



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
for  
TWIN CELL CULVERT (SITE NO. 8-610/C)  
HIGHWAY 26, STA. 17+617  
THORNBURY  
G.W.P. 43-00-00  
DISTRICT OF LONDON, ONTARIO**

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PML Ref.: 11KF065A-C3  
Index No. 110FIR and 111FDR  
GEOCRES No. 41A-226  
December 3, 2012



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**FOUNDATION INVESTIGATION REPORT**

for  
Twin Cell Culvert (Site No. 8-610/C)  
Highway 26, Sta. 17+617  
Thornbury  
G.W.P. 43-00-00  
District of London, Ontario

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**1. INTRODUCTION**

This report summarizes the results of the foundation investigation carried out for the new twin cell culvert replacement on Highway 26 near Thornbury. This isolated work unit is part of the rehabilitation of Highway 6, from Springmount to Hepworth. This work was carried out by Peto MacCallum Ltd. (PML) for McCormick Rankin (MRC), a member of MMM Group Ltd. (MMM), on behalf of the Ministry of Transportation of Ontario (MTO).

The purpose of this report is to summarize the subsurface stratigraphy and groundwater conditions encountered in the boreholes advanced during the foundation investigation at the new culvert site.

**2. SITE DESCRIPTION AND GEOLOGY**

The new twin culverts will replace the existing twin culverts located under the Highway 26 eastbound and westbound lanes, about 80 m west of the intersection of Highway 26 and Lakeshore Road in Thornbury, Ontario. The existing twin culverts are 1.7 m by 1.9 m CSP type pipe structures and convey the flow from the unnamed Watercourse WC-3.

Land use in the vicinity of the site includes the existing Highway 26 transportation corridor and vacant areas vegetated with grass, brush and scattered trees. The topography of the site is generally level. Site photographs of the culvert location are included in the Appendix A.

The geology in the vicinity of the site consists of three to four till strata over bedrock consisting of Ordovician Shale which is anticipated at about 23 m depth based on Drift Thickness Series Map of the Collingwood – Nottawasaga Area (Preliminary Map P.925).



### **3. INVESTIGATION PROCEDURES**

The subsurface investigation was carried out on December 6, 12 and 13, 2011. Three boreholes, CT3-1 to CT3-3 were drilled to 9.6 to 12.3 m, elevation 170.0 to 171.9, as shown on Drawing TWC-1, appended.

The boreholes were advanced with a truck-mounted CME 55 drill rig using continuous flight hollow stem augers. The equipment was supplied and operated by a specialist drilling contractor, working under the full-time supervision of a PML field supervisor. Since wet sand was contacted in the boreholes, a dynamic cone test was conducted near boreholes CT3-1 and CT3-2 to verify the SPT N values. Results of the dynamic cone test are shown on the borehole logs.

Soil samples were recovered from the boreholes at regular 0.75 and 1.5 m intervals of depth using the standard penetration test method. Standard penetration tests were conducted to assess the strength characteristics of the substrata. Soils were identified in accordance with the MTO soil classification manual procedures. The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open holes.

The boreholes were backfilled with a bentonite/cement mixture where required in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment.

The co-ordinates and ground elevations at the borehole locations were provided by MMM. The borehole locations are indicated on Drawing TWC-1. All elevations in this report are in metres.

The recovered soil samples were returned to our laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (30)
- Grain size distribution analyses (8)
- Atterberg Limits (1)



The laboratory grain size distribution charts are presented in Figures CT3-GS-1 to CT3-GS-6. The plasticity chart is presented in Figure CT3-PC-1. All of the test results are summarized on the Record of Borehole sheets.

#### **4. SUMMARIZED SUBSURFACE CONDITIONS**

Reference is made to the appended Record of Borehole Sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test results as well as groundwater observations. The results of laboratory particle size distributions, Atterberg Limits test and moisture content determinations are also shown on the Record of Borehole Sheets. The approximate borehole locations are presented on the foundation Drawing TWC-1.

Three boreholes (CT3-1 to CT3-3) were drilled along the alignment of this culvert to depths of 9.6 to 12.3 m, elevation 170.0 to 171.9. The subsurface stratigraphy revealed in the boreholes generally comprised of surficial topsoil or local fill underlain by silt and sand mixtures in varying proportions. The boreholes were terminated within the silty sand/sandy silt till stratum. Groundwater was observed in all the boreholes at the time of drilling; however it was only observed in boreholes CT3-1, and CT3-2 on completion of drilling.

##### **4.1.1 Topsoil**

A 200 and 300 mm thick layer of topsoil was contacted in boreholes CT3-1 and CT3-3, respectively.

##### **4.1.2 Sand and Gravel Fill**

A surficial fill stratum was contacted in borehole CT3-2 to 2.2 m, elevation 180.4 drilled off the shoulder of the highway. The fill consisted of compact sand and gravel. SPT N values in the fill ranged from 14 to 18.



#### 4.1.3 Sand and Gravel

Below the fill in Borehole CT3-2, a localized 0.8 m thick sand and gravel stratum was contacted from 2.2 m, elevation 180.4 to 3.0 m, elevation 179.6. SPT N value in the sand and gravel stratum was 12 indicating a compact relative density.

The results of grain size distribution analysis for a sample from this stratum are included in Figure CT3-GS-2. The moisture content of the sample was 7%.

#### 4.1.4 Silty Sand/Silt with Sand/Silt

Cohesionless deposits of varying gradations were encountered in the three boreholes.

Below the surficial topsoil in borehole CT3-3, a 2.2 m thick silty sand stratum was contacted to 2.5 m, elevation 179.0. SPT N values in the silty sand stratum ranged from 13 to 50 blows without penetration. The SPT N value of 50 blows without penetration is likely due to the presence of cobbles in this stratum.

Below the surficial topsoil layer in borehole CT3-1, a 1.4 m thick stratum of silt with sand was contacted to 1.6 m, elevation 179.5. SPT N values in this unit ranged from 6 to 9 indicating a loose relative density.

The results of grain size distribution analysis for a sample from this stratum are included in Figure CT3-GS-1. The moisture content of the sample was 32%, indicating a wet condition.

Below the sand and gravel in borehole CT3-2, a 0.7 m thick silt stratum with some sand was contacted from 3.0 m, elevation 179.6 to 3.7 m, elevation 178.9. The single SPT N value in the silt was 25 indicating a compact relative density.

Below the silt with sand layer in borehole CT3-1, a 4.4 m thick silt stratum was contacted from 1.6 m, elevation 179.5 to 6.0 m, elevation 175.1. SPT N values in this stratum ranged from 2 to 24 indicating a very loose to compact relative density. A localized very loose to loose layer of silt with SPT N values of 2 and 4 was contacted from elevation 175.4 to 176.6. This loose layer was confirmed by the dynamic cone test conducted adjacent to the borehole.



The results of grain size distribution analysis for two samples from the silt stratum are included in Figure CT3-GS-3. The moisture content of the sample from borehole CT3-2 was 11% while the moisture content of the sample from borehole CT3-1 was 23%.

#### 4.1.5 Clayey Silt

Below the silt stratum in borehole CT3-2, a 1.8 m thick soft clayey silt stratum was contacted from 3.7 m, elevation 178.9 to 5.5 m, elevation 177.1. SPT N values in the silt stratum were 3 and 13. Cobbles were contacted from elevation 175.8 to 176.5 within the clayey silt. The SPT N value of 13 was likely elevated due to presence of cobbles.

The results of the grain size distribution analysis for the clayey silt sample are included in Figure CT3-GS-4. The Atterberg liquid and plastic limits were 24 and 17 respectively, with a plasticity index of 7. A plasticity chart of the clayey silt sample is presented in Figure CT3-PC-1.

#### 4.1.6 Sandy Silt Till /Silt and Sand Till /Silty Sand Till

A cohesionless till deposit consisting of varying amounts of silt and sand was contacted in all three boreholes to the borehole termination depths of 9.6 to 12.3 m, elevation 170.0 to 171.9 as described in detail below.

