

FOUNDATION INVESTIGATION  
AND DESIGN REPORT

PROPOSED EXTENSION OF  
STRUCTURAL CULVERT 8-467C  
HIGHWAY 26 FROM FORMER  
ST. VINCENT/SYDENHAM TOWNLINE  
TO MEAFORD

G.W.P. 167-91-00  
Agreement # 3006-E-0002



I.E.  
Group

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## **PART A – FOUNDATION INVESTIGATION**

### **1.0 INTRODUCTION**

This report presents the results of a foundation investigation carried out in August 2007 by Infrastructure Engineering Group Inc. (IEG) on behalf of Stantec Consulting Ltd. (Stantec).

This assignment involves the rehabilitation of the pavement structure on Highway 26 from 0.3 km west of the former St. Vincent/Sydenham to 0.8 m west of the Town of Meaford west limit.

It includes the replacement/extension of a single existing structural culvert, as well as many non-structural culvert extensions and replacements. The project also includes intersection realignments, intersection improvements, construction of a new truck climbing lane, minor horizontal and vertical alignment improvements and electrical work.

Foundation investigation and recommendations are required for the design and construction of culvert replacements and extension as part of the improvement of Highway 26. A single structural culvert, nineteen (19) non-structural culverts, a swamp area, two high fill areas and a deep cut area are to be investigated. This report covers the structural culvert at Site 8-467C.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes and, based on the findings, to provide geotechnical recommendations for the foundation elements. Armour Stone wing walls will be required at the inlet of Structure 8-467C in accordance with the RFP terms of reference. Extension of the culvert may be required pending on the results of the culvert inspection specified under Section 6.3.1 of the RFP document.

Authorization to complete this assignment was given by Mr. Dan Green, P. Eng., of Stantec Consulting Ltd., the TPM Consultant who is completing this assignment for MTO under Agreement # 3006-E-0002.

### **2.0 SITE DESCRIPTION**

#### **2.1 Site Location**

Structure 8-467C is located at Station 11+393 on Highway 26, approximately 1.1 km east of the west limit of this Contract (Station 10+300). The east limit of this Contract is located 0.3 km east of the former St. Vincent/Sydenham Township Boundary (Station 10+000). Photographs of this culvert site are presented in Appendix “D”. The existing structure is a reinforced concrete, rigid frame open footing culvert with a span of 3.40 meters, a height of 1.80 meters and a length of 28.00 m, with an overfill height of approximately 3.0 m. The culvert opening dimensions were provided in the RFP documents.

The culvert site is located within a drainage valley in which the stream flows northerly. The approach embankments were built on both the east and west sides of the culvert, with a maximum height of approximately 4.8 m. The embankment slopes are typically 2.5H to 3H:1V and are grass covered. Signs of embankment erosion were observed at the time of this foundation investigation.

The headwalls that exist at both ends of the culvert are constructed of gabion baskets. Brown silt to silty clay deposit was noted at the streambed.

The groundwater condition was monitored during and upon completion of sampling. There was approximately 0.8 m of water running in the creek at the time of our field work between August 20 and 27, 2007 (Summer). This recorded water level is considered to be of a low flow condition.

## **2.2 Physiography and Topography**

Physiography for the areas includes from west to east, part of a limestone plain, a till plain and a clay plain. Drumlins occur throughout the region, but were not observed in the project corridor. Underlying bedrock geology is dominated by Silurian sandstone, shale, dolostone and siltstone for one-third of the project area. The remainder of the project area has Ordovician shale, limestone, dolostone and siltstone.

Overall, physiographic regions include, from west to east, the Bruce Peninsula (i.e., part of the Niagara Escarpment with shallower soils, more irregular rock types, and more water bodies as compared to further south) and the northern tip of the Bighead Valley (i.e., an indentation in the Niagara Escarpment that only touches the east end of the project corridor).

For most of this region, soils are brunisols and podzols (i.e. brown forest soils and grey-brown podzols) that have formed on calcareous till. The pH is neutral to alkaline. Slopes tend to be moderate.

Only two of the Niagara Escarpment Plan zoning designations, Escarpment Natural and Escarpment Rural Area, are located within the project limits within a relatively short section adjacent to the highway ROW. This section of the ROW includes the area where the westbound truck climbing lane is proposed.

The project limit also encroaches onto the plains forest of the Bayview Escarpment Area of Natural and Scientific Interest (ANSI) which was expanded in 1998 to include sections of land adjacent to the north side of Highway 26 (i.e. approximately 1 km of ROW in total), located 1 km east of the Sydenham/St. Vincent Township Line, and falls within the area of the westbound truck Climbing Lane. Much of this area has been disturbed and it is possible that the ANSI boundary extends to the highway simply to act as a buffer to the more sensitive ANSI features that are located further north.

The asphalt pavement surface over the existing culvert is near elevation 331.7 m while the ground surface at the base of the embankment and in the flood plain is near elevation 328.8 m.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Field Investigation**

Between August 20 and 27, 2007, a CME 55 drill rig was supplied by London Soil Test Ltd. and used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Three (3) boreholes were drilled and sampled to obtain data for foundation design of the proposed rehabilitation work and potential culvert extension. The locations of the boreholes are shown on Drawing 1.

The culvert borehole numbering system was established from the catchment area numbering system used in the Drainage Report of this project, as agreed with Stantec. The boreholes were numbered 8-467C-1 to 8-467C-3 for the subject culvert and the depths of sampling were as follows:

| <b>Borehole No.</b> | <b>Depth of Sampling (m)</b> |
|---------------------|------------------------------|
| 8-467C-1            | 4.11                         |
| 8-467C-2            | 7.62                         |
| 8-467C-3            | 3.66                         |

The boreholes were drilled using continuous flight solid stem augers. Soil samples were retrieved at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of depth of 0.75 m to the maximum depth of exploration.

Field pocket penetrometer was used on the retrieved SPT samples, where applicable, to determine the undrained shear strength of the cohesive soil deposits. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. All boreholes were grouted with a bentonite/cement mix at completion of sampling in accordance with Ontario Regulation 903.

Our field engineer, Mr. Ralph Billings, P. Eng., supervised the fieldwork and worked under the direction of the project engineer, Mr. Eric Chung, P. Eng. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled

containers and transported to IEG's London laboratory for further examination and laboratory testing.

The stations, offsets and ground surface elevations at the as drilled borehole locations were surveyed by AGM London and provided to IEG for the purpose of this report.

The results of the drilling, sampling, in-situ testing and groundwater observations are summarized on the Record of Borehole sheets and enclosed in Appendix "A".

### **3.2 Laboratory Analysis**

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses and Atterberg Limit tests were performed on selected samples.

The results of the laboratory testing are presented on the Record of Borehole sheets (Appendix "A"), and Laboratory Test Results (Figures 1 to 5, Appendix "B").

## **4.0 SUBSURFACE CONDITIONS**

### **4.1 General Subsurface Conditions**

Reference is made to the Record of Borehole sheets (Appendix "A") and Laboratory Test Results (Appendix "B") for detailed subsurface soil and groundwater conditions encountered in the boreholes. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, consequently, represent transitions between soil types rather than exact planes of geological change. The soil profiles depicting the subsurface conditions on Drawing 1 will vary between and beyond the borehole locations.

In general, the subsurface deposits at the site consist of loose to compact embankment fill placed on compact to very dense sand and gravel over compact to very dense sand and silt till.

#### **4.1.1 Pavement, Fill, Topsoil**

Borehole 8-467C-2, which was located at the north edge of existing pavement in the shoulder area, encountered 1050 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.96 m (Elevation 327.66 m). The fill consists of mainly mixed gravel, sand silt and clay, and with a 1 m thick layer of sandy topsoil at the bottom of the layer. Occasional cobbles are present within the fill layer.

A single grain size distribution of the embankment fill is shown on Figure 1 of Appendix "B".

Standard penetration tests yielded “N”-values generally from 8 to 21 blows per 0.3 m. This fill is brown to grey in colour and the measured natural moisture contents range from 8 to 13%. Based on the above field and laboratory test results, together and tactile examination, the fill materials exhibited loose to compact compactness condition. A single high “N”-value of over 100 blows per 0.3 m was encountered at a depth of 2.3 m, indicative of the presence of gravel or cobbles.

One (1) sample was tested and exhibited the following Atterberg Limit. These results are shown in Figure 2 of Appendix “B” and summarized below:

|                            |     |
|----------------------------|-----|
| Liquid Limit ( $W_L$ )     | 21% |
| Plastic Limit ( $W_P$ )    | 14% |
| Plasticity Index ( $I_P$ ) | 7%  |

Unit weight of the fill was not determined due to the disturbance of the soil samples during sampling and sample retrieval.

At Boreholes 8-467C-1 and 8-467C-3, topsoil was contacted to depths of 0.15 m.

