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257

GEOCRES No. 30M14-~~227~~

DIST. CR REGION

W.P. No. 282-86-01

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 407

LOCATION MARKHAM RD. UNDERPASS

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.1-30 SEPT. 1976

PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT FOR PROPOSED HIGHWAY 48 UNDERPASS HIGHWAY 407 EAST EXTENSION W.P. 282-86-01

Report

to

MINISTRY OF TRANSPORTATION ONTARIO

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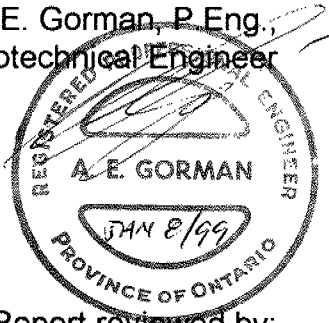
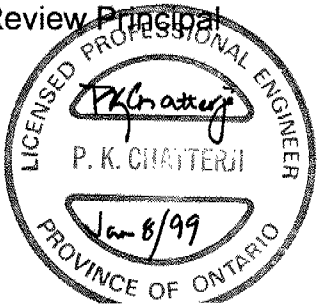


Report reviewed by:
P.K. Chatterji, P.Eng.,
Review Principal



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PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT FOR PROPOSED HIGHWAY 48 UNDERPASS HIGHWAY 407 EAST EXTENSION W.P. 282-86-01

1. INTRODUCTION

This report presents the results of the foundation investigation and design analysis carried out by Thurber Engineering Ltd. (Thurber) at the site of the proposed Highway 48 Underpass for the proposed Highway 407 East Extension in the Town of Markham. The purpose of the investigation was to explore the subsurface soil and groundwater conditions at the site and based on the data obtained provide borehole logs, laboratory test data, soil profile and a written description of the subsurface conditions. The purpose of the analysis of the data obtained during the investigation was to produce geotechnical recommendations for the design and construction of the structure foundations and associated earth works.

Thurber carried out the investigation as a consultant to the Ministry of Transportation Ontario (MTO) under Agreement 9820-7411-2877.

2. SITE DESCRIPTION

2.1 Site Location

The site lies at Station 24+350 (approximately) on Highway 407 and 10+000 on Highway 48 (Markham Road). It is located on the table land to the south and west of the Rouge River Valley and approximately half a kilometre south of Highway 7 in the Town of Markham.

At the time of the investigation, Highway 48 was carried on a detour to the west around the site. On the west, pavement for Highway 407 has been constructed up to the detour. To the east the land is currently in agricultural use up to the edge of the Rouge River Valley.

Residential development lies to the north and south of the site, especially on the east side of Highway 48.

2.2 Physiography

Physiographically, the site lies within a till plain known as the Halton Till, which consists mostly of clayey silt soils. It also lies in the area of the south slope of the Oak Ridges Moraine where buried granular deposits connected to the moraine are known to form aquifers. In some places these aquifers contain water under artesian pressure.

A short distance to the north and east lies the deeply incised valley of the Rouge River. Recent river alluvium and organic soils occur in the valley floor, but do not impact the subject site.

3. INVESTIGATION PROCEDURES

3.1 Field Investigation

Between November 9 and 16, 1998, a Bombardier mounted Mobile B-57 drill rig was used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Two deep boreholes and four shallower boreholes were drilled and sampled to obtain data for foundation design and two shallow holes were drilled for approach fill considerations. The approximate locations of the boreholes are shown on Drawing 15-64-4-01.

The boreholes were numbered 98-1 through 98-8 and the depths of sampling were as follows:

Borehole No.	Depth of Sampling (m)
98-1	15.7
98-2	11.1
98-3	22.9
98-4	5.0
98-5	11.1
98-6	11.1
98-7	26.1
98-8	5.2

The boreholes were drilled using solid stem augers but in one deep hole, casing had to be advanced and the soils within the casing washed out to allow piezometer installation at the required depth.

Samples were recovered at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT) . Samples were generally recovered at intervals of 0.75 m in the upper 3.0 m and thereafter at intervals of 1.5 m to depths which vary between the holes.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. Standpipe piezometers were installed in Boreholes 98-3 and 98-7 for future monitoring of the groundwater levels. The remaining holes were backfilled with drill cuttings.

The results of the drilling, sampling, in-situ testing and water level measurements are summarized on the borehole logs in Appendix A.

3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all recovered samples. In addition, grain size analyses and Atterberg limit tests were conducted on selected samples. The results of the laboratory testing are presented on the borehole logs in Appendix A, and in Figures B1 to B6 and C1 to C4 in Appendix B.

Two soil samples were selected and submitted for analysis for sulphate and pH testing. The results are shown in Table 1 in Appendix B.

4. DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

The subsoil stratigraphy encountered in the sampled boreholes consists of very stiff to hard, silt and sand till and clay and silt till overlying very dense sand and silt till. Surficial fill layers were also encountered.

Fill, Pavement, Topsoil

In all boreholes except 98-6, fill was encountered in thicknesses ranging between 0.6 to 2.3 m. The fill was variable from hole to hole, ranging from

clayey silt and sand to sand and gravel. The site lies on the alignment of Highway 48 and the fill is assumed to have been placed as part of the grading and pavement construction activities for the highway. The fill is generally compact or stiff, though some very dense sand and gravel was encountered in the old road base. Asphalt pavement was encountered in Boreholes 98-2, 98-4 and 98-8. Up to 500 mm of topsoil was encountered in Boreholes 98-5 and 98-6.

Silt and Sand (Till)

The main stratum penetrated by the boreholes was a thick layer of clayey silt and sand till with a Unified Classification of ML. This soil is essentially cohesive but does contain layers or zones of non-cohesive soil.

This layer extended from the underside of the fill to below Elevation 165.3 at Borehole 98-1 to 166.5 at Borehole 98-7. SPT values recorded in this layer ranged from 15 to 58 blows for 0.3 m penetration. Occasionally much higher values were recorded but these were possibly due to the presence of gravel, cobbles or boulders within the layer. Five of the remaining boreholes terminated within this layer.

Based on shear strength estimates from pocket penetrometer readings and from the recorded SPT values, the soil is classified as being very stiff to hard.

The stratum is brown with oxidized fissures present near the top, turning grey below an approximate depth of 5.0 m. The measured natural moisture contents range from 7 to 15%.

Clay and Silt (Till)

Below the silt and sand stratum described above, and below elevations ranging from 165.3 to 168.5, the soils are plastic and have a Unified Classification of CL (see Figures C2 and C4 in Appendix B). SPT values recorded in the layer ranged from 16 to 35 blows for 0.3 m penetration. Occasionally much higher values were recorded but these were possibly due to the presence of gravel, cobbles or boulders within the layer.

Based on shear strength estimates from pocket penetrometer readings and from the recorded SPT values, the soil is classified as being very stiff to hard.

This layer is grey and the measured natural moisture contents ranged from 9 to 22%.

Sand and Silt (Till)

A very dense sand and silt till was encountered below the clay and silt till. The top of the sand and silt till was noted to be at Elevation 163.6 in Borehole 98-3 and Elevation 161.0 in Borehole 98-7. Both these boreholes terminated in this very dense till. The SPT values recorded in this very dense, grey till were very high, all well over 100 for 0.3 m penetration. The water contents measured in the till ranged from 5 to 12%.

Cobbles and boulders should be expected in the till deposit.

Cobbles and Boulders

As indicated above, cobbles and boulders should be anticipated within any or all of the till deposits encountered on this site but particularly in the lower, sand and silt till.

4.2 Groundwater Data

On completion of drilling, the following observations of groundwater levels were made:

Borehole No.	Depth (m)	Observation
98-1	15.7	No free water but possible water table at 12.2 m based on wet samples.
98-2	11.1	Free water at 5.5 m.
98-3	22.9	Hole flushed on completion and piezometer installed - see below.
98-4	5.0	No free water.
98-5	11.1	Free water at 10.4 m.
98-6	11.1	Free water at 10.1 m.
98-7	26.1	Piezometer installed - see below.
98-8	5.2	No free water.

After completion of the piezometer installation in Boreholes 98-3 and 98-7, reading of water levels were taken at intervals as shown below:

	Depth to Water (m)	
Date	**BH M-98-3**	**BH M-98-7**
November 11, 1998	N/A	20.1
November 12, 1998	12.25	19.2
November 13, 1998	17.7	18.8
November 17, 1998	17.6	17.8
November 30, 1998	17.7	17.0

5. RECOMMENDATIONS FOR STRUCTURE FOUNDATIONS

5.1 Type of Structure

The structure anticipated to be built at this site consists of an underpass for Highway 407 under Highway 48 (Markham Road). The most probable general arrangement is believed to be a two-span structure with spans in the order of 40 m each.

The soil conditions encountered at the site are generally suitable for design of an integral abutment bridge. In the preparation of foundation recommendations, it has been assumed that this is the most probable arrangement for the proposed underpass.

5.2 Recommended Foundation Type

The soils encountered at the subject site are considered suitable for the support of bridge foundation elements on either driven piles or spread footings.

If piles are used, steel HP310X110 piles driven to practical refusal are recommended. To achieve the necessary flexibility for an integral abutment design, the top 3 m of each pile below the abutment stem must be surrounded by two concentric CSPs, generally as illustrated in Figure 7 of the MTO Report SO-96-01 "Integral Abutment Bridges". The inner CSP should be filled with a bentonite/cement mix or with loose, coarse sand. The grading requirements for the sand are shown in Appendix C.

In the case of spread footings, these may be founded either on the native, dense or hard soil or on engineered Granular A fill pads founded on native, hard or dense soil.

5.3 Axial Pile Capacity

It is recommended that steel HP310X110 piles be driven into the very dense glacial till encountered below elevations 161.0 to 163.6 in the two deeper boreholes drilled and sampled at the anticipated locations of the abutments (Boreholes 98-3 and 98-7). If this is done, the piles can be considered to be essentially end bearing in the very dense glacial till.

The following axial resistances are estimated for HP310X110 steel piles driven to practical refusal in the very dense glacial till below Elevation 161.0:

Factored axial resistance at ULS	= 1,600 kN
Axial resistance at SLS	= 1,100 kN

The minimum pile spacing should be calculated in accordance with the OHBDC.

5.4 Lateral Resistance

The lateral resistance of the piles and the depth to the point of contraflexure may be analyzed on the basis of an assumed value of k_s, the coefficient of horizontal subgrade reaction, of 40 MN/m^3 for the native soils. The loose sand surrounding the upper 3 m of the pile may be assumed to have a value of k_s = 1.2 MN/m^3.

5.5 Pile Driving

The piles should be provided with driving shoes in accordance with OPSD 3301.00.

Pile should be driven to Elevation 161.0 and driving should then be carefully monitored and controlled employing the Hiley Dynamic Pile Driving Formula in accordance with MTO Standards SS 103-10 or SS 103-11 and assuming an ultimate resistance of 3,200 kN.