Below the silt in borehole CT3-1, a 5.1 m thick sandy silt till stratum was contacted from 6.0 m, elevation 175.1 to the borehole termination depth of 11.1 m, elevation 170.0. SPT N values in this stratum ranged from 7 to 64 indicating a loose to very dense relative density.

The results of the grain size distribution analysis for the sandy silt till sample are included in Figure CT3-GS-5. The moisture content of the recovered sample was 11%.

Underlying the clayey silt stratum in borehole CT3-2, a 6.8 m thick, a sandy silt stratum was contacted from 5.5 m, elevation 177.1 to the borehole termination depth of 12.3 m, elevation 170.3. SPT N values in this stratum ranged from 18 to 50 blows per 80 mm, indicating a compact to very dense





relative density. Shale fragments were contacted below 10.5 m, elevation 172.1. A sand and gravel layer was contacted below 11.9 m, elevation 170.7 in this stratum.

Below the silty sand stratum in borehole CT3-3, a 2.1 m thick silt and sand till stratum was contacted from 2.5 m, elevation 179.0 to 4.6 m depth, elevation 176.9. SPT N values in this stratum ranged from 9 to 65 indicating a loose to very dense relative density.

The results of the grain size distribution analysis for two samples recovered from this stratum are included in Figure CT3-GS-6. Moisture contents of the samples were 7 and 8%.

Below the silt and sand till stratum, a 5.0 m thick silty sand till stratum was contacted from 4.6 m, elevation 176.9 to the borehole termination depth of 9.6 m, elevation 171.9 in borehole CT3-3. SPT N values in this stratum ranged from 25 to 92 blows indicating a compact to very dense relative density. Shale fragments were observed in this stratum below 7.6 m, elevation 173.9 and sandy silt seams were observed below 9.1 m, elevation 172.4.

#### 4.1.7 Groundwater

During augering, groundwater was observed at 0.9 to 3.6 m, elevation 179.0 to 180.6 in all the boreholes. Ground water was observed at 1.2 and 6.4 m, elevation 179.9 and 176.2, respectively in boreholes CT3-1 and CT3-2, on completion of drilling. Groundwater was not observed in boreholes CT3-3 on completion of drilling. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

### 5. MISCELLANEOUS

Mr Alan Lo carried out the field investigation for this study under the supervision of Mrs. N .S. Balakumaran, P. Eng. Aardvaark Drilling Ltd. supplied the drill rig for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.



## 6. CLOSURE

This Foundation Investigation Report was prepared by Mr. H. Gharegrat, P. Eng., and reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Project Manager carried out an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



