



PICKERING-OSHAWA SECTION



Ministry of
Transportation and
Communications



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

PICKERING-OSHAWA SECTION

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

W O GGE 001-018 DIST 6

HWY GO-ALRT STR SITE

OSHAWA PROJECT

THORNTON ROAD CROSSING

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D. Garner (2)
G.C.E. Burkhardt
J. Lyle (2)
J. Ball
H. Clelland
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W. Lin
C. Watson
R. Hore
T.J. Kovich (cover only)
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1.0 INTRODUCTION

On behalf of GO-ALRT, the Ministry of Transportation and Communications has retained Golder Associates to carry out a foundation investigation for the proposed crossing of the GO-ALRT track at Thornton Road in Oshawa, Ontario.

Golder Associates conducted a subsurface investigation for the GO-ALRT/Thornton Road crossing some 30 m north of the present site in September, 1983. Subsequently, the horizontal alignment was relocated and the vertical alignment was changed from embankment to cut section. These changes necessitated the present subsurface investigation.

The purpose of the latest investigation was to determine the subsurface conditions at the site and based on these, to provide recommendations relating to the geotechnical design of the GO-ALRT cut and the Thornton Road bridge structures.

2.0 SITE AND PROJECT DESCRIPTION

The site is located about 1 km north of Highway 401 at Thornton Road in the City of Oshawa, Regional Municipality of Durham. An Ontario Hydro substation is located along the northern limit of the proposed GO-ALRT right-of-way west of Thornton Road. The centreline of the proposed GO-ALRT line traverses farmland on both sides of Thornton Road.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The site is located in the physiographic region known as the Iroquois plain. The overburden soils in the area consist of glacial till deposited during the last glacial advance. The present Lake Ontario basin was subsequently inundated by glacial Lake Iroquois following the recession of the ice. The shoreline of this glacial lake is located just north of the site. The depth to bedrock at the site is unknown.

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in each of the boreholes, put down as part of the current investigation, together with the results of laboratory tests carried out on representative samples, are given on the attached Record of Borehole sheets, 101 to 108, including 103A and on Figures 1 to 11, inclusive. Boreholes 7 and 8 from the 1983 investigation were put down within the relocated area of the site and the Record of Borehole sheets for these boreholes are included in Appendix B. Laboratory test results from samples from these boreholes have been included in the relevant figures. It should be noted that the stratigraphic boundaries shown on the Record of Borehole sheets are approximate and are not intended to define an exact plane of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The Record of Borehole sheets have been summarized on Drawing A.

The deepest stratum encountered in the investigation is a layer of highly overconsolidated silty clay. This material is overlain by a deposit of very hard silty clay till, which in turn is overlain by three zones of silt till. The middle silt till zone is the weakest material on site and, in place, contains layers of varved

clay. The upper silt till zone is overlain by topsoil or fill material. 'N'* values, in situ vane shear strengths and water contents have been plotted against elevation in Figure 9.

3.2.1 Topsoil and Fill

Up to 0.85 m of organic sandy silt topsoil was found below the ground surface in all boreholes except Borehole 103. Borehole 103, located on the shoulder of the existing Thornton Road, encountered about 40 mm of asphalt overlying approximately 1 m of silty sand and gravel fill. Borehole 7, put down as part of the previous investigation and located on the gravel driveway, encountered about 1.5 m of sand and gravel fill. A layer of organic material, which is probably the original topsoil, was encountered beneath this granular fill.

3.2.2 Silt Till

The predominant soil type at the site is a glacial till consisting primarily of silt. The silt is very sandy in places although it is generally plastic and contains varying amounts of clay. Trace amounts of gravel and occasional boulders were found throughout the deposit. The till has a low plasticity based on plasticity indexes of less than 12, with an average value of about 7. The till can generally be classified as a silt or clay of low plasticity. Typical grain size curves are shown on Figures 1 and 2. The results of Atterberg limits tests are shown on Figure 7.

The till has three distinct zones; an upper weathered crust extending to a depth of about 4.5 m below ground surface, a weaker zone extending to between 7.5 and 10.0 m depth and a very hard zone to about 16 m depth.

*'N' Values - Standard Penetration Resistance
Refer to Explanation of Terms

The upper weathered zone of the till has a very stiff to hard consistency with 'N' values of 15 or more. The zone is brown in colour and contains many rust stained fissures at random orientations. The water content of samples of till from this zone is generally around 10 per cent. The unit weight of a sample of this material was 23.1 kN/cu.m.

The middle zone of the till is considerably weaker and more variable in composition than the overlying and underlying materials. 'N' values as low as 4 and generally of about 10 blows/ft. were obtained within this zone. In situ vane tests were carried out in this zone and measured undrained shear strengths as low as 30 kPa although shear strengths in excess of 45 kPa were more common. The sensitivity of the till is typically between 1 and 4, with a maximum measured value of 4.7. The water content of samples of till from this weaker zone ranged between 9 and 21 per cent and were typically about 12 per cent. The unit weight of a sample of the till was 21.6 kN/cu.m.

The composition of this till deposit varies within and between boreholes from a loose sandy silt with trace clay and gravel, to a firm to very stiff silty clay with sand and trace gravel. Additionally, a thin deposit of varved clay was encountered within the weak till in Boreholes 101, 105 and 106. Because continuous sampling was not carried out, it is possible that a thin layer of this material is present at the location of the other boreholes.

A series of four stress controlled, drained triaxial tests were conducted using 'undisturbed' samples of the weak silt till from Borehole 107, Sample 7a (2 tests) and Borehole 102, Sample 7a (2 tests). The results of these "S" tests are presented on Figure 10. The tests on Sample 107/7a indicated effective stress parameters of $\phi' = 32.5^\circ$ and $c' = 0$. Tests on Sample 102/7a indicated effective stress parameters of $\phi' = 36.0^\circ$ and $c' = 0$.

The lower zone of the till is very hard as indicated by the 'N' values in excess of 60. Samples of the till within this zone had water contents ranging from 6 to 9 per cent. The unit weight of a sample of the very hard silt till was found to be 23.9 kN/cu.m. Boreholes 104, 105 and 106 were terminated within this zone. Borehole 105 encountered refusal to augering on a boulder.

3.2.3 Varved Clay

A thin deposit of varved clay was encountered within the weak till zone in Boreholes 101, 105 and 106. Each varve was about 10 mm thick and was comprised of a dark grey and a light grey layer. A sample of the dark grey material was found to have a clay size content in excess of 50 per cent and a plasticity index of 32. A sample of the light grey material had a clay content of about 25 per cent and a plasticity index of 11. The results of the particle size determinations and the plasticity characteristics of this material are shown on Figures 4 and 8, respectively. The water contents of samples of the dark grey material was determined for two samples and were found to be 34 and 36 per cent. The water contents of two samples of the lighter material were measured to be 14 and 24 per cent.

A series of three stress controlled undrained triaxial tests were conducted on samples from Borehole 101, Sample 8. The results of these tests are presented on Figure 11. The triaxial tests indicated that the effective stress parameters for this material are $\phi' = 30^\circ$ and $c' = 11.5$ kPa.

3.2.4 Silty Clay Till

Approximately 3.5 m of dark grey silty clay till was encountered in Boreholes 102, 103A and 108. Boreholes 101 and 107 also encountered this material and these boreholes were terminated within the deposit. The till is very hard in consistency as indicated by 'N' values in excess of

60 blows/300 mm. Typical particle size distributions for this material are shown on Figure 5. A liquid limit of 29 per cent and a plasticity index of 15 were measured on a sample from Borehole 8. The water content of samples of the till was found to increase with depth from about 11 to 23 per cent.

3.2.5 Silty Clay

Boreholes 102, 103A and 108 were terminated within a deposit of dark grey faintly layered silty clay. A typical particle size distribution is shown on Figure 6. The silty clay is hard in consistency with 'N' values ranging from 33 to in excess of 60 blows/300 mm. The water content of a sample of the silty clay from Borehole 101 was measured to be 28 per cent.

3.3 Groundwater Conditions

On March 14, 1985, the water levels in some of the piezometers sealed into deep strata on the site had not stabilized. The levels in some of these installations had risen to within 2 m of ground surface by that date. Other installations in comparable strata show groundwater levels as deep as 13 m; however, the information from the previous investigation indicates that the groundwater level in these deep layers is generally within 5 m of the surface.

The groundwater monitoring installations located within and above the weak till strata are subject to seasonal variation. On March 14, 1985, during a seasonal thaw, these installations indicated groundwater levels between 0.4 and 1.4 m below ground surface. On September 14, 1983, one week after drilling, the piezometer at 3.2 m depth in Borehole 8 was dry. Table 1 summarizes water level readings taken at the site.

TABLE 1WATER LEVEL READINGSDEPTH OF WATER BELOW GROUND LEVEL

| <u>Borehole and Installation</u> | <u>83/09/14</u> | <u>85/02/04</u> | <u>85/02/08</u> | <u>85/02/21</u> | <u>85/03/14</u> |
|--------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 7 | 5.2 m | - | - | - | - |
| 8 | Dry to 3.5 m | - | - | - | - |
| 101(A) | - | 5.7 | 5.3 | 5.1 | 4.4 |
| 101(B) | - | 1.8 | 1.7 | 1.6 | 0.4 |
| 102(A) | - | - | 10.3 | 8.6 | 7.2 |
| 102(B) | - | - | 1.9 | 1.4 | Blocked |
| 103A(A) | - | - | 18.1 | 13.1 | 7.3 |
| 103A(B) | - | - | 8.6 | 2.9 | 1.9 |
| 104 | - | 2.7 | 2.8 | 1.7 | 1.8 |
| 105 | - | - | Dry | 13.3 | 13.0 |
| 106(A) | - | 2.5 | 2.4 | 2.4 | 1.4 |
| 106(B) | - | 1.4 | 1.4 | 0.9 | 0.4 |
| 107(A) | - | 12.1 | 10.2 | 6.3 | 2.8 |
| 107(B) | - | 4.5 | 2.1 | 1.6 | 0.6 |
| 108 | - | 13.8 | 12.2 | 8.8 | 5.5 |

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Preliminary plans of the proposed structure were provided in a drawing titled "Preliminary Structural Site Plan" drawing PD1-601. This plan indicates that the proposed GO-ALRT alignment passes beneath Thornton Road in a cutting of 12 m maximum depth. A single span bridge structure is proposed to carry Thornton Road over the cutting. The approaches to the bridge structure would be supported by retaining walls. It is understood that the retaining walls will probably parallel the GO-ALRT line, but it is possible that an alternative in which the retaining walls will be parallel to Thornton Road, will be constructed. It is further understood that the grade of Thornton Road will be lowered by some 2 m from its present elevation.

4.2 Abutments and Retaining Walls

It is recommended that the bridge abutments and the retaining walls be founded on spread footings within the hard lower zone of the silt till. Spread footings should be located within undisturbed material at a depth of at least 1.2 m below the final grade outside the wall or abutment. Under these conditions, the factored bearing capacities at U.L.S. and S.L.S., Type II bearing capacities for spread footings may be taken as 800 kPa and 350 kPa, respectively. The S.L.S. Type II value will ensure settlement of less than 25 mm. The U.L.S. bearing value should be reduced in accordance with the inclination of load on the foundation.

For retaining walls and bridge abutments, the lateral earth loads will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure. The following recommendations are made concerning the lateral loading of abutments and retaining walls.

- o Selected "free draining" granular fill, such as MTC Granular 'B', Type 1, in accordance with MTC specifications should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the structures' footings.
- o All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structures.
- o Longitudinal drains should be provided within the granular backfill to ensure that it is positively drained. These drains should be located at the lowest elevation permitted by the available outfall. Ideally, the drains should be located immediately behind the heel of the wall. If drains are located above the heel of the wall, destabilizing water pressures must be taken account of in the earth pressure and sliding resistance computations.
- o Structures retaining horizontal ground and backfilled in the prescribed manner may be designed based on earth pressures of 8.0 kPa and 6.5 kPa per metre of retained height for

U.L.S. and S.L.S. Type II, respectively. Where retaining walls support sloping backfill, placed as described above, the corresponding design earth pressures are 10 kPa and 8 kPa per metre of wall height, for U.L.S. and S.L.S. Type II, respectively.

- o The shear resistance along the base of spread footings poured directly on undisturbed, freshly excavated native material may be taken as 0.45 times the effective vertical force on the footing.