If the driven pile encounters refusal above Elevation 161.0, the Engineer must be notified immediately. Refusal is defined as less than 25 mm penetration for each of two consecutive series of 50 blows.

The pile driving should be carried out using a hammer capable of delivering energy approaching but not exceeding 70 kJ per blow.

During the driving process, piles which have already been driven should be monitored to determine if they are heaving due to the effects of driving adjacent piles. If this phenomenon occurs, the affected piles must be re-driven.

It is recommended that 15% of the piles (and at least one pile in each foundation element be restruck the day after initial installation. If relaxation

is deemed to have occurred, then all piles in that foundation element should be restruck.

5.6 Pile Driving Note

The pile driving note to be added to the drawings is Note 2 in Clause 2.5.11 of the Structural Manual. The ultimate capacity should be 3,200 kN and the piles should be driven below Elevation 161.0.

5.7 Spread Footings

Spread footings may be designed to bear on the undisturbed, hard or dense, native soil at the elevations and bearing resistances shown below:

Highest Elevation	Factored ULS (kPa)	SLS (kPa)
177.3	600	400

The SLS value given above is based on a maximum settlement of 25 mm under the footing.

Where footings will be supported on engineered fill pads, the fill should meet the requirements of OPSS Form 1010 for Granular A. All topsoil and other deleterious material should be stripped and the underside of the fill pad should bear on dense native soil. A typical arrangement for an engineered fill pad is attached as Figure 1.

A footing placed on an engineered fill pad may be proportioned on the basis of the following geotechnical bearing resistances:

- SLS = 350 kPa
- factored ULS = 900 kPa

To ensure adequate load distribution to the underlying soil, the engineered fill pad should be at least 2.0 m thick and must be founded at the lower of 1.5 m below existing grade or below any existing fill, topsoil or other soft/deleterious materials.

5.8 Sliding Resistance

The sliding resistance of the footings must be checked using the following factored base shear factors:

Founding Material	Factored Basal Shear Factor
Granular "A"	0.46
Native soil	0.36

6. EARTH PRESSURE

The lateral earth pressures to be used in design should be computed in accordance with Section 6-7 of the OHBDC .

Granular backfill should be placed behind the abutment walls and wing walls to conform to the minimum requirements illustrated in OPSD 3501.00. The granular backfill should conform to Ontario Provincial Standard Specifications (OPSS) 1010 for either Granular B, Type 1 or Granular A. The fill should be placed in accordance with OPSS 501. A perforated subdrain should be installed behind the base of the walls as shown in OPSD 3501.00 to maintain the granular fill in a drained condition. The subdrain should be provided with a positive outlet to the highway drainage system. To maintain free draining characteristics in Granular B, the maximum percentage passing 75 µm should be limited to 5%.

For the above backfill and drainage conditions, the abutment walls and wing walls may be designed based on the following unfactored earth pressure distributions:

$P_h = K \gamma h$

where;

K = earth pressure coefficient, use value from table below.

γ = unit weight of soil, = 21.2 kN/m^3 for Granular B
= 22.8 kN/m^3 for Granular A

h = depth below top of wall, m

Wall Type	Earth Pressure Coefficient (K)			
	OPSS Granular A $\phi' = 35°$		OPSS Granular B $\phi' = 30°$	
	Horizontal Ground Surface Behind Wall	Sloping Ground Surface (2H:1V)	Horizontal Ground Surface Behind Wall	Sloping Ground Surface (2H:1V)
Restrained Wall	0.43	-	0.50	-
Unrestrained Wall	0.27	0.40	0.33	0.55

The above parameters are based on an assumption of a horizontal ground surface behind the abutment walls. If concrete approach slabs are not provided, an additional load equivalent to 600 mm of fill should be superimposed on the wall loadings to account for traffic surcharge loading.

If an integral abutment design is used, the ballast wall/pile cap will move against the retained fill in some circumstances. Accordingly, the design should be based on an earth pressure coefficient between the at rest and passive cases, as outlined in the OHBDC.

A Retained Soil System (RSS) may be used for the abutment wall and wing walls. In such cases, the designers should include the following in the contract:

- the longitudinal extent of the walls in plan
- the space constraints from the top of the RSS to the base of the RSS in transverse direction in plan
- elevation of top and bottom of RSS
- performance requirements (High Performance)
- appearance requirement (typically High Appearance)
- the required NSSP for RSS

Additional lateral pressure must be added to account for compaction induced forces. The additional pressure must be computed in accordance with Section 6-7.4.3 of the OHBDC.

7. APPROACH EMBANKMENT DESIGN

It is anticipated that the approach embankments will be in the order of 5 to 6 m high adjacent to the structure.

If the approach embankments are constructed from the locally available inorganic soils, it is expected that they can be safely constructed with side slopes of 2H:1V. The fill stability will, however, be dependent on the material used to construct the embankments and this must be carefully reviewed at the design stage. Fill should be placed and compacted in accordance with OPSS 501.

Based on the findings of the field investigation, no foundation stability problems are anticipated under embankments constructed to 6 m height with 2H:1V side or forward slopes.

If the embankments need to be higher than 8.0 m, a 2.0 m wide berm should be incorporated in the slope design within each 8.0 m vertical interval.

8. EXCAVATION AND GROUNDWATER CONTROL

The only excavation anticipated for bridge construction at this site will be that required for a footing or pile cap at the central pier. Depending on the design that is finally selected, the anticipated maximum depth of excavation below existing ground surface is 4.0 m. Excavation to that depth should not present any special difficulties to normal, heavy duty excavating equipment. Some groundwater seepage may occur from the fill or sandy partings, but no serious groundwater problems are anticipated and the water can be removed by pumping from a local sump. The water table measured is below this depth of excavation, therefore no prior dewatering will be required.

It is recommended that the base of any footing excavation be protected by a mass concrete working slab at least 150 mm thick immediately after completion of excavation and approval of the footing base..

All excavation must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the soils within the anticipated depth of excavation are classified as Type 2.

9. FROST PROTECTION

The design depth of frost penetration for this project is 1.2 m. All pile caps and footings designed for this site must be provided with at least 1.2 m of soil cover as protection against frost penetration.

10. CONSTRUCTION CONCERNS

The main construction concern identified at this site is the need to ensure that piles are driven into the very dense glacial till below Elevation 161.0.

11. CONSTRUCTION INSPECTION AND MONITORING

During construction, all foundation installation, excavation and approach embankment construction activities should be monitored by geotechnical personnel to ensure that the foundation recommendations and design are being correctly implemented and that the soil conditions encountered do not differ materially from the interpretation used in this report.

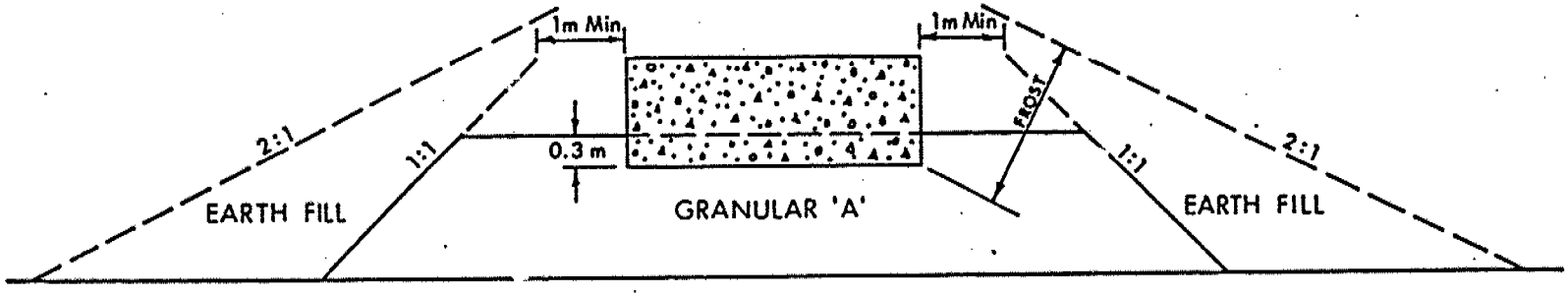
12. STATEMENT OF LIMITATIONS

The information provided in the preliminary Foundation Investigation and Design Report can be relied upon with the following limitations and exceptions:

Any interpretations of data or opinions expressed in the report are not warranted: and

Although the accuracy of the subsurface information at the borehole locations is warranted, the respondent must satisfy itself as to the sufficiency of the information presented and obtain any updating or additional information, and perform any studies, analyses or investigations that the respondent deems necessary in order to prepare its submission. Interpretations of subsurface conditions are not warranted.

The preliminary recommendations provided are intended for bidding purposes only. The design and performance of the foundations are the responsibility of the selected proponent. The selected proponent must develop the final foundation design through interactive participation between its structural and foundation engineers.



X SECTION

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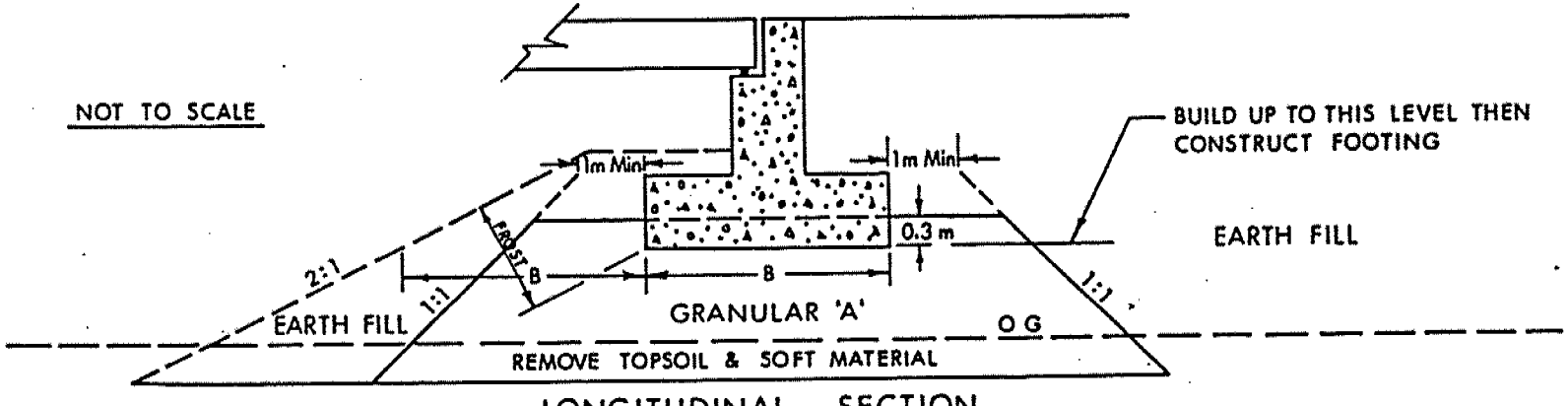

LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 1

DIST
CONT No.
WP No. 282-86-01

HIGHWAY 48 UNDERPASS

SHEET

THURBER ENGINEERING LTD.

