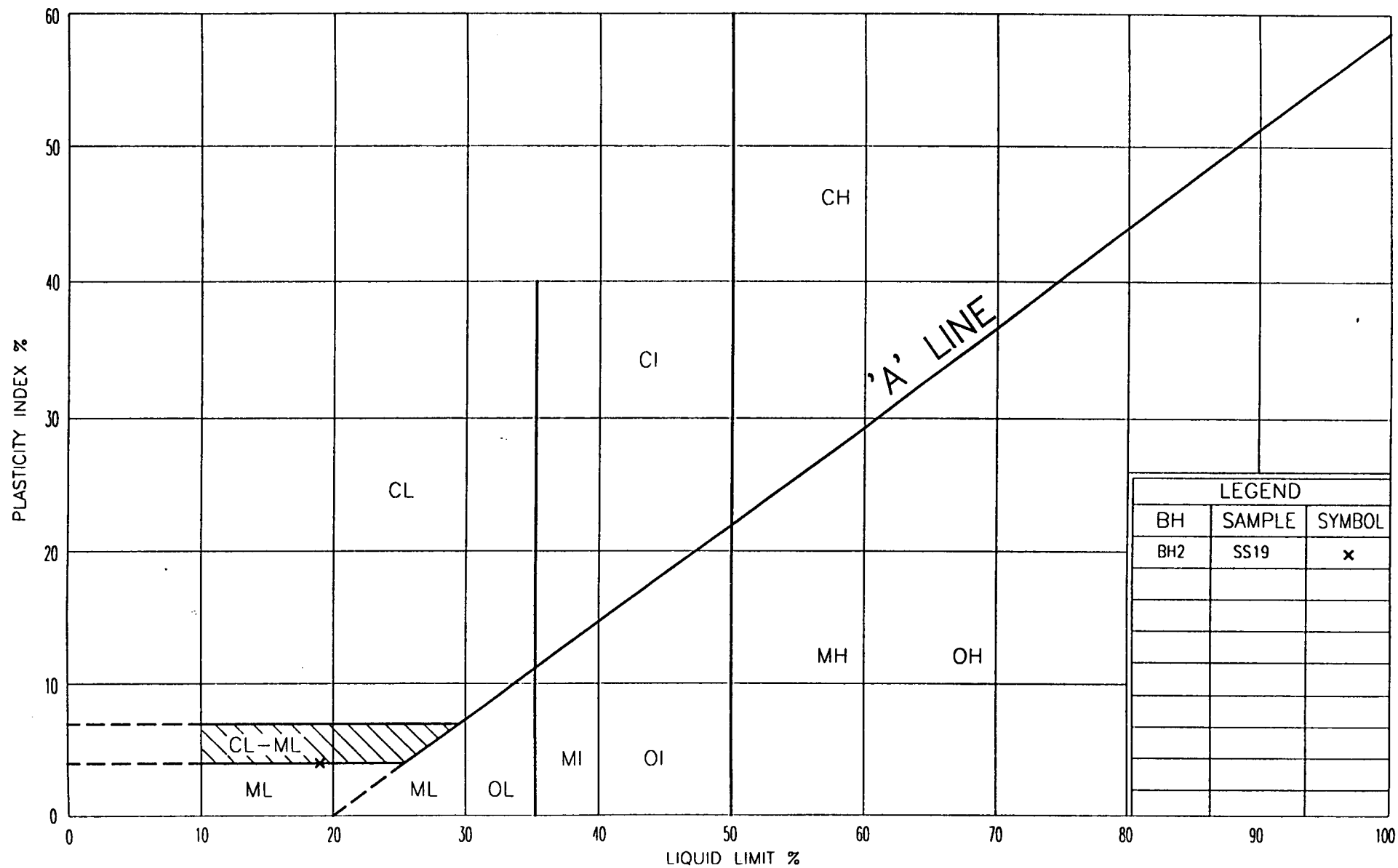
# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)