Harry Gharegrat, MS, P.Eng.  
Senior Engineer

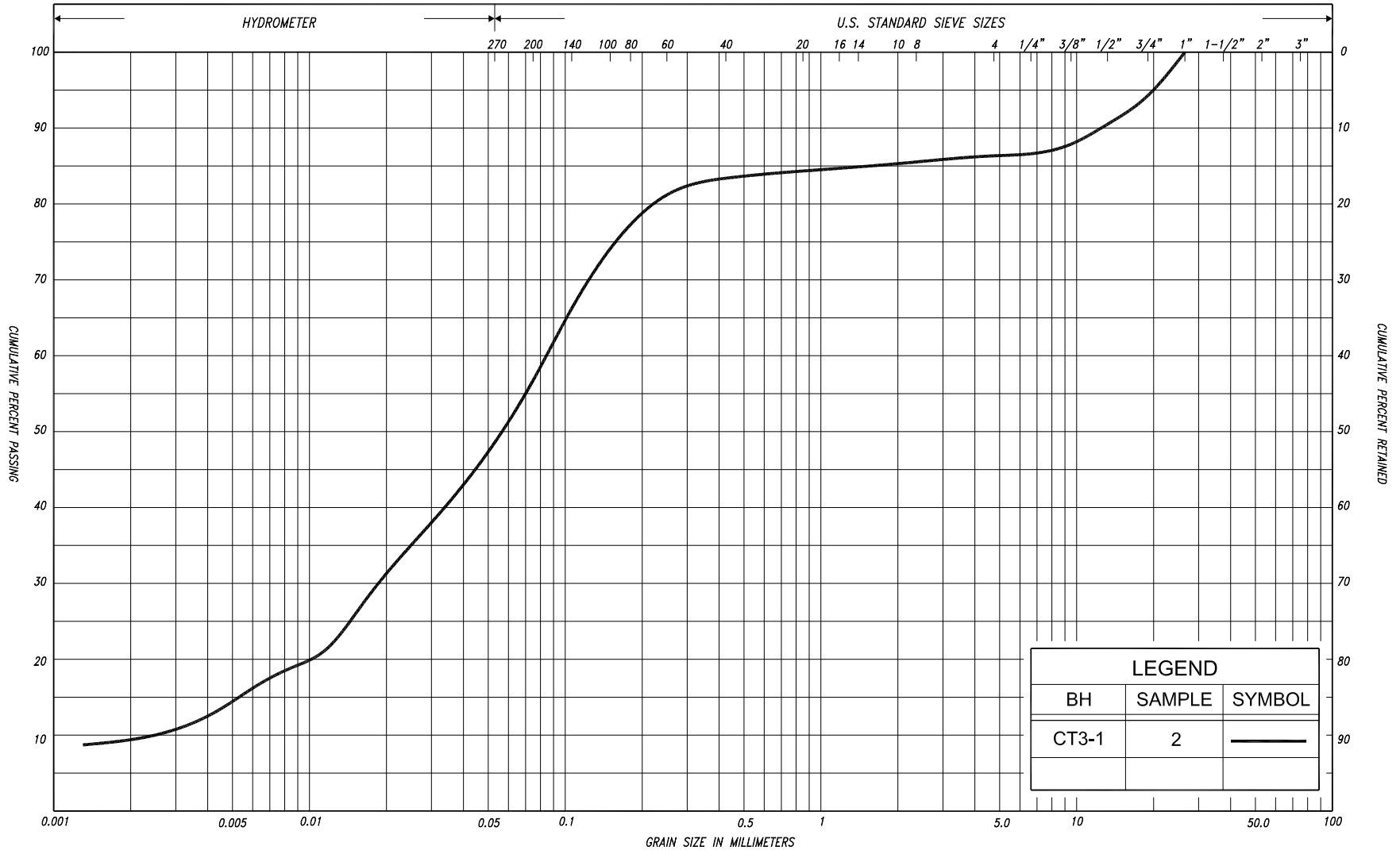


C.M. P. Nascimento, P.Eng.,  
Project Manager

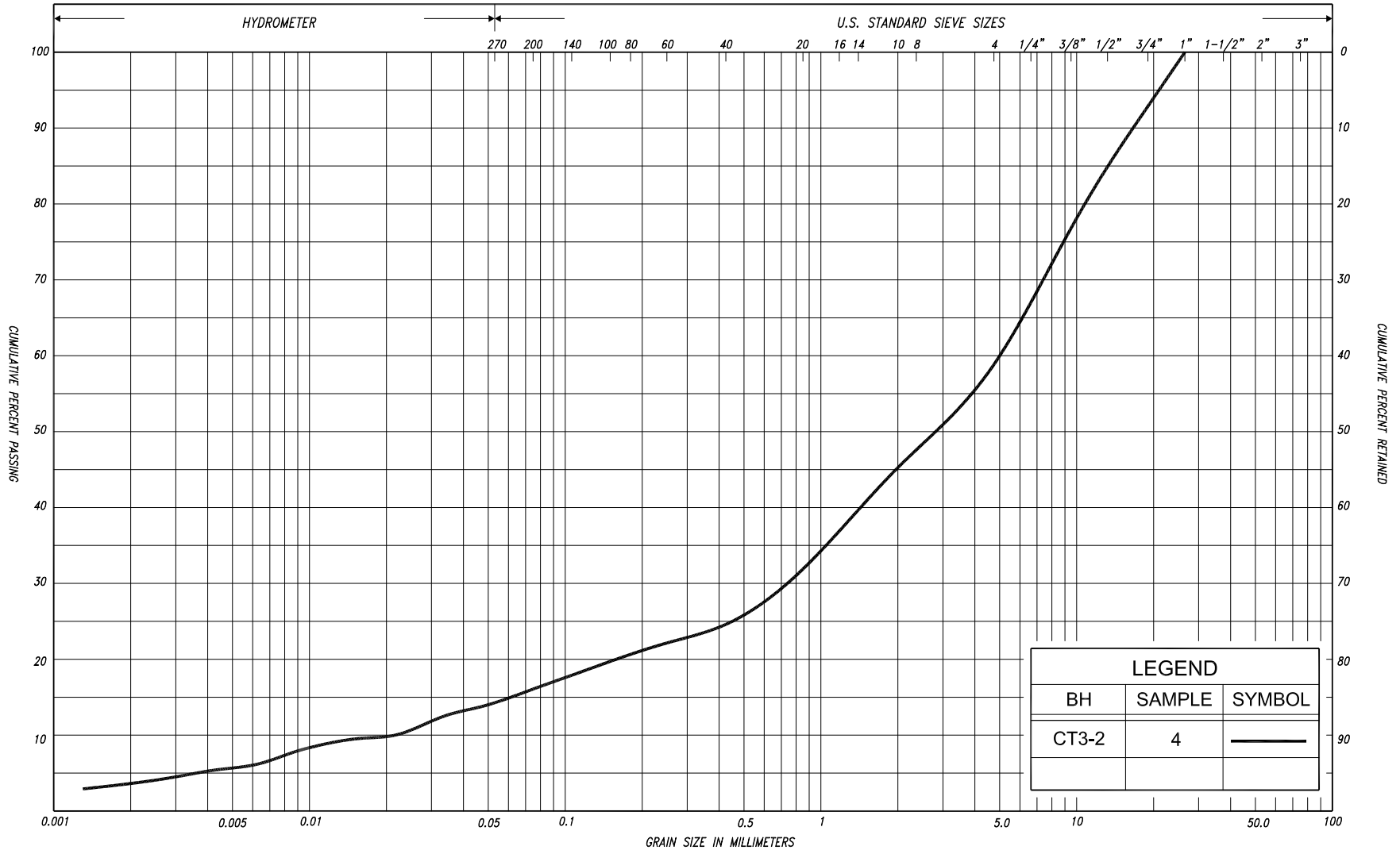


Brian R. Gray, MEng., P.Eng.  
MTO Designated Principal Contact

HG:hg-nk



|             |      |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |             |
|-------------|------|--|--------|--|--------|---------|--------|------|--------|--|--------|--|--------|--|----------|---------|---------|-------------|
| SILT & CLAY |      |  |        |  | FINE   |         | MEDIUM |      | COARSE |  | GRAVEL |  |        |  | COB BLES | UNIFIED |         |             |
|             |      |  |        |  | SAND   |         |        |      |        |  |        |  |        |  |          |         |         |             |
| CLAY        | FINE |  | MEDIUM |  | COARSE |         | FINE   |      | MEDIUM |  | COARSE |  | GRAVEL |  |          |         | COBBLES | M.I.T.      |
|             | SILT |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |             |
| CLAY        |      |  | SILT   |  |        | V. FINE | FINE   | MED. | COARSE |  | GRAVEL |  |        |  |          |         |         | U.S. BUREAU |
|             |      |  |        |  | SAND   |         |        |      |        |  |        |  |        |  |          |         |         |             |



|             |      |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |        |             |
|-------------|------|--|--------|--|--------|---------|--------|------|--------|--|--------|--|--------|--|----------|---------|---------|--------|-------------|
| SILT & CLAY |      |  |        |  | FINE   |         | MEDIUM |      | COARSE |  | GRAVEL |  |        |  | COB BLES | UNIFIED |         |        |             |
|             |      |  |        |  | SAND   |         |        |      |        |  |        |  |        |  |          |         |         |        |             |
| CLAY        | FINE |  | MEDIUM |  | COARSE |         | FINE   |      | MEDIUM |  | COARSE |  | GRAVEL |  |          |         | COBBLES | M.I.T. |             |
|             | SILT |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |        |             |
| CLAY        |      |  | SILT   |  |        | V. FINE | FINE   | MED. | COARSE |  | GRAVEL |  |        |  |          |         |         |        | U.S. BUREAU |
|             |      |  |        |  |        | SAND    |        |      |        |  |        |  |        |  |          |         |         |        |             |



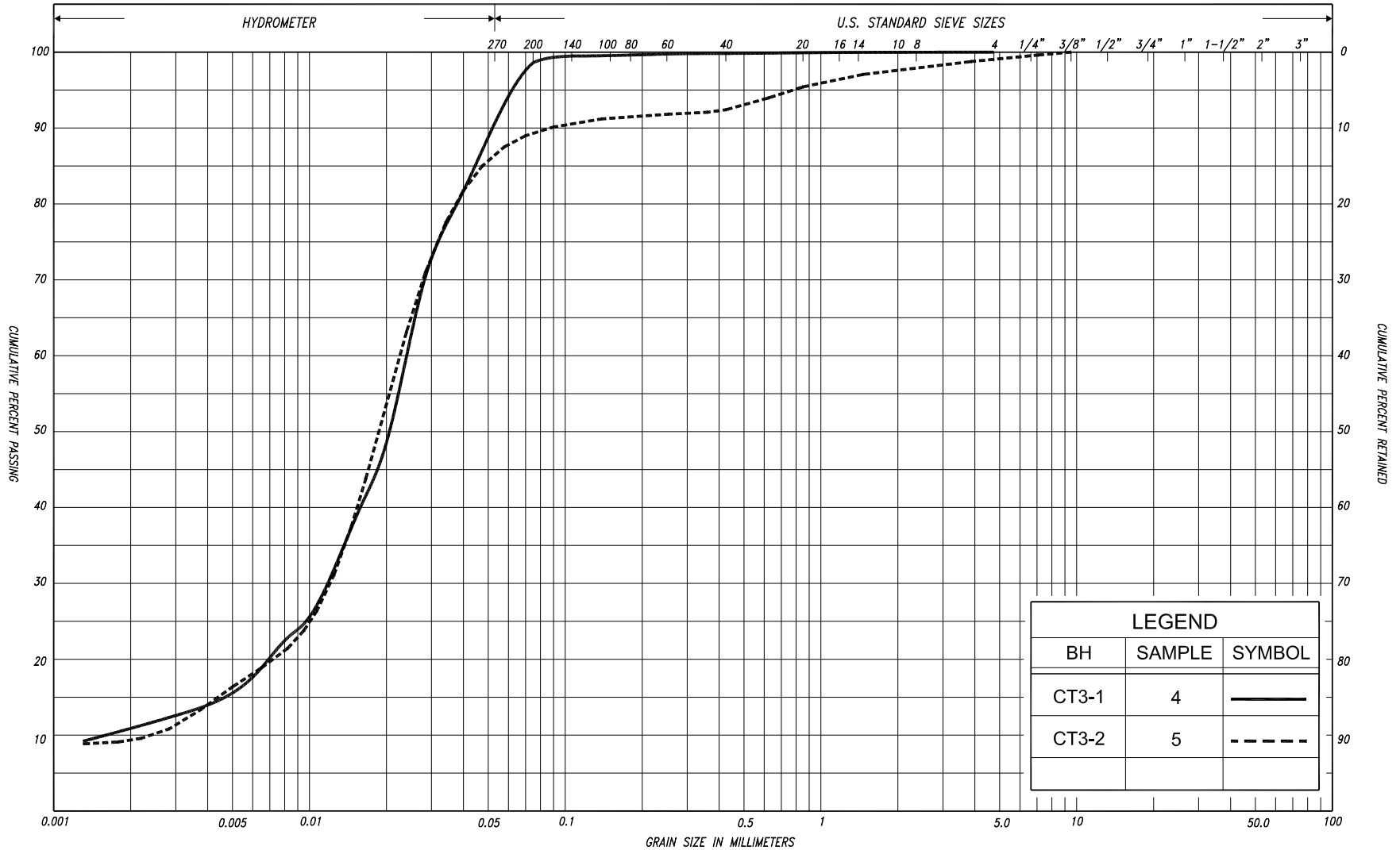
## GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL, some silt, trace clay