Retaining walls parallel to Thornton Road are not recommended from a geotechnical viewpoint since, along most of their length, their base would be in the upper softer materials which are not suitable for the support of spread footings. If other considerations lead to the selection of this arrangement, the walls which are not at the base of the cut can be founded on piles driven into the hard till which is present at about elevation 97 m. Because of the possible presence of boulders, a steel H Pile is considered to provide the most suitable foundation although care must be taken to detect any deflection during driving. An HP 310 x 110 pile driven with a hammer of rated energy approaching, but not exceeding 55 kJ to an average set of 2.5 mm per blow for 10 blows, or to elevation 94 m, will have a factored capacity at U.L.S. of 1000 kN. The capacity at S.L.S. can be taken as 700 kN. The piles should not be driven below elevation 94 m as the soil below elevation 87 m is less competent.

4.3 Temporary Excavations

The stability of temporary excavations will be controlled by the thin layer of firm clay which was encountered at a maximum depth of 7.0 m (Borehole 101). An undrained analysis of this condition with side slopes of 2 horizontal

to 1 vertical gave a minimum factor of safety of 1.3. This side slope may be used for temporary cuts (open for less than 6 months) if surcharge loads are kept at least 5 m from the top of the slope, and if the slopes are monitored on a daily basis.

The silt till is well graded and is therefore relatively impermeable and relatively insensitive to disturbance due to upward seepage. Extensive dewatering of the silt till will not be required. It is anticipated that seepage into the excavation can be controlled using sumps and ditches. Local sloughing of the slope may take place in zones of water seepage and this can be controlled through the placement of a granular blanket over the affected area. Cross slope ditches are recommended for the control of water flowing down the slope.

4.4 Permanent Cut Slopes

Slope stability analyses have been carried out for various slope geometries and drainage conditions. The analyses were based on a limit equilibrium method originally developed by Sarma (1973). Searches for critical circular arcs were carried out by computer and the critical surfaces obtained are shown in Figures 12 and 13.

Groundwater levels near the existing ground surface, combined with the low permeability of the till and clay deposits, will result in high porewater pressures within the banks of the GO-ALRT cuts. The results of the analyses showed that slopes as flat as 3.5:1 would be surficially unstable in the long term. The surficial instability can be controlled by the placement of a granular blanket and if a 0.5 m deep, free draining blanket is placed on the slope, the gradient may be increased to 3:1.

It is understood that the available property restricts the location of the top of the slope to a line some 2.5 m beyond a 2:1 top-of-slope line drawn from the base of the cut. For the anticipated 12 m maximum depth of cut, the above 3:1 slope will fall outside the property line. An alternative which will allow the cuts to remain within the property line is to cut the slope at 1.9:1 and to place a 1.5 m deep Granular 'B' blanket on the slope below 3.5 m vertical depth from the top of the cut. Drains having a minimum depth of 1.5 m should be placed at the base of the upper slope and at the toe of the slope as shown on the recommended slope profile, Figure 13. An upper 0.5 m granular blanket is required to ensure a minimum factor of safety of 1.2 in the long term. This is satisfactory for the effective stress analysis adopted.

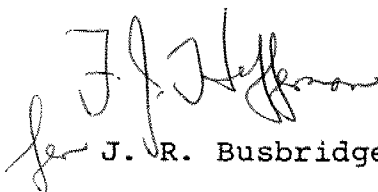
A third alternative is to construct a low retaining wall at the base of the cut as shown in Figure 14. The design of this wall should be in accordance with the above geotechnical recommendations.

The choice of slope treatment should be based on an economic comparison of the alternatives. All slopes should be topsoiled and seeded to prevent erosion. Once final grades and sections have been selected, the slope design must be reviewed by a qualified geotechnical engineer.

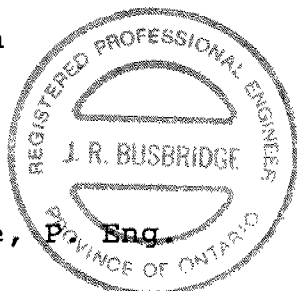
GOLDER ASSOCIATES



M. R. Ankenmann



J. R. Busbridge, P. Eng.



MRA/JRB/cg

APPENDIX A
INVESTIGATION PROCEDURE

April, 1985

851-1016

The field work for this investigation was carried out between January 29 and February 8, 1985. During this period, nine boreholes were put down at the locations shown on the borehole location plan (Figure 66E-001-18A). The boreholes were put down using a track-mounted CME 55 power auger drillrig supplied and operated by K & S Drilling Limited. The field work was supervised by an engineer from Golder Associates who directed the drilling and sampling operations, supervised the in situ testing and logged the boreholes.

The boreholes were advanced through the soil using continuous flight solid stem augers. At regular intervals of depth in each borehole, samples of the soil were obtained as part of the Standard Penetration Test using a conventional split barrel sampler. Within the weak till zone, in situ vane tests were carried out to measure the soil's undrained shear strength. Thin-walled type samples of the soil were obtained for detailed laboratory testing. Standpipes were sealed into different strata in the boreholes to permit monitoring of groundwater levels across the site.

The locations and elevations of the boreholes were surveyed by Golder Associates. The elevations are referenced to the temporary benchmark - cut cross S.E. side concrete base of fence post Station 28+236 26.5 mL. The Geodetic elevation of this point is 103.996 m and was supplied by MTC staff.

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 (RQD), 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

| | | | |
|----|---------------------|----|---------------------------|
| SS | SPLIT SPOON | TP | THINWALL PISTON |
| WS | WASH SAMPLE | OS | OSTERBERG SAMPLE |
| ST | SLOTTED TUBE SAMPLE | RC | ROCK CORE |
| BS | BLOCK SAMPLE | PH | TW ADVANCED HYDRAULICALLY |
| CS | CHUNK SAMPLE | PM | TW ADVANCED MANUALLY |
| TW | THINWALL OPEN | FS | FOIL SAMPLE |

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_f | 1 | SENSITIVITY = $\frac{c_u}{\tau_r}$ |

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 |

PHYSICAL PROPERTIES OF SOIL

| | | | | | | | | |
|-----------------------|------------------------|--------------------------------|------------|------|---|------------|------------------------|--|
| ρ_s | kg/m^3 | DENSITY OF SOLID PARTICLES | e | 1, % | VOID RATIO | e_{\min} | 1, % | VOID RATIO IN DENSEST STATE |
| γ_s | kN/m^3 | UNIT WEIGHT OF SOLID PARTICLES | n | 1, % | POROSITY | I_D | 1 | DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$ |
| ρ_w | kg/m^3 | DENSITY OF WATER | w | 1, % | WATER CONTENT | D | mm | GRAIN DIAMETER |
| γ_w | kN/m^3 | UNIT WEIGHT OF WATER | S_r | % | DEGREE OF SATURATION | D_n | mm | n PERCENT - DIAMETER |
| ρ | kg/m^3 | DENSITY OF SOIL | w_L | % | LIQUID LIMIT | C_u | 1 | UNIFORMITY COEFFICIENT |
| γ | kN/m^3 | UNIT WEIGHT OF SOIL | w_p | % | PLASTIC LIMIT | h | m | HYDRAULIC HEAD OR POTENTIAL |
| ρ_d | kg/m^3 | DENSITY OF DRY SOIL | w_s | % | SHRINKAGE LIMIT | q | m^3/s | RATE OF DISCHARGE |
| γ_d | kN/m^3 | UNIT WEIGHT OF DRY SOIL | I_p | % | PLASTICITY INDEX = $w_L - w_p$ | v | m/s | DISCHARGE VELOCITY |
| ρ_{sat} | kg/m^3 | DENSITY OF SATURATED SOIL | I_L | 1 | LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$ | i | 1 | HYDRAULIC GRADIENT |
| γ_{sat} | kN/m^3 | UNIT WEIGHT OF SATURATED SOIL | I_C | 1 | CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$ | k | m/s | HYDRAULIC CONDUCTIVITY |
| ρ' | kg/m^3 | DENSITY OF SUBMERGED SOIL | e_{\max} | 1, % | VOID RATIO IN LOOSEST STATE | j | kN/m^2 | SEEPAGE FORCE |
| γ' | kN/m^3 | UNIT WEIGHT OF SUBMERGED SOIL | | | | | | |

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,983.9 N; 353,900.3E ORIGINATED BY M.A.
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
DATUM GEODETIC DATE 1985 01 31 TO 1985 02 01 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|---------------------|---------|------|------------|----------------------------|-----------------|--|----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | | | | | |
| 105.4 | GROUND SURFACE | | | | | | | | | | | | | GR SA SI CL |
| 105.0 | TOPSOIL | | | | | | | | | | | | | |
| 0.4 | Silt till with varying amounts of sand & clay, trace gravel. Generally ML, silt of low plasticity fissured from 100.2 to 103.3 m. | | 1 | SS | 18 | | | | | | | | | 5 34 46 15 |
| | | | 2 | SS | 36 | | | | | | | | | 9 40 38 13 |
| | | | 3 | SS | 60 | | | | | | | | | |
| | | | 4 | SS | 36 | | | | | | | | | |
| | Very stiff to hard | Light brown | | | | | | | | | | | | |
| 100.2 | | | 5 | SS | 25 | | | | | | | | | |
| 5.2 | Silt till with varying amounts of sand & clay, trace gravel. CL, clay of low plasticity. | | 6 | SS | 12 | | | | | | | | | 12 25 41 22 |
| | Stiff to very stiff | Grey | 7 | TW | PH | | | | | | | | | |
| 98.4 | | | 8 | TW | PH | | | | | | | | | |
| 7.0 | Varved clay - 10 mm varves | | 9 | SS | 8 | | | | | | | | | 3 33 38 26 |
| 97.8 | Firm to stiff | Light and dark grey | | | | | | | | | | | | 1 8 39 52 |
| 7.6 | Silt till, sandy trace gravel and clay. | | | | | | | | | | | | | |
| 96.3 | Loose | Grey | 10 | SS | 75/75mm | | | | | | | | | |
| 9.1 | Silt till with varying amounts of sand and clay, trace gravel occasional boulders. Generally ML, silt of low plasticity. | | 11 | SS | 62 | | | | | | | | | |
| | | | 12 | SS | 100/100mm | | | | | | | | | |
| | | | 13 | SS | 100/125mm | | | | | | | | | |
| | | | 14 | SS | 50/50mm | | | | | | | | | 2 33 40 25 |
| 89.4 | Hard | Grey | | | | | | | | | | | | |
| 16.0 | Silty clay till some sand. | | 15 | SS | 100/125mm | | | | | | | | | |
| 88.4 | Hard | dark grey | | | | | | | | | | | | |
| 17.0 | END OF BOREHOLE | | | | | | | | | | | | | |

SEAL

B

SEAL

A

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEV. 101.0 m
AND IN PIE-
ZOMETER 'B'
AT ELEV.
105.0 m ON
85 03 14

RECORD OF BOREHOLE No 102

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,006.4 N; 353,910.8 E ORIGINATED BY M.A.
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EEO/RM
 DATUM GEODETIC DATE 1985 02 04 CHECKED BY M.A.

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|------------|----------------------------|--------------------|---|----|----|----|-----|----------------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | |
| 105.0 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | | | | | | | | | | | | |
| 104.1 | | | | | | | | | | | | | | |
| 0.9 | Silt till with varying amounts of sand & clay trace gravel. Generally ML, silt of low plasticity. Stiff to hard Light brown | | 1 | SS | 13 | | 104 | | | | | | | |
| | | | 2 | SS | 40 | | | | | | | | | |
| | | | 3 | SS | 63 | | | | | | | | | |
| 101.3 | | | 4 | SS | 23 | | 102 | | | | | | | |
| 3.7 | Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasticity. Firm to very stiff Grey | | 5 | SS | 10 | | | | | | | | | |
| | | | 6 | TW | PH | | 100 | | | | | | | 11 36 39 14 |
| | | | 7 | TW | PH | | | | | | | | | 5 39 36 20 |
| | | | 8 | SS | 4 | | | | | | | | | |
| 96.2 | | | 9 | SS | 8 | | 98 | | | | | | | |
| 8.8 | Silt till with varying amounts of sand and clay trace gravel. Generally ML, silt of low plasticity. Hard Grey | | 10 | SS | 95/150mm | | 96 | | | | | | | 8 45 38 9 |
| | | | 11 | SS | 100/75mm | | 94 | | | | | | | |
| | | | 12 | SS | 95/100mm | | 92 | | | | | | | |
| 90.5 | | | 13 | SS | 100/75mm | | 90 | | | | | | | |
| 14.5 | Silty clay till some sand. Hard Dark grey | | 14 | SS | 100/150mm | | 88 | | | | | | | 0 17 45 38 |
| 87.5 | | | 15 | SS | 145 | | 86 | | | | | | | |
| 17.5 | Silty clay layered. Hard Dark grey | | 16 | SS | 67 | | 84 | | | | | | | |
| 84.7 | | | 17 | SS | 53 | | | | | | | | | 0 1 35 64 |
| 20.3 | END OF BOREHOLE | | | | | | | | | | | | | |

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEV. 97.8 m
ON 85 02 02
AND IN PIE-
ZOMETER 'B'
AT ELEV.
103.6 m ON
85 03 14

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,997.5 N; 353,927.3 E ORIGINATED BY M.A.
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
DATUM GEODETIC DATE 1985 02 05 CHECKED BY M.A.