23

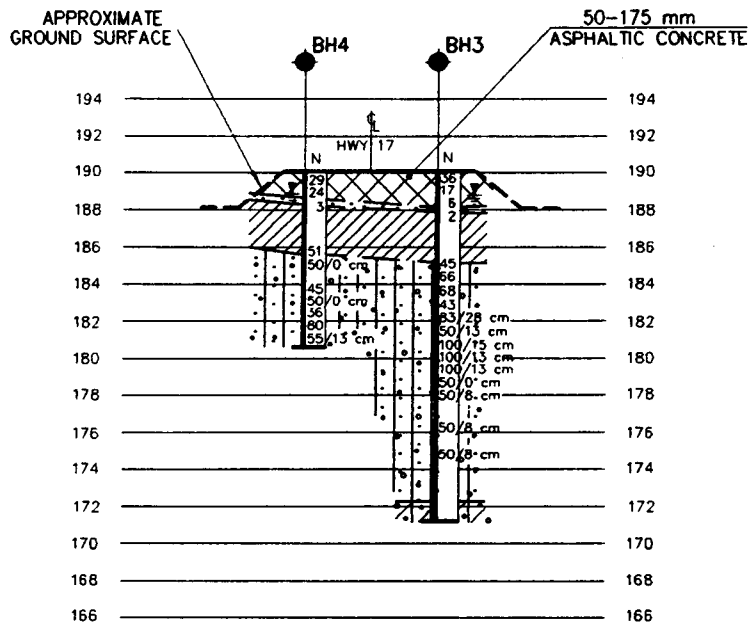


PLASTICITY CHART  
SILT to CLAYEY SILT

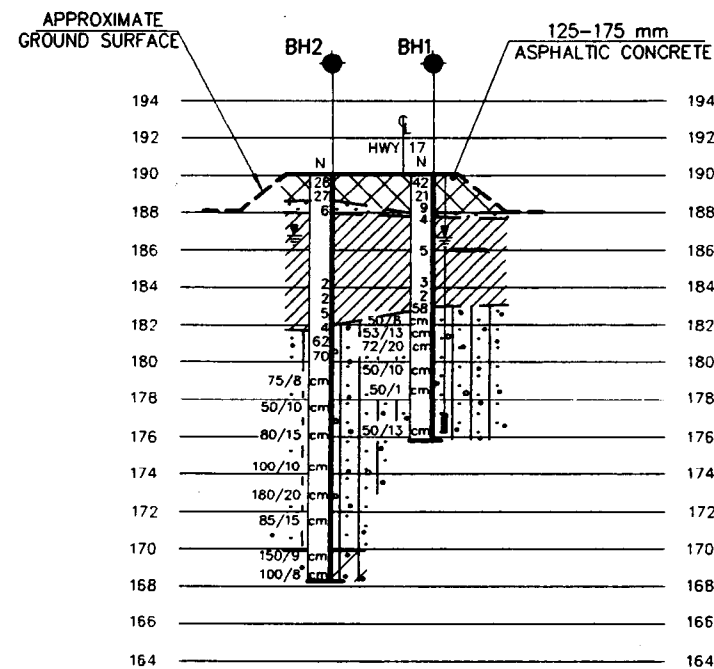