FIG No. CT3-GS-2

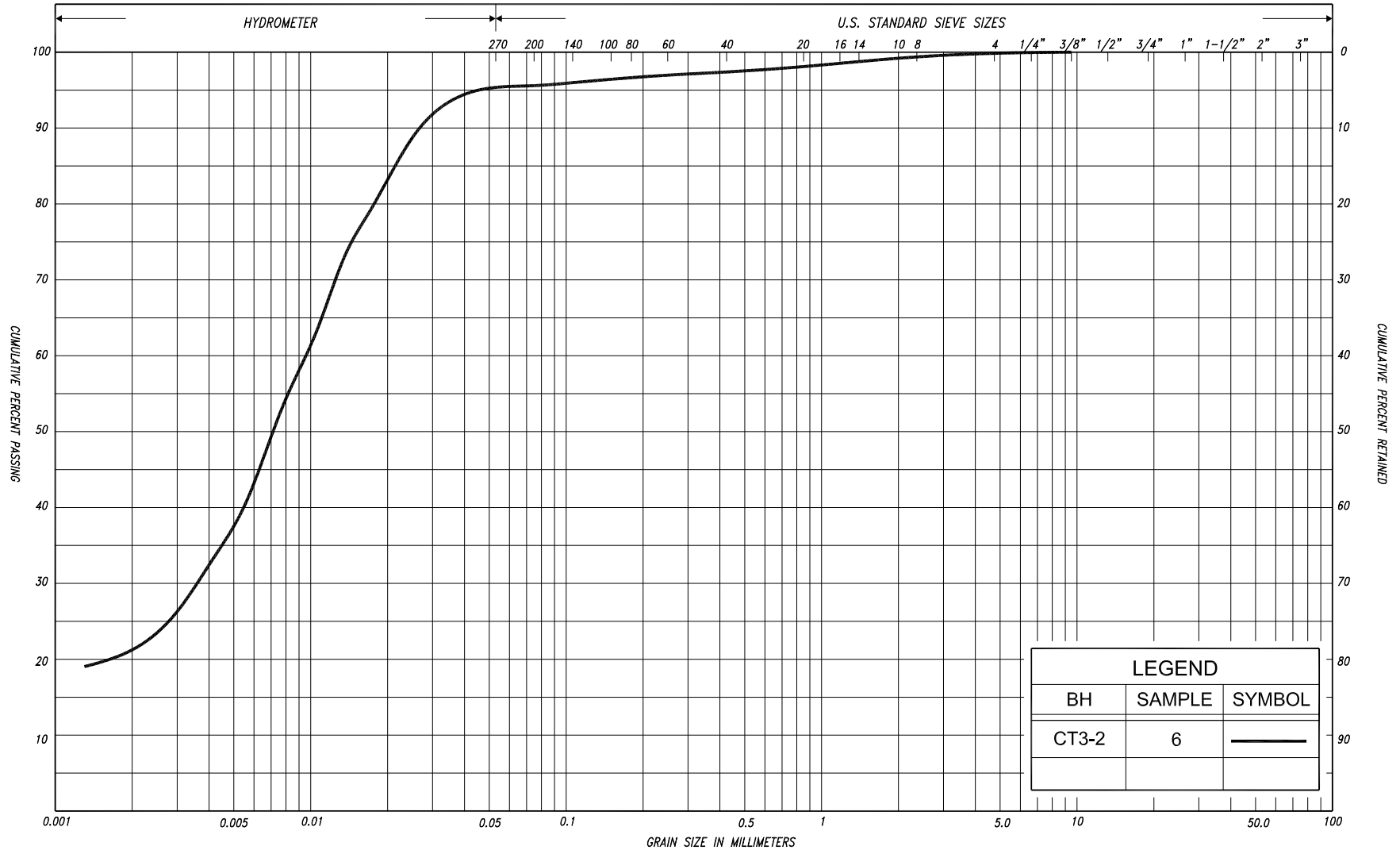
HWY: 26


G.W.P. No. 43-00-00



| LEGEND |        |           |
|--------|--------|-----------|
| BH     | SAMPLE | SYMBOL    |
| CT3-1  | 4      | ————      |
| CT3-2  | 5      | - - - - - |
|        |        |           |

|             |      |  |        |  |        |         |        |      |        |      |        |        |        |        |             |         |         |             |
|-------------|------|--|--------|--|--------|---------|--------|------|--------|------|--------|--------|--------|--------|-------------|---------|---------|-------------|
| SILT & CLAY |      |  |        |  | FINE   |         | MEDIUM |      | COARSE |      | GRAVEL |        |        |        | COB<br>BLES | UNIFIED |         |             |
|             |      |  |        |  | SAND   |         |        |      |        |      |        |        |        |        |             |         |         |             |
| CLAY        | FINE |  | MEDIUM |  | COARSE |         | FINE   |      | MEDIUM |      | COARSE |        | GRAVEL |        |             |         | COBBLES | M.I.T.      |
|             | SILT |  |        |  |        |         |        |      |        |      |        |        |        |        |             |         |         |             |
| CLAY        |      |  | SILT   |  |        | V. FINE |        | FINE |        | MED. |        | COARSE |        | GRAVEL |             |         |         | U.S. BUREAU |
|             |      |  |        |  | SAND   |         |        |      |        |      |        |        |        |        |             |         |         |             |



| LEGEND |        |   |
|--------|--------|---|
| BH     | SAMPLE | SYMBOL  |
| CT3-2  | 6      |  |
|        |        |   |

|             |      |  |        |  |        |         |      |      |        |      |        |        |        |        |  |        |         |        |             |             |         |
|-------------|------|--|--------|--|--------|---------|------|------|--------|------|--------|--------|--------|--------|--|--------|---------|--------|-------------|-------------|---------|
| SILT & CLAY |      |  |        |  |        |         |      |      |        | FINE |        | MEDIUM |        | COARSE |  | GRAVEL |         |        |             | COB<br>BLES | UNIFIED |
|             |      |  |        |  |        |         |      |      |        | SAND |        |        |        |        |  |        |         |        |             |             |         |
| CLAY        | FINE |  | MEDIUM |  | COARSE |         | FINE |      | MEDIUM |      | COARSE |        | GRAVEL |        |  |        | COBBLES | M.I.T. |             |             |         |
|             | SILT |  |        |  |        |         |      |      |        |      |        |        |        |        |  |        |         |        |             |             |         |
| CLAY        |      |  | SILT   |  |        | V. FINE | FINE | MED. | COARSE |      | GRAVEL |        |        |        |  |        |         |        | U.S. BUREAU |             |         |
|             |      |  |        |  |        | SAND    |      |      |        |      |        |        |        |        |  |        |         |        |             |             |         |