[illegible]

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 103A

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,994.7 N; 353,912.9 E ORIGINATED BY M.A.
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
 DATUM GEODETIC DATE 1985 02 07 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 105.8 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 105.3 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.5 | Silt till with varying amounts of sand and clay trace gravel. Generally ML, silt of low plasticity. Fissured below elev. 104.3 m; approx. 150 mm sand layer at elev. 104.7 m | | 1 | SS | 25 | | | | | | | | | | | | |
| | | | 2 | SS | 37 | | 104 | | | | | | | | | | |
| | | | 3 | SS | 45 | | | | | | | | | | | | |
| | | | 4 | SS | 115 | | 102 | | | | | | | | | | |
| | | | 5 | SS | 48 | | | | | | | | | | | | |
| 100.6 | Very stiff Light Brown | | 6 | SS | 20 | | | | | | | | | | | | |
| 5.2 | Silt till with varying amounts of sand and clay, trace gravel. Generally CL, clay of low plasticity. | | 7 | SS | 12 | | 100 | | | | | | | | | | |
| | | | 8 | SS | 12 | | | | | | | | | | | | |
| | Very stiff to hard Grey | | 9 | SS | 6/150 mm | | 98 | | | | | | | | | | |
| 97.3 | | | 10 | SS | 80/150 mm | | 96 | | | | | | | | | | |
| 8.5 | Silt till with varying amounts of sand and clay trace gravel occasional boulders. Generally ML silt of low plasticity. | | 11 | SS | 98/150 mm | | 94 | | | | | | | | | | |
| | | | 12 | SS | 100/50 mm | | | | | | | | | | | | |
| | | | 13 | SS | 100/100 mm | | | | | | | | | | | | |
| | | | 14 | SS | 70/50 mm | | 90 | | | | | | | | | | |
| 90.0 | Hard Grey | | | | | | | | | | | | | | | | |
| 15.8 | Silty clay till some sand. | | 15 | SS | 107 | | 88 | | | | | | | | | | |
| 86.8 | Hard Dark grey | | 16 | SS | 64 | | | | | | | | | | | | |
| 19.0 | Silty clay trace sand layered. | | | | | | | | | | | | | | | | |
| 85.5 | Hard Dark grey | | 17 | SS | 33 | | 86 | | | | | | | | | | |
| 20.3 | END OF BOREHOLE | | | | | | 84 | | | | | | | | | | |

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEV. 98.5 m
AND IN PIE-
ZOMETER 'B'
AT ELEV.
103.9 m ON
85 03 14

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 105

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,022.7 N; 353,939.8 E ORIGINATED BY M.A.
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
 DATUM GEODETIC DATE 1985 02 08 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|--|------------|---------|------|---------------|----------------------------|--------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 105.3 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 104.8 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.5 | Silt till with varying amounts of sand & clay trace gravel fissured below elev. 103.8 m. Generally ML, silt of low plasticity. Very stiff to hard Light Brown | | 1 | SS | 15 | | 104 | | | | | | | | | | |
| | | | 2 | SS | 53 | | | | | | | | | | | | |
| | | | 3 | SS | 42 | | | | | | | | | | | | |
| 101.6 | | | 4 | SS | 34 | | 102 | | | | | | | | | | |
| 3.7 | Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasti- city. | | 5 | SS | 16 | | | | | | | | | | | | |
| | | | 6 | SS | 11 | | | | | | | | | | | | |
| 98.7 | Stiff Grey | | 7 | SS | 4 | | 100 | | | | | | | | | | |
| 6.6 | Varved clay, inclined varves approx. 10mm thick Light & dark grey | | | | | | | | | | | | | | | | |
| 97.6 | Silt till with varying amounts of sand & clay trace gravel generally CL clay of low plasti- city. | | 8 | SS | 3 | | 98 | | | | | | | | | | |
| 96.9 | | | | | | | | | | | | | | | | | |
| 8.4 | Stiff Grey | | 9 | SS | 110/ 150mm | | 96 | | | | | | | | | | |
| | Silt till with varying amounts of sand & clay trace gravel occasional boulders. Generally ML, silt of low plasticity. | | 10 | SS | 100/ 50mm | | 94 | | | | | | | | | | |
| | | | 11 | SS | 130/ 75mm | | | | | | | | | | | | |
| 93.0 | Hard Grey | | | | | | 92 | | | | | | | | | | |
| 12.3 | END OF BOREHOLE | | | | | | 90 | | | | | | | | | | |

WATER LEVEL
IN PIEZOME-
TER AT ELEV.
104.0 m ON
85 03 14

RECORD OF BOREHOLE No 106

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,992.6 N: 353,950.3 E ORIGINATED BY M.A.
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
 DATUM GEODETIC DATE 1985 01 29 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 40 60 80 100 | | | | | | | | | |
| | | | | | | | | SHEAR STRENGTH, kPa | | | | | | | | | |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | WATER CONTENT (%) | | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL | x LAB VANE | 20 40 60 80 100 | | | | | | | |
| | | | | | | | | 20 40 60 80 100 | | | | | 10 20 30 | | | | |
| 107.0 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 106.5 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.5 | Silt till with varying amounts of sand and clay trace gravel fissured throughout. Generally ML, silt of low plasticity. | | 1 | SS | 19 | | | | | | | | | | | | |
| | | | 2 | SS | 20 | | | | | | | | | | | | |
| | | | 3 | SS | 59 | | | | | | | | | | | | |
| | | | 4 | SS | 85/150mm | | | | | | | | | | | | |
| | | | 5 | SS | 57 | | | | | | | | | | | | |
| | Very stiff to hard Light brown | | 6 | SS | 22 | | | | | | | | | | | | |
| 101.8 | Varved clay 10 mm thick varves. Light & Stiff Dark Grey | | 7 | SS | 4 | | | | | | | | | | | | |
| 5.2 | | | | | | | | | | | | | | | | | |
| 100.3 | Silty sand till trace to some gravel trace clay occasional sand lenses. | | 8 | SS | 7 | | | | | | | | | | | | |
| 6.7 | | | 9 | SS | 8 | | | | | | | | | | | | |
| | | | 10 | SS | 16 | | | | | | | | | | | | |
| 96.9 | Loose to Compact Grey | | | | | | | | | | | | | | | | |
| 10.1 | Silt till with varying amounts of sand & clay trace gravel. Hard Grey | | | | | | | | | | | | | | | | |
| 95.9 | | | 11 | SS | 61 | | | | | | | | | | | | |
| 11.1 | END OF BOREHOLE | | | | | | | | | | | | | | | | |

SEAL

A

B

2

28

43

27

29

46

21

4

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEVATION
105.6 m AND
IN PIEZOME-
TER 'B' AT
ELEV.106.6m
ON 85 03 14

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEVATION
105.6 m AND
IN PIEZOME-
TER 'B' AT
ELEV.106.6m
ON 85 03 14

RECORD OF BOREHOLE No 107

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,680,011.0 N; 353,950.0 E ORIGINATED BY M.A.
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EEO/RM
DATUM GEODETIC DATE 1985 01 31 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|------------|----------------------------|--------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 106.4 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 105.7 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.7 | Silt till with varying amounts of sand & clay trace gravel fissured from elev. 102.7 m to 104.9 m. Generally ML, silt of low plasticity. Very stiff to hard | | 1 | SS | 19 | | 106 | | | | | | | | | | |
| | | | 2 | SS | 28 | | | | | | | | | | | | |
| | | | 3 | SS | 30 | | 104 | | | | | | | | | | |
| | | | 4 | SS | 29 | | | | | | | | | | | | |
| 102.4 | | | 5 | SS | 18 | | 102 | | | | | | | | | | |
| 4.0 | Silt till, sandy in places. Varying amounts of clay trace gravel. Non plastic to ML, silt of low plasticity. Firm to Hard | | 6 | TW | PH | | 100 | | | | | | | | | | |
| | | | 7 | TW | PH | | | | | | | | | | | | |
| 99.2 | | | | | | | | | | | | | | | | | |
| 7.2 | Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasticity. Firm to Hard | | 8 | SS | 8 | | 98 | | | | | | | | | | |
| 97.2 | | | | | | | | | | | | | | | | | |
| 9.2 | Silt till with varying amounts of sand & clay trace gravel. Generally ML silt of low plasticity. Hard | | 9 | SS | 38 | | 96 | | | | | | | | | | |
| | | | 10 | SS | 88/150 mm | | | | | | | | | | | | |
| | | | 11 | SS | 120/125 mm | | 94 | | | | | | | | | | |
| | | | 12 | SS | 100/100 mm | | 92 | | | | | | | | | | |
| | | | 13 | SS | 100/75 mm | | 90 | | | | | | | | | | |
| 89.9 | | | | | | | | | | | | | | | | | |
| 16.5 | Silty clay till some sand trace gravel. Hard | | 14 | SS | 93 | | 88 | | | | | | | | | | |
| 87.6 | | | | | | | | | | | | | | | | | |
| 18.8 | END OF BOREHOLE | | 15 | SS | 62 | | 86 | | | | | | | | | | |

WATER LEVEL
IN PIEZOME-
TER 'A' AT
ELEV. 103.6m
AND IN
PIEZOMETER
'B' AT ELEV.
105.8 m ON
85 03 14

RECORD OF BOREHOLE No 108

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,040.8 N; 353,978.0 E ORIGINATED BY M.A.
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM
 DATUM GEODETIC DATE 1985 01 30 CHECKED BY M.A.

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|---------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 106.3 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.6 | SILT TILL with varying amounts of sand & clay trace gravel fissured below elev. 104.8 m occasional boulders generally ML silt of low plasticity. Very stiff to hard Light Brown | | 1 | SS | 17 | | | | | | | | | | | | |
| | | | 2 | SS | 28 | | | | | | | | | | | | |
| | | | 3 | SS | 36 | | | | | | | | | | | | |
| | | | 4 | SS | 29 | | | | | | | | | | | | |
| 101.8 | SILT TILL with varying amounts of sand & clay trace gravel generally CL clay of low plas- ticity. Firm to very stiff Grey | | 5 | SS | 11 | | | | | | | | | | | | |
| 4.5 | | | 6 | TW | PH | | | | | | | | | | | | |
| 99.0 | SILT TILL with varying amounts of sand and clay trace gravel oc- casional boulders. Generally ML silt of low plasticity. Hard Grey | | 7 | SS | 83 | | | | | | | | | | | | |
| 7.3 | | | 8 | SS | 77 | | | | | | | | | | | | |
| | | | 9 | SS | 110/ 150mm | | | | | | | | | | | | |
| | | | 10 | SS | 135/ 150mm | | | | | | | | | | | | |
| 91.8 | Silty clay till some sand trace gravel. Hard Dark grey | | 11 | SS | 133/ 125mm | | | | | | | | | | | | |
| 14.5 | | | 12 | SS | 105/ 150mm | | | | | | | | | | | | |
| | Silty clay trace sand layered Hard Dark grey | | 13 | SS | 97 | | | | | | | | | | | | |
| | | | 14 | SS | 81 | | | | | | | | | | | | |
| 87.1 | END OF BOREHOLE | | 15 | SS | 38 | | | | | | | | | | | | |
| 19.2 | | | | | | | | | | | | | | | | | |
| 86.0 | | | | | | | | | | | | | | | | | |
| 20.3 | | | | | | | | | | | | | | | | | |

+³, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE

WATER LEVEL
IN PIEZOME-
TER AT ELEV.
100.8 m ON
85 03 14

APPENDIX B

RECORD OF BOREHOLE SHEETS
(PREVIOUS INVESTIGATION)

April, 1985

851-1016

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,024.9 N; 353,912.3 E ORIGINATED BY JKB
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO
DATUM Geodetic DATE 1983 09 02 CHECKED BY HCO

[illegible]