#### **4.1.2 Sand to Sand and Gravel**

The topsoil at Borehole 8-467C-3 and the embankment fill at Borehole 8-467C-2 are underlain by a silty sand to sand and gravel deposit which extends to a depth of 5.94 m (Elevation 325.68 m) at Borehole 8-467C-2, and 2.13 m (Elevation 326.70 m) at Borehole 8-467C-3. Three (3) grain size analyses were performed and the results are plotted on Figure 3 of Appendix “B”.

Standard penetration testing yielded “N”-values of 10 to 63 blows per 0.3 m. It is noted that the upper 1.5 m stratum of the deposit consists of silty sand in Borehole 8-467C-3, with “N”-value of 10, and therefore was compact. Generally, the sand to sand and gravel is in dense to very dense compactness condition. The natural moisture content was measured between 6 and 12%.

#### **4.1.3 Sand and Silt Till**

A stratum of brown sand and silt till is present below the topsoil or sand to sand and gravel layers, and extends beyond the maximum depth of exploration at 4.11 m, 7.62 m and 3.66 m below the existing ground surface of Boreholes 8-467C-1, 2 and 3, respectively. Clayey silt layers are present within the sand and silt till in Borehole 8-467C-2 at depths of between 5.94 m and 6.40 m below the present ground surface. Silty clay layers are also present in Borehole 8-467C-1 at depths of between 3.05 m and 4.11 m below the existing ground surface.

Three (3) grain size analyses were performed on the sand and silt till deposit and the results are presented on Figure 4 of Appendix “B”. The deposit contained predominantly sand and silt particles, with trace to some clay and some gravel to gravelly.



Two (2) samples of the clayey silt and silty clay layers were tested and exhibited the following Atterberg Limits. These results are shown in Figure 5 of Appendix "B" and summarized below:

|                            |                              |
|----------------------------|------------------------------|
| Liquid Limit ( $W_L$ )     | 17 and 22%, average at 19.5% |
| Plastic Limit ( $W_P$ )    | 12 and 15%, average at 13.5% |
| Plasticity Index ( $I_p$ ) | 5 and 7 %, average 6.0%      |

The natural moisture contents were in the range of 6 to 14%. These results are characteristic of silt soils (CL-ML) with clayey low plasticity (CL) layers.

Standard penetration tests yielded "N"-values from 13 to over 100 blows per 0.3 m. It is noted that the upper 2.1 m stratum at Borehole 8-467C-1 had the "N"-values of 13 and 20, and therefore was compact. Generally, the sand and till deposit was in dense to very dense compactness condition.

#### 4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. There was approximately 0.8 m of water running in the creek at the time of our field work between August 20 and 27, 2007 (Summer). This recorded water level is considered to be of a low flow condition.

On completion of drilling, free groundwater was observed in the boreholes and summarized below:

| Borehole | Water Level in Borehole, m<br>(Elevation, m) | Remarks  |
|----------|--|--|
| 8-467C-1 | 2.1<br>(327.41)                              | Measured at completion   |
| 8-467C-2 | 5.3 m<br>(326.32)                            | Dry cave-in to 4.6 m,<br>Elevation 327.02 m.<br>Spoon wet at 5.3 m, Elevation<br>326.32 m (assumed water<br>level based on moisture<br>content). |
| 8-467C-3 | 1.5<br>(327.33)                              | Measured at completion   |

The water level in Borehole 8-467C-3 was observed in a sand and gravel deposit and would infer the groundwater level, as well as the water level in the creek at the time of field work.

It should be noted that the groundwater level will fluctuate seasonally and in response to weather events. Under adverse conditions, water could be perched within the embankment fill. It is reasonable to assume that groundwater could be similar to the water level in the creek during high flow conditions.

## **PART B – FOUNDATION DESIGN**

### **5.0 DISCUSSION AND RECOMMENDATIONS**

#### **5.1 General**

This section of the report provides our recommendations on the geotechnical aspects of foundation design of the proposed extension of Structure 8-467C, based on our interpretation of the factual information obtained during this investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

Structure 8-467C is located at Station 11+393 on Highway 26, approximately 1.1 km east of the west limit of this Contract (Station 10+300). The east limit of this Contract is located 0.3 km east of the former St. Vincent/Sydenham Township Boundary (Station 10+000). Photographs of this culvert site are presented in Appendix “D”. The existing structure is a reinforced concrete, rigid frame open footing culvert with a span of 3.40 meters, a height of 1.80 meters and a length of 28.00 m, with an overfill height of approximately 3.0 m.

The culvert site is located within a drainage valley in which the stream flows northerly. The approach embankments were built on both the east and west sides of the culvert, with a maximum height of approximately 4.8 m. The embankment slopes are typically 2.5H to 3H:1V and are grass covered. Signs of embankment slope instability were observed at the time of this foundation investigation.

The headwalls that exist at both ends of the culvert are constructed of gabion baskets. Brown silt to silty clay deposit was noted at the streambed.

The groundwater condition was monitored during and upon completion of sampling. There was approximately 0.8 m of water running in the creek at the time of our field work between August 20 and 27, 2007 (Summer). This recorded water level is considered to be of a low flow condition.

In general, the subsurface deposits at the site consist of loose to compact embankment fill placed on compact to very dense sand and gravel over compact to very dense sand and silt till.

The Culvert Inspection and Evaluation Report and PDR recommended culvert rehabilitation along with repair or replacement of the gabion retaining walls, subject to Stantec’s culvert inspection. This report covers the potential replacement of the wingwalls and extension of the culvert. The culvert extension, if required, will consist of either a precast concrete box culvert, a cast-in-place box culvert or a rigid frame open-footing culvert.

It is assumed that culvert extension, if required, will be of similar dimensions as those of the existing culvert.

The proposed invert elevation of the new culvert will be established at Elevation 326.70 m. Based on a base slab thickness in the order of 300 mm and a bedding thickness of 375 mm, the bedding subgrade for the proposed precast culvert extension will be placed on Elevation 326.0± m, and the subgrade for an open footing culvert at 325.3 m.

## 5.2 Closed Box Culvert

The culvert should be designed to CAN/CSA-S6-06 and to withstand the appropriate weight of overfill, traffic loadings (CL-625-ONT), temporary construction loads and critical loading effects during construction. If the base slab does not have adequate frost cover/protection, it should be designed for frost pressures.

The soils encountered at the subject site are considered suitable for the support of a box culvert foundation. Results of all boreholes put down along the proposed culvert alignment indicate that the founding subgrade consists of dense to very dense sand and gravel and/or sand and silt till.

Based on the borehole results, the box culvert should be designed to bear on the native, undisturbed sand and gravel and/or sand and silt till at the elevation and bearing resistances shown below:

| <b>Highest Elevation<br/>(m)</b> | <b>Factored Geotechnical<br/>Resistance at ULS<br/>(kPa)</b> | <b>Geotechnical Reaction<br/>at SLS<br/>(kPa)</b> |
|----------------------------------|--|---|
| 326.0±                           | 800  | 400   |

The SLS value given above is based on a maximum settlement of 25mm. This can be achieved provided the founding subgrade is not disturbed during construction.

Minor dewatering with strategically located sumps and trenches will likely be required to facilitate foundation construction.

As per CAN/CSA-S6-06, Clause 1.9.5.6, a cut-off wall of sufficient depth and strength shall be provided at the ends of the culvert to prevent undermining. The depth of the cut-off wall should be designed cognizant of the hydraulic condition (CAN/CSA-S6-06, Section 1.9) and the frost depth of 1.4 m (OPSD 3090.101).

Foundation preparation for cast-in-place construction should be carried out in accordance with Sub-section 902.07.05.02 of OPSS 902 and Sub-section 902.07.02.02 of SSP902S01. Under wet weather and or site condition, the sand and gravel and sand and silt till could easily be disturbed. In this regard, a 50 mm thick layer of lean concrete should be placed on the subgrade immediately after subgrade preparation to protect its integrity under wet conditions.

A 300 mm thick OPSS Granular "A" bedding and a 75mm thick levelling granular course as per OPSS422, or bedding as specified by the precast manufacturer should be placed on the prepared subgrade to achieve a uniform support for a precast concrete culvert. The Granular "A" layer should be compacted to 98% of the material's standard Proctor maximum dry density (SPMDD). The levelling course should consist of OPSS 1002 fine aggregates (concrete sand), or as specified by the precast manufacturer.

### **5.3 Open Footing Culvert (Spread Footing Foundations)**

Based on the borehole results, spread footings may be used for the culvert walls, headwalls (wingwalls) and retaining walls, and designed to bear on the undisturbed native, undisturbed sand and gravel and/or sand and silt till at the elevations and bearing resistances shown below:

| <b>Borehole No.</b> | <b>Highest Elevation (m)</b> | <b>Factored Geotechnical Resistance at ULS (kPa)</b> | <b>Geotechnical Reaction at SLS (kPa)</b> |
|---------------------|------------------------------|--|---|
| 8-467C-1            | 327.20                       | 600  | 300                                       |
| 8-467C-2            | 327.50                       | 600  | 300                                       |
| 8-467C-3            | 327.00                       | 600  | 300                                       |

The SLS value given above is based on a maximum settlement of 25 mm and a footing width of up to 2 m. This can be achieved provided that the founding subgrade is undisturbed during the construction.