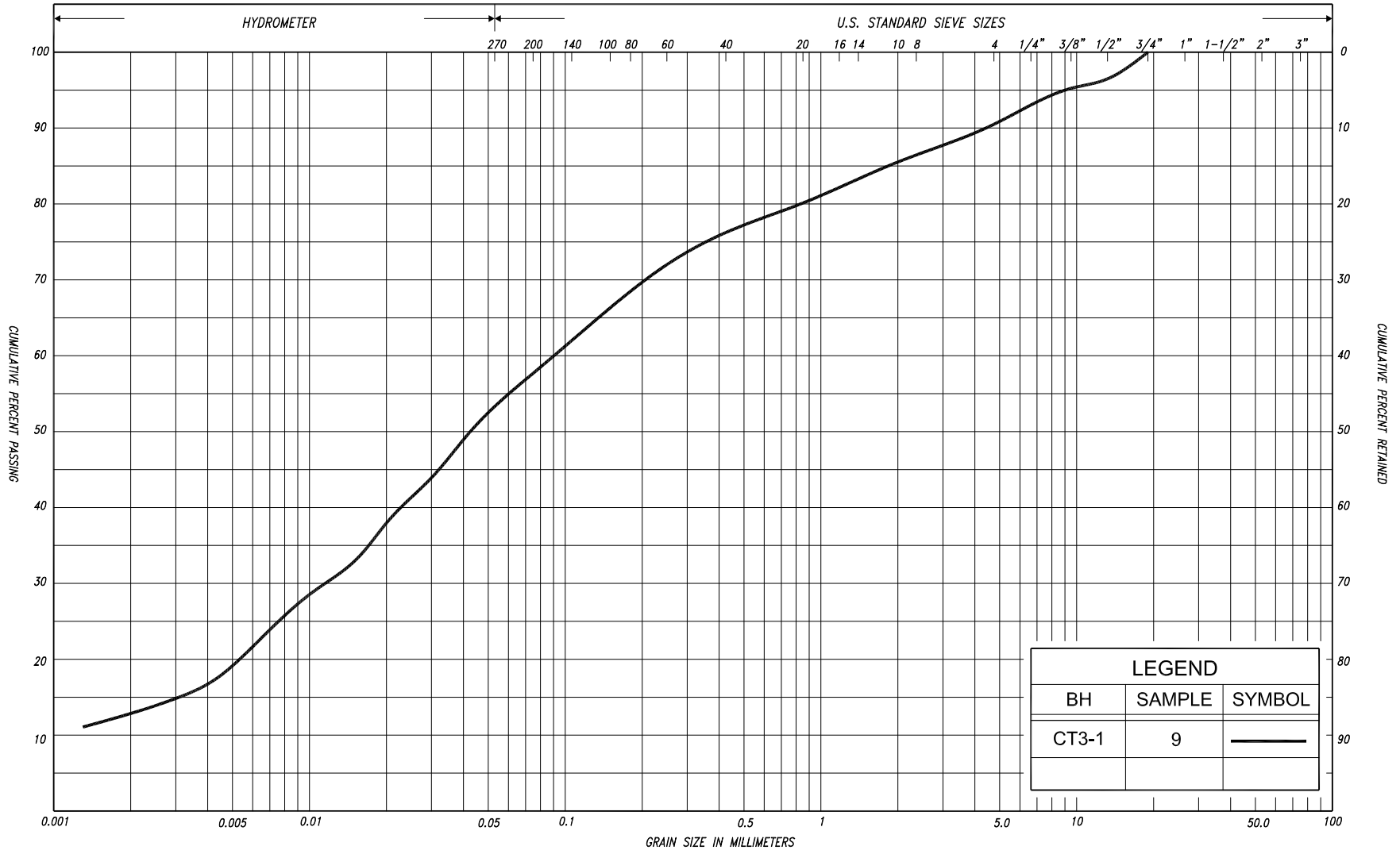
## GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand (CL)

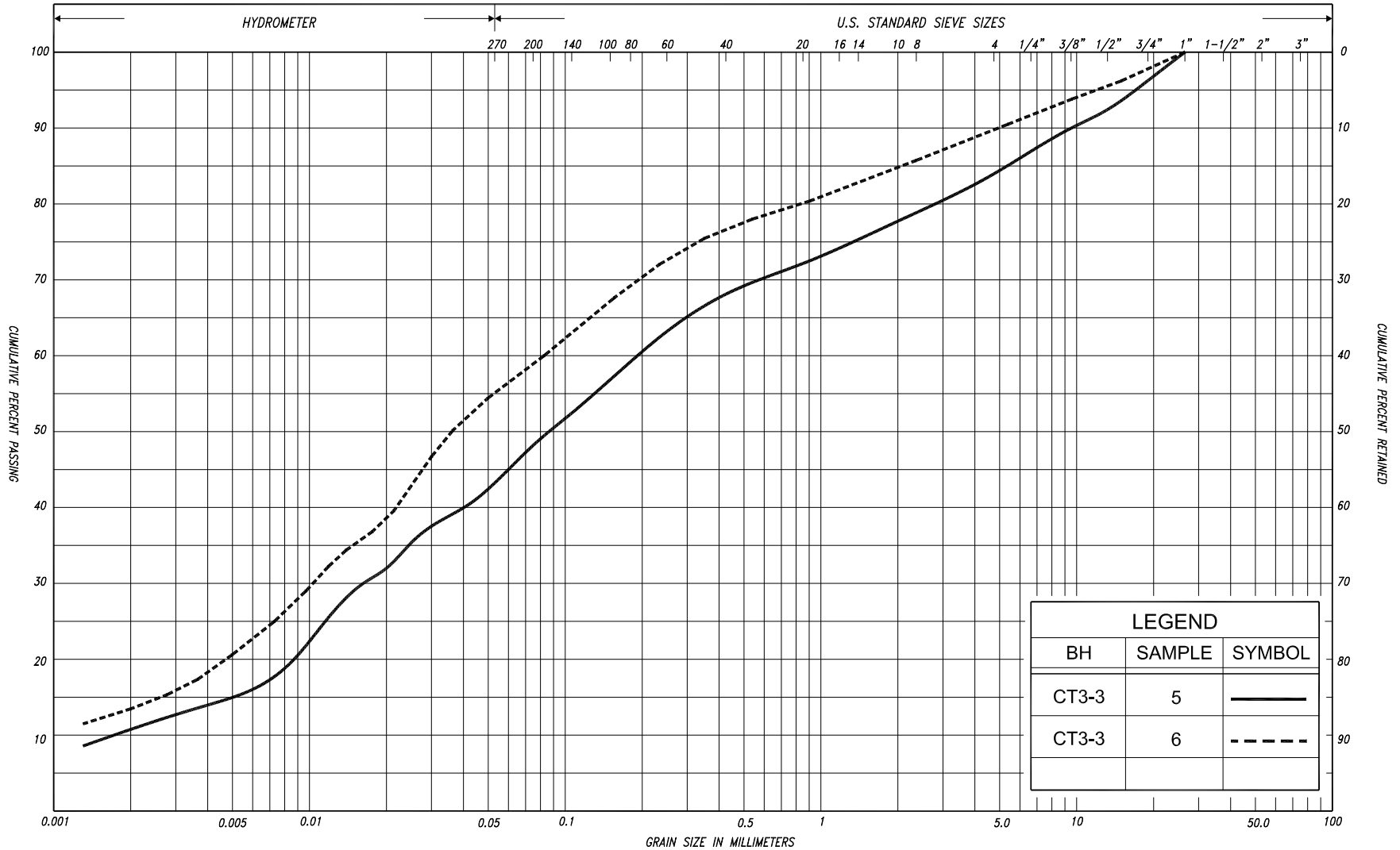
FIG No. CT3-GS-4

HWY: 26

G.W.P. No. 43-00-00



|             |      |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |             |
|-------------|------|--|--------|--|--------|---------|--------|------|--------|--|--------|--|--------|--|----------|---------|---------|-------------|
| SILT & CLAY |      |  |        |  | FINE   |         | MEDIUM |      | COARSE |  | GRAVEL |  |        |  | COB BLES | UNIFIED |         |             |
|             |      |  |        |  | SAND   |         |        |      |        |  |        |  |        |  |          |         |         |             |
| CLAY        | FINE |  | MEDIUM |  | COARSE |         | FINE   |      | MEDIUM |  | COARSE |  | GRAVEL |  |          |         | COBBLES | M.I.T.      |
|             | SILT |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |             |
| CLAY        |      |  | SILT   |  |        | V. FINE | FINE   | MED. | COARSE |  | GRAVEL |  |        |  |          |         |         | U.S. BUREAU |
| SAND        |      |  |        |  |        |         |        |      |        |  |        |  |        |  |          |         |         |             |



|             |  |  |      |  |  |        |  |  |        |  |  |        |  |  |         |             |
|-------------|--|--|------|--|--|--------|--|--|--------|--|--|--------|--|--|---------|-------------|
| SILT & CLAY |  |  | FINE |  |  | MEDIUM |  |  | COARSE |  |  | GRAVEL |  |  | COBBLES | UNIFIED     |
| CLAY        |  |  | FINE |  |  | MEDIUM |  |  | COARSE |  |  | GRAVEL |  |  | COBBLES | M.I.T.      |
| CLAY        |  |  | SILT |  |  | SAND   |  |  | GRAVEL |  |  | GRAVEL |  |  | COBBLES | U.S. BUREAU |
| CLAY        |  |  | SILT |  |  | SAND   |  |  | GRAVEL |  |  | GRAVEL |  |  | COBBLES | U.S. BUREAU |
| CLAY        |  |  | SILT |  |  | SAND   |  |  | GRAVEL |  |  | GRAVEL |  |  | COBBLES | U.S. BUREAU |
| CLAY        |  |  | SILT |  |  | SAND   |  |  | GRAVEL |  |  | GRAVEL |  |  | COBBLES | U.S. BUREAU |