+3, x5: Numbers refer to Sensitivity

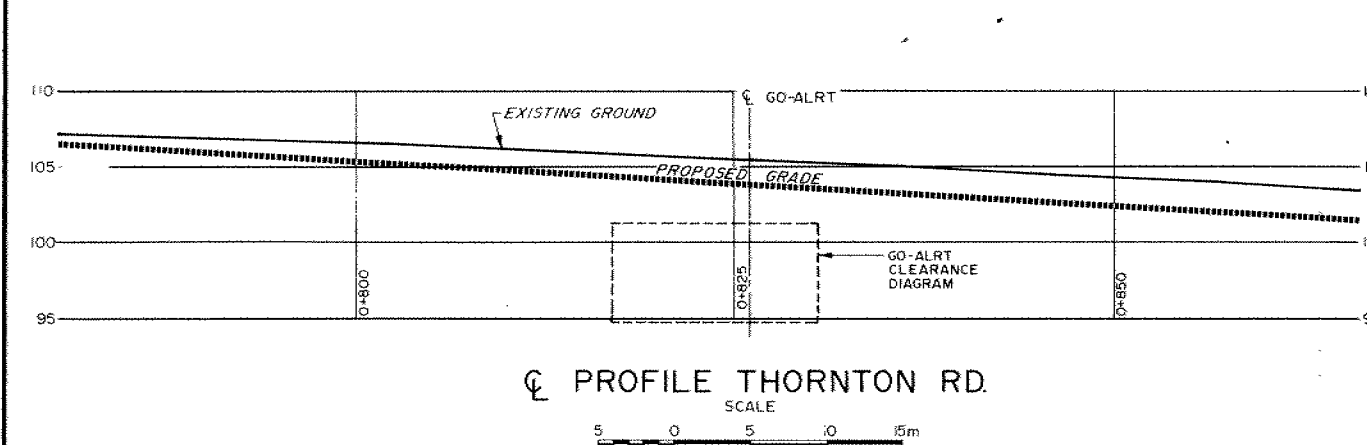
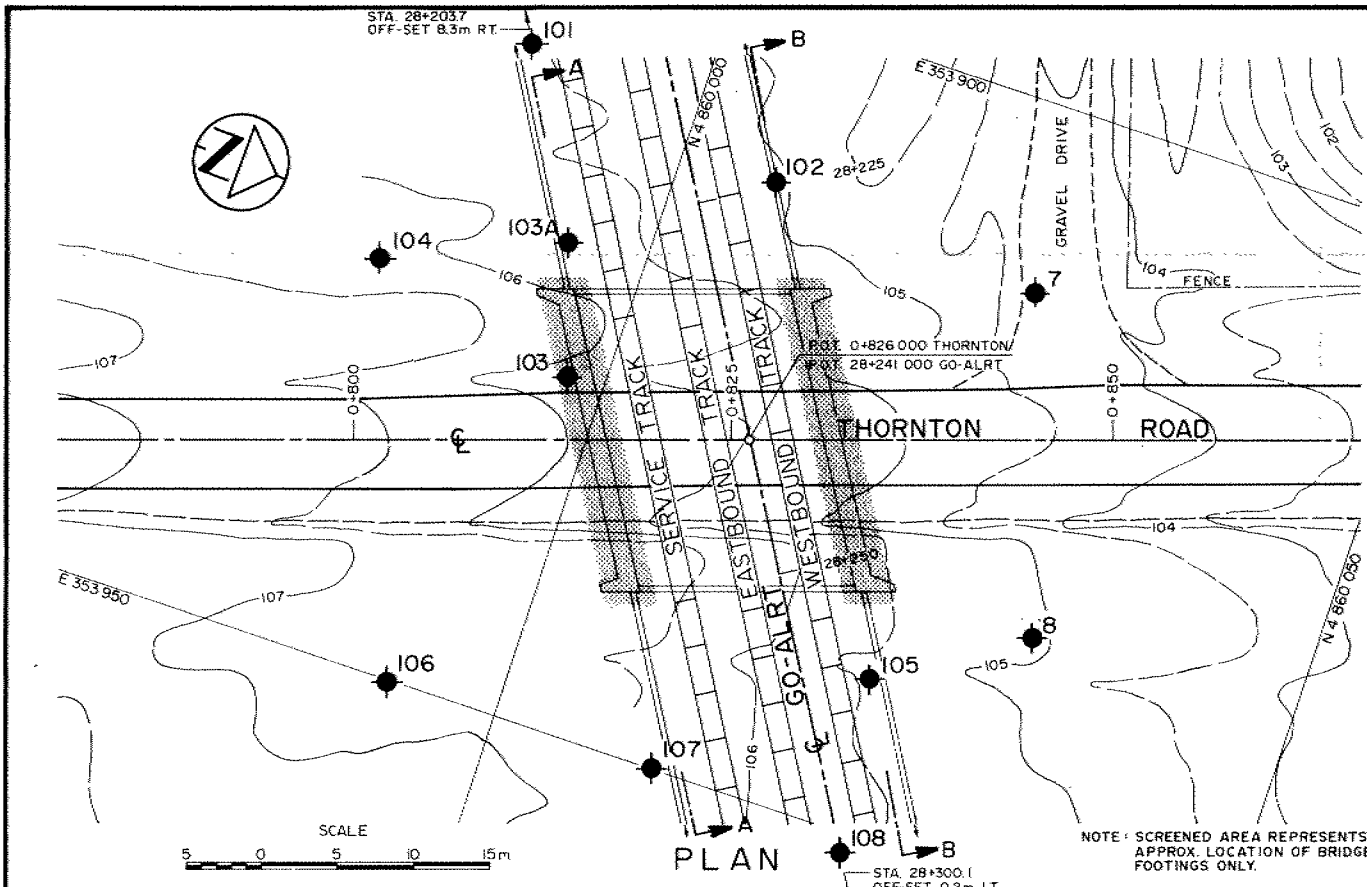
20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

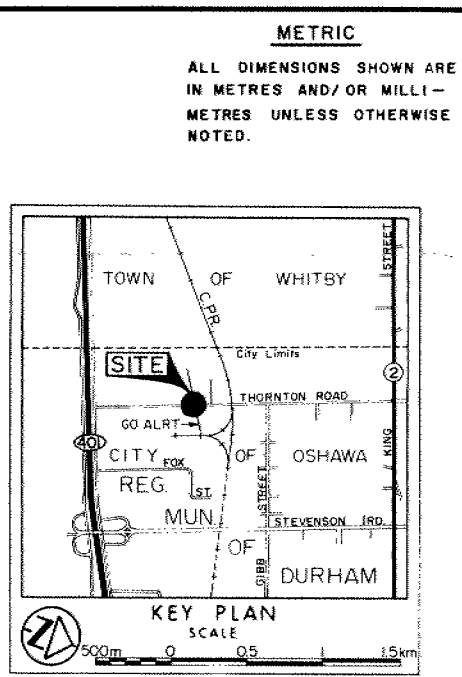
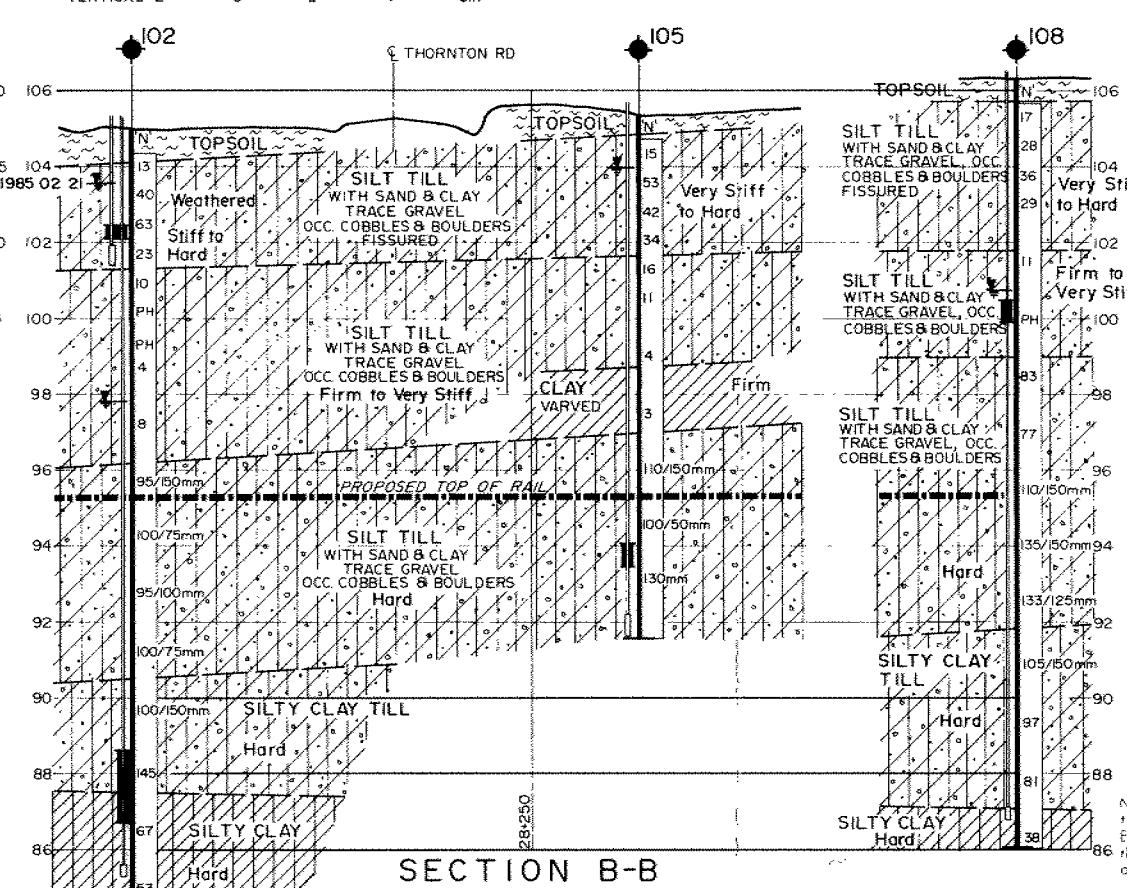
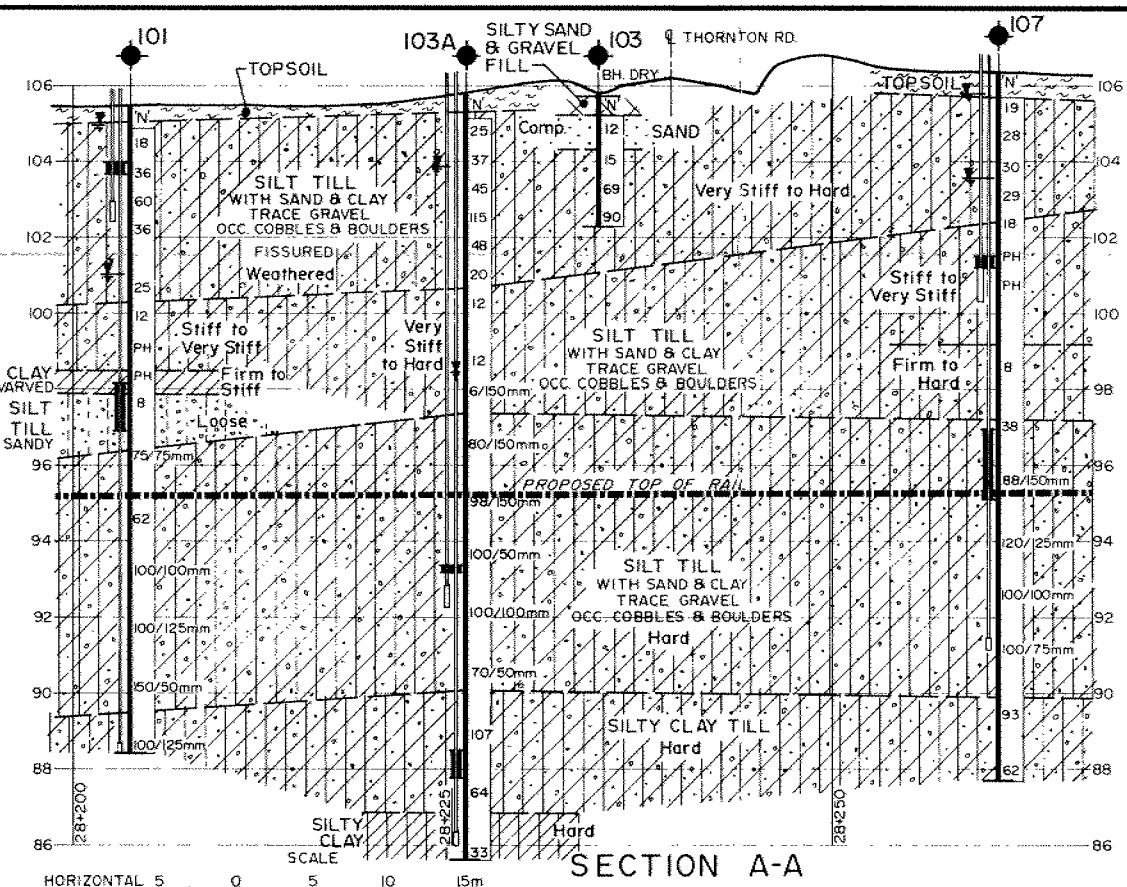
METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,032.0 N; 353,933.7 E ORIGINATED BY JKB
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO
 DATUM Geodetic DATE 1983.09.07 CHECKED BY HCO

| 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 γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|------------|----------------------------|--------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 104.9 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.3 | TOPSOIL | | | | | | | | | | | | | | | | |
| | Sandy silt some clay trace gravel (TILL) fissured between elev. 102.8 and 100.9. Silty clay pocket at elev. 100.9 m. | | 1 | SS | 22 | | 104 | | | | | | | | | | |
| | | | 2 | SS | 29 | | | | | | | | | | | | |
| | | | 3 | SS | 42 | | | | | | | | | | | | |
| | | | 4 | SS | 31 | | | | | | | | | | | | |
| | | | 5 | SS | 9 | | | | | | | | | | | | |
| | | | 6 | TW | PH | | 100 | | | | | | | | | | |
| | | | 7 | TW | PH | | | | | | | | | | | | |
| | | | 8 | SS | 16 | | 98 | | | | | | | | | | |
| 95.9 | Brown be- coming Dense to Loose grey below elevation 100.6 m | | 9 | SS | 90/ | | | | | | | | | | | | |
| 9.0 | Sandy silt some clay trace gravel (TILL) | | 10 | SS | 100/ | | | | | | | | | | | | |
| 92.7 | Very Dense Grey | | 11 | SS | 100/ | | | | | | | | | | | | |
| 12.2 | Silty clay some sand trace gravel (TILL) | | 12 | SS | 100/ | | | | | | | | | | | | |
| 89.4 | Hard Grey | | 13 | SS | 112/ | | 90 | | | | | | | | | | |
| 15.5 | END OF BOREHOLE | | | | | | 88 | | | | | | | | | | |



NOTE: FOR SOIL STRATA AND INSITU TESTING RESULTS FOR BOREHOLES 7, 8, 104 AND 106 REFER TO RECORD OF BOREHOLE SHEETS.



