



**THURBER** ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
OVERHEAD SIGN SUPPORT  
CASSELMAN COMMERCIAL VEHICLE INSPECTION FACILITY  
UNITED COUNTIES OF PRESCOTT AND RUSSELL  
G.W.P. 4017-16-00  
ASSIGNMENT NUMBER: 4015-E-0015**

**GEOCRES NUMBER: 31D-258**

**SUBMITTED TO  
MCINTOSH PERRY CONSULTING ENGINEERS LTD. / LEA CONSULTING LTD.  
JOINT VENTURE**

**JUNE 2017  
18122**

## Table of Contents

### PART 1: FACTUAL INFORMATION

1	INTRODUCTION .....	1
2	SITE DESCRIPTION .....	1
3	SITE INVESTIGATION .....	2
3.1	Previous Investigations .....	2
3.2	Field Investigation .....	2
3.3	Laboratory Testing .....	3
4	DESCRIPTION OF SUBSURFACE CONDITIONS .....	3
4.1	Overview / General .....	3
4.2	Asphalt.....	3
4.3	Fill.....	4
4.4	Clay .....	4
4.5	Refusal and Inferred Bedrock .....	4
4.6	Groundwater .....	5
5	MISCELLANEOUS .....	6

### PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6	GENERAL.....	7
6.1	Proposed Structure .....	7
6.2	Geotechnical Assessment.....	7
7	FOUNDATION RECOMMENDATIONS .....	8
7.1	Design Parameters .....	8
7.2	Caisson Installation.....	10
7.3	Cement Type and Corrosion Potential .....	10
7.4	Dewatering .....	10
7.5	Erosion Protection.....	10
8	CONSTRUCTION CONSIDERATIONS .....	11
8.1	Construction Concerns .....	11
9	CLOSURE .....	12



## **APPENDICES**

Appendix A	Borehole Locations and Soil Strata Drawings
Appendix B	Record of Borehole Sheet
Appendix C	Laboratory Test Results
Appendix D	Nonstandard Special Provision - Augured Caisson Construction for Traffic Control Sign Foundation Support
	List of Referenced Specifications

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the design and construction of an overhead sign support for a traffic controller sign at the existing Casselman Commercial Vehicle Inspection Facility (CVIF). Thurber carried out the investigation as a subconsultant to McIntosh Perry Consulting Engineers Ltd. – Lea Consulting Ltd. Joint Venture (MPCE-LEA) under Assignment 11 of Agreement No. 4015-E-0015.

A base plan indicating the location of the proposed sign was provided by MPCE-LEA for the preparation of this report.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of borehole, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

**2 SITE DESCRIPTION**

The CVIF is located on Highway 417 westbound, approximately 1.8 km west of the Highway 417 / County Road 138 interchange, in the United Counties of Prescott and Russell, Ontario. The location of the facility is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

At present, the facility includes a scale house and vehicle scale, three at-grade inspection bays, a garage structure and associated paved lane ways. The proposed location of the traffic controller sign is approximately 50 m west of the existing vehicle scale in the grassed boulevard adjacent to the west entrance to the inspection facility. There is an existing traffic controller sign located approximately 30 m west of the vehicle scales. The lands surrounding the site are flat, poorly drained and consist of agriculture fields to the north and south of Highway 417.

The site is located within a physiographic region known as the Winchester Clay Plain. This is an area of low relief, lying almost entirely within the drainage basin of the South Nation River. Although the sensitive marine clay plains are dominant, the Leda clay in the area is underlain by a thin layer of glacial till and bedrock (Chapman and Putnam, 1984).

### 3 SITE INVESTIGATION

#### 3.1 Previous Investigations

##### 1976 Investigation

GEOCRE Report 31G-177 presents the results of the investigation carried out for the existing CVIF. The investigation was completed in 1976 and included three sampled boreholes, one dynamic cone test, and laboratory testing, located in the area of the proposed scale house and scales. The boreholes were advanced to refusal but bedrock was not proven as part of the investigation.

The stratigraphy in the area of the CVIF is generally described as very soft to firm sensitive clay overlying compact to very dense glacial till, underlain by limestone bedrock.

It should be noted that settlement issues were noted in the original Foundation Investigation Report and surcharge loading was recommended in the area of the buildings and scales.