METRIC
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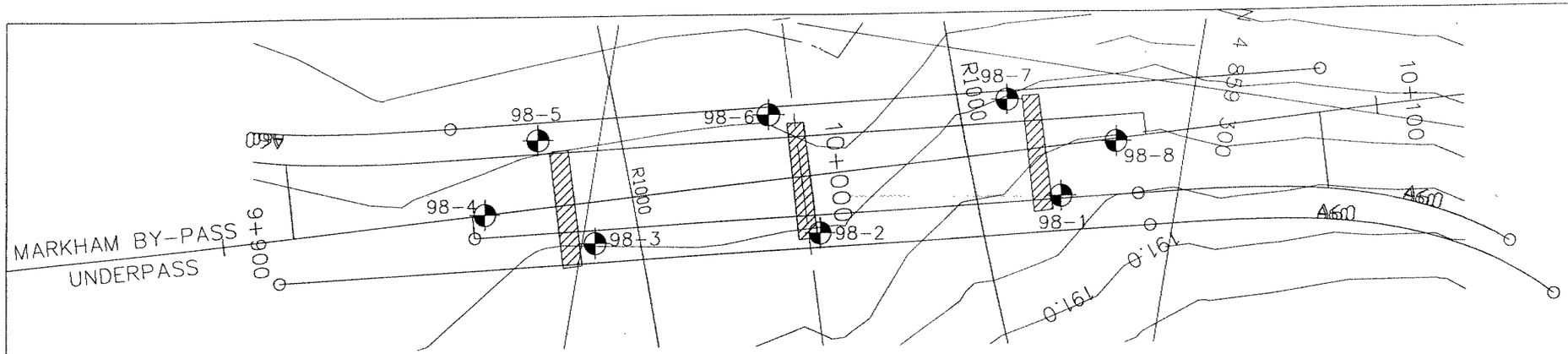
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



MARKHAM BY-PASS UNDERPASS
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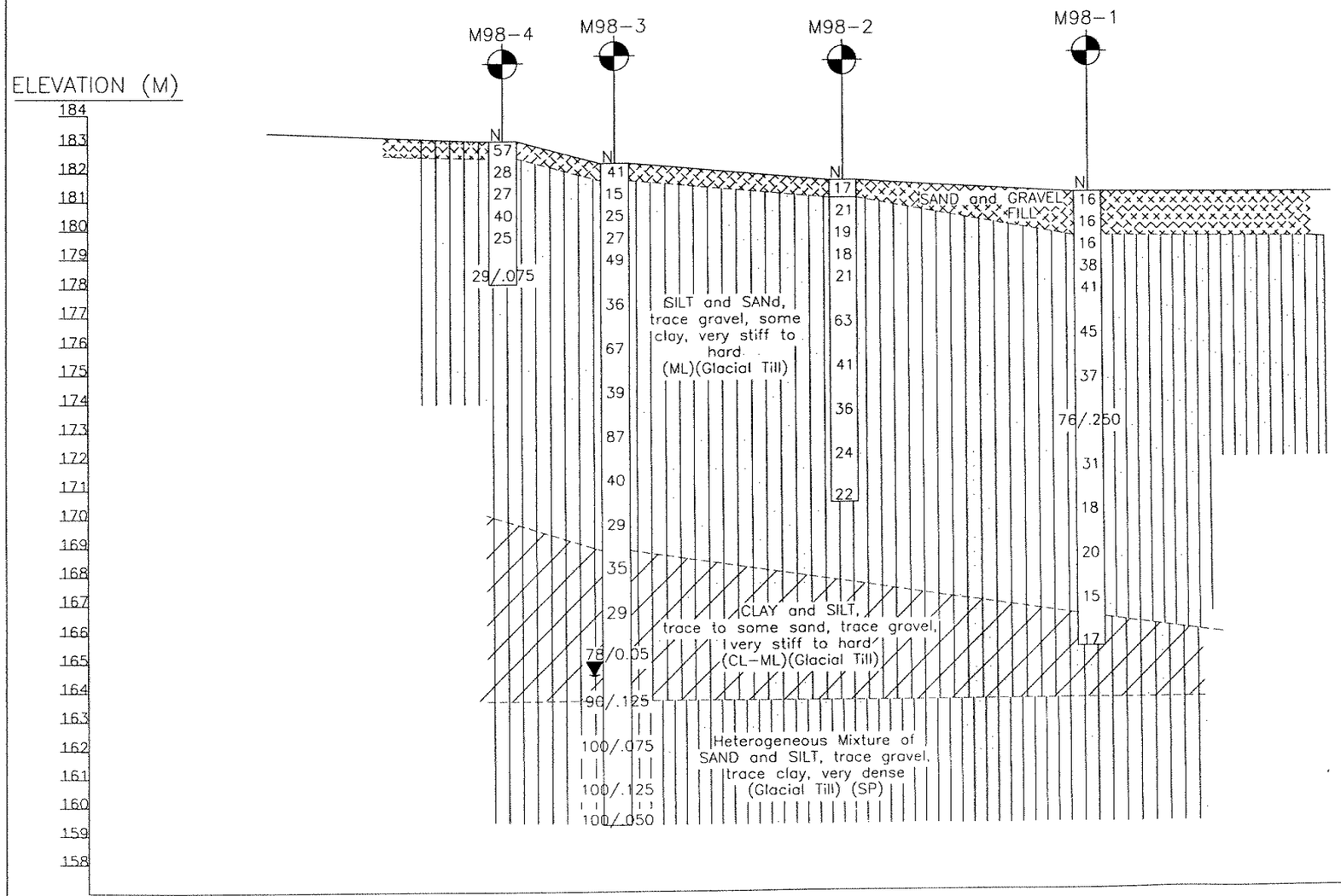

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LEGEND

M98-1 Borehole

WL November 30, 1998

'N' Blows/0.3m (Std. Pen Test)

No	ELEV.	LOCATION	
		NORTHING	EASTING
M98-1	181.01	4857917.99	324284.32
M98-2	181.59	4857958.05	324276.07
M98-3	182.23	4857998.00	324271.96
M98-4	183.03	4858017.24	324275.81
M98-5	181.98	4858008.69	324289.10
M98-6	181.28	4857969.24	324295.61
M98-7	181.01	4857928.17	324301.24
M98-8	181.28	4857909.21	324294.65

15-64-4-1

DIST
CONT No.
WP No. 282-86-01

SHEET

HIGHWAY 48 UNDERPASS

THURBER ENGINEERING LTD.

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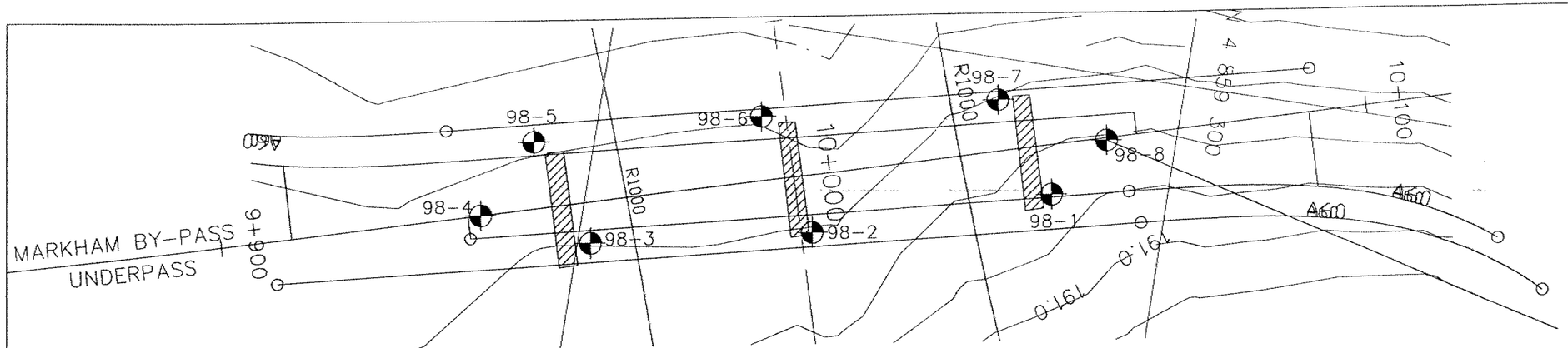
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



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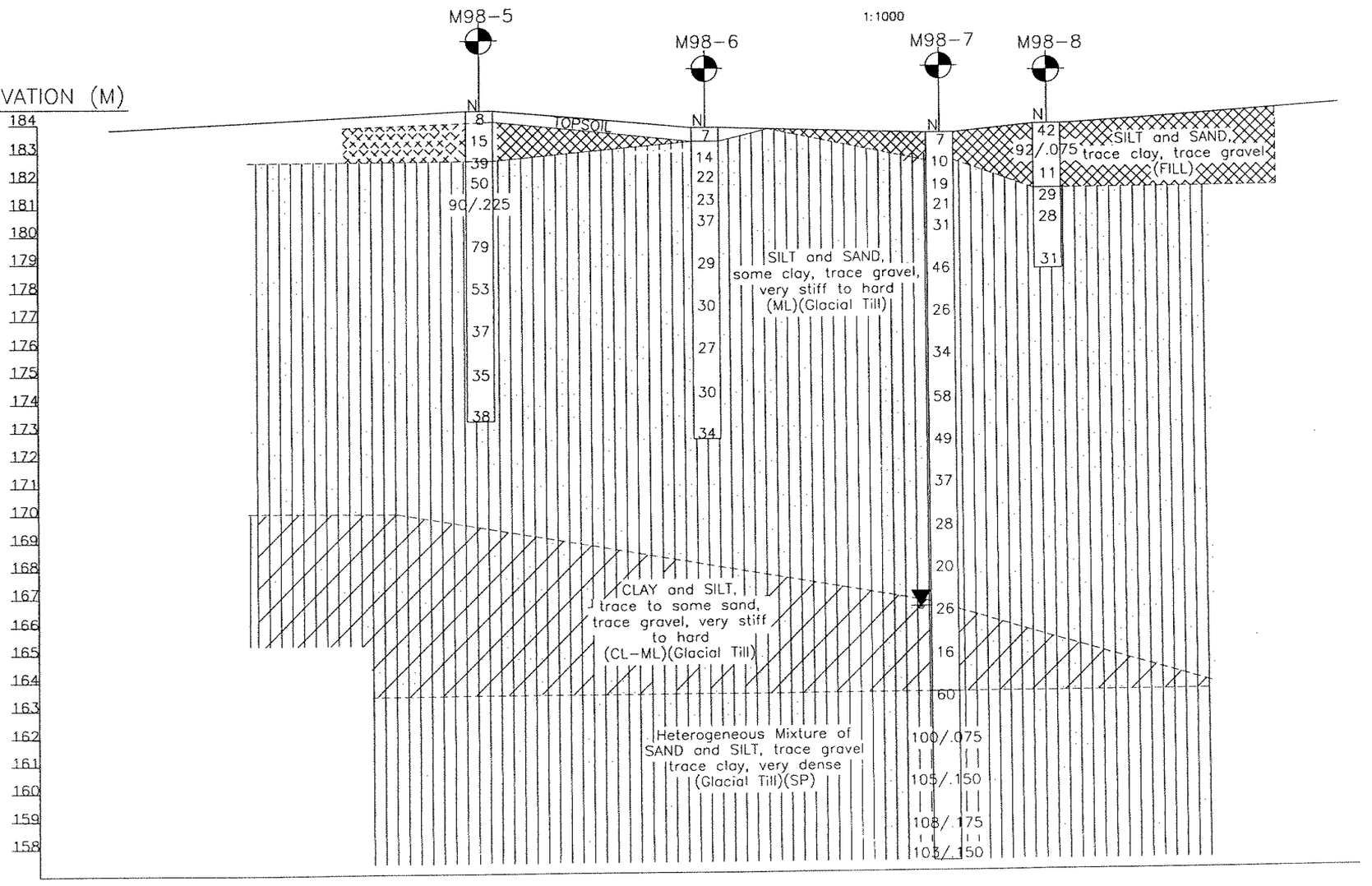