Under inclined loading conditions, the bearing resistance at ULS should be reduced in accordance with Clause 6.7.4 of CAN/CSA-S6-06.

Immediately upon excavation, the exposed subgrade should be inspected and approved by the geotechnical engineer.

## 5.4 Lateral Earth Pressures

The lateral earth pressures acting on the culvert walls, headwalls (wing walls) and retaining walls (armour stone, gabion etc.) will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure whether it is restrained or unrestrained. The lateral earth pressures to be used in the design should be computed in accordance with Section 6.9 of the CAN/CSA-S6-06.

Granular backfill should be constructed behind the culvert walls, headwalls (wing walls) and retaining walls as per OPSD-3121.150, with particular attention to the frost taper requirement. The granular backfill should conform to OPSS 1010 for either Granular "A" or Granular "B" Type III. To maintain free draining characteristics in granular fill materials, the maximum percentage passing the No. 200 sieve (75 µm) should be limited to 5%.

The backfill should be constructed as per OPSS 902 and 501, and SSP902S01. A perforated subdrain should be installed behind the walls with a positive outlet or wall drains as per OPSD-3190.100 to drain the granular fill above the stream water level. Alternatively, the culvert walls could be designed to resist hydrostatic pressure.

The lateral earth pressure,  $P_h$ , acting on the headwalls (wing walls) or retaining walls may be computed using the equivalent fluid pressures presented in Clause 6.9.2.3 of the CAN/CSA-S6-06, or employing the following equation based on unfactored earth pressure distributions:

$$P_h = K (\gamma h + q)$$

Where:

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

$\gamma$  = unit weight of soil, = 21.2 kN/m<sup>3</sup> for Granular "B"  
= 22.8 kN/m<sup>3</sup> for Granular "A"

$h$  = depth below top of wall, m

$q$  = live load surcharge pressure, equivalent fill height of 0.8 m  
as per Clause 6.9.5 of CHBDC and CAN/CSA-S6-06

| Wall Type                   | Earth Pressure Coefficient (K)    |  |
|-----------------------------|-----------------------------------|--|
|                             | Granular "A"<br>$\phi = 35^\circ$ | Granular "B"<br>$\phi = 30 \text{ to } 35^\circ$ |
| Restrained Wall ( $K_o$ )   | 0.43                              | 0.50 to 0.43                                     |
| Unrestrained Wall ( $K_a$ ) | 0.27                              | 0.33 to 0.27                                     |

The submerged unit weight of the backfill should be used for any submerged portion of the granular backfill when calculating the lateral earth pressure.

The above parameters are based on a horizontal back slope (not exceeding 5 degrees) behind the headwalls. A compaction surcharge equal to 12 kPa should be included in the lateral earth

pressures for the structural design of the headwalls and retaining walls in accordance with Clause 6.9.3 of the CAN/CSA-S6-06.

The sliding resistance of the cast-in-place footings should be checked. The unfactored horizontal resistance (Clause 6.7.5, CAN/CSA-S6-06) against sliding can be calculated using a coefficient of friction (friction factor) of 0.45 between concrete and sand and silt till or 0.55 between concrete and sand and gravel, as per Table 24.4 CFEM 4<sup>th</sup> Edition, 2006.

For a precast concrete culvert, the friction factor and adhesion should be reduced by a factor of 0.67.

Vibratory equipment for use behind the culvert walls, headwalls (wing walls) and retaining walls should be restricted in size as per current MTO practices, and should conform to OPSS 501 and SSP105S10.

## **5.5 Embankment Widening**

The existing approach embankments are up to 4.8 m high adjacent to the existing culvert. For the widening of the embankment, the surficial topsoil and any deleterious materials should be stripped or excavated prior to placing fill materials. The embankment widening should then be constructed as per OPSD-202.010, 202.030 and 208.010, with emphasis on adequate benching of the subgrade for receiving the embankment fill. The fill to be used for embankment construction can either be imported silty clay or granular materials, but granular materials are preferred for compaction and drainage.

Backfill adjacent to the structure should be carried out in conformance with OPSS 902, SSP902S01 and OPSD-3121.150, and the fill should be placed and compacted in accordance with OPSS 501 and SSP105S10.

Based on the findings of the field investigation, no foundation stability or settlement problems due to widening the approach embankments on the inorganic native soils are anticipated for embankment slope of 2.5H:1V and up to 4.8 m high. The fill placement should begin at the toe of the embankment, in leveled lifts and each lift compacted to at least 98% SPMDD. Benching into the existing embankment slope at 1 m high steps is recommended as per OPSD 208.010.

After stripping, the exposed subgrade should be inspected and approved by the geotechnical engineer. The approved subgrade should then be proof-rolled using a heavy compactor, as directed by the engineer. Unless the excavation is carried out in wet weather conditions, no unusual dewatering is anticipated during stripping and preparation of the subgrade to receive the embankment fills. Where necessary, dewatering can be carried out using gravity drainage and pumping from open filtered sumps in accordance with OPSS 517 and 902, and SSP902S01, with emphasis on the requirements of OPSS 518.

Measures should be incorporated into the design and staging to ensure that the slope surfaces are protected from surface erosion in accordance with the requirements of OPSS 577. Proper erosion control measures should be implemented both during construction of the embankment fills and permanently. Sediment control during construction should be carried out by installing silt fences. Properly designed erosion control blankets could also be placed on any new embankments and adjacent disturbed embankments after completion of fill placement. A vegetative cover should be established as soon as practical upon completion of fill placement to minimize the chances of surface erosion.

Revetments such as rip-rap blanket should be provided at the toe of the slope and the ends of the culvert to prevent erosion/scour by stream action in accordance with OPSS 511 and OPSD 810.010. The design of the rip-rap blanket should be carried out cognizant of the stream hydraulics.

## **5.6 Excavation, Groundwater Control and Temporary Shoring**

Excavation for this project will involve the construction of the box culvert or footings for the culvert walls, headwalls (wing walls) and retaining walls. Depending on the design that is finally selected, the anticipated maximum depth of excavation below the existing grade of Highway 26 is in the order of 6 m.

Excavation to depths of up to 6 m should not present any special difficulties using heavy excavation equipment, provided it is constructed in accordance with OPSS 501, 517, 518, 539, 577 and 902, SSP902S01 and OPSD-803.010 and 3121.150. However, the buried utilities alongside the embankments will likely be in conflict with the excavation. Excavation and protection procedures shall conform to OPSS 539 and should be reviewed with the utility companies or authorities prior to construction. Based on the subsurface soil and groundwater conditions encountered at this site, a Permit to Take Water (PTTW) in accordance with Ontario Regulation 387/04 will not be required for the purpose of excavation.

The water in the creek can be controlled by temporary diversion or dam and pump method. The anticipated minor groundwater ingress can be controlled using intercept ditches and pumping from filtered sump pits.

It is noted that a "Permit To Take Water" (PTTW, Regulation 387/04) will be required from the MOE (Ministry of Environment) when the total quantity of water to be handled exceeds 50,000 litres/day while employing temporary pumping of water, flow passages through culverts, stream diversion or dam and pump method as groundwater control measures (unwatering). It may take up to 90 days for MOE to review an application and issue a permit.

It should be pointed out that if the founding soil is disturbed, excessive settlements could occur after structural loads are applied. The founding level will be located below the streambed and, therefore, a minimum 50 mm thick lean concrete working mat should be placed immediately after excavation and subgrade preparation for footings to protect the integrity of the bearing



surface and to facilitate placement of reinforcing steel. All foundation excavations, bearing surfaces, and placement of lean concrete mat should be inspected and approved by the geotechnical engineer.

All excavation must be carried out in compliance with the requirements of the Occupational Health and Safety Act (OHSA). For this purpose, the unsaturated upper fill and compact sand and silt till, and the sand and gravel deposits encountered at this site are classified as Type 3 soils and the dense to very dense sand and silt till soils are classified as Type 2 soils. Saturated cohesionless soils are classified as Type 4 soils.

For the Type 2 soils, the excavation shall be cut to near vertical in the bottom 1.2 m and then trimmed back to 1H:1V. Within the Type 3 soils and above the water table, the excavation shall be cut to no steeper than 1H : 1V throughout. Side slopes of 3H:1V or flatter shall be used for excavation within Type 4 soils.

Temporary support within the overfill of the existing and the new partially constructed embankment/culvert may be required to facilitate culvert construction and to maintain access for construction and local traffic, and emergency vehicles. The staging of different phases of this work should be examined to determine if roadway protection is required. Roadway protection is generally a contractor design/build item in accordance with Performance Level 2 of OPSS 539, SP105S19 and current MTO practices.