## GRAIN SIZE DISTRIBUTION

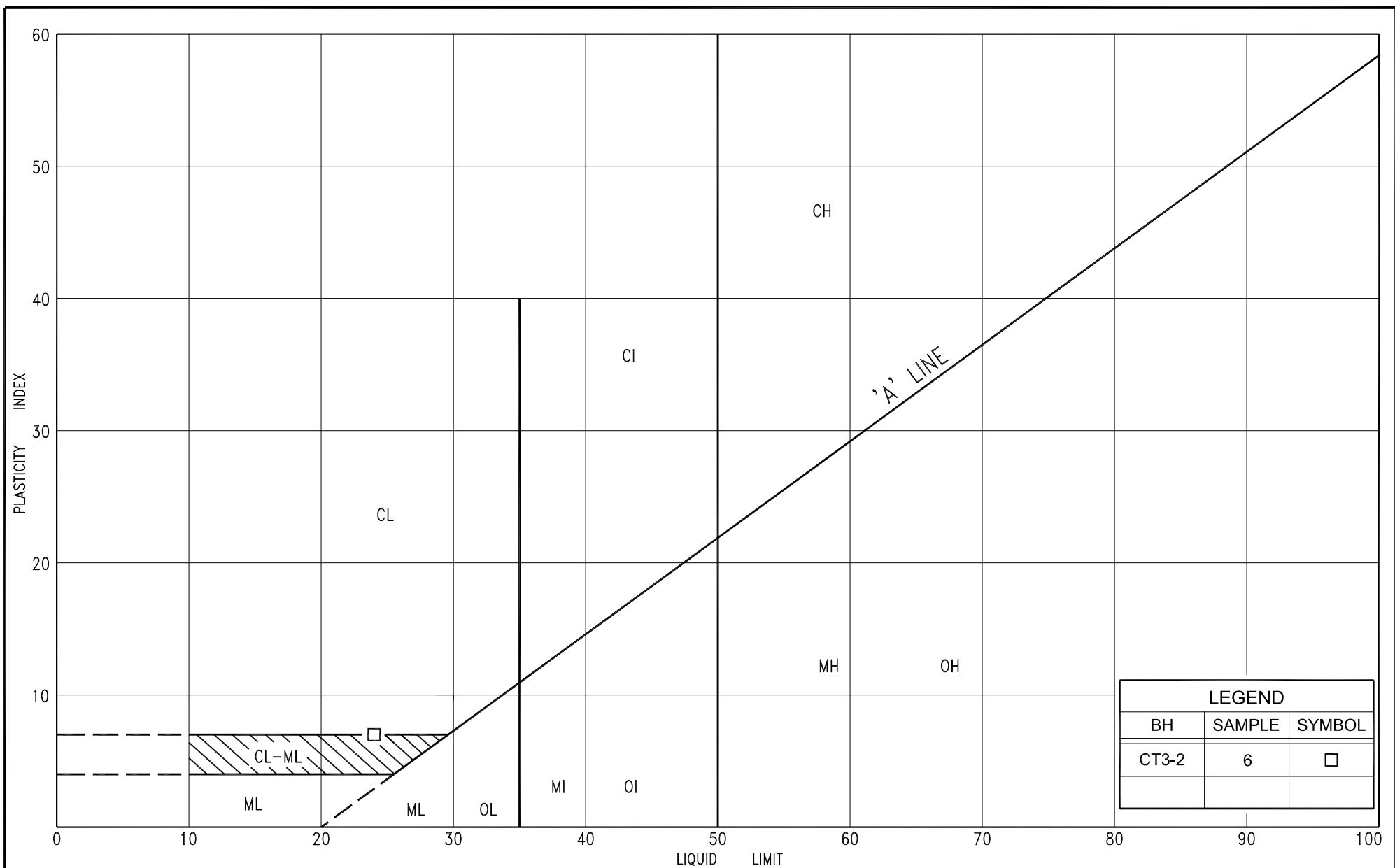
SILT AND SAND, some clay, trace to some gravel  
(TILL)

FIG No. CT3-GS-6

HWY: 26

G.W.P. No. 43-00-00





**PLASTICITY CHART**  
CLAYEY SILT, trace sand (CL)

FIG No. CT3-PC-1  
HWY: 26  
G.W.P. No. 43-00-00

## 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.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

| PERCENT BY MASS | 0 - 10 | 10 - 20 | 20 - 30 | 30 - 40           | > 40           |
|-----------------|--------|---------|---------|-------------------|----------------|
|                 | TRACE  | SOME    | WITH    | ADJECTIVE (SILTY) | AND (AND SILT) |

**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:

| R Q D (%) | 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                |
| F V FIELD VANE          |                                |

### STRESS AND STRAIN

|                                      |     |                               |
|--------------------------------------|-----|-------------------------------|
| $u_w$                                | kPa | PORE WATER PRESSURE           |
| $u$                                  | 1   | PORE PRESSURE RATIO           |
| $\sigma$                             | kPa | TOTAL NORMAL STRESS           |
| $\sigma'$                            | kPa | EFFECTIVE NORMAL STRESS       |
| $\tau$                               | kPa | SHEAR STRESS                  |
| $\sigma_1, \sigma_2, \sigma_3$       | kPa | PRINCIPAL STRESSES            |
| $\epsilon$                           | %   | LINEAR STRAIN                 |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | %   | PRINCIPAL STRAINS             |
| $E$                                  | kPa | MODULUS OF LINEAR DEFORMATION |
| $G$                                  | kPa | MODULUS OF SHEAR DEFORMATION  |
| $\mu$                                | 1   | COEFFICIENT OF FRICTION       |

### MECHANICAL PROPERTIES OF SOIL

|                |                   |                                      |
|----------------|-------------------|--------------------------------------|
| $m_v$          | kPa <sup>-1</sup> | COEFFICIENT OF VOLUME CHANGE         |
| $C_c$          | 1                 | COMPRESSION INDEX                    |
| $C_s$          | 1                 | SWELLING INDEX                       |
| $C_\alpha$     | 1                 | RATE OF SECONDARY CONSOLIDATION      |
| $c_v$          | m <sup>2</sup> /s | COEFFICIENT OF CONSOLIDATION         |
| $H$            | m                 | DRAINAGE PATH                        |
| $T_v$          | 1                 | TIME FACTOR                          |
| $U$            | %                 | DEGREE OF CONSOLIDATION              |
| $\sigma'_{vo}$ | kPa               | EFFECTIVE OVERBURDEN PRESSURE        |
| $\sigma'_p$    | kPa               | PRECONSOLIDATION PRESSURE            |
| $\tau_f$       | kPa               | SHEAR STRENGTH                       |
| $c'$           | kPa               | EFFECTIVE COHESION INTERCEPT         |
| $\phi'$        | -°                | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| $c_u$          | kPa               | APPARENT COHESION INTERCEPT          |
| $\phi_u$       | -°                | APPARENT ANGLE OF INTERNAL FRICTION  |
| $\tau_R$       | kPa               | RESIDUAL SHEAR STRENGTH              |
| $\tau_r$       | kPa               | REMOULDED SHEAR STRENGTH             |
| $S_i$          | 1                 | SENSITIVITY = $\frac{c_u}{\tau_r}$   |