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M98-4	183.03	4858017.24	324275.81
M98-5	181.98	4858008.69	324289.10
M98-6	181.28	4857969.24	324295.61
M98-7	181.01	4857928.17	324301.24
M98-8	181.28	4857909.21	324294.65

15-64-4-2

APPENDIX A

BOREHOLE LOGS

- Borehole Logs 98-1 to 98-8

THURBER

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:

RQD (%)	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

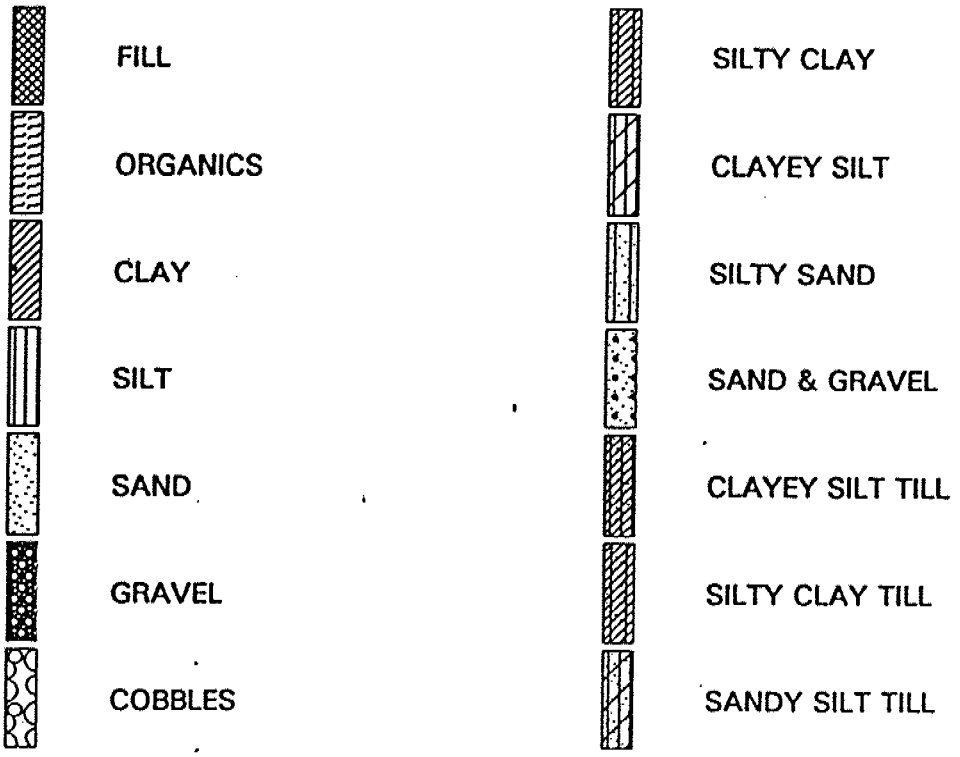
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
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

THURBER

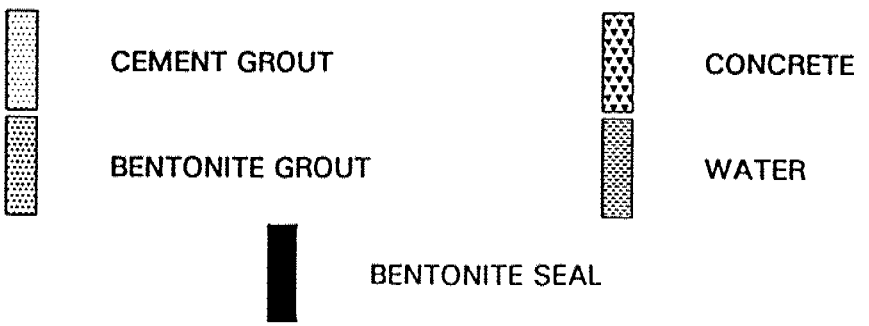
BOREHOLE GRAPHIC SYMBOLS

SOILS



ROCK

OTHER



THURBER

TTCHTCH2 6209 95/03/14

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W_L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W_L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W_L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W_L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

THURBER

RECORD OF BOREHOLE No 98-1 1 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857918.0 E 324284.3 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.09 - 98.11.09 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0							181				
0.0	Sandy SILT, trace clay, trace gravel, moist, brown and grey, compact: (FILL)		1	SS	16						
179.7			2	SS	16		180		54.25		
1.3	**SILT and SAND**, some clay, trace gravel, oxidized fissures, moist, brown, very stiff to hard (TILL)(ML)		3	SS	16						
			4	SS	38		179		42.25		
			5	SS	41		178				0 43 44 14
			6	SS	45		177				
	grey below 5m						176				
			7	SS	37		175				1 46 42 11
			8	SS	76/.250		174				
			9	SS	31		173				
	stiff		10	SS	18		172				
	possible groundwater at 12.0m		11	SS	20		171				
			12	SS	15		170				0 44 44 12
							169				
							168				
							167				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-1 2 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857918.0 E 324284.3 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.09 - 98.11.09 CHECKED BY AEG

SOIL PROFILE		STRAT PLOT	SAMPLES			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 w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION		NUMBER	TYPE	"N" VALUES						
							166				
165.3			13	SS	17				○		
15.7	END OF BOREHOLE AT 15.7m. BOREHOLE OPEN TO 15.24m. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 98-2 1 OF 1 METRIC

W.P. 282-86-01 LOCATION N 4857958.1 E324276.1 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.12 - 98.11.12 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.6											
0.0 / 181.0	**ASPHALT over SAND and GRAVEL**, brown, compact: (FILL)		1	SS	17		181				
0.6	**SILT and SAND**, some clay, oxidized fissures, moist, brown, stiff to hard (TILL)(CL-ML)		2	SS	21						
			3	SS	19		180				
			4	SS	18		179				
			5	SS	21						0 34 44 22
							178				
			6	SS	63		177				
	grey below 5m						176				
			7	SS	41		175				
			8	SS	36		174				0 47 39 14
							173				
			9	SS	24		172				
							171				
170.5			10	SS	22						0 46 40 14
11.1	END OF BOREHOLE AT 11.13m. BOREHOLE OPEN TO 8.23m ON COMPLETION OF DRILLING.										

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

$\frac{20}{15 \; 5}$ (%) STRAIN AT FAILURE
$\frac{10}{}$

RECORD OF BOREHOLE No 98-3 1 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857998.0 E 324271.9 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.11 - 98.11.11 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.2											
0.0 / 181.6	**SAND and GRAVEL,** some silt, brown, dense: (FILL)		1	SS	41		182				
0.6	**SILT and SAND,** some clay, oxidized fissures, moist, brown, stiff to hard (TILL)(ML)		2	SS	15		181				
			3	SS	25						
			4	SS	27		180				0 47 44 9
			5	SS	49		179				
							178				
			6	SS	36						
	grey below 5m						177				
			7	SS	67		176				
							175				
			8	SS	39						0 38 52 10
							174				
			9	SS	87		173				
							172				
			10	SS	40						
							171				
			11	SS	29		170				
168.8											
13.4	**CLAY and SILT,** sandy, trace gravel, moist to wet, grey, very stiff to hard (TILL)(CL)		12	SS	35		169				
							168				1 25 42 32

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-3 2 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857998.0 E 324271.9 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.11 - 98.11.11 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			13	SS	29		167		○		
							166				
			14	SS	78/ 0.05		165		○		
163.6			15	SS	90/ .125		164		○		
18.6	Heterogeneous mixture of **SAND and SILT,** trace clay, trace gravel, wet, grey, very dense (TILL)(ML)		16	SS	100/ .075		163		○		12 61 23 4
							162				
			17	SS	100/ .125		161		○		
159.3							160				3 81 12 4
22.9	END OF BOREHOLE AT 22.91m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.		18	SS	100/ .050				○		

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
12/11/98	12.25	169.98
13/11/98	17.70	164.53
17/11/98	17.60	164.63
30/11/98	17.70	164.53

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-4 1 OF 1 METRIC

W.P. 282-86-01 LOCATION N 4858017.2 E 324275.8 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.13 - 98.11.13 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.0											
0.0	**ASPHALT** over Gravelly **SAND**, some silt, very dense: (FILL)		1	SS	57		183		○		
182.4											
0.6	**SILT and SAND**, some clay to clayey, oxidized fissures, moist, brown, very stiff to hard (TILL)(CL-ML)		2	SS	28		182		○		
			3	SS	27				○		
			4	SS	40		181		○		0 37 43 20
			5	SS	25		180		○		
							179		✓		
178.1			6	SS	29/.075				○		0 44 41 15
4.9	END OF BOREHOLE AT 4.95m. BOREHOLE OPEN TO 4.95m. BOREHOLE DRY ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-5 1 OF 1 METRIC

W.P. 282-86-01 LOCATION N 4858008.7 E 324289.1 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.13 - 98.11.13 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.0											
0.0 / 181.5	**TOPSOIL**		1	SS	8						
0.5	**SILT and SAND,** some clay to clayey, some asphalt fragments, moist, brown (FILL)		2	SS	15		181				
180.2			3	SS	39						
1.8	**SILT and SAND,** some clay to clayey, trace gravel, oxidized fissures, moist, brown, very stiff to hard (TILL)(ML)		4	SS	50		180				0 41 42 17
			5	SS	90/ .225		179				
							178				
			6	SS	79		177				
	grey below 5.5m						176				
			7	SS	53						0 45 42 13
							175				
			8	SS	37		174				
							173				
			9	SS	35						
							172				
170.9			10	SS	38		171				
11.1	END OF BOREHOLE AT 11.12m. BOREHOLE OPEN TO 10.67m. ON COMPLETION OF DRILLING, FREE GROUNDWATER AT 10.4m DEPTH. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-6 1 OF 1 METRIC

W.P. 282-86-01 LOCATION N 4857969.2 E 324295.6 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.13 - 98.11.13 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3											
0.0 180.8	**TOPSOIL**		1	SS	7		181				
0.5	**SILT and SAND,** some clay to clayey, trace gravel, oxidized fissures, moist, brown, very stiff to hard (TILL)(ML)		2	SS	14		180				
			3	SS	22						1 42 41 16
			4	SS	23		179				
			5	SS	37		178				
			6	SS	29		177				0 46 43 11
	grey below 5m						176				
	occasional wet sand seams below 6.0m		7	SS	30		175				
			8	SS	27		174				
			9	SS	30		173				
							172				
170.2			10	SS	34		171				2 45 41 12
11.1	END OF BOREHOLE AT 11.12m. BOREHOLE OPEN TO 10.67m. ON COMPLETION OF DRILLING, FREE GROUNDWATER AT 10.1m DEPTH. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.										