##### 2016 Investigation

Thurber carried out an investigation for the design and construction of a low bay inspection bay at the existing CVIF in November 2016, that included two sampled boreholes and laboratory testing. In general, the stratigraphy in the boreholes is characterized by an asphalt pavement, overlying gravel and sand fill, overlying native clay, overlying glacial till, and underlain by inferred bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the previous MTO investigation.

#### 3.2 Field Investigation

The field investigation for the traffic control sign was carried out on March 24, 2017, and included advancing one borehole. The approximate location and elevation of the borehole is shown on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1. It should be noted that due to a conflict with existing buried utilities at the proposed sign location, Borehole 17-1 was advanced approximately 2 m south of the proposed sign location within the asphalt laneway.

**Table 3-1: Borehole Summary**

<b>Borehole</b>	<b>Northing (m)</b>	<b>Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Depth (m)</b>
17-1	5021341.4	186567.5	65.7	14.5

Due to the relatively low strength of the clay, the borehole was extended to auger refusal at a depth of approximately 14.5 m below surface.

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call, to obtain utility locates/clearances for the intended borehole location. In addition, MTO traffic operations was contacted to obtain ATMS Fibre utility locates and Black & McDonald Limited were contacted to obtain MTO electric locates for the intended borehole location.

The borehole was advanced with a truck mounted CME drill rig equipped with hollow stem augers. The subsurface stratigraphy encountered in the borehole was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the borehole via the

completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. In-situ shear vane testing was carried out within the cohesive strata. All soil samples recovered from the borehole were placed in moisture-proof containers and the samples were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing.

Groundwater inflow was not encountered in the open borehole prior to backfilling. The borehole was backfilled with a low-permeability combination of auger cuttings and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903. The borehole was capped with 150 mm of cold patch asphalt.

The as-drilled location of the borehole and ground surface elevation at the borehole location was surveyed by Thurber on March 24, 2017. The temporary benchmark (TBM) used was the southwest corner of the existing garage structure. The location of the TBM is indicated on Drawing No. 1 in Appendix A. The geodetic elevation of the TBM was indicated on the drawings provided by MPCE-LEA as 65.787 m.

### **3.3 Laboratory Testing**

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analyses and Atterberg Limits testing were also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, resistivity, soluble sulphate and chloride concentrations was carried out on a soil sample of the native clay material. A copy of the chemical analysis results is provided in Appendix C.

The laboratory test results are presented on the Record of Borehole sheet in Appendix B and are illustrated on the figures in Appendix C.

## **4 DESCRIPTION OF SUBSURFACE CONDITIONS**

### **4.1 Overview / General**

Reference is made to the Record of Borehole sheet in Appendix B for details of the soil stratigraphy encountered in the borehole. A stratigraphic profile for the site is presented on the Drawing No. 1 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Borehole governs any interpretation of the site conditions.

In general, the stratigraphy in the borehole is characterized by an asphalt pavement, overlying gravel and sand fill, overlying native clay, and underlain by inferred bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the previous investigations at this site.

More detailed descriptions of the individual strata are presented below.

### **4.2 Asphalt**

The thickness of the asphalt measured at the borehole location was 100 mm.

### **4.3 Fill**

#### **Silty Sand with Gravel**

A fill layer consisting predominantly of sand and gravel with varying amounts of silt was encountered below the asphalt surface in the borehole. The fill material became clayey below a depth of 1.5 m. The top of this layer has an elevation of 65.6 m. The thickness of this layer is 2.6 m. The SPT 'N' values were 33 and 34 indicating a dense condition.

The moisture content of the samples tested ranged from 3% to 9%. The results of grain size analysis completed on samples of this material indicated a gravel content of 15% and 27%, a sand content of 43% and 50%, and a fines content (combined silt and clay size particles) of 30% and 35%. The results of the grain size analysis are illustrated on Figure 1 in Appendix C.

### **4.4 Clay**

#### **Clay Crust**

A brown clay crust deposit was encountered below the granular fill layer in the borehole. The top of this layer was identified at elevation 63.0 m. The thickness of this layer was 1.0 m. The SPT 'N' value was 4.

The moisture content of the samples tested was 34% and 58%. The results of grain size analysis testing completed on a sample of this material indicated a gravel content of 0%, a sand content of 0%, a silt content of 27%, and a clay content of 73%. The results of the grain size analysis are illustrated on Figure 2 in Appendix C.