Geotechnical parameters for the design of temporary support structures are provided in Sections 5.3 and 5.4. In addition, a unit weight of  $22 \text{ kN/m}^3$  and an internal friction angle,  $\phi$ , of  $29^\circ$  can be used for design if the existing embankment is to be supported.

## **5.7 Frost Protection**

This project is located in the Owen Sound Operations District. The design frost penetration depth for this project is 1.4 m in accordance with OPSD 3090.101. All foundations and spread footings should be provided with at least 1.4 m of soil cover for adequate frost protection. Alternatively, frost protection can be provided by equivalent thermal insulation.

## **5.8 Scour Depth**

The footings should be founded below the anticipated local and general scour depths as per CAN/CSA-S6-06, Clause 1.9, Hydraulic Design; and CHBDC (2006) - Section 1.9. Sand and silt till as well as sand and gravel could be exposed at the streambed, and their permissible velocities are 1.8 m/s and 1.2 m/s respectively (based on American Society of Civil Engineers publication, 1926, reprinted as Design Chart 2.17, MTO Drainage Management Manual 1997).

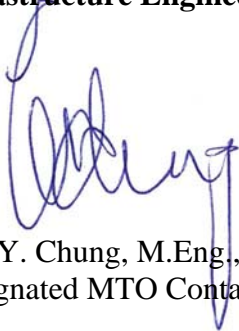
## 6.0 STATEMENT OF LIMITATION

We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

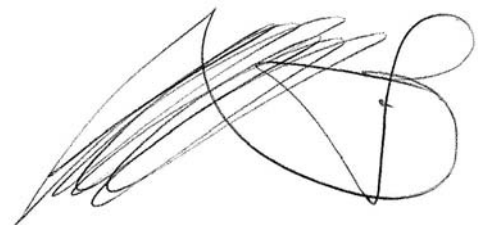
The Limitations of Report, as Quoted in Appendix "C", is an integral part of this report.

We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,  
**Infrastructure Engineering Group Inc.**



Eric Y. Chung, M.Eng., P.Eng.  
Designated MTO Contact



Joseph Law, P.Eng.  
Project Manager



Tom O'Dwyer, P. Eng.  
Quality Review Engineer



Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 167-91-00 - Rehabilitation of Highway 26  
From Former St. Vincent/Sydenham Townline to Meaford  
Agreement # 3006-E-0002

07-6-IEG1-8-467C  
Final Report  
Drawing 1  
May 17, 2010

Drawing 1  
Borehole Locations  
And  
Soil Strata

METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

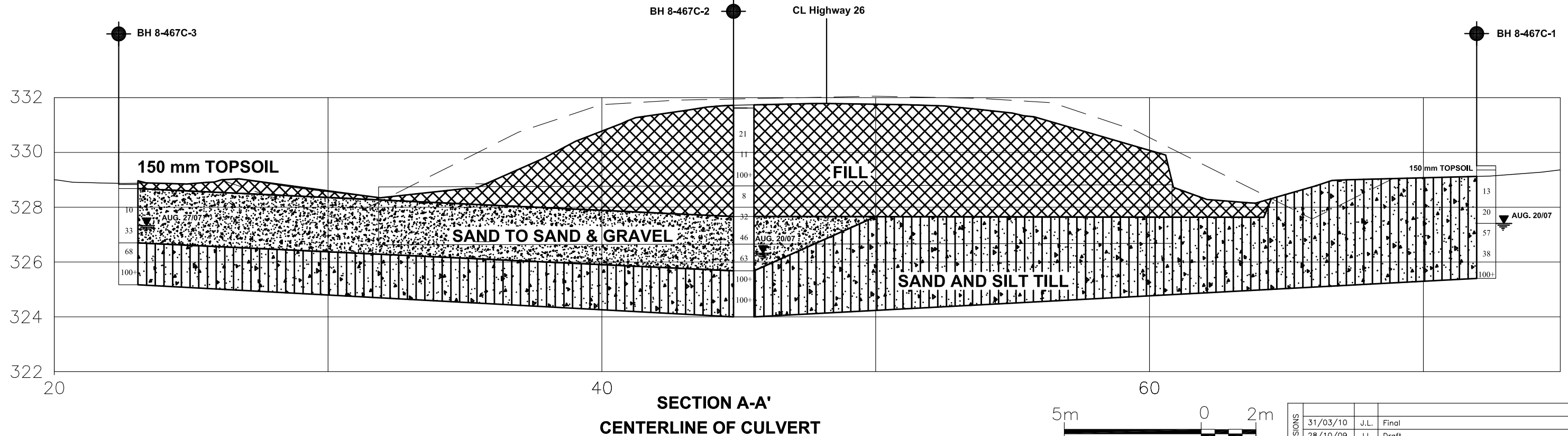
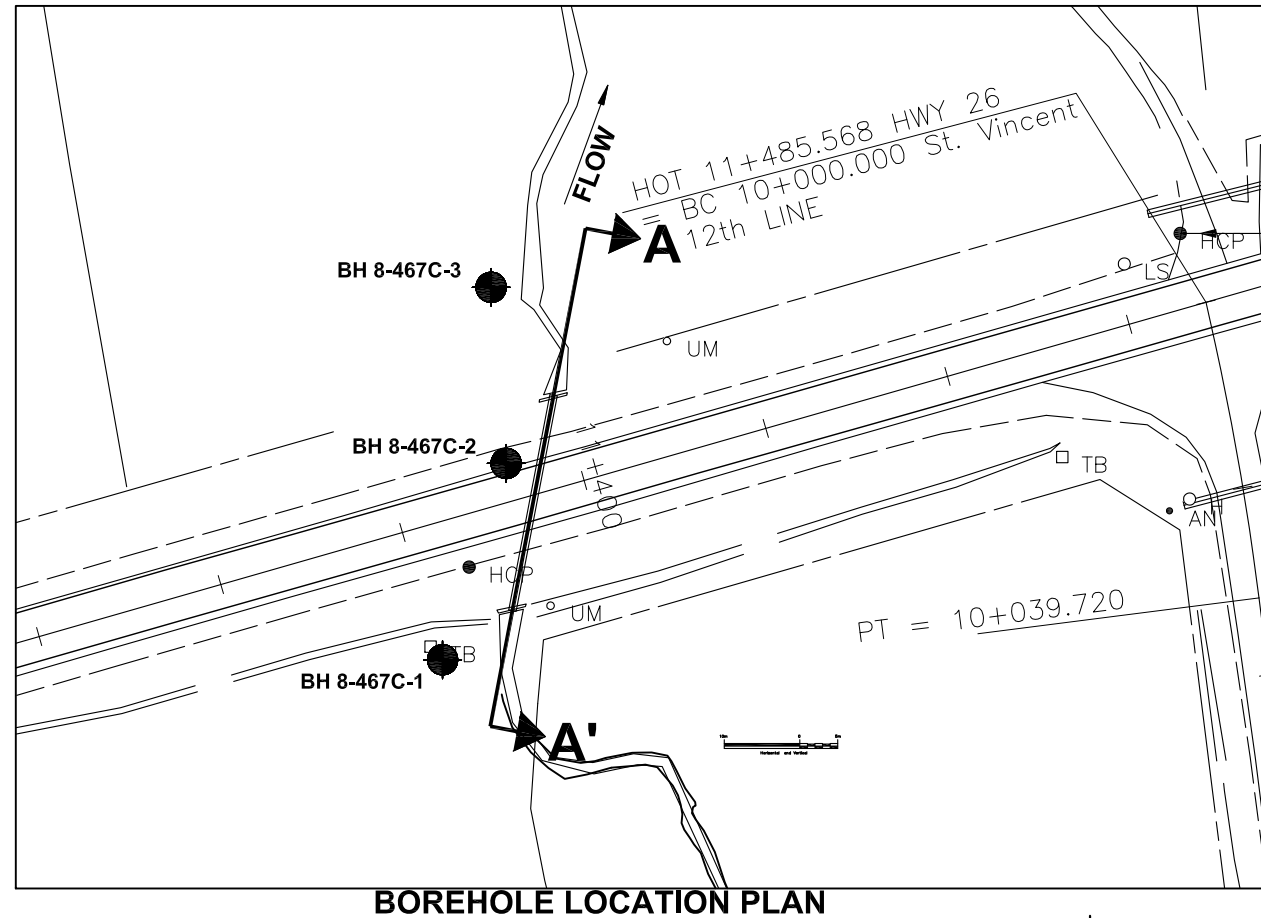
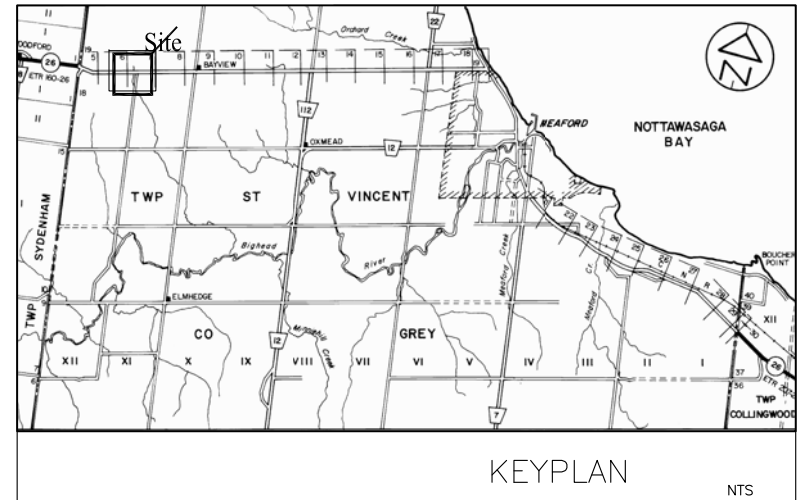
CONT No xxxx-xxxx  
WP No GWP 167-91-00