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

$15 \overset{20}{\oplus} 5$ 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 98-7 1 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857928.2 E 324301.2 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.10 - 98.11.10 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0							181				
0.0	**SILT and SAND,** trace gravel, trace clay, trace organics, moist, grey (FILL)		1	SS	7						23 58 19
180.0							180				
1.0	**SILT and SAND,** trace to some clay, moist, brown, very stiff to hard (TILL)(ML)		2	SS	10						
			3	SS	19		179				
			4	SS	21						
			5	SS	31		178				
			6	SS	46		177				
	possible wet seam at 5m, grey below						176				
			7	SS	26		175				0 44 46 10
			8	SS	34		174				
			9	SS	58		173				0 47 43 10
			10	SS	49		172				
			11	SS	37		171				
			12	SS	28		170				
166.5							169				
14.5	**CLAY and SILT,**						168				
							167				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 98-7 2 OF 2 METRIC

W.P. 282-86-01 LOCATION N 4857928.2 E 324301.2 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.10 - 98.11.10 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	trace to some sand, moist to wet, grey, very stiff to hard (TILL)(CL-ML)		13	SS	20		166				
							165				
			14	SS	26		164				
							163				
			15	SS	16		162				0 50 40 10
161.0											
20.0	Heterogeneous mixture of **SAND and SILT**, trace gravel, trace clay, wet, grey, very dense: (Glacial Till)		16	SS	60		161				
			17	SS	100/.075		160				
							159				
			18	SS	105/.150		158				44 44 12
							157				
			19	SS	108/.175		156				
154.9			20	SS	103/.150		155				6 81 10 3
26.1	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
11/11/98	20.10	160.91
12/11/98	19.20	161.81
13/11/98	18.80	162.21
17/11/98	17.80	163.21
30/11/98	17.00	164.01

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

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

RECORD OF BOREHOLE No 98-8 1 OF 1 METRIC

W.P. 282-86-01 LOCATION N 4857909.2 E 324294.7 ORIGINATED BY EK

DIST CR HWY 407 BOREHOLE TYPE 100mm SOLID STEM AUGERS COMPILED BY WM

DATUM Geodetic DATE 98.11.09 - 98.11.09 CHECKED BY AEG

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3											
0.0	**ASPHALT** - 100mm over Gravelly **SAND**, silty, moist, brown, very dense (FILL)		1	SS	42		181		○		31 55 13
			2	SS	92/.075				○		
179.8							180				
1.5	Sandy SILT, some clay, stiff (FILL)		3	SS	11				○		
179.0							179		○H		
2.3	**SAND and SILT**, clayey, oxidized fissures, moist, brown, very stiff to hard (TILL)(ML)		4	SS	29						0 35 48 17
			5	SS	28		178		○		
							177				
176.1			6	SS	31				○		
5.2	END OF BOREHOLE AT 5.18m. BOREHOLE OPEN TO 5.13m. ON COMPLETION OF DRILLING, NO FREE WATER.										

+ ³, × ³: Numbers refer to Sensitivity

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

APPENDIX B

LABORATORY TEST RESULTS

- Figures B1 to B6 - Grain Size analyses

- Figures C1 to C4 - Plasticity Charts

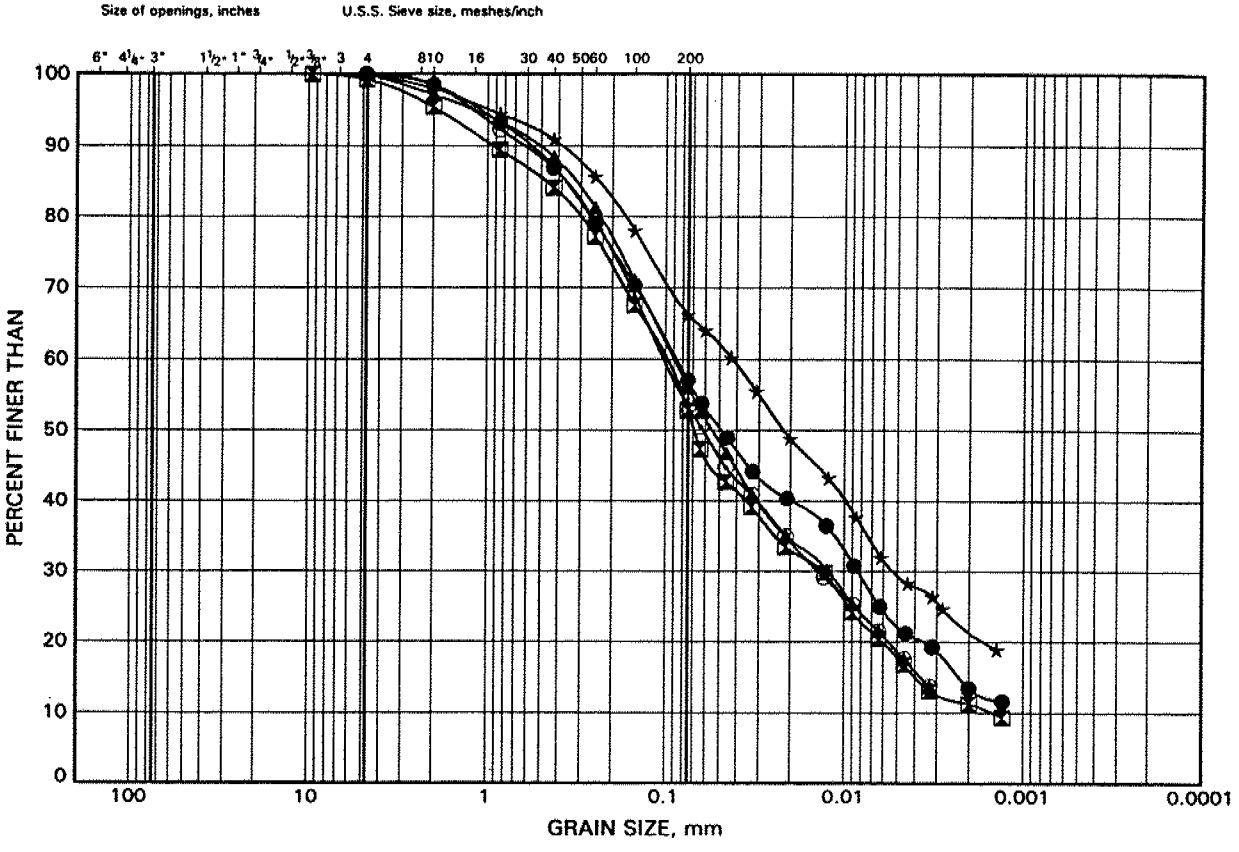
- Table 1 - pH and Sulphate

THURBER

HWY 407/HWY 48

GRAIN SIZE DISTRIBUTION

FIGURE B1



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-1	3.28	177.73
⊠	98-1	6.32	174.69
▲	98-1	12.42	168.59
★	98-2	3.28	178.31
⊙	98-2	7.85	173.74

Date December 1998

Project 282-86-01

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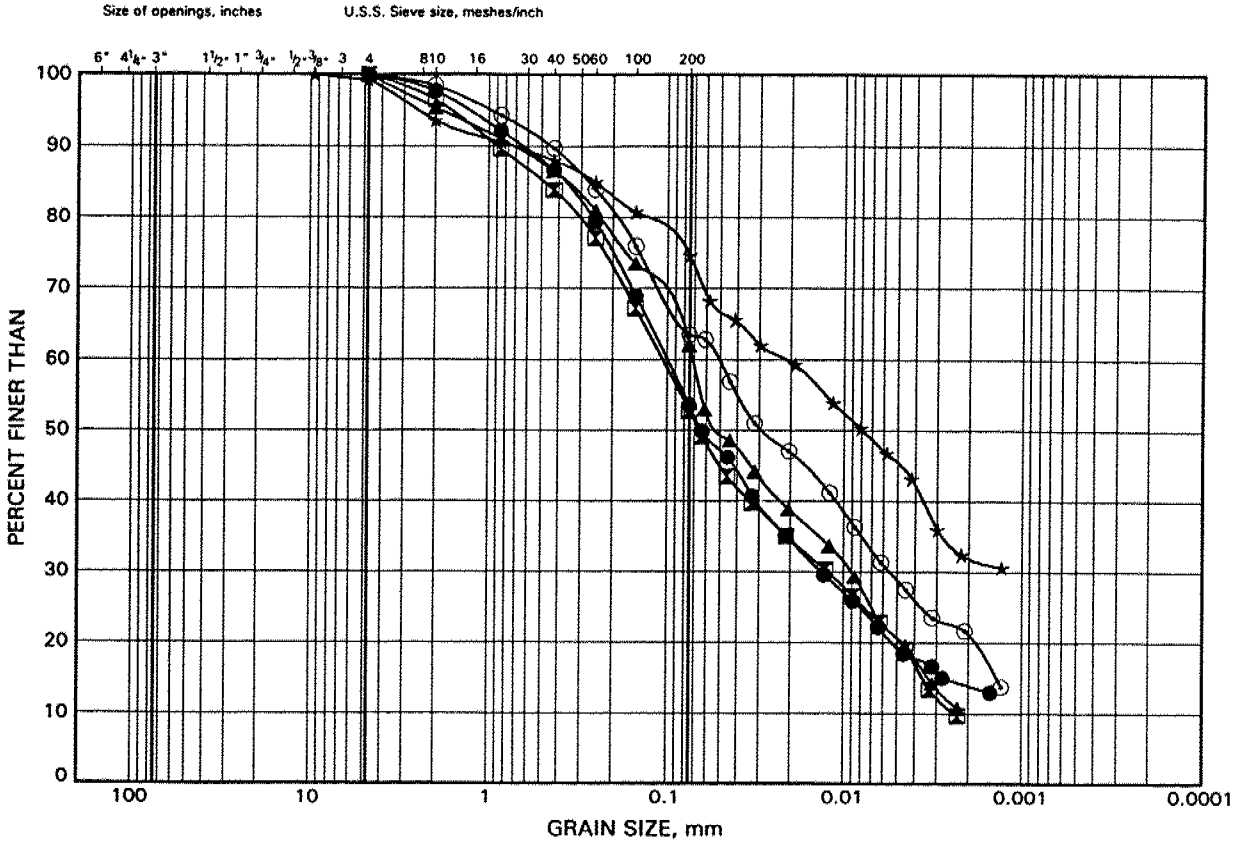
HWY 407/HWY 48