The results of Atterberg Limits testing completed on a sample of this material indicated a liquid limit of 71, a plastic limit of 21, and plasticity index of 50, indicating a clay of high plasticity. Atterberg Limits analysis results are illustrated on Figure 3 in Appendix C.

#### **Clay**

A grey clay deposit was encountered below the clay crust. The top of this layer had an elevation of 62.1 m. The thickness of this layer was 10.7 m. In-situ shear vane test results indicated an undrained shear strength ranging from 25 kPa to 45 kPa; indicating a firm consistency.

The moisture content of the samples tested ranged from 55% to 82%. The results of grain size analysis completed on samples of this material indicated a gravel content of 0%, a sand content of 2% and 7%, silt content of 21% and 24%, and clay content of 69% and 77%. The results of the grain size analysis testing are illustrated on Figure 2 in Appendix C.

The results of Atterberg Limits testing completed on samples of this material indicated a liquid limit of 53 and 60, a plastic limit of 25 and 26, and plasticity index of 28 and 34, indicating a clay of high plasticity. Atterberg Limits analysis results are illustrated on Figure 3 in Appendix C.

### **4.5 Refusal and Inferred Bedrock**

Auger refusal was encountered beneath the clay stratum. The auger refusal has been inferred to be probable bedrock. The inferred bedrock surface was encountered at elevation 51.3 m.

#### **4.6 Groundwater**

Groundwater inflow was not encountered in the open borehole during drilling.

This observation is considered a short-term reading and seasonal fluctuations of the groundwater level are to be expected. The groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall. It is noted that free water was observed within the granular base and subbase material during a pavement investigation at this site. As such, it should be noted that perched groundwater could be encountered during excavation activities at a higher elevation than noted above.



## 5 MISCELLANEOUS

Thurber staked and/or marked the borehole location in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole location, and provided the ground surface elevation based on contract drawings provided by MPCE-LEA. George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated the drill rig to carry out the drilling, sampling, and in-situ testing. The drilling, and sampling operations in the field were supervised on a full-time basis by Mr. Sean O'Bryan of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.



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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**6 GENERAL**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the design and construction of an overhead sign support for a traffic controller sign at the existing Casselman Commercial Vehicle Inspection Facility (CVIF). Geotechnical recommendations are provided to assist the design team in designing a suitable foundation for the proposed structure.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections address the foundation aspects for design and construction of a traffic controller sign at the existing CVIF. The discussions and recommendations presented in this report are based on the information provided by MPCE-LEA and on the factual data obtained during this investigation.

**6.1 Proposed Structure**

It is understood that the Ministry wants to install a traffic controller sign at the existing Casselman CVIF. The proposed location of the sign is anticipated to be located near Station 10+860, approximately 50 m west of the existing vehicle scales in a grassed boulevard adjacent to the west entrance to the inspection facility. A cantilever, static sign support foundation is to be used to support the overhead sign. The approximate location of the new traffic controller sign is illustrated on Drawing No. 1 in Appendix A.

It is noted that the borehole for the proposed sign support was drilled in the adjacent paved area due to a conflict with a buried storm sewer and MTO electrical conduits. It is understood that the utilities will be relocated as required as part of the project.

**6.2 Geotechnical Assessment**

In general, the stratigraphy encountered in the borehole consists of granular fill to a depth of 2.7 m, underlain by a clay deposit. The upper 0.9 m of the clay was brown in colour and had a

firm consistency. Below a depth of 3.7 m, the clay was typically grey in colour with an average undrained shear strength of 28 kPa indicating a firm consistency. The inferred bedrock surface was encountered at elevation 51.3 m.

Where site conditions permit, the foundation for the sign would be in accordance with the standard design and details provided in Section 3.5.4 of the MTO Sign Support Manual. The standard design assumes the following minimum soil parameters below the frost layer.

		Case 1 (Sand)	Case 2 (Soft Clay)
Length of Caisson Below Frost Layer	Upper 2/3	$\phi = 28^\circ$	$C_u = 25 \text{ kPa}$
	Lower 2/3	$\phi = 30^\circ$	$C_u = 50 \text{ kPa}$

The strength of the clay at this site does not meet the design assumptions to allow for the use of the standard foundation shown on Drawing SS118-3 Static Sign Support Footing Details (Ground Mounted); hence a site-specific caisson design will be required for this site.