Culvert # 8-467C  
Highway 26  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
1

I.E. Infrastructure Engineering Group Inc.  
Pavement & Construction Materials Consulting Engineers  
GTA • Kitchener • London • Windsor



NOTES

1. 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 ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. SUBGRADE ELEVATION OF THE EXISTING FOOTING NOT KNOWN AND IS ESTIMATED TO BE AT 1.4m BELOW THE CREEK BED.
4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.



| REVISIONS         | DATE     | BY                              | DISCRIPTION |
|-------------------|----------|---------------------------------|-------------|
|                   | DATE     | BY                              | DISCRIPTION |
|                   | 31/03/10 | J.L.                            | Final       |
|                   | 28/10/09 | J.L.                            | Draft       |
| Geocres : 41A-210 |          |                                 |             |
| HWY No.           |          | HWY 26                          |             |
| SUBM'D            |          | J.L. CHECKED E.C. DATE 25/01/08 |             |
| DRAWN             |          | J.L. CHECKED J.L. APPROVED E.C. |             |
| DIST              |          | Owen Sound                      |             |
| SITE              |          | 8-467C                          |             |
| DWG               |          | 1                               |             |

Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 167-91-00 - Rehabilitation of Highway 26  
From Former St. Vincent/Sydenham Townline to Meaford  
Agreement # 3006-E-0002

07-6-IEG1-8-467C  
Final Report  
Appendix A  
May 17, 2010

## Appendix A

### Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes 8-467C-1 TO 3

## 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 1" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

| $c_u$ (kPa) | 0 - 12    | 12 - 25 | 25 - 50 | 50 - 100 | 100 - 200  | > 200 |
|-------------|-----------|---------|---------|----------|------------|-------|
|             | VERY SOFT | SOFT    | FIRM    | STIFF    | VERY STIFF | HARD  |

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

| N (BLOWS/0.3m) | 0 - 5      | 5 - 10 | 10 - 30 | 30 - 50 | > 50       |
|----------------|------------|--------|---------|---------|------------|
|                | VERY LOOSE | LOOSE  | COMPACT | DENSE   | VERY DENSE |

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

| RQD (%) | 0 - 25    | 25 - 50 | 50 - 75 | 75 - 90 | 90 - 100  |
|---------|-----------|---------|---------|---------|-----------|
|         | VERY POOR | POOR    | FAIR    | GOOD    | EXCELLENT |

**JOINTING AND BEDDING:**

| SPACING  | 50mm       | 50 - 300mm | 0.3m - 1m  | 1m - 3m | > 3m       |
|----------|------------|------------|------------|---------|------------|
| JOINTING | VERY CLOSE | CLOSE      | MOD. CLOSE | WIDE    | VERY WIDE  |
| BEDDING  | VERY THIN  | THIN       | MEDIUM     | THICK   | VERY THICK |

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

|     |                     |     |                             |
|-----|---------------------|-----|-----------------------------|
| S S | SPLIT SPOON         | T P | THINWALL PISTON             |
| W S | WASH SAMPLE         | O S | OSTERBERG SAMPLE            |
| S T | SLOTTED TUBE SAMPLE | R C | ROCK CORE                   |
| B S | BLOCK SAMPLE        | P H | T.W. ADVANCED HYDRAULICALLY |
| C S | CHUNK SAMPLE        | P M | T.W. ADVANCED MANUALLY      |
| T W | THINWALL OPEN       | F S | FOIL SAMPLE                 |

### STRESS AND STRAIN

|                                      |     |                               |
|--------------------------------------|-----|-------------------------------|
| $u_w$                                | kPa | PORE WATER PRESSURE           |
| $r_u$                                | 1   | PORE PRESSURE RATIO           |
| $\sigma$                             | 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              |
| $\tau_c$       | kPa               | REMOULDED SHEAR STRENGTH             |
| $S_t$          | 1                 | SENSITIVITY = $\frac{c_u}{\tau_c}$   |

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 8-467C-1

1 OF 1

METRIC

W.P. GWP 167-91-00 LOCATION Northing - 4940391, Easting - 208872 ORIGINATED BY RB  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY NN  
 DATUM Geodetic DATE 20.8.07 - 20.8.07 CHECKED BY JL

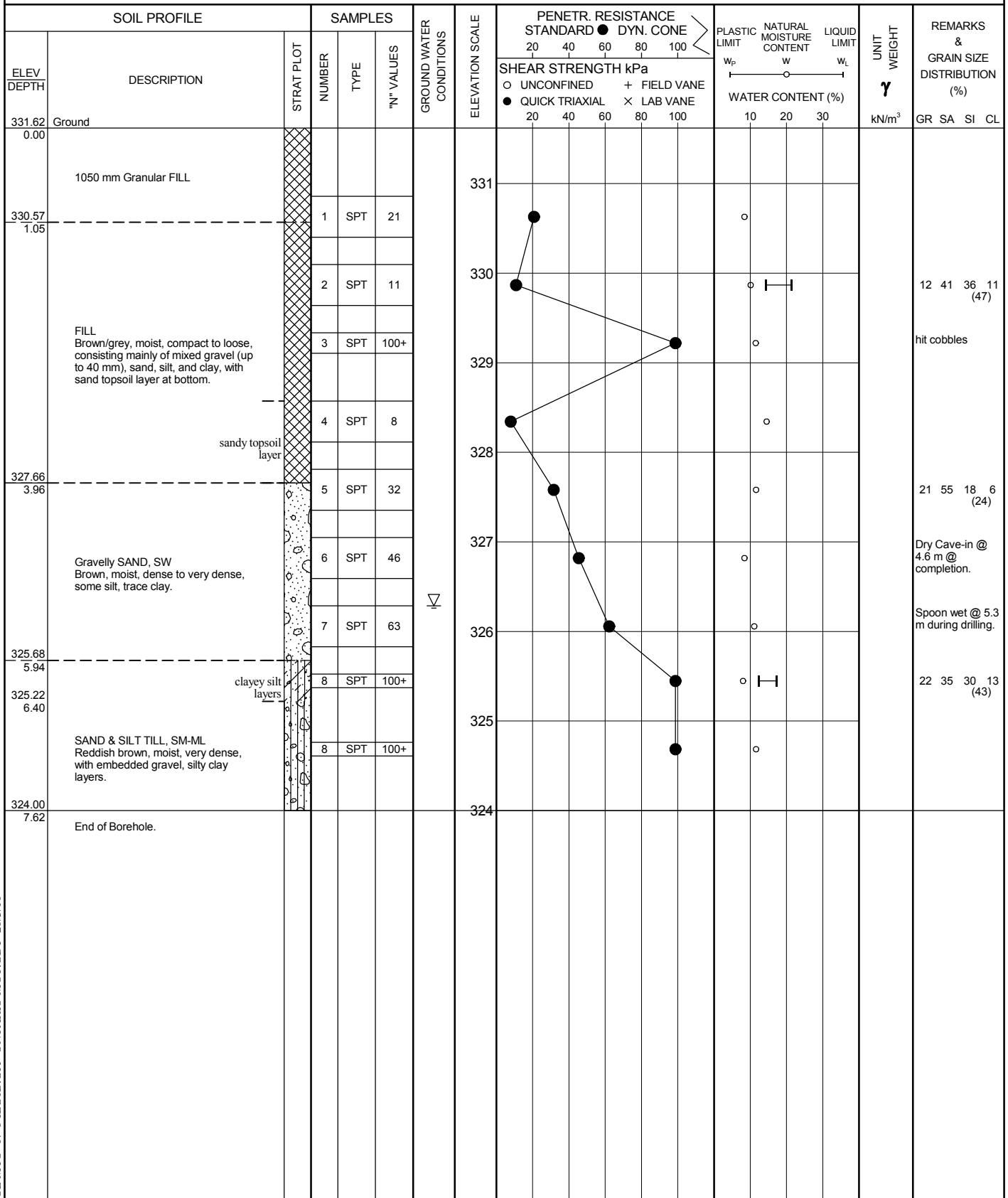
| SOIL PROFILE   |                           |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | PENETR. RESISTANCE<br>STANDARD  DYN. CONE  |    | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                    |  |  |  |                     |
|----------------|---------------------------|------------|---------|------|------------|----------------------------|-----------------|--|----|------------------------------------|-------------------------------------|-----------------------------------|--------------------|---|--------------------|--|--|--|---------------------|
| ELEV<br>DEPTH  | DESCRIPTION               | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa<br>UNCONFINED    + FIELD VANE<br>QUICK TRIAXIAL    x LAB VANE |    |                                    |                                     |                                   |                    |   | WATER CONTENT (%)  |  |  |  |                     |
|                |                           |            |         |      |            |                            |                 | 20   | 40 | 60                                 | 80                                  | 100                               | 10                 | 20  | 30                 |  |  |  |                     |
| 329.51<br>0.00 | Ground<br>150 mm TOPSOIL. |            |         |      |            |                            |                 |  |    |                                    |                                     |                                   |                    |   | 0 42 44 14<br>(58) |  |  |  |                     |
|                |                           |            | 1       | SPT  | 13         |                            |                 |  |    |                                    |                                     |                                   |                    |   |                    |  |  | Water level<br>measured @ 2.1<br>m @ completion. |                     |
|                |                           |            | 2       | SPT  | 20         |                            |                 |  |    |                                    |                                     |                                   |                    |   |                    |  |  |  |                     |
|                |                           |            | 3       | SPT  | 57         |                            |                 |  |    |                                    |                                     |                                   |                    |   |                    |  |  |  |                     |
| 326.46<br>3.05 |                           |            | 4       | SPT  | 38         |                            |                 |  |    |                                    |                                     |                                   |                    |   |                    |  |  |  | 13 25 38 24<br>(61) |
|                |                           |            | 5       | SPT  | 100+       |                            |                 |  |    |                                    |                                     |                                   |                    |   |                    |  |  |  |                     |
| 325.40<br>4.11 | End of borehole.          |            |         |      |            |                            |                 |  |    |                                    |                                     |                                   |                    | Sampler and<br>auger refusal @<br>4.11 m.         |                    |  |  |  |                     |