GRAIN SIZE DISTRIBUTION

FIGURE B2



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-2	10.90	170.69
⊠	98-3	2.51	179.72
▲	98-3	7.85	174.38
★	98-3	13.94	168.29
⊙	98-4	2.51	180.52

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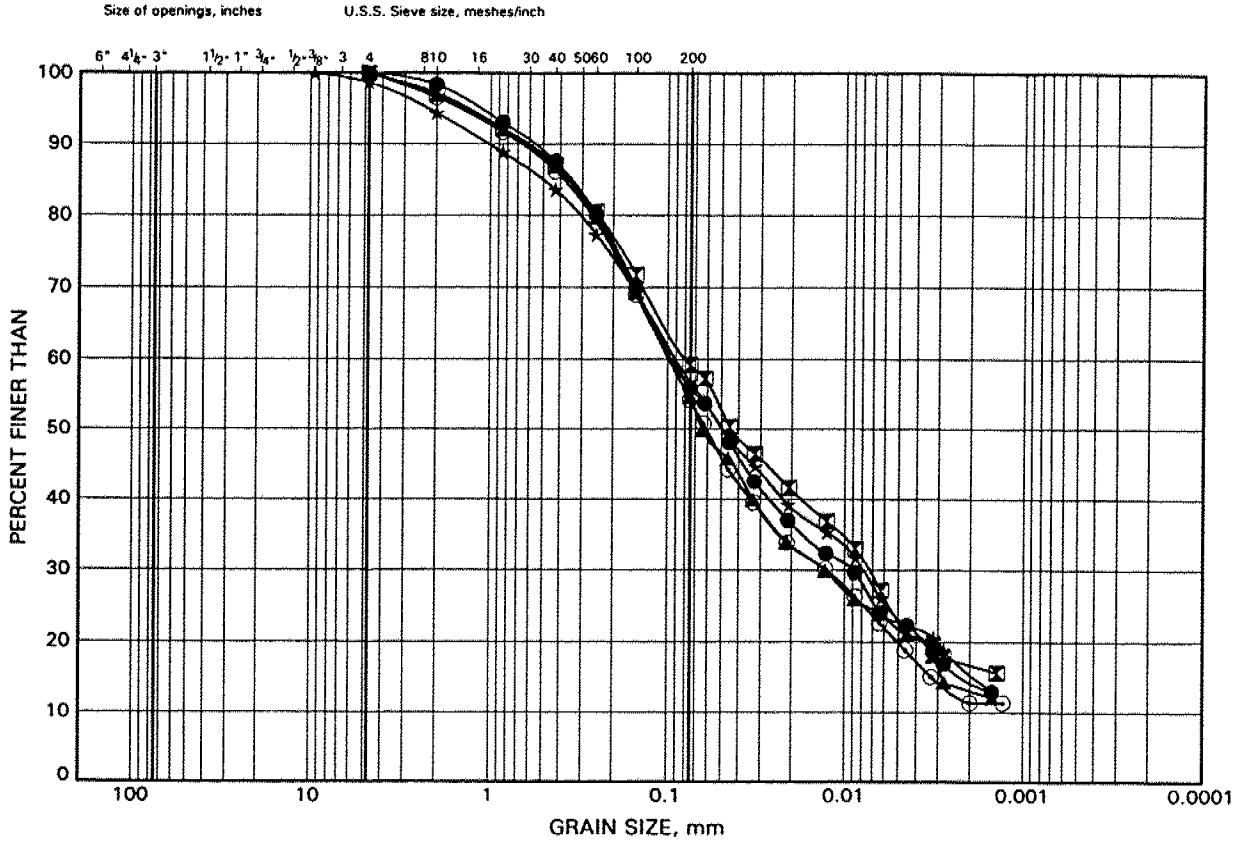
GRAIN SIZE DISTRIBUTION

FIGURE B3



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-4	4.80	178.23
⊠	98-5	2.51	179.47
▲	98-5	6.32	175.66
★	98-6	1.73	179.55
⊙	98-6	4.80	176.48

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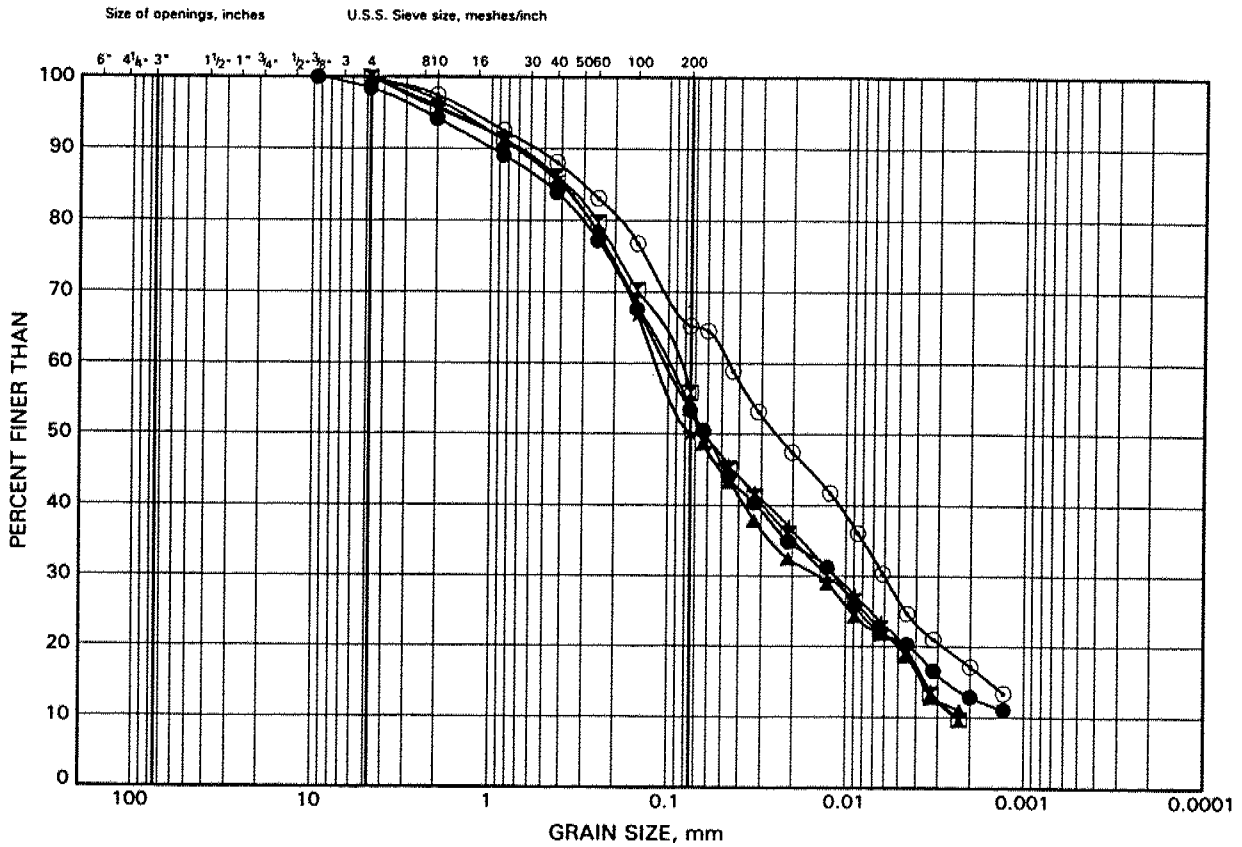
GRAIN SIZE DISTRIBUTION

FIGURE B4



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-6	10.90	170.38
⊠	98-7	6.32	174.69
▲	98-7	9.37	171.64
★	98-7	18.52	162.49
⊙	98-8	2.59	178.69

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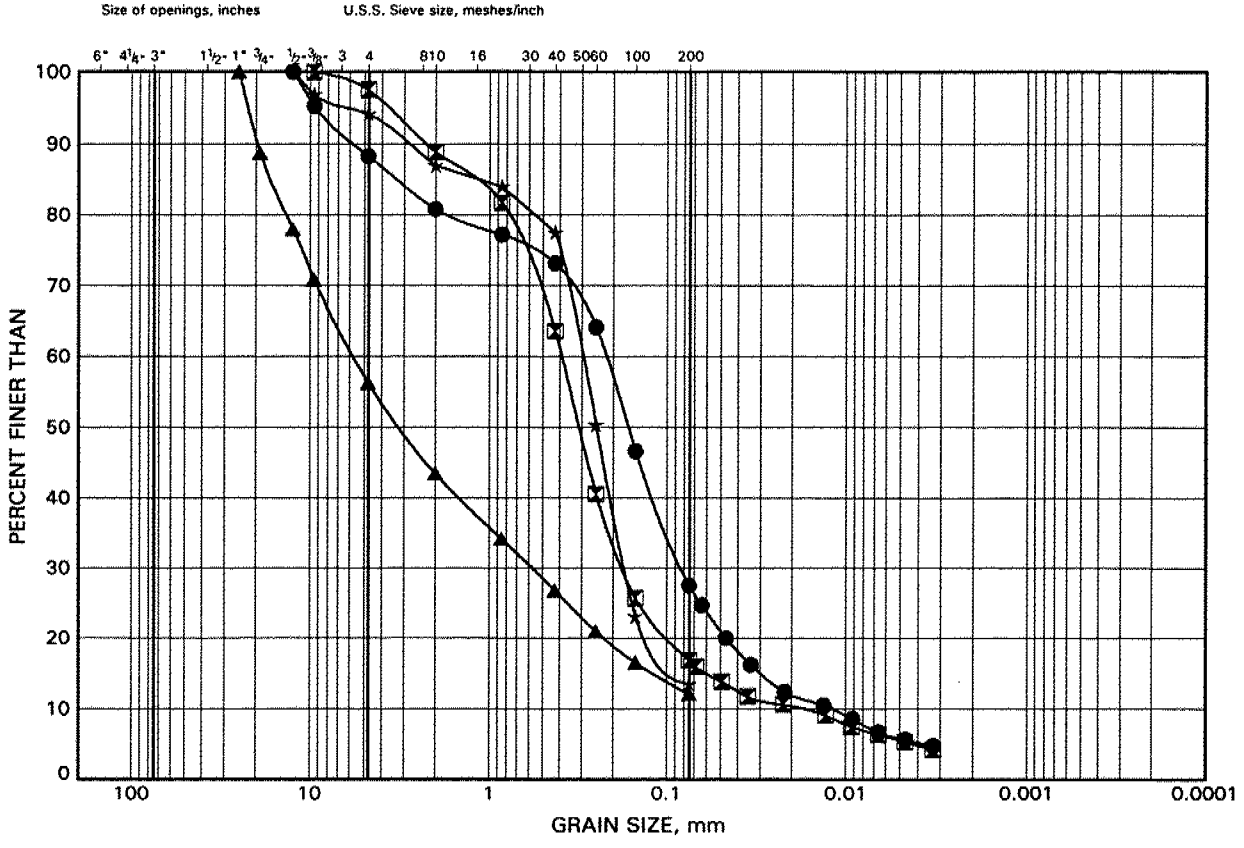
GRAIN SIZE DISTRIBUTION