FIG No 12  
W.P. 108-99--00

## ENCLOSURES



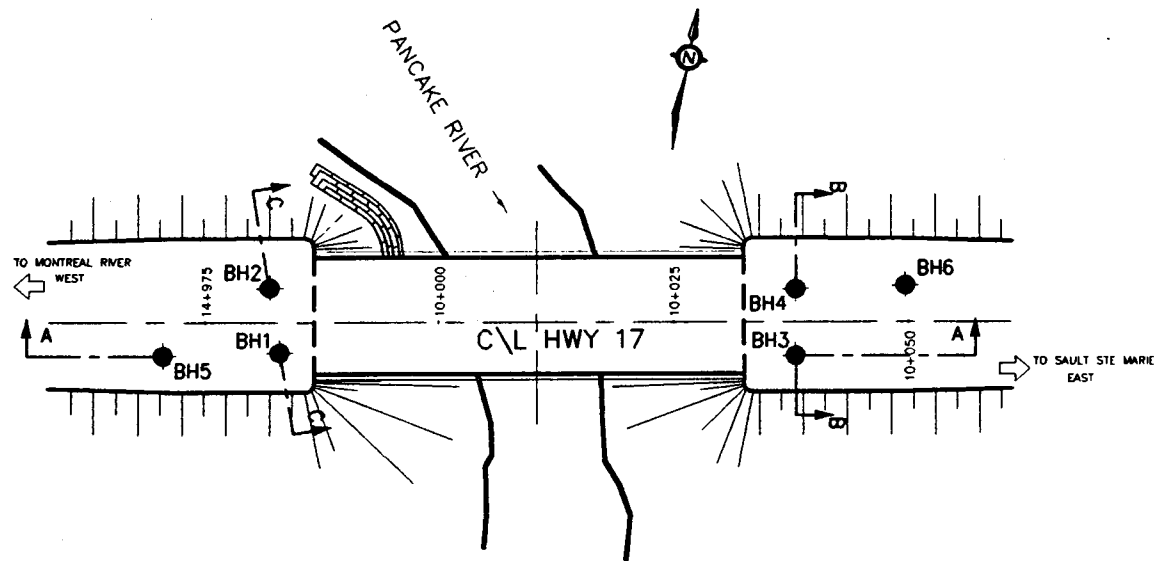
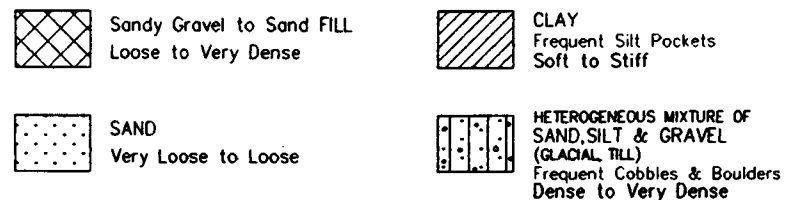