## 7 FOUNDATION RECOMMENDATIONS

### 7.1 Design Parameters

For design analysis, the following unfactored, geotechnical soil properties outlined in Table 7-1 may be used.

**Table 7-1: Geotechnical Model**

Elevation (m)		Soil Type	Design Properties
From	To		
65.6	63.0	Fill: Silty sand and gravel trace to some clay	Total Unit, $\gamma_t = 20.5 \text{ kN/m}^3$ Friction Angle, $\phi' = 30^\circ$
63.0	62.0	Clay Crust	Total Unit, $\gamma_t = 17.5 \text{ kN/m}^3$ Undrained Shear Strength, $S_u = 50 \text{ kPa}$ Unconfined Compressive Strength, $q_u = 100 \text{ kPa}$
62.0	51.2	Native Clay	Total Unit, $\gamma_t = 16.0 \text{ kN/m}^3$ Undrained Shear Strength, $S_u = 25 \text{ kPa}$ Unconfined Compressive Strength, $q_u = 50 \text{ kPa}$

The frost penetration depth at this site is 1.8 m as per OPSD 3090.101. As noted in the MTO Sign Support Manual, resistance from within the frost penetration depth should be neglected.

A design water level elevation of 65.7 m (existing ground surface) has been assumed for this site.

## Horizontal Subgrade Reaction

The interaction between a caisson and the surrounding soil may be analysed using horizontal subgrade reaction theory. The coefficient of horizontal subgrade reaction ( $k_h$ ) (Terzaghi, 1955) as well as ultimate lateral resistance ( $p_{ult}$ ) may be calculated based on the following equations in conjunction with the parameter values provided in Table 7-2.

### For cohesionless soils

$$k_h = \frac{n_h Z}{B}$$

$$p_{ult} = 3 \gamma Z K_p$$

### For cohesive soils

$$k_h = \frac{67 S_u}{B}$$

$$p_{ult} = 9 S_u; \text{ at and below at depth of } 3D \text{ and reduced to } 2S_u \text{ at the ground surface}$$

where:

$k_h$  = coefficient of horizontal subgrade reaction

$n_h$  = coefficient related to soil density

$Z$  = depth of embedment (m)

$B$  = width perpendicular to load direction (m)

$S_u$  = undrained shear strength (kPa)

$p_{ult}$  = ultimate lateral resistance (kPa)

The geotechnical parameters for use in assessment are presented in Table 7-2.

**Table 7-2: Parameters for Lateral Pile Resistance**

Borehole	Elevation (m)	Soil	Effect Unit Weight $\gamma'$ (kN/m <sup>3</sup> )	$n_h$ (kPa/m)	$S_u$ (kPa)	$K_p$
17-1	65.6 to 63.0	Silty Sand with gravel	10.7	3,500	–	3.0
	63.0 to 62.0	Clay Crust	7.7	–	50	2.6
	62.0 to 51.2	Native Clay	6.2	–	25	

The elevations provided above are based on the borehole data and existing grades. The unit weights provided in the table are for soils below the groundwater level and are buoyant (effective) unit weights for use in the lateral resistance calculations.

The spring constant,  $K$ , for analysis may be obtained by the expression

$$K = k_h L D$$

where:

$k_h$  = coefficient of horizontal subgrade reaction (kN/m)

$L$  = Length of segment (m)

$D$  = Width (m)

The factored lateral resistance at SLS determined based on the data and methods provided above should incorporate a resistance factor ( $\phi_{gs}$ ) of 0.8 as per Table 6.2 of the CHBDC (static analysis – typical degree of understanding).

## 7.2 Caisson Installation

Caissons must be installed in accordance with OPSS.PROV 903.

The soil conditions observed at the site suggest that where the augured hole extends into the fill material below the groundwater level and further into the native sensitive firm clay, the hole is not expected to remain open. Consequently, the use of a temporary liner will be required as part of the construction process. The use of tremie concrete may also be required depending on the groundwater conditions encountered at time of installation.

Recommended wording for an NSSP addressing these requirements is provided in Appendix D.

## 7.3 Cement Type and Corrosion Potential

A soil sample was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations to buried infrastructure. The analysis results are summarized in the Table 7-3. A copy of the test results is provided in Appendix C.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in the Table 7-3 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

**Table 7-3: Results of Chemical Analysis**

Borehole	Sample	Depth m	pH	Resistivity (Ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
17-1	SS5	4.8	7.72	1600	35	368

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater.