### PHYSICAL PROPERTIES OF SOIL

|                |                   |                                |       |      |   |           |                   |   |
|----------------|-------------------|--------------------------------|-------|------|---|-----------|-------------------|---|
| $\rho_s$       | kg/m <sup>3</sup> | DENSITY OF SOLID PARTICLES     | $n$   | 1, % | POROSITY                                  | $e_{max}$ | 1, %              | VOID RATIO IN LOOSEST STATE                             |
| $\gamma_s$     | kN/m <sup>3</sup> | UNIT WEIGHT OF SOLID PARTICLES | $w$   | 1, % | WATER CONTENT                             | $e_{min}$ | 1, %              | VOID RATIO IN DENSEST STATE                             |
| $\rho_w$       | kg/m <sup>3</sup> | DENSITY OF WATER               | $S_r$ | %    | DEGREE OF SATURATION                      | $I_D$     | 1                 | DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$ |
| $\gamma_w$     | kN/m <sup>3</sup> | UNIT WEIGHT OF WATER           | $w_L$ | %    | LIQUID LIMIT                              | $D$       | mm                | GRAIN DIAMETER  |
| $\rho$         | kg/m <sup>3</sup> | DENSITY OF SOIL                | $w_p$ | %    | PLASTIC LIMIT                             | $D_n$     | mm                | n PERCENT - DIAMETER                                    |
| $\gamma$       | kN/m <sup>3</sup> | UNIT WEIGHT OF SOIL            | $w_s$ | %    | SHRINKAGE LIMIT                           | $C_u$     | 1                 | UNIFORMITY COEFFICIENT                                  |
| $\rho_d$       | kg/m <sup>3</sup> | DENSITY OF DRY SOIL            | $I_p$ | %    | PLASTICITY INDEX = $w_L - w_p$            | $h$       | m                 | HYDRAULIC HEAD OR POTENTIAL                             |
| $\gamma_d$     | kN/m <sup>3</sup> | UNIT WEIGHT OF DRY SOIL        | $I_L$ | 1    | LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$   | $q$       | m <sup>3</sup> /s | RATE OF DISCHARGE                                       |
| $\rho_{sat}$   | kg/m <sup>3</sup> | DENSITY OF SATURATED SOIL      | $I_C$ | 1    | CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$ | $v$       | m/s               | DISCHARGE VELOCITY                                      |
| $\gamma_{sat}$ | kN/m <sup>3</sup> | UNIT WEIGHT OF SATURATED SOIL  | DTPL  |      | DRIER THAN PLASTIC LIMIT                  | $i$       | 1                 | HYDRAULIC GRADIENT                                      |
| $\rho'$        | kg/m <sup>3</sup> | DENSITY OF SUBMERGED SOIL      | APL   |      | ABOUT PLASTIC LIMIT                       | $k$       | m/s               | HYDRAULIC CONDUCTIVITY                                  |
| $\gamma'$      | kN/m <sup>3</sup> | UNIT WEIGHT OF SUBMERGED SOIL  | WTP   |      | WETTER THAN PLASTIC LIMIT                 | $j$       | kN/m <sup>3</sup> | SEEPAGE FORCE   |
| $e$            | 1, %              | VOID RATIO                     |       |      |   |           |                   |   |

**RECORD OF BOREHOLE No CT3-1**

1 of 1

**METRIC**

**G.W.P.** 43-00-00      **LOCATION** Co-ords: 4 934 794.0 N ; 230 981.0 E      **ORIGINATED BY** A.L.  
**DIST** London      **HWY** 6      **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers      **COMPILED BY** H.G.  
**DATUM** Geodetic      **DATE** December 06, 2011      **CHECKED BY** B.R.G.

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |     |    | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |                   |  |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|-----|----|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | 'N' VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |     |    |                                    |                                     |                                   |  |  | WATER CONTENT (%) |  |  |
|               |  |            |         |      |            |                            |                 | ○ UNCONFINED + FIELD VANE                   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 | ● QUICK TRIAXIAL × LAB VANE                 |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 181.1         | Ground Surface   |            |         |      |            |                            | 20              | 40  | 60 | 80 | 100 | 20 | 40                                 | 60                                  |                                   |  |  |                   |  |  |
| 0.0           | Topsoil  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 180.9         | Silt with sand<br>some gravel, trace clay<br>rootlets, oxidized partings |            | 1       | SS   | 6          | *<br>▼<br>*<br>▽           |                 |   |    |    |     |    |                                    |                                     |                                   | 15 28 48 9                               |  |                   |  |  |
| 0.2           | Loose Brown Moist<br>to wet  |            | 2       | SS   | 9          |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 179.5         |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 1.6           | Silt<br>some clay, trace sand  |            | 3       | SS   | 11         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               | Compact to Grey Wet<br>very loose  |            | 4       | SS   | 10         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            | 5       | SS   | 4**        |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            | 6       | SS   | 2**        |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            | 7       | SS   | 24         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               | cobbles  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 175.1         |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 6.0           | Sandy silt<br>some clay, some gravel                                     |            | 8       | SS   | 7          |                            |                 |   |    |    |     |    |                                    |                                     |                                   | 10 32 45 13                              |  |                   |  |  |
|               | Loose to Grey Moist<br>very dense  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               | (TILL)   |            | 9       | SS   | 19         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            | 10      | SS   | 64         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               | sand and gravel layer  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 170.0         |  |            | 11      | SS   | 51         |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
| 11.1          | End of borehole  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |
|               |  |            | </      |      |            |                            |                 |   |    |    |     |    |                                    |                                     |                                   |  |  |                   |  |  |

**RECORD OF BOREHOLE No CT3-2**

1 of 1

**METRIC**

**G.W.P.** 43-00-00      **LOCATION** Co-ords: 4 934 789.0 N ; 230 949.8 E      **ORIGINATED BY** A.L.  
**DIST** London      **HWY** 6      **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers      **COMPILED BY** H.G.  
**DATUM** Geodetic      **DATE** December 06 and 12, 2011      **CHECKED BY** B.R.G.

| SOIL PROFILE  |  |            | SAMPLES |      |  | GROUND WATER<br>CONDITIONS | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |                   |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|------------|---------|------|--|----------------------------|---|--|--|-------------------|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | 'N' VALUES   |                            | SHEAR STRENGTH kPa                          |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            | 20 40 60 80 100                             |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            | 20 40 60 80 100                             |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      | ○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |                            |   |  |  | WATER CONTENT (%) |  |                                    |                                     |                                   |  |  |
| 182.6         | Ground Surface   |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 0.0           | Sand and gravel  |            | 1       | SS   | 15   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Compact Brown Moist  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | trace silt   |            | 2       | SS   | 14   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | (FILL)   |            | 3       | SS   | 18   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 180.4         |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 2.2           | Sand and gravel  |            | 4       | SS   | 12   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | trace silt, trace clay   |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Compact Brown Moist  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 179.6         |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 3.0           | Silt, some sand  |            | 5       | SS   | 25   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | trace clay, trace gravel                                       |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 178.9         | Compact Grey Moist to wet                                      |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 3.7           | Clayey silt, trace sand  |            | 6       | SS   | 3**  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Soft Grey Moist  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | cobbles  |            | 7       | SS   | 13   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | sand and gravel layer  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 177.1         |  |            | 8       | SS   | 18   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 5.5           | Sandy silt   |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | trace clay, trace gravel                                       |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Compact to Grey Moist very dense                               |            | 9       | SS   | 31   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | (TILL)   |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            | 10      | SS   | 34   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            | 11      | SS   | 51   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | shale fragments  |            | 12      | SS   | 80   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | sand and gravel layer  |            | 13      | SS   | 50/8cm   |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 170.3         |  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
| 12.3          | End of borehole  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Samples 11 and 13: Sampler bouncing                            |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | * 2011 12 06 & 12  |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Water level observed during drilling                           |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | Water level measured after drilling                            |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |
|               | NOTE: Dynamic cone was carried-out 1.5m east of borehole CT3-2 |            |         |      |  |                            |   |  |  |                   |  |                                    |                                     |                                   |  |  |