SECTION B-B

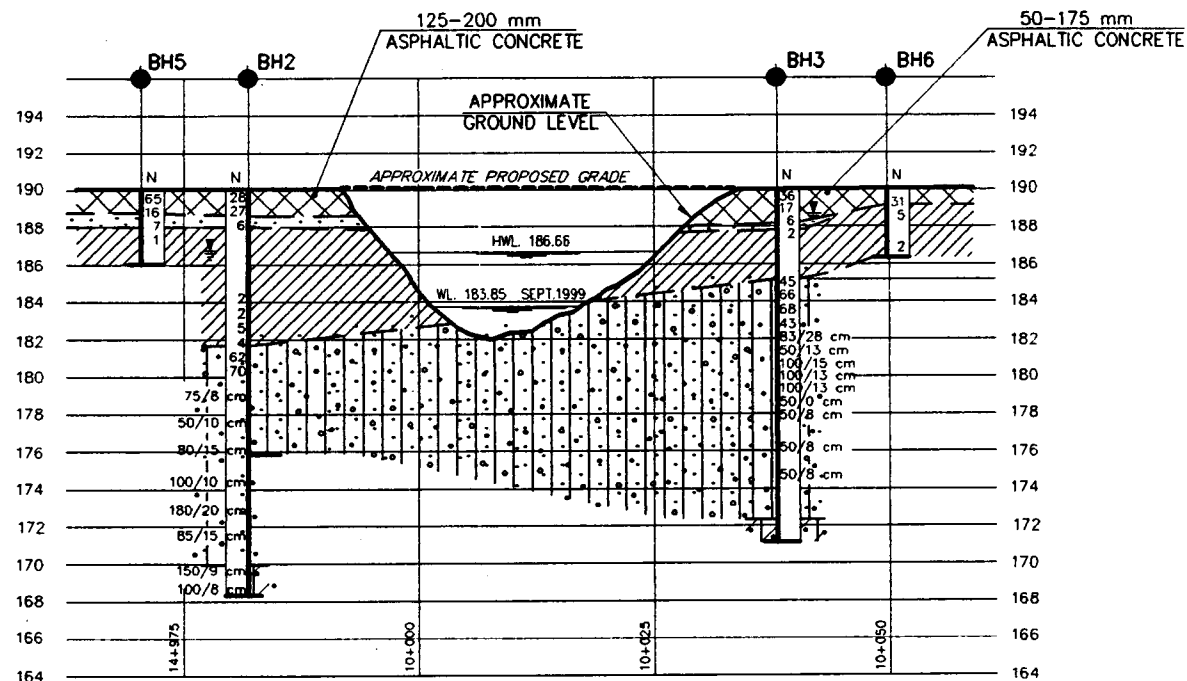


SECTION C-C

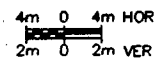
SOIL STRATIGRAPHY LEGEND



PLAN



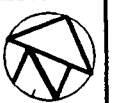
SECTION A-A



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES - METRES.

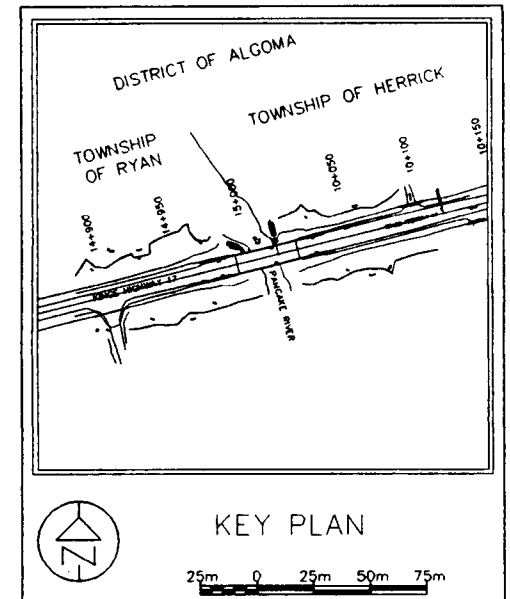
CONT. No.  
W.P. No. 108-99-00

PANCAKE RIVER BRIDGE  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

AGRA Earth & Environmental Ltd.



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 - Sept. 1999
- WL in Piezometer
- Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
BH1	190.0	5 202 623	254 816
BH2	190.0	5 202 613	254 818
BH3	190.0	5 202 599	254 867
BH4	190.0	5 202 607	254 871
BH5	190.2	5 202 629	254 802
BH6	190.0	5 202 601	254 884

NOTE -

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen.Cond.

REV	DATE	BY	DESCRIPTION

HWY No 17	DIST 62
SUBMIT AD CHECKED EC DATE November, 1999 SITE 385-5	
DRAWN MA CHECKED GO	DWG 1

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W P 108-39-00 LOCATION N 5202622 8 E 254815 6 ORIGINATED BY MA  
 DIST 62 HWY 17 BOREHOLE TYPE Hollow Stem Augering/Wash Boring COMPILED BY AD  
 DATUM Geodetic DATE 21 September 1999 CHECKED BY SP