FIGURE B5



COBBLE SIZE	GRAVEL		SAND			FINE GRAINED
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-3	19.85	162.38
⊠	98-3	22.65	159.58
▲	98-7	22.94	158.07
★	98-7	25.90	155.11

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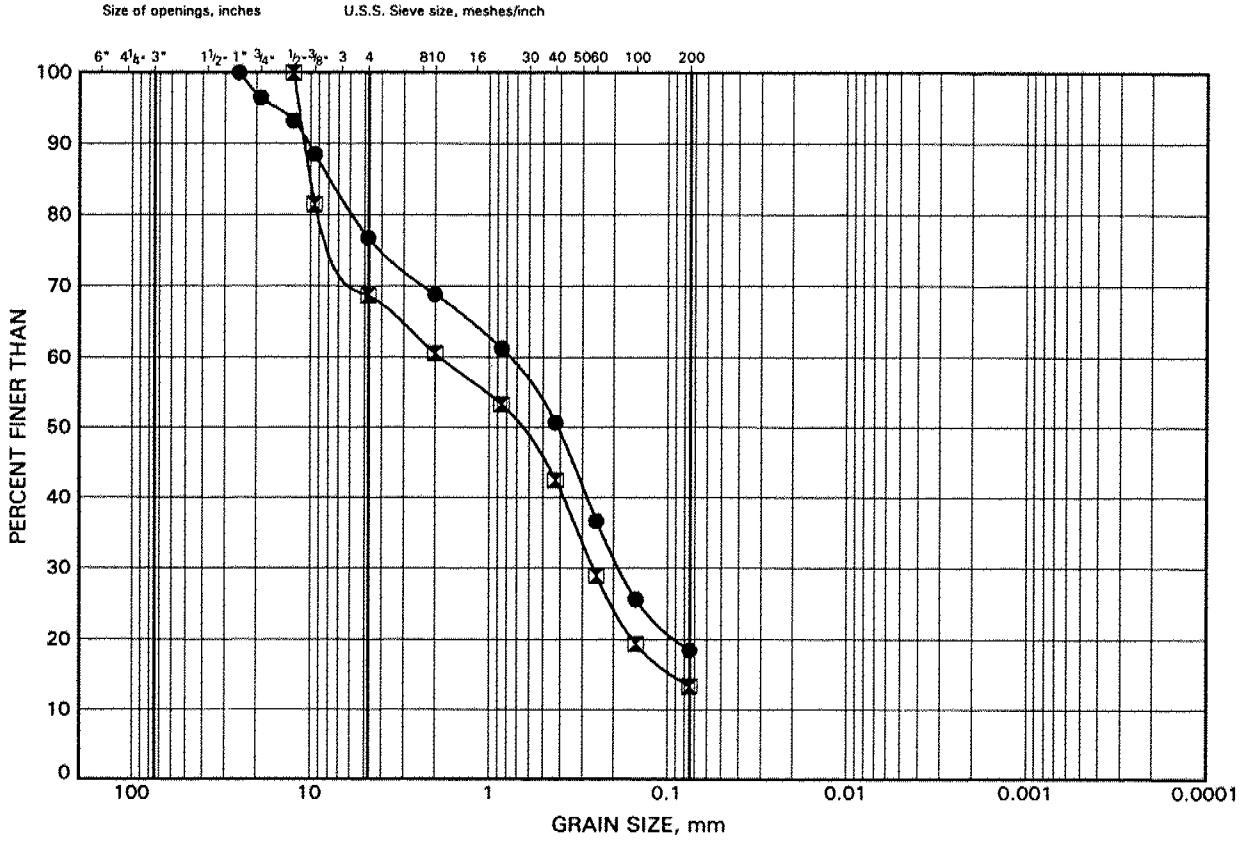
GRAIN SIZE DISTRIBUTION

FIGURE B6



COBBLE SIZE	GRAVEL		SAND			SILT and CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-7	0.22	180.79
⊠	98-8	0.38	180.90

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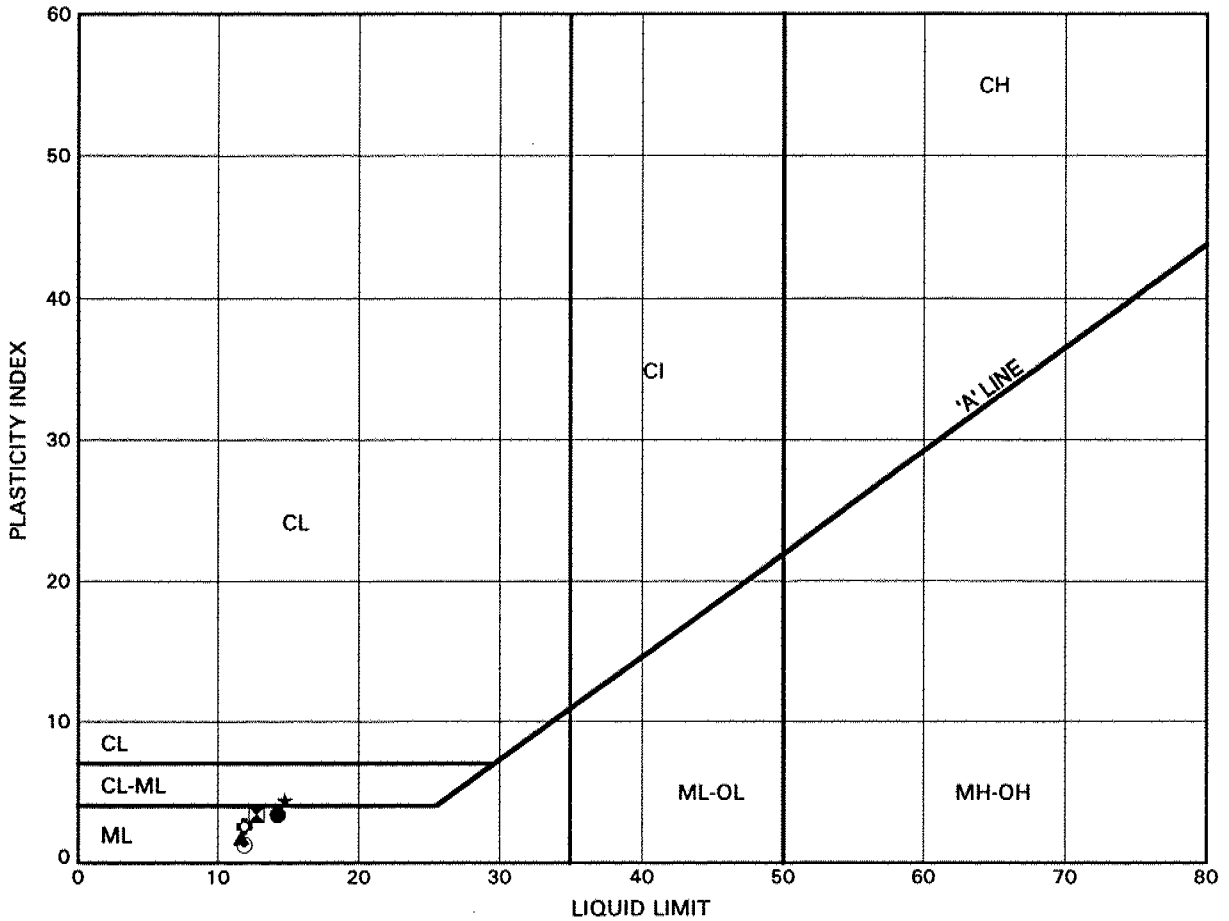
ATTERBERG LIMITS TEST RESULTS

FIGURE C1



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-1	3.28	177.73
⊠	98-1	6.32	174.69
▲	98-1	12.42	168.59
★	98-2	3.28	178.31
⊙	98-2	7.85	173.74
✿	98-2	10.90	170.69