# RECORD OF BOREHOLE No 8-467C-2

1 OF 1

METRIC

W.P. GWP 167-91-00 LOCATION Northing - 4940417, Easting - 208880 ORIGINATED BY RB  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY NN  
 DATUM Geodetic DATE 20.8.07 - 20.8.07 CHECKED BY JL



JOE MTO 07-6-IEGIB.GPJ ONTARIO MOT.GDT 20/3/10

+ 3, X 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS



# RECORD OF BOREHOLE No 8-467C-3

1 OF 1

METRIC

W.P. GWP 167-91-00 LOCATION Northing - 4940440, Easting - 208878 ORIGINATED BY RB  
 DIST Owen Sound HWY 26 BOREHOLE TYPE S/S Augering, 110 mm dia. COMPILED BY NN  
 DATUM Geodetic DATE 27.8.07 - 27.8.07 CHECKED BY JL

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | PENETR. RESISTANCE<br>STANDARD ● DYN. CONE |              | 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>(%)                      |  |  |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|--------------|------------------------------------|-------------------------------------|-----------------------------------|--|--|--|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                         |              |                                    |                                     |                                   |  |  |  |  |  |
|               |  |            |         |      |            |                            |                 | ○ UNCONFINED                               | + FIELD VANE |                                    |                                     |                                   |  |  |  |  |  |
|               |  |            |         |      |            |                            |                 | ● QUICK TRIAXIAL                           | × LAB VANE   |                                    |                                     |                                   |  |  |  |  |  |
|               |  |            |         |      |            |                            | 20              | 40   | 60           | 80                                 | 100                                 | WATER CONTENT (%)                 |  |  |  |  |  |
| 328.83        | Ground   |            |         |      |            |                            |                 |  |              |                                    |                                     |                                   |  |  |  |  |  |
| 0.00          | 150 mm TOPSOIL.  |            |         |      |            |                            |                 |  |              |                                    |                                     |                                   |  |  |  |  |  |
|               | Silty SAND to SAND & GRAVEL,<br>SW-GW to SM<br>Brown to reddish brown, moist to wet,<br>compact to dense, some silt and<br>trace clay. |            | 1       | SPT  | 10         |                            | 328             |  |              |                                    | ○                                   |                                   |  | 19 54 18 9<br>(27)   |  |  |  |
|               |  |            | 2       | SPT  | 33         |                            | 327             |  |              |                                    | ○                                   |                                   |  | 48 36 11 5<br>(16)   |  |  |  |
| 326.70        |  |            | 3       | SPT  | 68         |                            |                 |  |              |                                    | ○                                   | I                                 |  | Water level<br>measured @ 1.5<br>m @ completion.<br>10 45 39 6<br>(46) |  |  |  |
| 2.13          | SAND & SILT TILL, SM-ML<br>Reddish brown, moist, very dense,<br>with embedded gravel.  |            | 4       | SPT  | 100+       |                            | 326             |  |              |                                    | ○                                   |                                   |  |  |  |  |  |
| 325.17        | End of borehole.   |            |         |      |            |                            |                 |  |              |                                    |                                     |                                   |  | Auger refusal @<br>3.66 m. Possible<br>boulder or<br>bedrock.          |  |  |  |
| 3.66          |  |            |         |      |            |                            |                 |  |              |                                    |                                     |                                   |  |  |  |  |  |

JOE MTO 07-6-IEG1B.GPJ ONTARIO MOT.GDT 20/3/10

+ 3, X 3: Numbers refer to  
Sensitivity

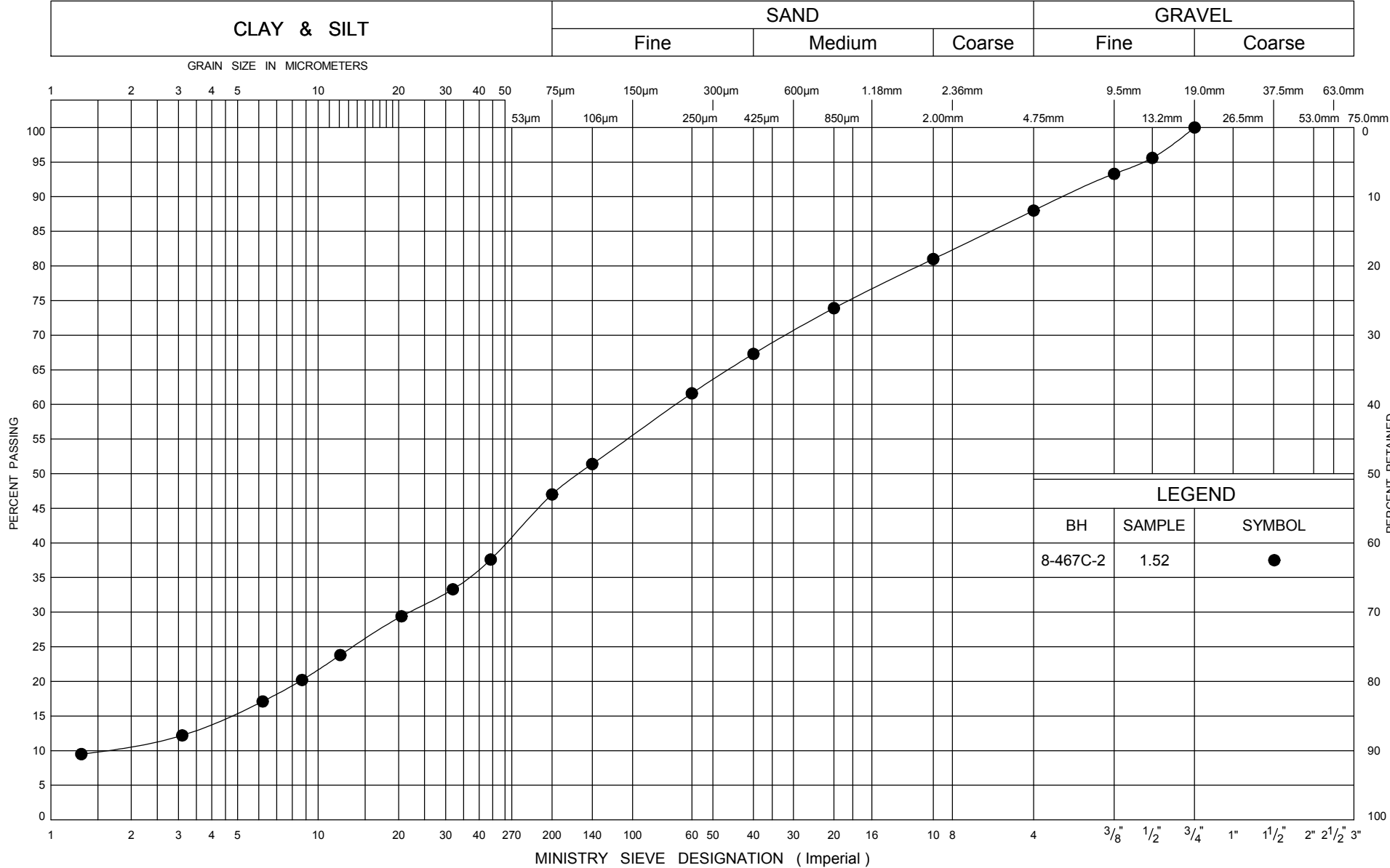
○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## Appendix B