## 7.4 Dewatering

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit construction in a dry and stable caisson excavation. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater perched within the pavement structure, or surface runoff will tend to seep into, and accumulate in proposed caisson excavation negatively affecting sidewall stability of the augured shaft.

## 7.5 Erosion Protection

The contractor should provide temporary erosion and sediment control measures in accordance with OPSD 805 as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

## **8 CONSTRUCTION CONSIDERATIONS**

### **8.1 Construction Concerns**

Potential construction concerns include, but are not necessarily limited to, the following:

- Augured holes for caissons are not expected to remain open on their own. Consequently, the use of a temporary liner will be required as part of the construction process.
- The sensitive clay is easily disturbed and the disturbed clay at the base of a drilled hole may not support a rebar cage.

The successful performance of the structure will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations by the QVE will be required during construction to confirm that the recommendations are correctly implemented and material specifications are met.

## 9 CLOSURE

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.



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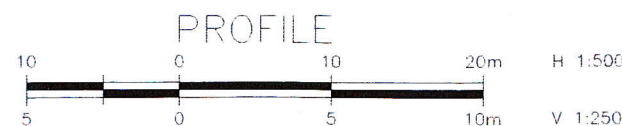
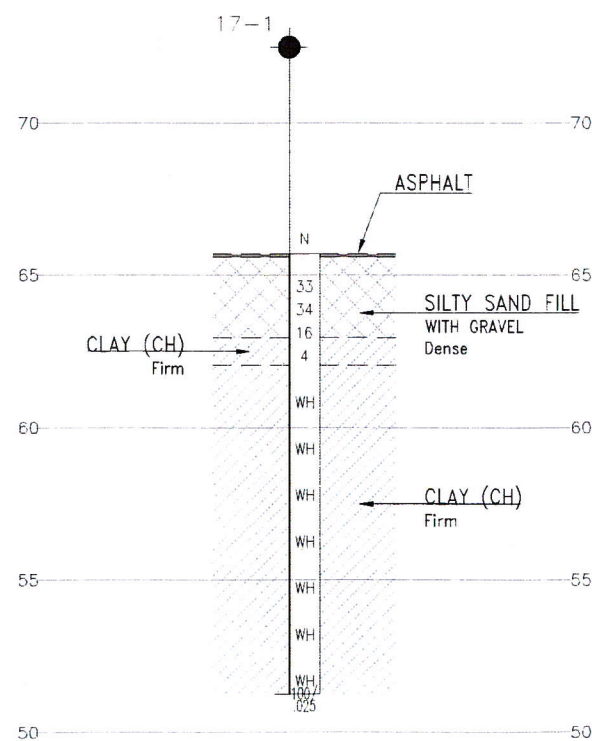
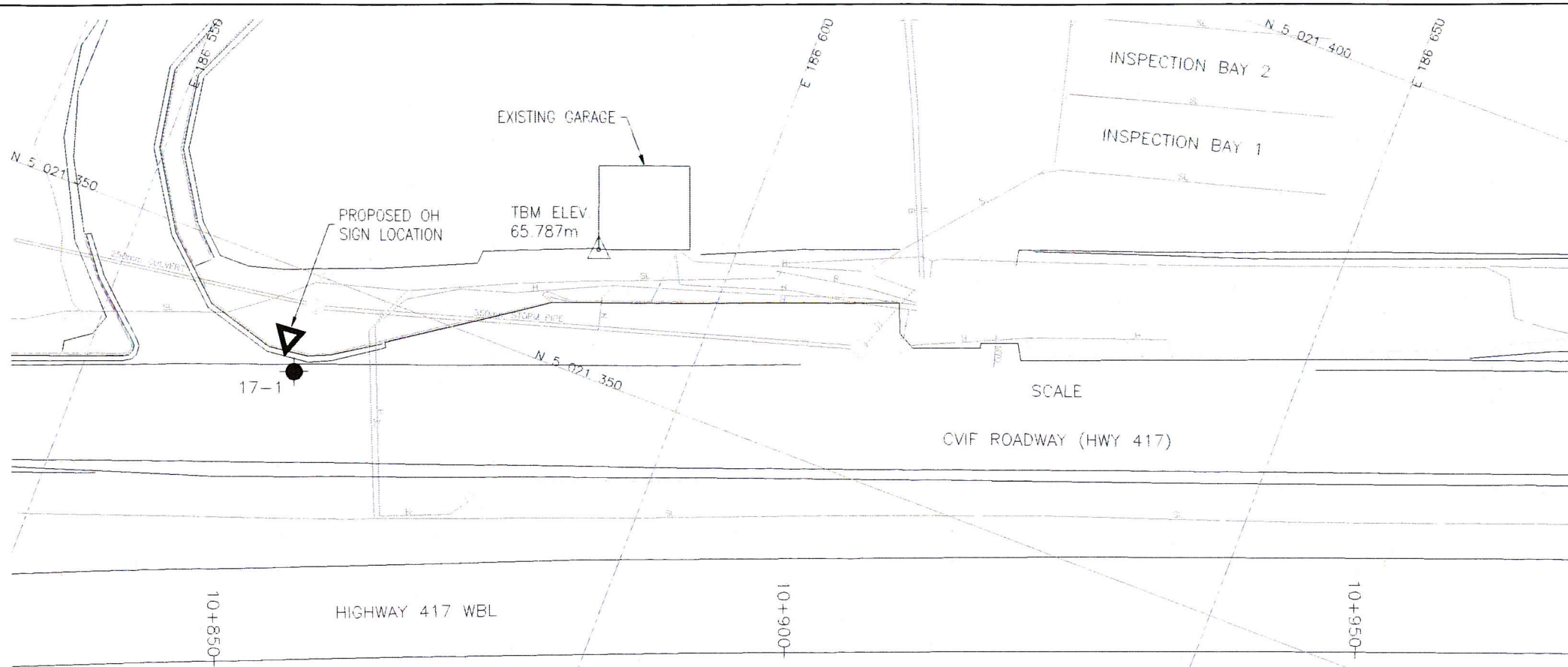