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1985 03 14
- Seal
- Piezometer

| No | ELEVATION | CO-ORDINATES NORTH | EAST |
|------|-----------|--------------------|-----------|
| 7 | 104.1 | 4 860 024.9 | 353 912.3 |
| 8 | 104.9 | 4 860 032.0 | 353 933.7 |
| 101 | 105.4 | 4 859 983.9 | 353 900.3 |
| 102 | 105.0 | 4 860 006.4 | 353 910.8 |
| 103 | 105.8 | 4 859 997.5 | 353 927.3 |
| 103A | 105.8 | 4 859 994.7 | 353 918.9 |
| 104 | 106.3 | 4 859 983.2 | 353 923.9 |
| 105 | 105.3 | 4 860 022.7 | 353 939.8 |
| 106 | 107.0 | 4 859 992.6 | 353 950.3 |
| 107 | 106.4 | 4 860 011.0 | 353 950.0 |
| 108 | 106.3 | 4 860 040.8 | 353 978.0 |

NOTE

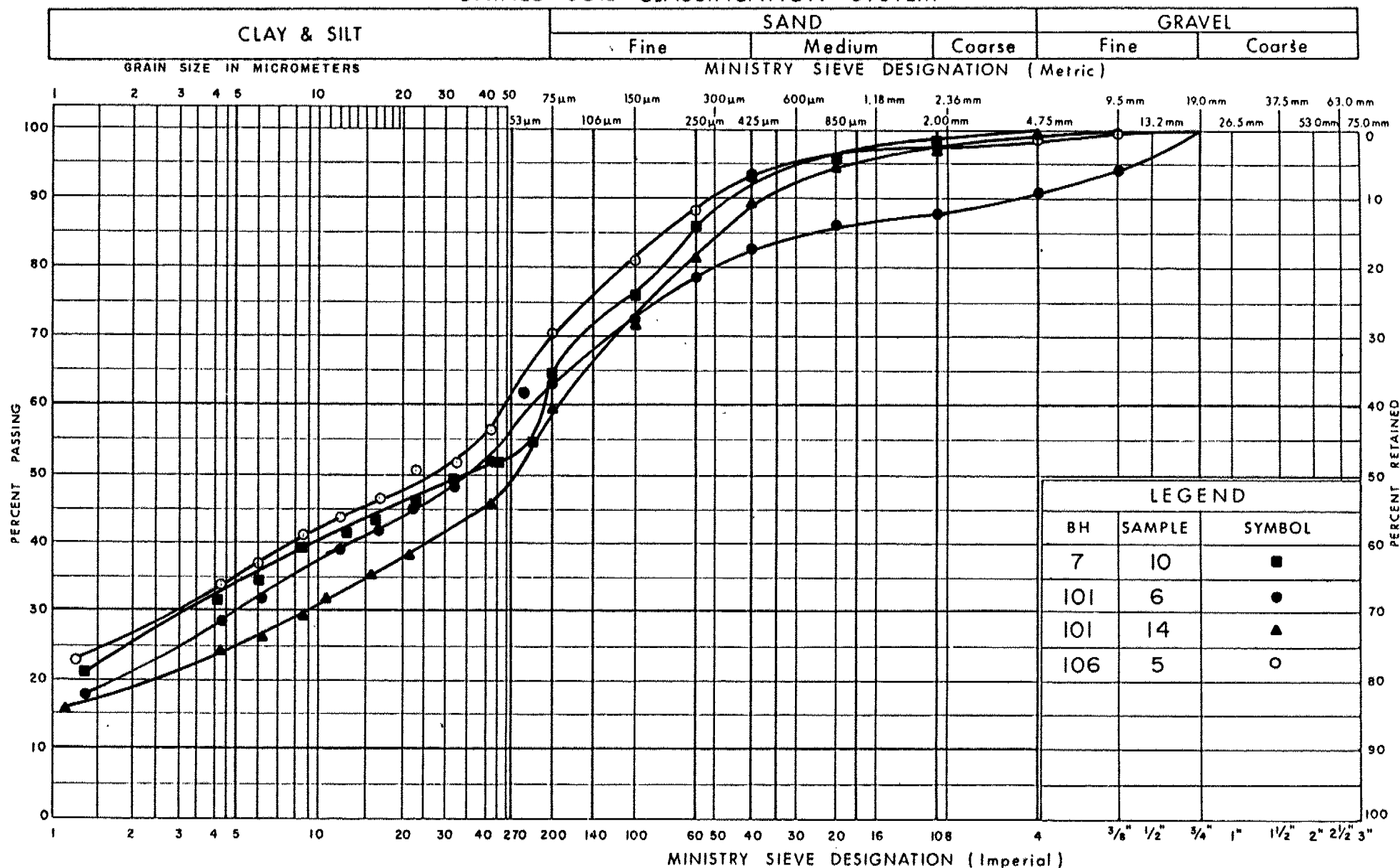
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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 102-2 of Form 100.

GO-ALRT REF

| | | | | | | | | | | | | | |
|--------------------|--|-----------|--|---------------------------------|--|----------------|--|---|--|---|--|--|--|
| REFERENCE DRAWINGS | | REVISIONS | | DRAWN BY: EFO 1985 02 19 | | DESIGNED BY: | | <p>Golder Associates CONSULTING GEOTECHNICAL AND MINING ENGINEERS</p> | <p>GO-ALRT Ministry of Transportation and Communications</p> | <p>PROPOSED UNDERPASS AT THORNTON ROAD GO ALRT EXTENSION - OSHAWA BOREHOLE LOCATIONS & SOIL STRATA</p> | | | |
| | | | | CHK'D BY: M.A. 1985 04 08 | | APPROVED BY: | | | | | | | |
| | | | | SCALE: | | FULL SIZE ONLY | | | | | | | |
| | | | | AS NOTED | | | | | | | | | |
| | | | | | | | | PROJECT MANAGER | | <p>CONTRACT NO</p> <p>DWG NO GGE0018A</p> <p>REV</p> <p>SHEET</p> | | | |

UNIFIED SOIL CLASSIFICATION SYSTEM



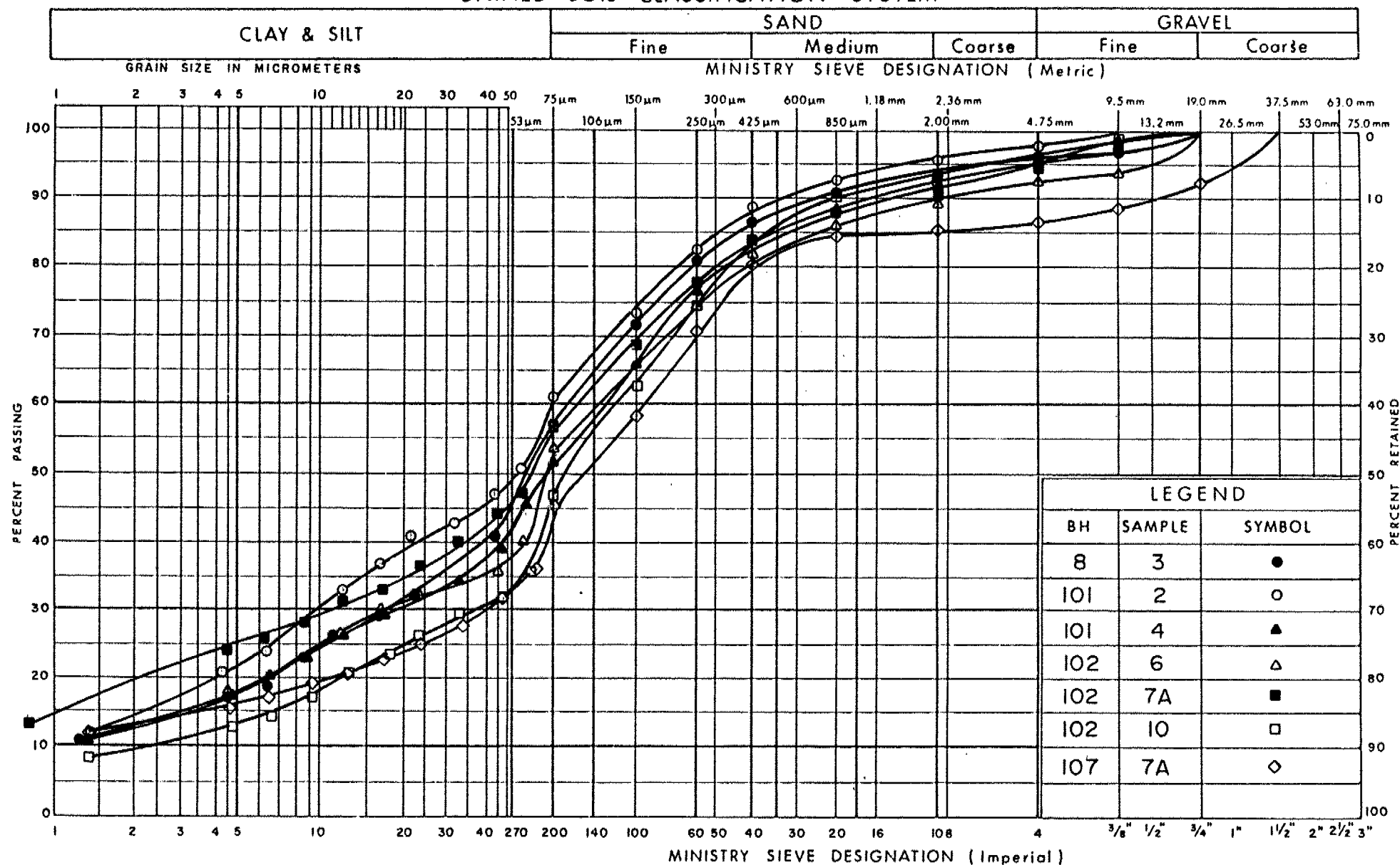
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT TILL