### Laboratory Test Results

|                         |                    |
|-------------------------|--------------------|
| Grain Size Distribution | Figures 1, 3 and 4 |
| Plasticity Chart        | Figures 2 and 5    |

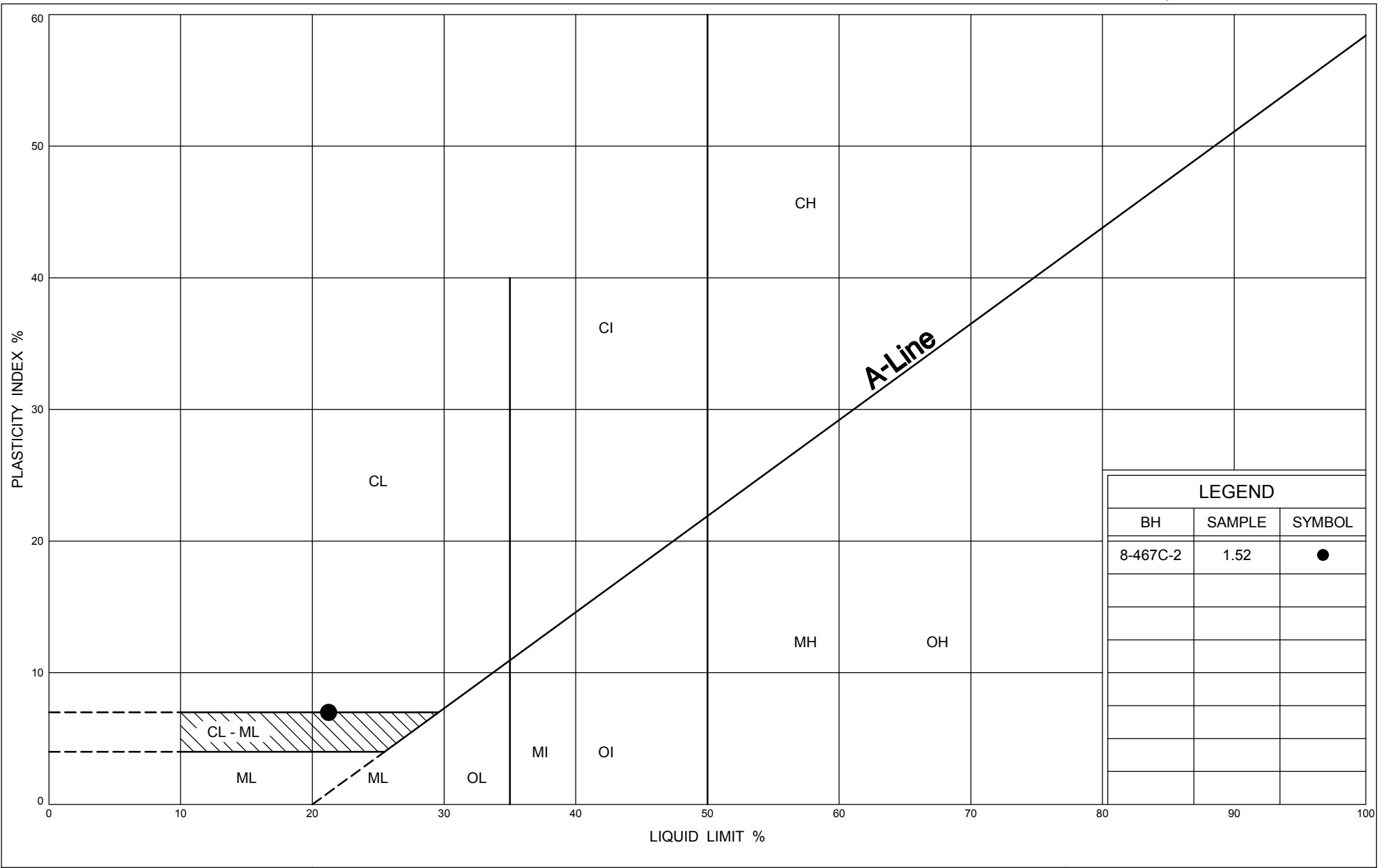
UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
FILL

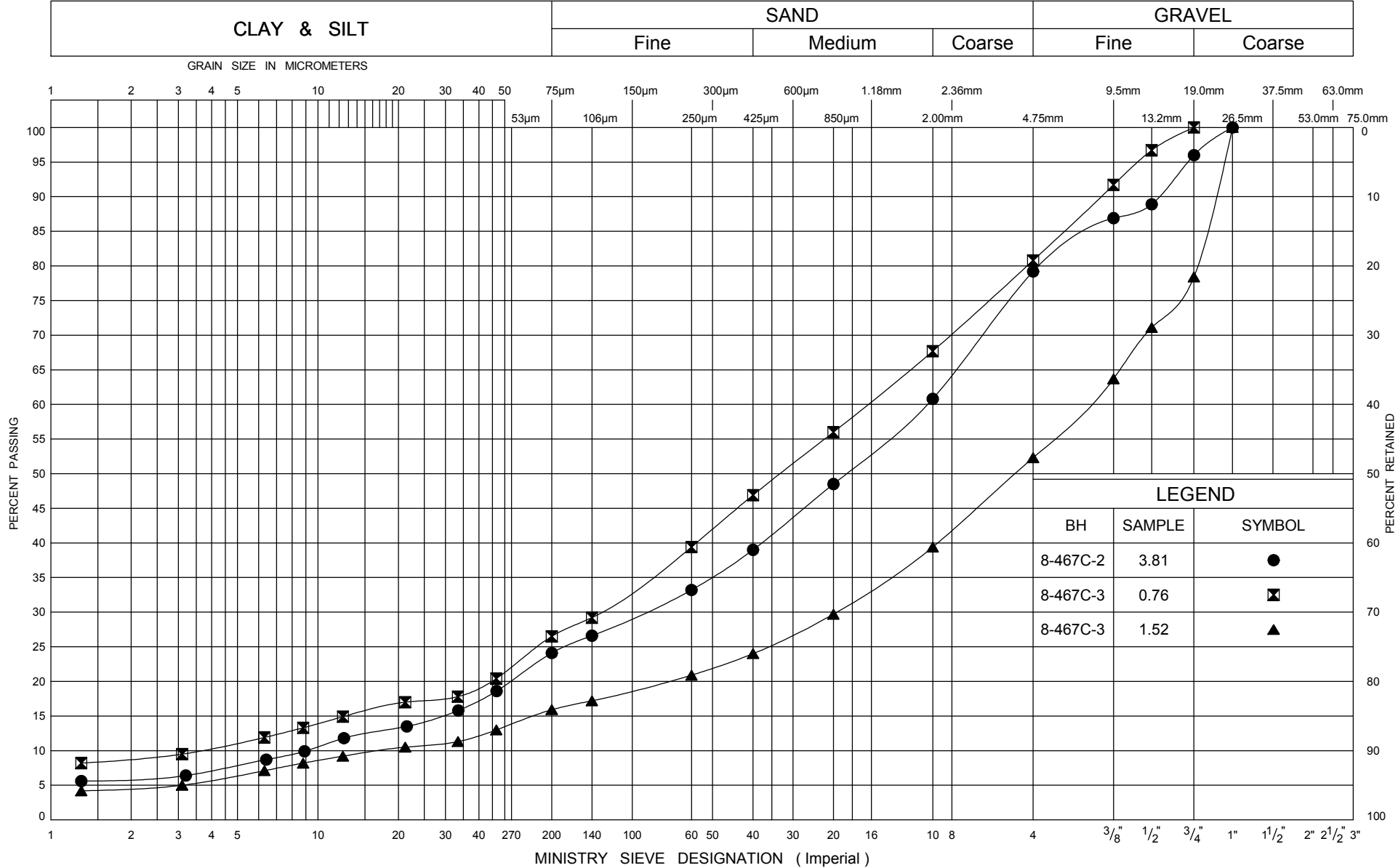
FIG No 1  
GWP 167-91-00  
Hwy 26 - Sydenham Townline to Meaford





| LEGEND   |        |        |
|----------|--------|--------|
| BH       | SAMPLE | SYMBOL |
| 8-467C-2 | 1.52   | ●      |
|          |        |        |
|          |        |        |
|          |        |        |
|          |        |        |
|          |        |        |
|          |        |        |
|          |        |        |
|          |        |        |