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100					
190.0													
0.3	175mm ASPHALTIC CONCRETE		1	AS									
	0.3m Sandy Gravel FILL		2	SS	42								
	brown		3	SS	21								
	Sand FILL												
	trace Gravel												
	loose to dense, damp												
188.0			4	SS	9								
187.8	brown SAND damp												
2.2	reddish-brown		5	SS	4							20.3	
	CLAY TO SILTY CLAY												
	frequent grey Silt pockets, trace Sand, wet												
	firm		6	TW	-								0 6 27 67
	stiff												TW6: CU test
	trace Gravel		7	SS	5								
	firm												
			8	SS	3							18.0	0 4 23 73
			9	SS	2								
182.9			10	SS	58								
7.1	brown												
	HETEROGENEOUS MIXTURE OF		11	SS	50/8								
	SAND, SILT & GRAVEL												
	(GLACIAL TILL)		12	SS	50/13								24 29 40 6
	frequent Cobbles & Boulders												
	very dense, damp to moist		13	SS	72/20							22.8	Auger refusal @ 9.3m on boulder
													Advance using core drilling and wash boring
			14	RC									RC17
	boulder												REC=100%
	boulder		15	SS	50/7								R O D =100%
													RC18
			16	SS	50/7								REC=100%
													R O D =90%
	boulder		17	RC									
	boulder												
	boulder		18	RC									
	boulder												
	boulder												
175.8			19	SS	50/10								
14.2	END OF BOREHOLE												
	Piezometer installed @13.4m												
	Water Level												
	Sept 22/99 3.3m												
	Sept 24/99 3.4m												
	Sept 27/99 3.1m												
	Piezometer installed @9.3m												
	Water Level												
	Sept 22/99 3.4m												
	Sept 24/99 3.4m												
	Sept 27/99 3.1m												

RECORD OF BOREHOLE No 2										1 OF 2		METRIC				
W.P. 108-39-00		LOCATION N 5202613 5 E 254818 2				ORIGINATED BY MA										
DIST 62 H/WY 17		BOREHOLE TYPE Hollow Stem Augering/Wash Boring				COMPILED BY AC										
DATUM Geodetic		DATE 25 September 1999				CHECKED BY SP										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT $w_p$	NATURAL MOISTURE CONTENT $w$	LIQUID LIMIT $w_L$	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80
190.0	125mm ASPHALTIC CONCRETE		1	SS	28											
0.0	0.2m Sandy Gravel FILL		2	SS	27											
188.6	brown Sand FILL trace Gravel compact, damp		3	SS	27											
1.4	brown SAND loose, damp		4	SS	6											
188.0	reddish-brown CLAY TO SILTY CLAY frequent grey Silt pockets, some Sand soft to firm wet		5	TW	-											
187.0			6	TW	-											
186.0	trace Gravel		7	SS	2											
185.0			8	SS	2											
184.0			9	SS	5											
183.0	varved		10	SS	4											
182.0			11	SS	62											
181.0			12	SS	70											
180.0			13	SS	50/10											
179.0			14	SS	80/15											
178.0		15	SS	180/20												
177.0		16	SS	85/15												
176.0		17	SS	85/15												
175.0		18	SS	85/15												
174.0																
173.0																
172.0																
171.0																

Continued Next Page

+ 3, X 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

2 OF 2

METRIC

W P 108-99-00 LOCATION N 5202613 5 E 254818 2 ORIGINATED BY MA  
 DIST 62 HWY 17 BOREHOLE TYPE Hollow Stem Augering/Wash Boring COMPILED BY AD  
 DATUM Geodetic DATE 26 September 1999 CHECKED BY SP

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 (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20 40 60 80 100										
20.7	reddish brown HETEROGENEOUS MIXTURE OF SILT, CLAY & GRAVEL (GLACIAL TILL) hard damp		1	SS	50/2	169									23.1			
168.3			30	SS	100/2													
21.8	END OF BOREHOLE  Water Level in open hole on completion 3.3m																	

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W P 108-39-00 LOCATION N 5202598 7 E 254867 2 ORIGINATED BY MA  
 DIST 62 HWY 17 BOREHOLE TYPE Hollow Stem Augering/Wash Boring COMPILED BY AD  
 DATUM Geodetic DATE 24 September 1999 CHECKED BY SP