FIG No 1

W P GGE-001-18

UNIFIED SOIL CLASSIFICATION SYSTEM



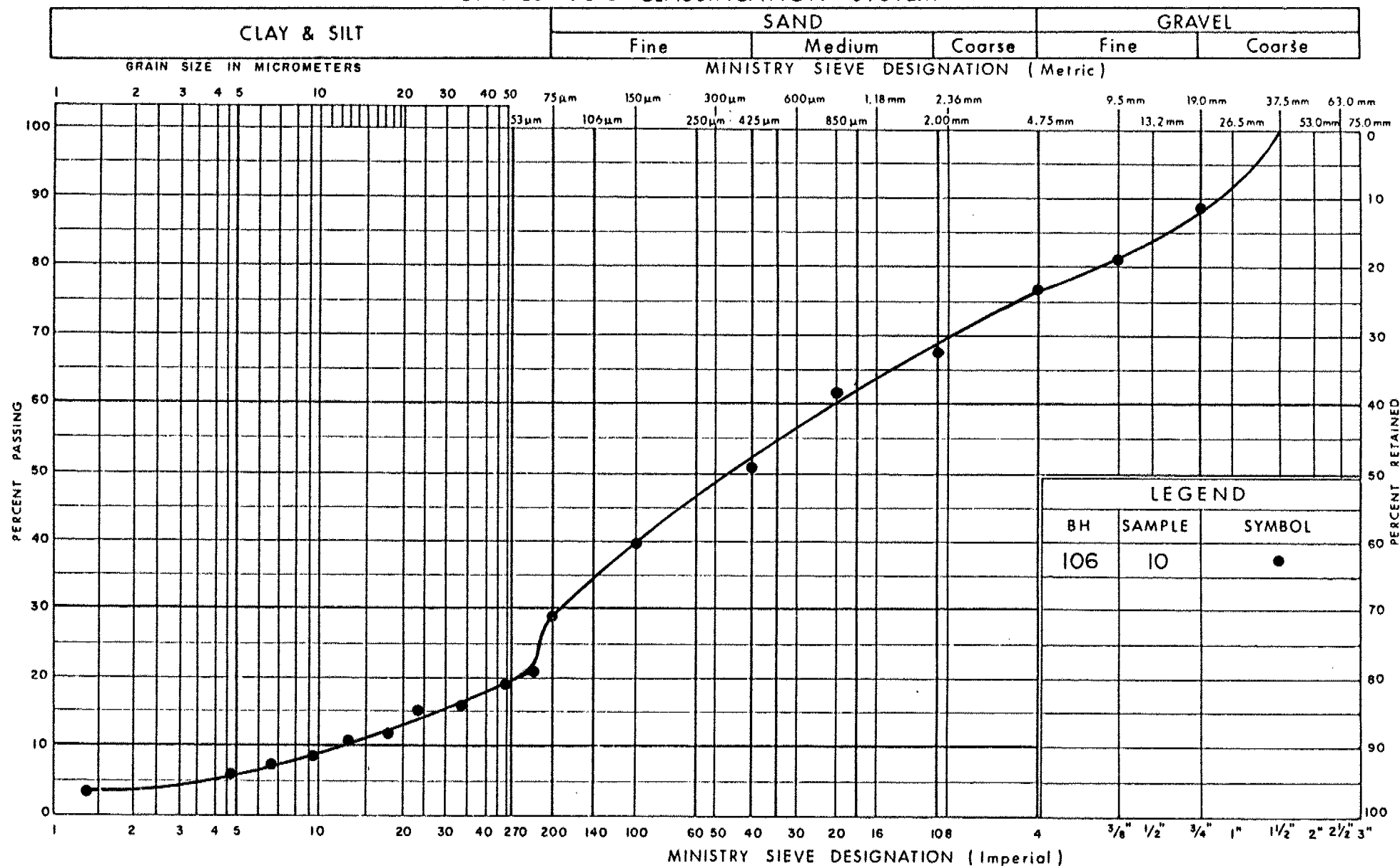
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT TILL

FIG No 2

W P GGE-001-18

UNIFIED SOIL CLASSIFICATION SYSTEM



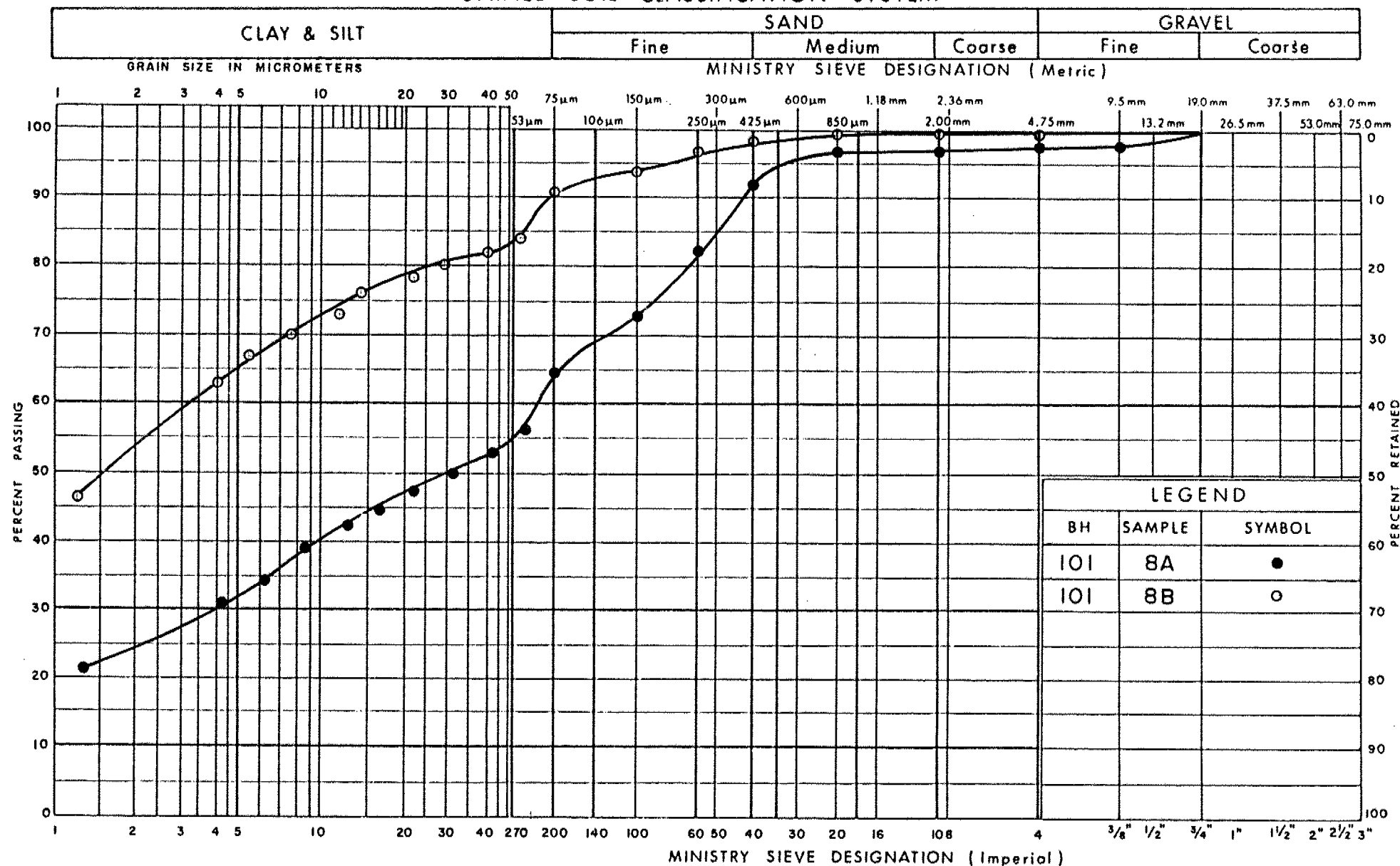
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY SAND TILL

FIG No 3

W P GGE-001-18

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND

| BH | SAMPLE | SYMBOL |
|-----|--------|--------|
| 101 | 8A | ● |
| 101 | 8B | ○ |



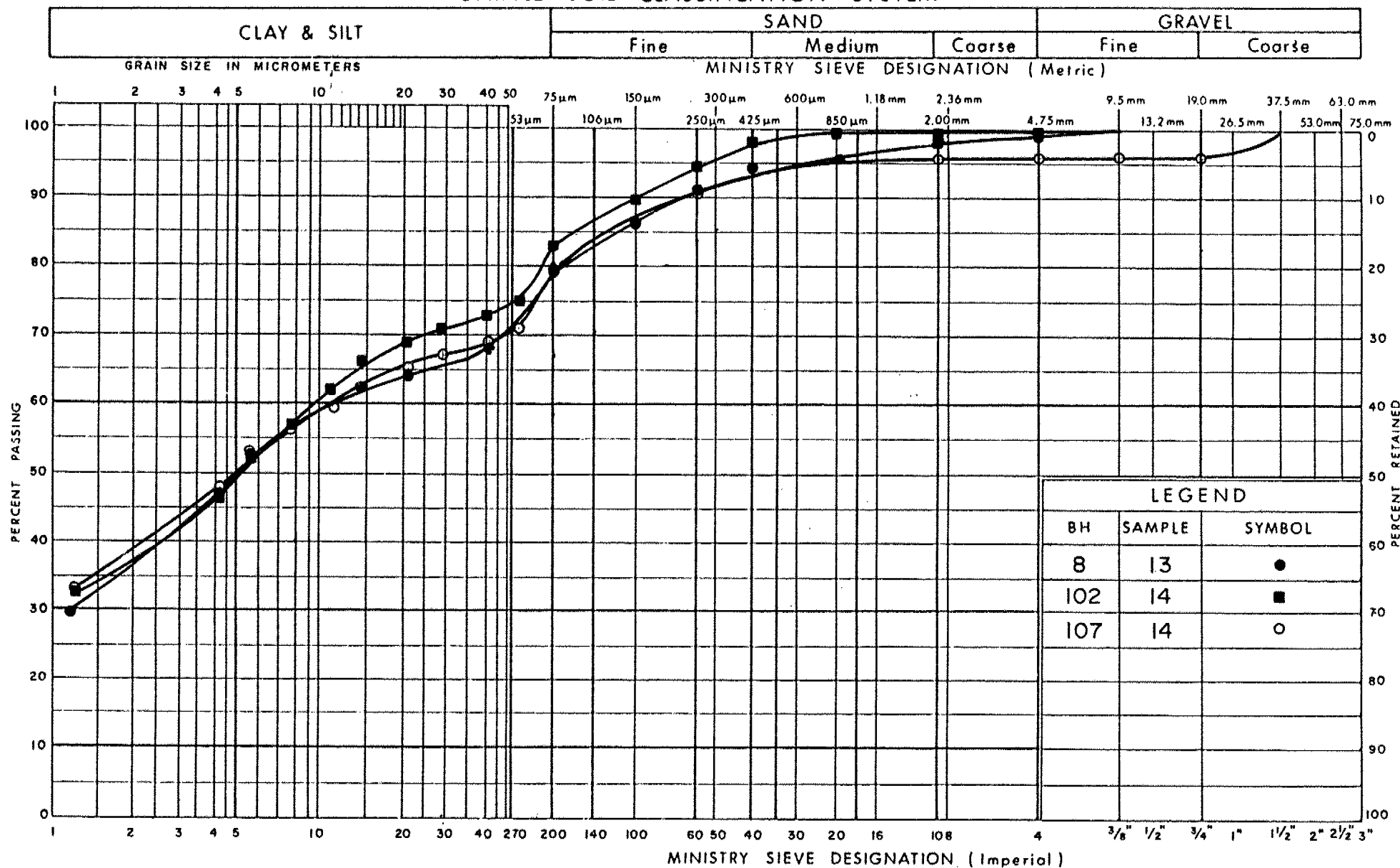
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Communications