# UNIFIED SOIL CLASSIFICATION SYSTEM



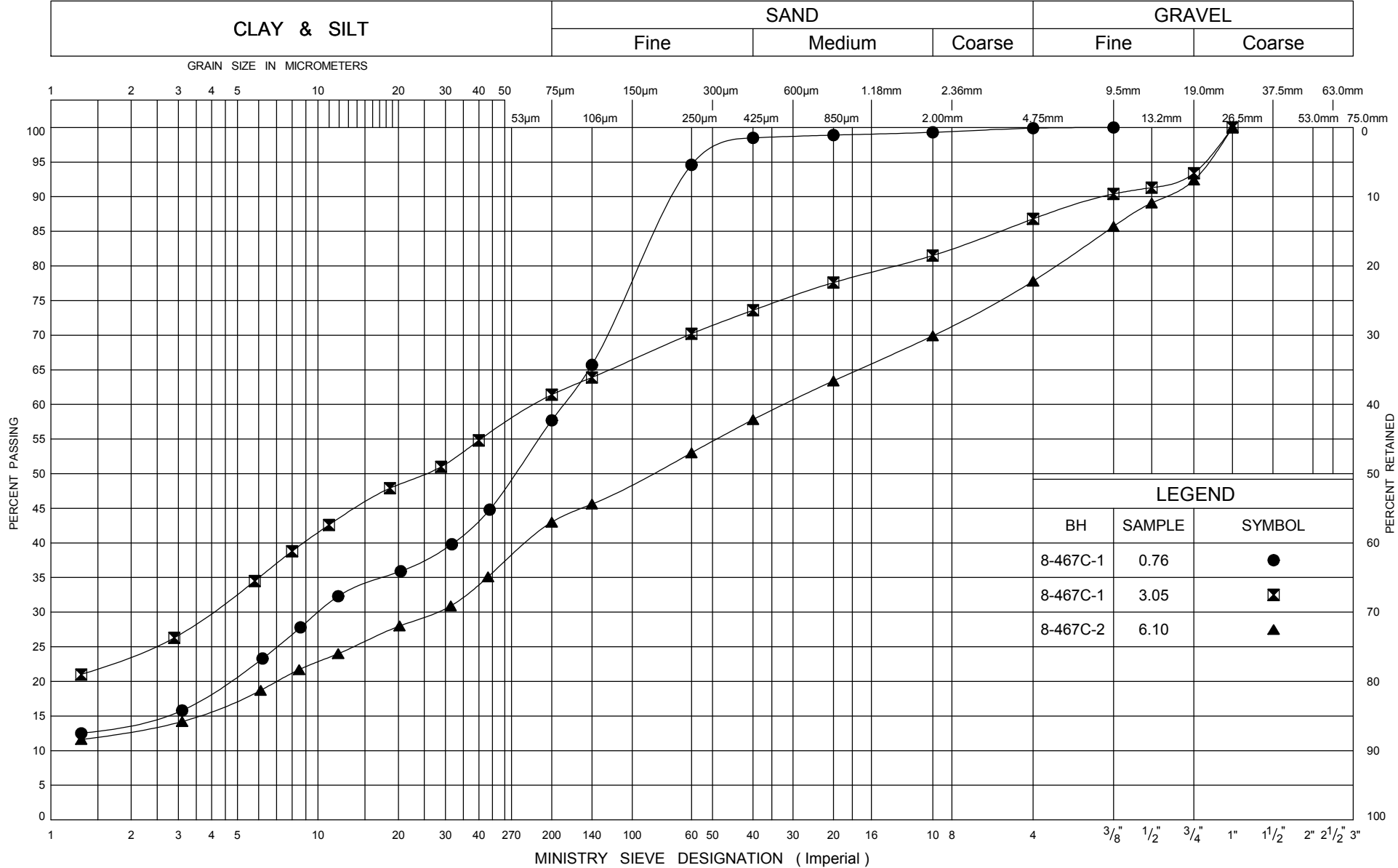
ONTARIO MOT GRAIN SIZE LARGE CULVERTS 07-6-IEG1B.GPJ ONTARIO.MOT.GDT 27/10/09

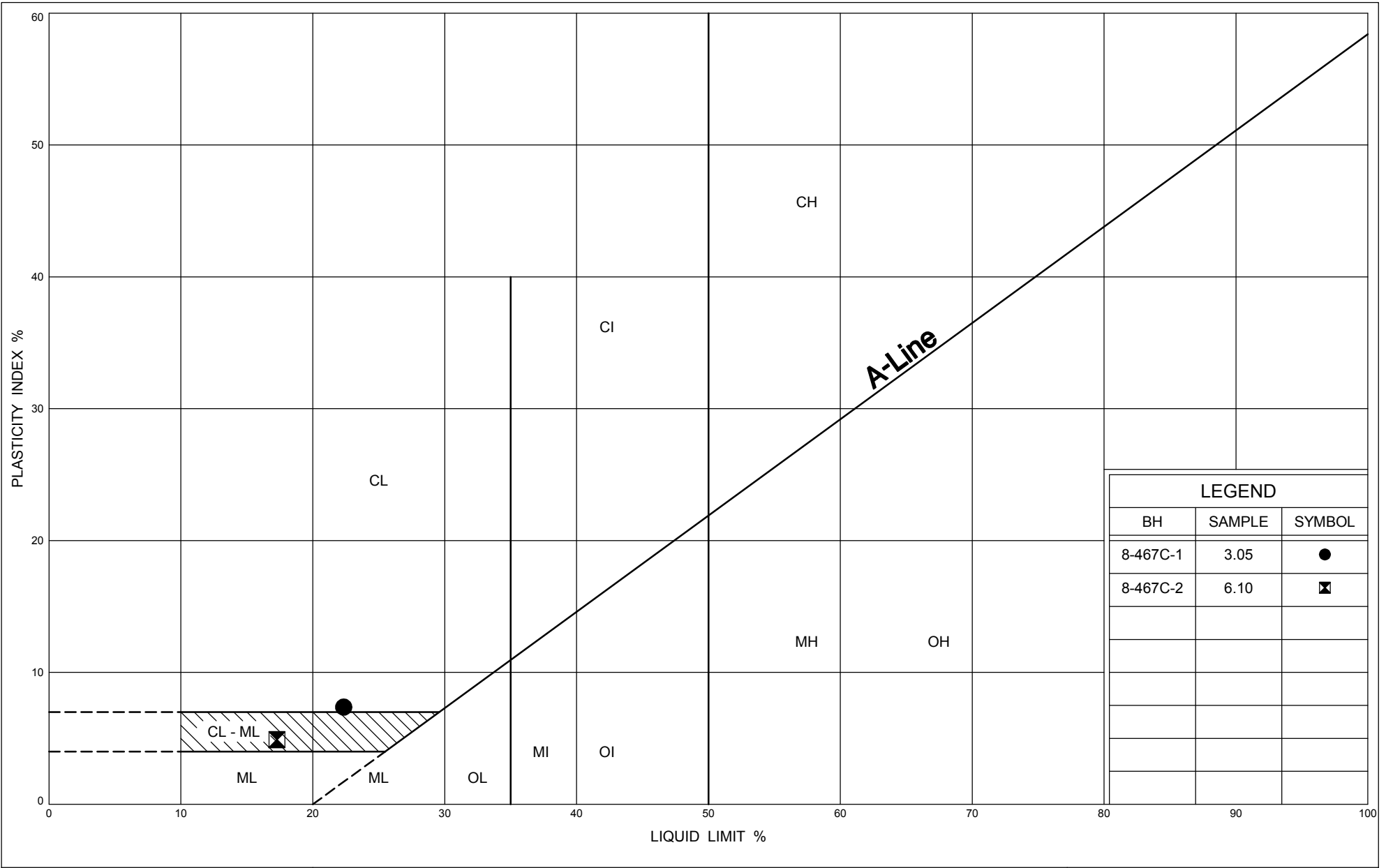


GRAIN SIZE DISTRIBUTION  
SAND TO SAND & GRAVEL, SW, SM TO SW-GW

FIG No 3  
GWP 167-91-00  
Hwy 26 - Sydenham Townline to Meaford

# UNIFIED SOIL CLASSIFICATION SYSTEM





Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 167-91-00 - Rehabilitation of Highway 26  
From Former St. Vincent/Sydenham Townline to Meaford  
Agreement # 3006-E-0002

07-6-IEG1-8-467C  
Final Report  
Appendix C  
May 17, 2010

## Appendix C

### Limitations of Report



## **APPENDIX C**

### **LIMITATIONS OF REPORT**

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Infrastructure Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, IEG recommends that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

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## Appendix D

### Site Photographs



8-467C General View



8-467C Outlet



8-467C Inlet



8-467C Inlet





8-467C Outlet



8-467C Inlet