**RECORD OF BOREHOLE No CT3-3**

1 of 1

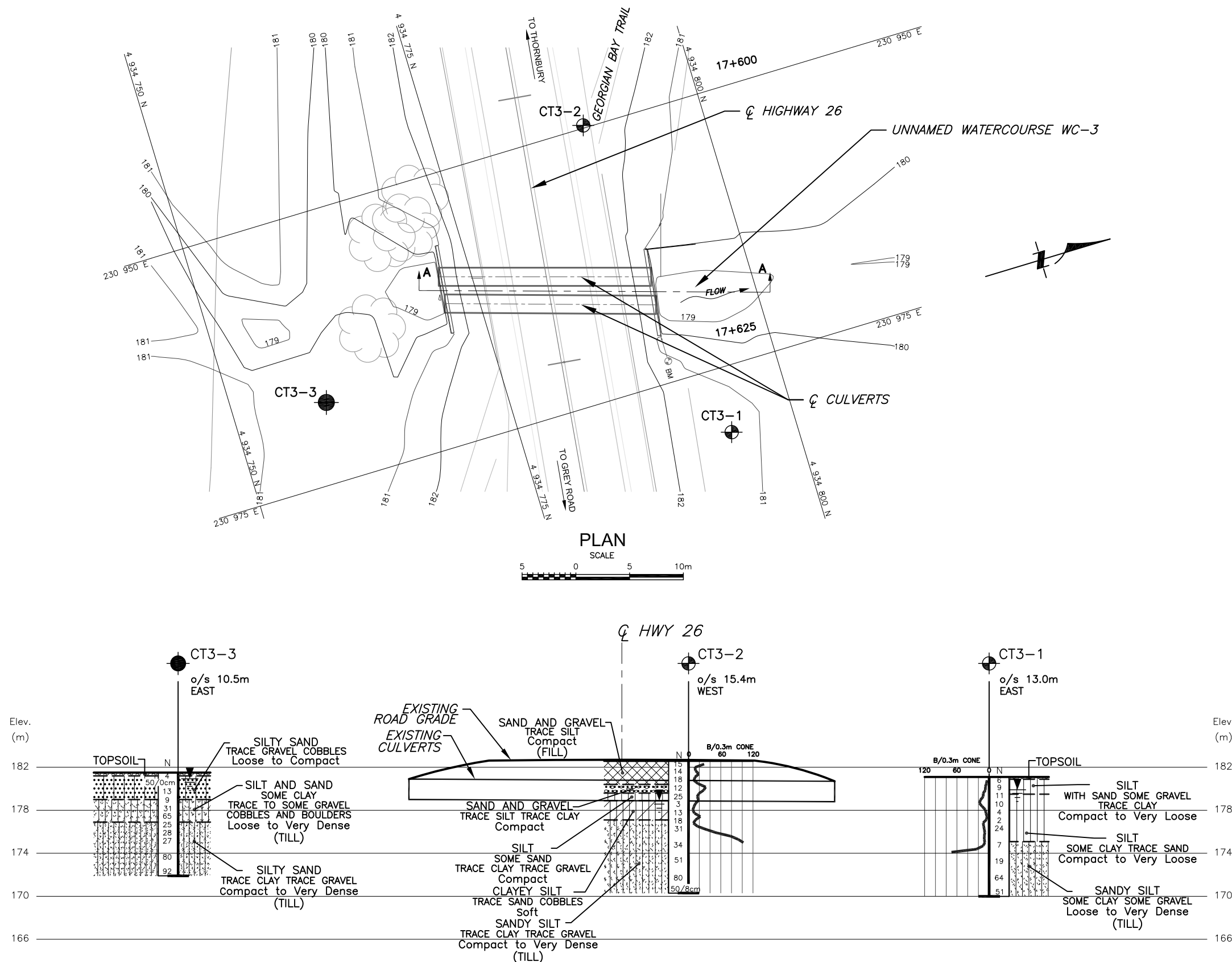
**METRIC**

**G.W.P.** 43-00-00      **LOCATION** Co-ords: 4 934 758.7 N ; 230 967.5 E      **ORIGINATED BY** A.L.  
**DIST** London      **HWY** 6      **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers      **COMPILED BY** H.G.  
**DATUM** Geodetic      **DATE** December 12 and 13, 2011      **CHECKED BY** B.R.G.

| SOIL PROFILE |  |            | SAMPLES |      | GROUND WATER CONDITIONS | DYNAMIC CONE PENETRATION RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |   |                | UNIT WEIGHT $\gamma$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|---------|------|-------------------------|--|----|----|----|-----|---|---|----------------|----------------------|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE |                         | SHEAR STRENGTH kPa                       |    |    |    |     | W <sub>p</sub>                                      | w | W <sub>L</sub> |                      |                                       |
| 181.5        | Ground Surface   |            |         |      |                         | 20                                       | 40 | 60 | 80 | 100 |   |   |                |                      |                                       |
| 0.0          | Topsoil  |            |         |      |                         |  |    |    |    |     |   |   |                |                      |                                       |
| 181.2        | Silty sand, trace gravel cobbles, rootlets                         |            | 1       | SS   | 4                       |  |    |    |    |     |   |   |                |                      |                                       |
| 0.3          | Loose to Dark Wet compact grey                                     |            | 2       | SS   | 50/0cm                  |  |    |    |    |     |   |   |                |                      |                                       |
|              |  |            | 3       | SS   | 13                      |  |    |    |    |     |   |   |                |                      |                                       |
| 179.0        | Silt and sand, some clay trace to some gravel cobbles and boulders |            | 4       | SS   | 9                       |  |    |    |    |     |   |   |                |                      |                                       |
| 2.5          | Loose to Grey Moist very dense                                     |            | 5       | SS   | 31                      |  |    |    |    |     |   |   |                |                      |                                       |
|              | (TILL)   |            | 6       | SS   | 65                      |  |    |    |    |     |   |   |                |                      |                                       |
| 176.9        | Silty sand trace clay, trace gravel                                |            | 7       | SS   | 25                      |  |    |    |    |     |   |   |                |                      |                                       |
| 4.6          | Compact to Grey Wet very dense                                     |            | 8       | SS   | 28                      |  |    |    |    |     |   |   |                |                      |                                       |
|              | (TILL)   |            | 9       | SS   | 27                      |  |    |    |    |     |   |   |                |                      |                                       |
|              | shale fragments  |            | 10      | SS   | 80                      |  |    |    |    |     |   |   |                |                      |                                       |
|              | sandy silt seams   |            | 11      | SS   | 92                      |  |    |    |    |     |   |   |                |                      |                                       |
| 171.9        | End of borehole  |            |         |      |                         |  |    |    |    |     |   |   |                |                      |                                       |
| 9.6          | Sample 2: Sampler bouncing   |            |         |      |                         |  |    |    |    |     |   |   |                |                      |                                       |
|              | * 2011 12 12   |            |         |      |                         |  |    |    |    |     |   |   |                |                      |                                       |
|              | Water level observed during drilling                               |            |         |      |                         |  |    |    |    |     |   |   |                |                      |                                       |



KEY PLAN  
NOT TO SCALE



- NOTES:
- GENERAL ARRANGEMENT DRAWING WAS NOT AVAILABLE AT THE TIME OF DRAFT REPORT. COORDINATES AND ELEVATIONS WERE ESTIMATED FROM THE REFERENCE DRAWING.
  - THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
  - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
  - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



— NOTE —  
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
|           |      |    |             |
|           |      |    |             |
|           |      |    |             |

Geocres No. 41A-226

| HWY No | 26 | DIST       | London             |
|--------|----|------------|--------------------|
| SUBM'D | NA | CHECKED HG | DATE DEC. 03, 2012 |
| DRAWN  | NA | CHECKED GD | APPROVED BRG       |

DATE DEC. 03, 2012

SITE 8-610/C

DWG TWC-1



## **APPENDIX A**

### Site Photographs





**Photograph 1:** Looking west along Highway 26 towards the culvert. Drill rig is on borehole CT3-2. (December 6, 2011)



**Photograph 2:** Looking southwest towards culvert from borehole CT3-1. (December 6, 2011)





**Photograph 3:** Looking west along Highway 26. Drill rig is on CT3-3.  
(December 12, 2011)