GRAIN SIZE DISTRIBUTION VARVED CLAY

FIG No 4

W P GGE-001-18

UNIFIED SOIL CLASSIFICATION SYSTEM



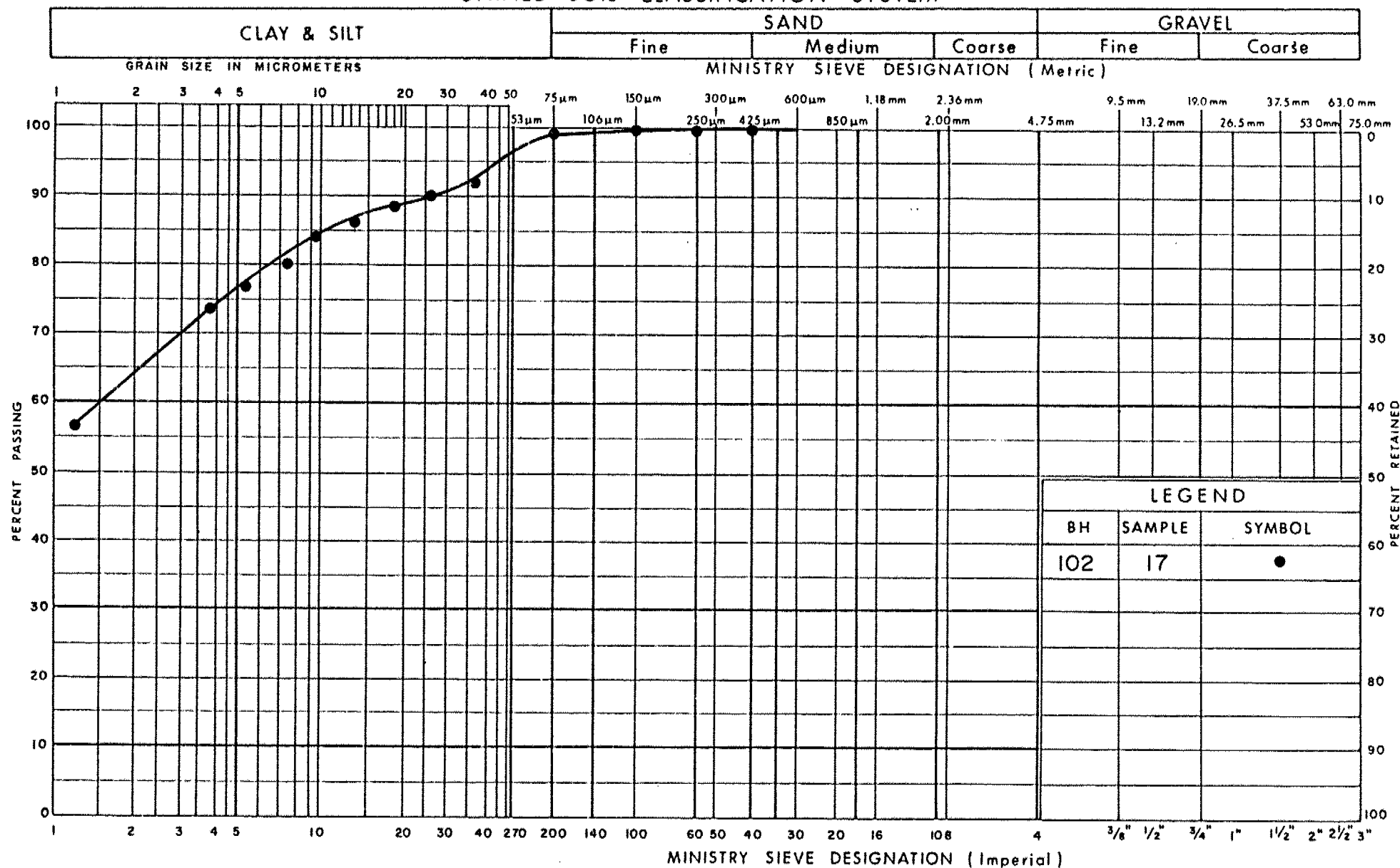
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Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY TILL

FIG No 5

W P GGE-001-18

UNIFIED SOIL CLASSIFICATION SYSTEM

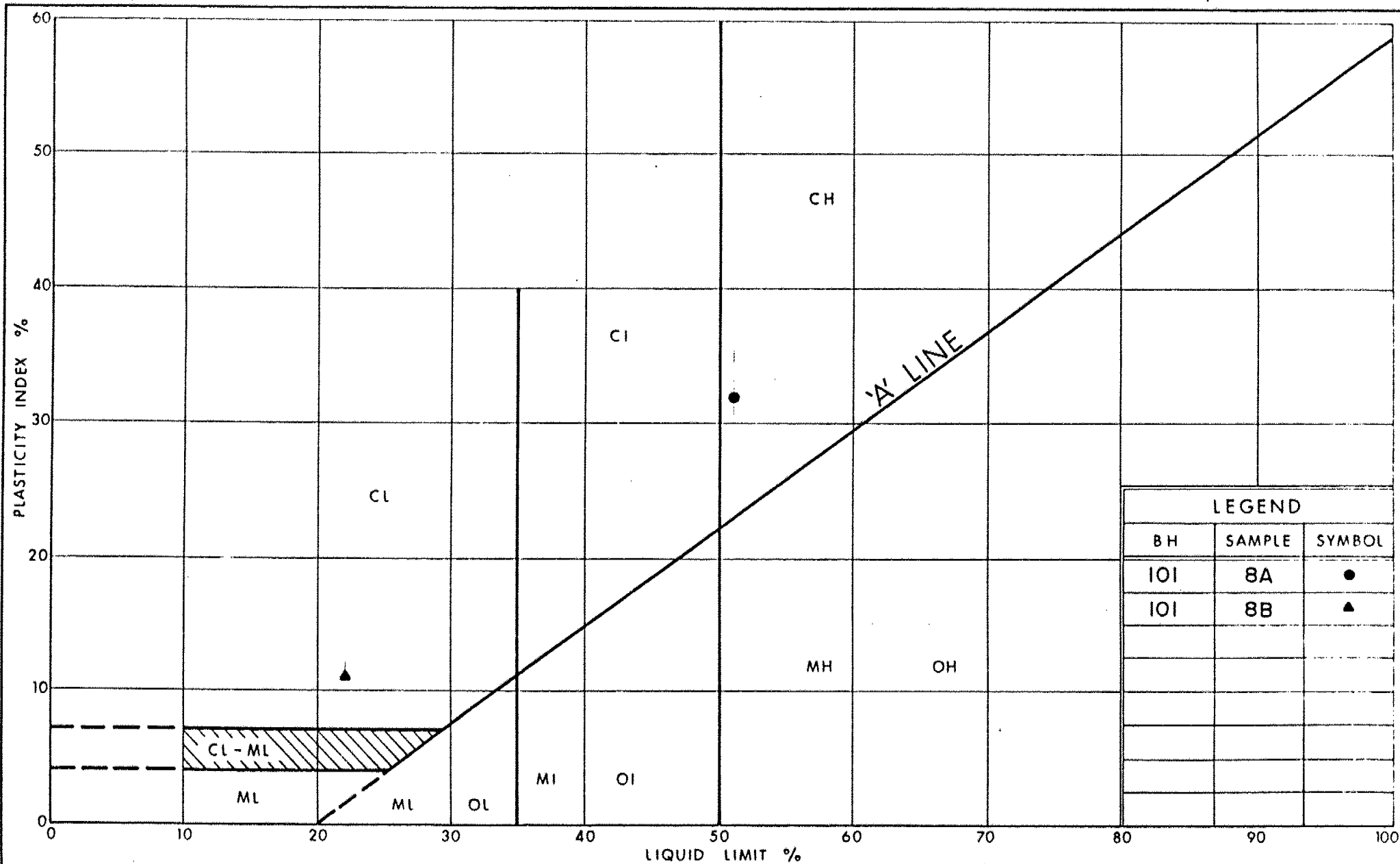


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GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 6

W P GGE-001-18

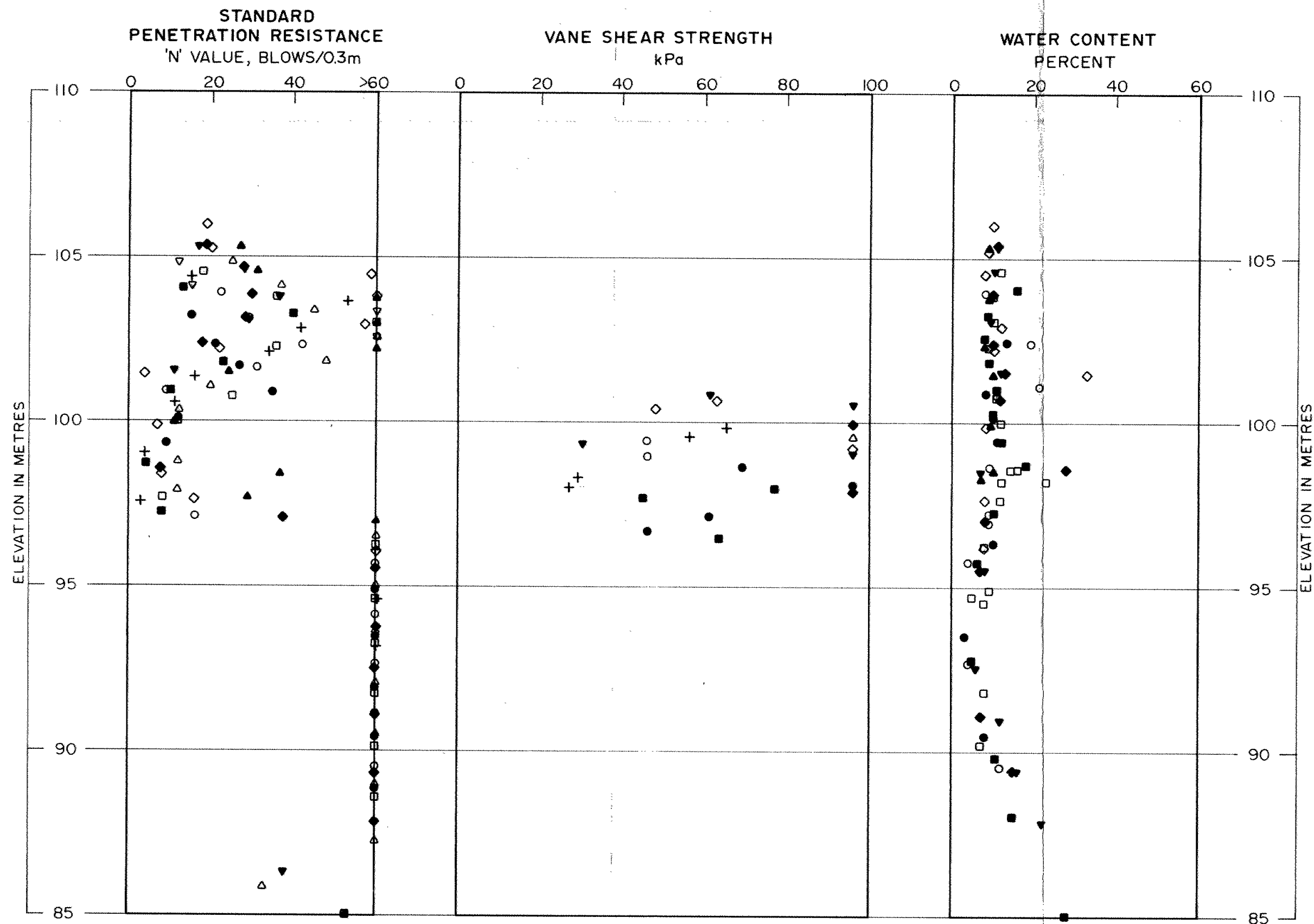


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PLASTICITY CHART VARVED CLAY

FIG No 8

W P GGE-001-18



LEGEND

- Borehole 7
- Borehole 8
- Borehole 101
- Borehole 102
- ▽, △ Borehole 103, 103A
- ▲ Borehole 104
- + Borehole 105
- ◇ Borehole 106
- ◆ Borehole 107
- ▼ Borehole 108



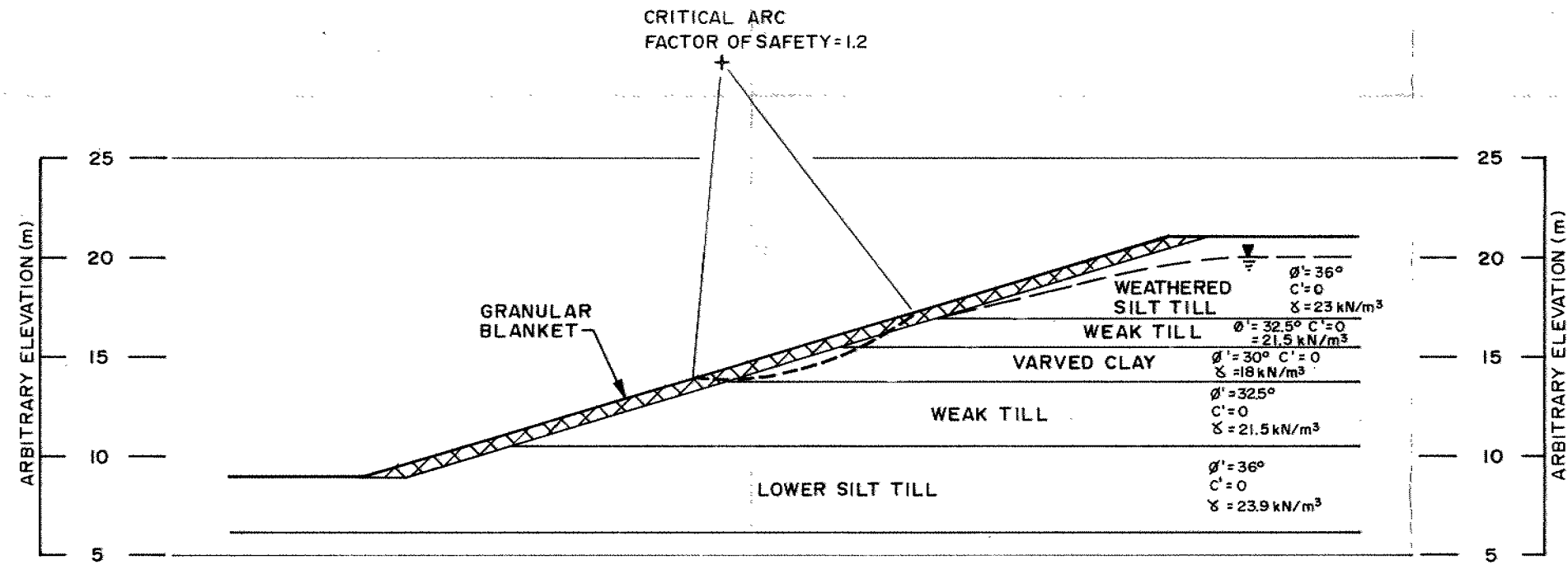
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SUMMARY OF SOILS PROPERTIES