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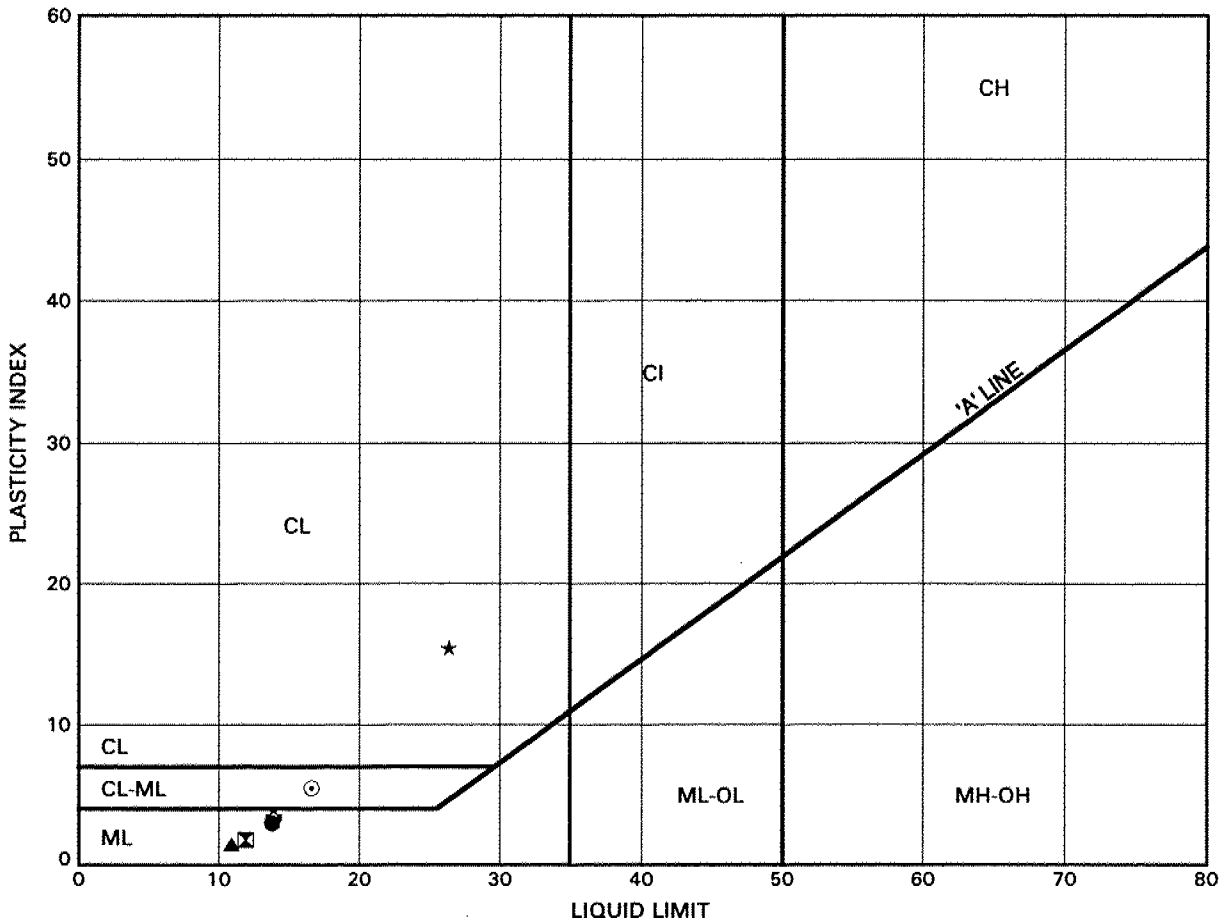
THURBALT 5664M 98/12/22

HWY 407/HWY 48

ATTERBERG LIMITS TEST RESULTS

FIGURE C2



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-3	2.51	179.72
⊠	98-3	7.85	174.38
▲	98-3	10.90	171.33
★	98-3	13.94	168.29
⊙	98-4	2.59	180.44
✪	98-4	4.80	178.23

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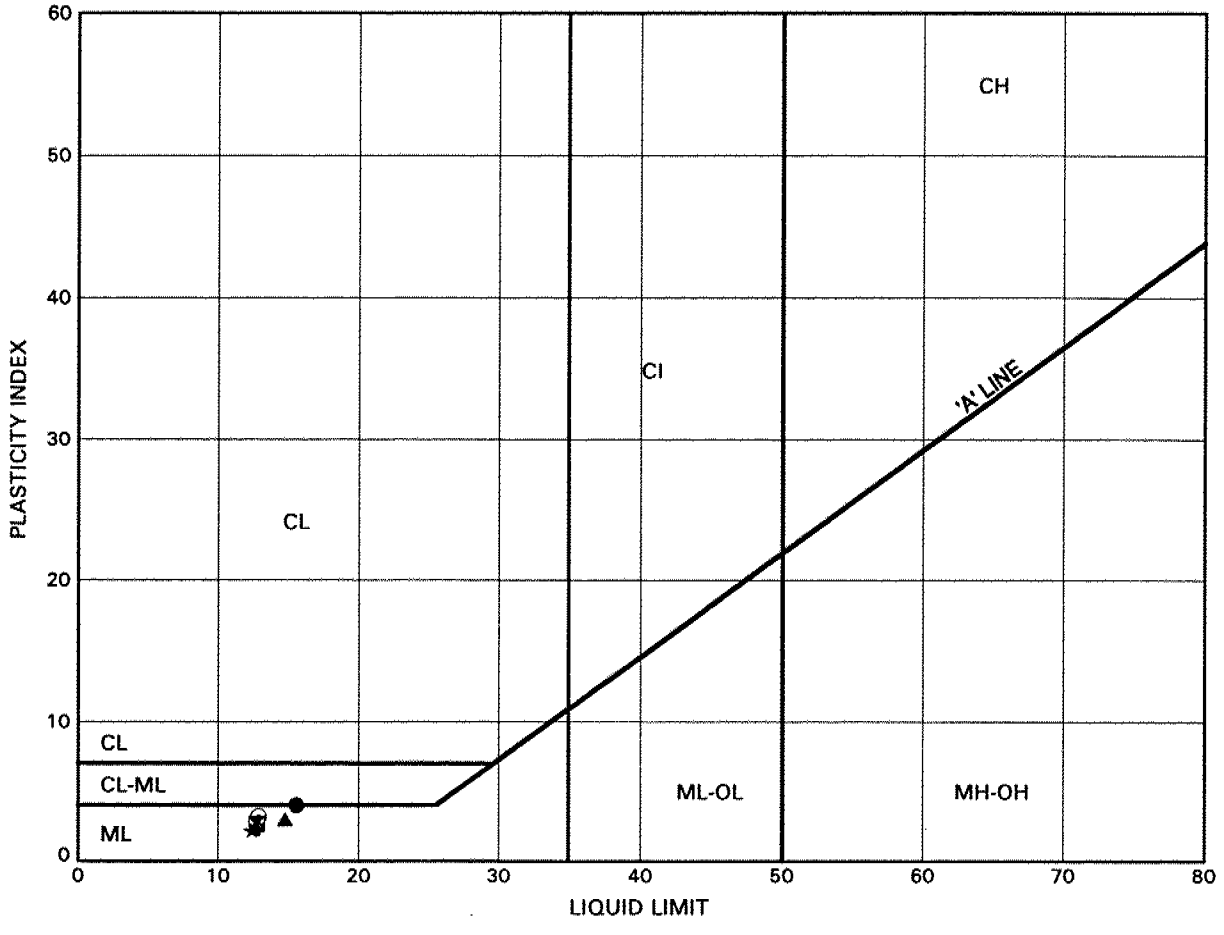
HWY 407/HWY 48

ATTERBERG LIMITS TEST RESULTS

FIGURE C3



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-5	2.51	179.47
⊠	98-5	6.32	175.66
▲	98-6	1.73	179.55
★	98-6	4.80	176.48
⊙	98-6	10.90	170.38
✪	98-7	6.32	174.69

Date December 1998

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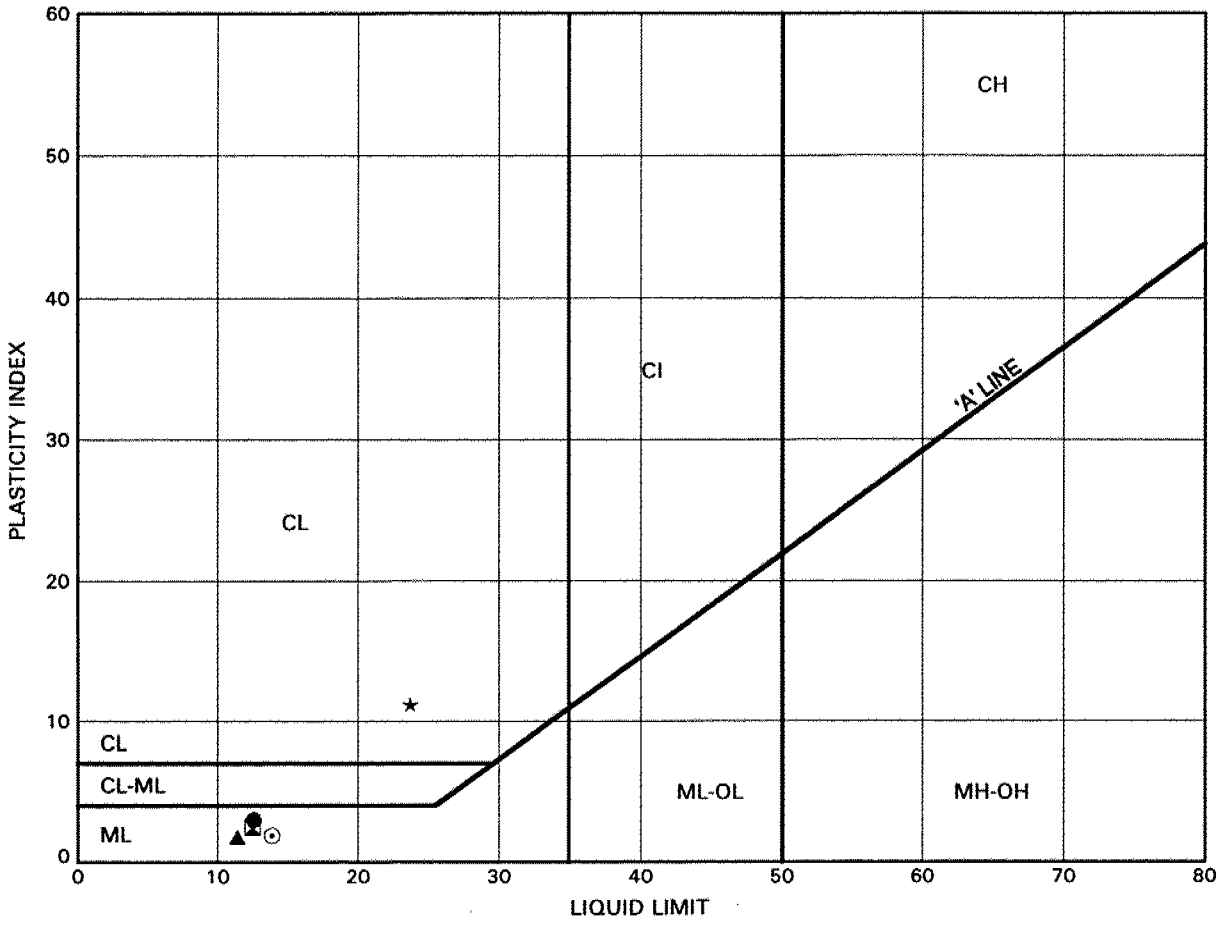
HWY 407/HWY 48

ATTERBERG LIMITS TEST RESULTS

FIGURE C4



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	98-7	9.37	171.64
⊠	98-7	12.42	168.59
▲	98-7	13.94	167.07
★	98-7	18.52	162.49
⊙	98-8	2.59	178.69

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THURBALT 5664M 98/12/22

Table 1

Results of pH and Sulphate Testing

Sample	Depth (m)	pH	Sulphates (ppm)
98-3, Sa 3	1.75	8.43	102
98-7, Sa 3	1.85	8.48	21

APPENDIX C

GRADING OF SAND

for

BACKFILL OF PILES

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The space around the piles in the integral abutment design should be filled with sand meeting the following grading:

MTO Sieve Designation	Percentage Passing by Mass
2 mm (#10)	100
600 µm (#30)	80 - 100
425 µm (#40)	40 - 80
250 µm (#60)	5 - 25
150 µm (#100)	0 - 6