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**APPENDIX A**  
**BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS**

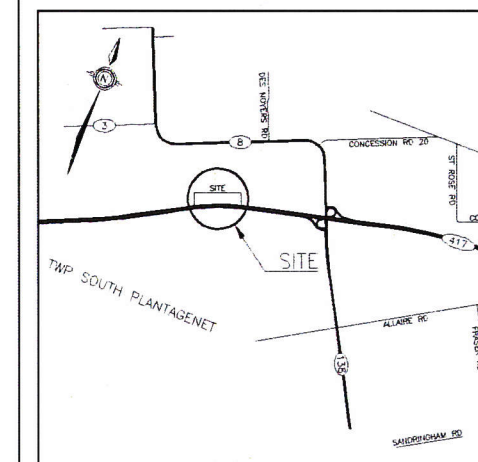
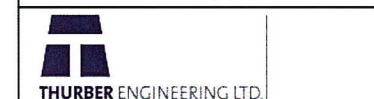




METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 4017-16-00

CASSELMAN VEHICLE  
INSPECTION FACILITY  
OVERHEAD SIGN SUPPORT  
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

●	Borehole by Thurber
+	Borehole by Others
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60 Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-1	65.700	5021341.373	186567.486

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Borehole locations are shown in MTM Zone 8 coordinates.

GEOCRES No.



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JM	CHK -	CODE
DRAWN	MFA	CHK KCP	SITE
			LOAD
			DATE
			JUNE 2017
			STRUCT
			DWG 1

**APPENDIX B**  
**RECORD OF BOREHOLE SHEET**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

### TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

### TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

### RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

### DYNAMIC CONE PENETRATION TEST (DCPT):

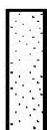
Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

### STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders  
Cobbles  
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

### TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

### SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT “N” Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

### MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit

## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

### TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

### DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

### STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

# RECORD OF BOREHOLE No 17-1

1 OF 2

METRIC

GWP# 4017-16-00 LOCATION Casselman CVIF N 5 021 341.4 E 186 567.5 ORIGINATED BY SOB  
 HWY 417 BOREHOLE TYPE HSA COMPILED BY JM  
 DATUM Geodetic DATE 2017.03.24 - 2017.03.24 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
				WATER CONTENT (%)																
65.7								20	40	60	80	100								
0.0	100 mm ASPHALT																			
0.1	Silty sand with gravel Dense Brown FILL		1	GS																
			1	SS	33															
	- Clayey below 1.5 m		2	SS	34															
63.0			3	SS	16															
2.7	CLAY (CH) Firm Brown		4	SS	4															
62.1																				
3.7	CLAY (CH to Cl) Firm Grey																			
			5	SS	WH															
			6	SS	WH															
			7	SS	WH															
			8	SS	WH															
					</															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
15  
10 (%) STRAIN AT FAILURE



## METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>UNIT WEIGHT γ</div> <div>REMARKS &amp; GRAIN SIZE DISTRIBUTION (%)</div>					
Continued From Previous Page					
51.3 14.4	CLAY Firm Grey				
			9	SS	WH
			10	SS	WH
			11	SS	WH
			12	SS	100/25mm
End of Borehole Auger refusal on probable bedrock					

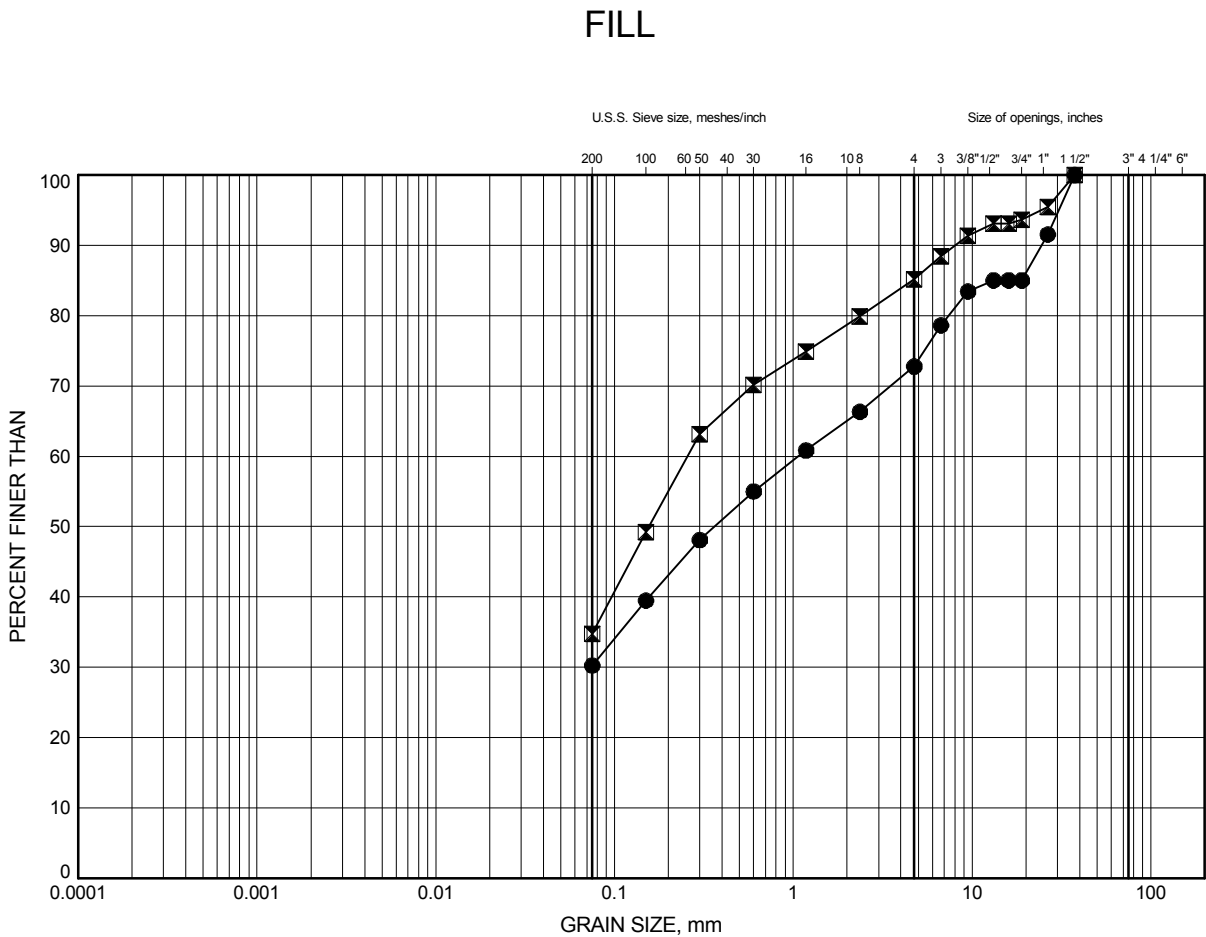
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity