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 10 20 30
190.0	175mm ASPHALTIC CONCRETE		1	AS										54 42 (4)		
0.0	0.3m Sandy Gravel FILL		2	SS	36										0 96 (4)	
189.1	brown Sand FILL		3	SS	17											
0.9	with Gravel dense damp															
188.2	brown Sand FILL															
188.2	compact damp															
188.2	50mm Organic layer		4	SS	6											
187.8	brown SAND loose damp															
2.2	reddish-brown CLAY TO SILTY		5	SS	2								18.5			
	CLAY wet		6	TW	-									16.9	0 3 25 72	
	trace Sand		7	TW	-											
	firm to stiff		8	SS	45									23.9		
	varved		9	SS	66									22.9	11 34 48 7	
	frequent grey Silt pockets		10	SS	68									23.1		
			11	SS	43									22.9		
			12	SS	83/28									23.6		
			13	SS	50/13											
			14	SS	100/15											
			15	SS	100/15									23.8	15 60 23 2	
			16	SS	100/15											
			17	SS	50/8											
			18	SS	50/8											
			19	SS	50/8									24.3		

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W P 108-99-00 LOCATION N 5202606 9 E 254870 8 ORIGINATED BY MA  
 DIST 52 HWY 17 BOREHOLE TYPE Solid Stem Augering/Wash Boring COMPILED BY AD  
 DATUM Geodetic DATE 23 September 1999 CHECKED BY SP

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
190.0	100mm ASPHALTIC CONCRETE		1	AS	-									
0.0	0.4m Sandy Gravel FILL		2	SS	29									
	brown Sand FILL		3	SS	24									
188.5	with Gravel, trace topsoil pockets													
188.5	compact, damp to moist													
188.2	brown SAND		4	SS	3									
188.2	trace Silt, very loose, wet													
188.2	10 mm Organic layer													
188.2	reddish-brown CLAY TO SILTY CLAY													
188.2	frequent grey Silt pockets, trace Sand													
188.2	wet													
	firm		5	AS	-									
	stiff													
185.5			6	SS	51									
4.4	grey		7	SS	59/6									
	HETEROGENEOUS MIXTURE OF													
	SAND, SILT & GRAVEL													
	(GLACIAL TILL)													
	frequent Cobbles & Boulders		8	SS	45									
	dense to very dense		9	SS	55/6									
	moist to wet		10	SS	36									
			11	SS	80									
180.6			12	SS	55/13									
9.4	END OF BOREHOLE													
	Water Level in open hole on completion													
	Sept 24/99 1.1m													

RECORD OF BOREHOLE No 5										1 OF 1		METRIC	
W P 108-99-00		LOCATION N 5202629 3 E 254801 5				ORIGINATED BY MA							
DIST 52 HWY 17		BOREHOLE TYPE Hollow Stem Augering				COMPILED BY AD							
DATUM Geodetic		DATE 24 September 1999				CHECKED BY SP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	10 20 30		
190.2	200mm ASPHALTIC CONCRETE		1	AS	-								
0.0	brown Sandy Gravel FILL		2	SS	65								
189.5	very dense, damp												
0.7	brown Sand FILL		3	SS	16								
188.8	compact, damp												
1.4	brown SAND		4	SS	7								
188.0	loose, damp												
2.2	reddish-brown CLAY TO SILTY CLAY		5	SS	1								
	occasional grey Silt pockets, trace Sand												
	firm wet												
186.2			6	TW	-								
4.0	END OF BOREHOLE												

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W/P 108-99-20 LOCATION N 5202601 3 E 254884 4 ORIGINATED BY MA  
 DIST 62 H/WY 17 BOREHOLE TYPE Hollow Stem Augering COMPILED BY AC  
 DATUM Geocentric DATE 24 September 1999 CHECKED BY SP

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
190.0	50mm ASPHALTIC CONCRETE		1	AS	-			20	40	60	80	100						
0.0	0.2m Sandy Gravel FILL		2	SS	31													
189.2	brown Sand FILL																	
0.8	with Gravel dense damp reddish-brown CLAY TO SILTY CLAY frequent grey Silt pockets trace Sand moist to wet		3	SS	5													
			4	TW	-								20.3	0 4 87 9				
			5	SS	2								17.9	TW4: Consolidation Test				
186.4																		
3.7	END OF BOREHOLE																	