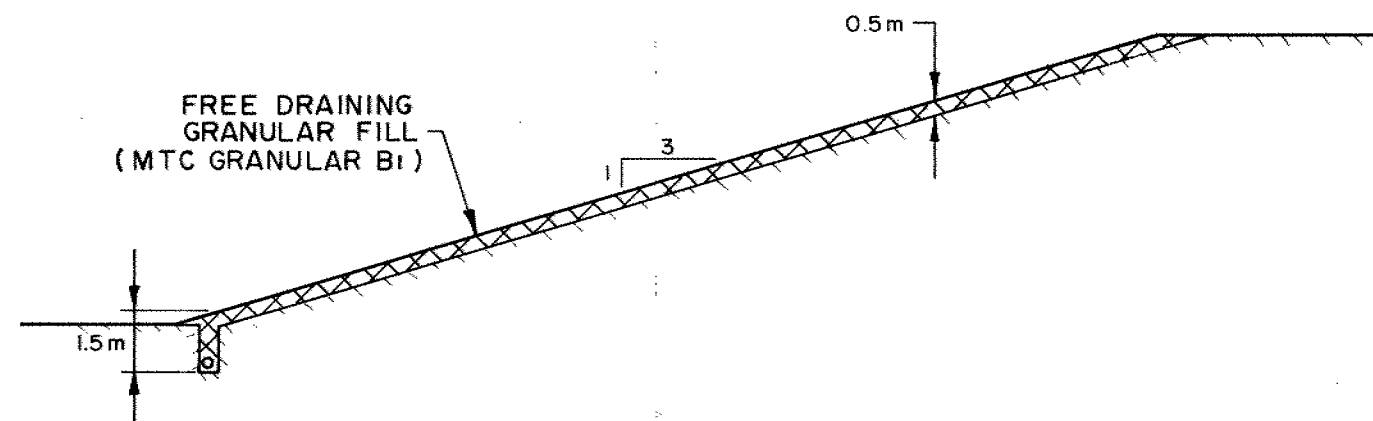
FIG No 9

WP GGE-001-18

OVERSIZE DRAWING(S)



STABILITY ANALYSIS
NOT TO SCALE



SUGGESTED SLOPE PROFILE
NOT TO SCALE

NOTES

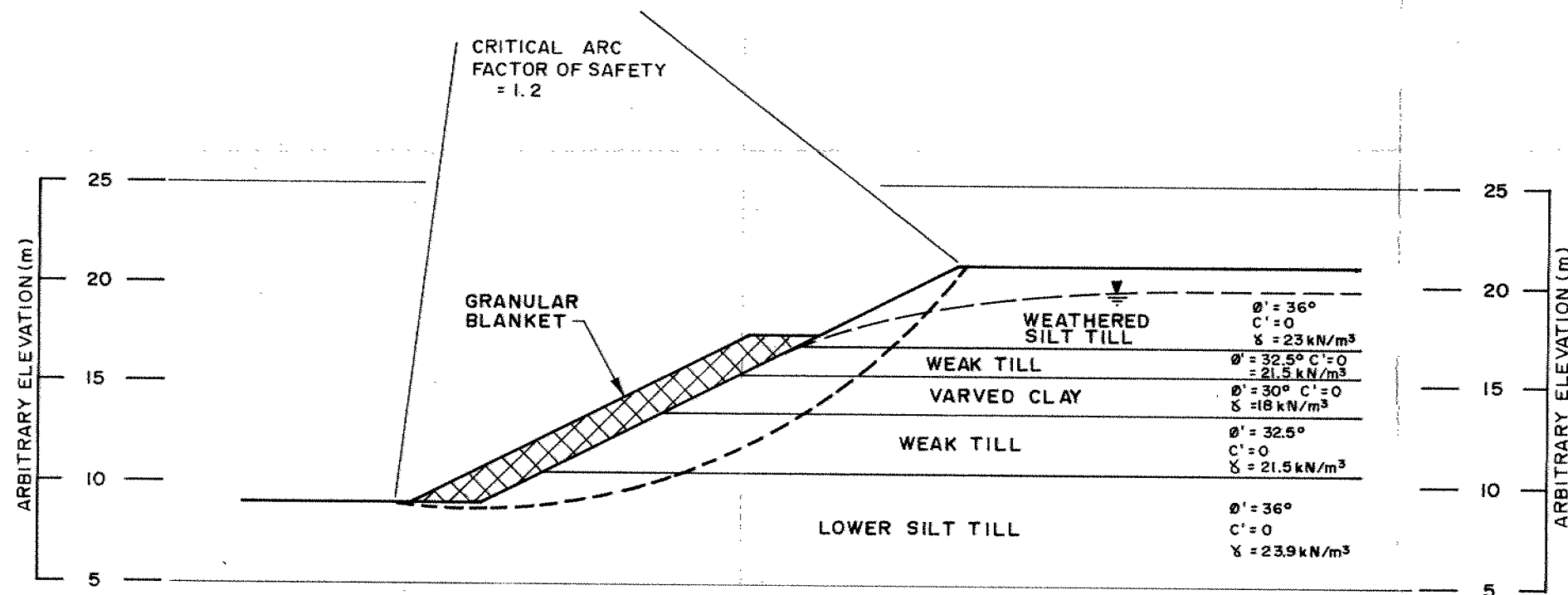
- ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
- GRANULAR BLANKET TO BE PLACED IMMEDIATELY FOLLOWING EXCAVATION OF SLOPES TO FINAL GRADE.
- DRAIN TO BE INSTALLED FOLLOWING PLACEMENT OF BLANKET AND WITHIN 4 WEEKS OF EXCAVATION OF SLOPES TO FINAL GRADE.



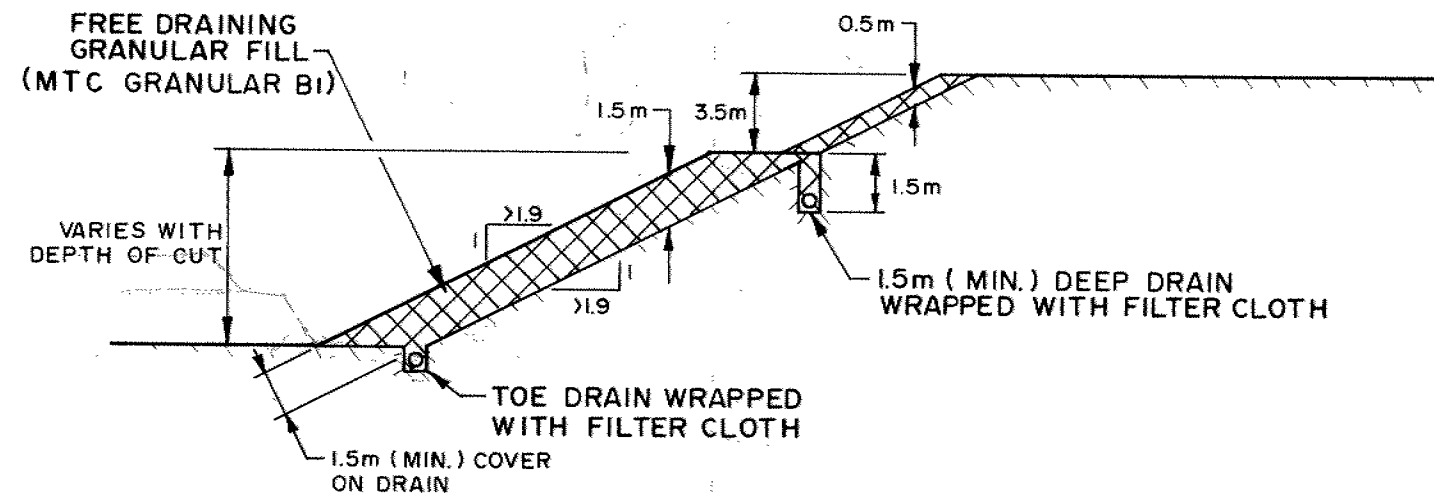
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CUT SLOPE ANALYSIS AND DESIGN
3:1 SLOPE WITH GRANULAR BLANKET AND DRAIN

FIG No 12
WP GGE-001-18



STABILITY ANALYSIS
NOT TO SCALE



SUGGESTED SLOPE PROFILE
NOT TO SCALE

NOTES

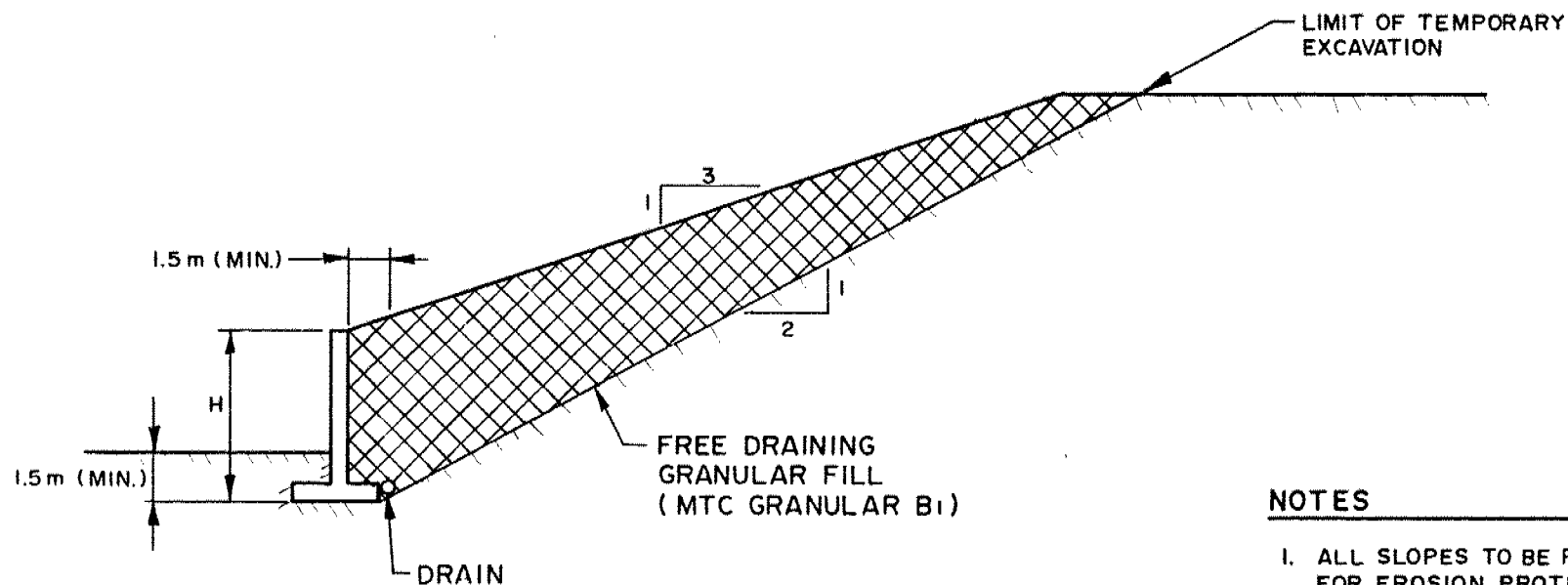
1. ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
2. GRANULAR BERM TO BE PLACED IMMEDIATELY FOLLOWING EXCAVATION OF SLOPES TO FINAL GRADE.
3. DRAINS TO BE INSTALLED FOLLOWING PLACEMENT OF BERM AND WITHIN 4 WEEKS OF EXCAVATION OF SLOPES TO FINAL GRADE.



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Communications

CUT SLOPE ANALYSIS AND DESIGN
2:1 SLOPE WITH GRANULAR BERM AND DRAINS

FIG No 13
WP GGE-001-18



SUGGESTED SLOPE PROFILE

NOT TO SCALE

NOTES

1. ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
2. MINIMUM COVER ON RETAINING WALL FOOTING 1.5m.
3. EARTH PRESSURE FROM $P=KH$
FOR ULS. $K=10 \text{ kN/m}^3$
FOR SLS. $K=8 \text{ kN/m}^3$



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CUT SLOPE ANALYSIS AND DESIGN

3:1 SLOPE WITH LOW RETAINING WALL

FIG No 14

W P GGE-001-18