## **APPENDIX C LABORATORY TEST RESULTS**

Casselman Commercial Vehicle Inspection Facility  
**GRAIN SIZE DISTRIBUTION**

FIGURE 1



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.07	64.66
⊠	17-1	1.83	63.90

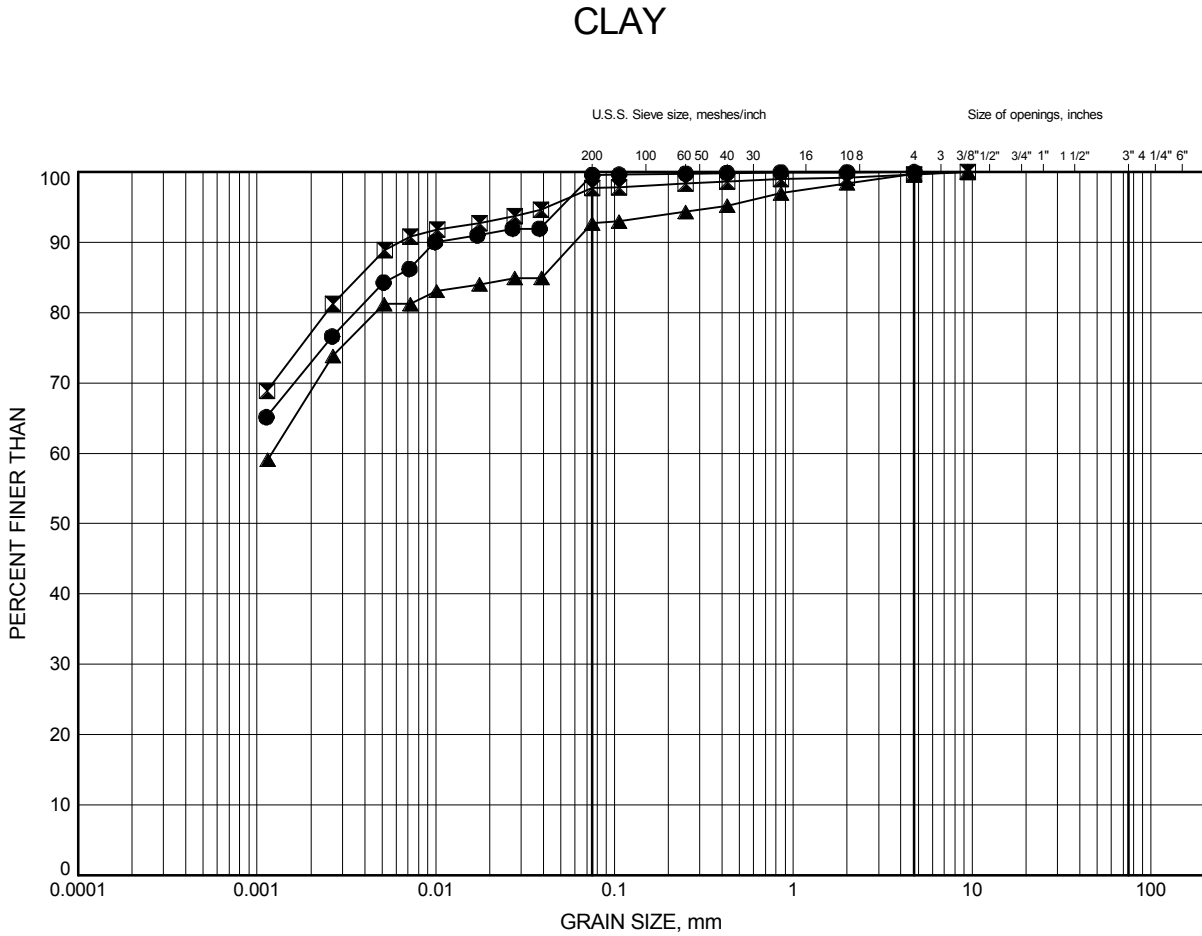
Date May 2017  
 GWP# 4017-16-00



Prep'd KE  
 Chkd. KP

Casselman Commercial Vehicle Inspection Facility  
GRAIN SIZE DISTRIBUTION

FIGURE 2



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	3.35	62.37
⊠	17-1	7.92	57.80
▲	17-1	14.02	51.71

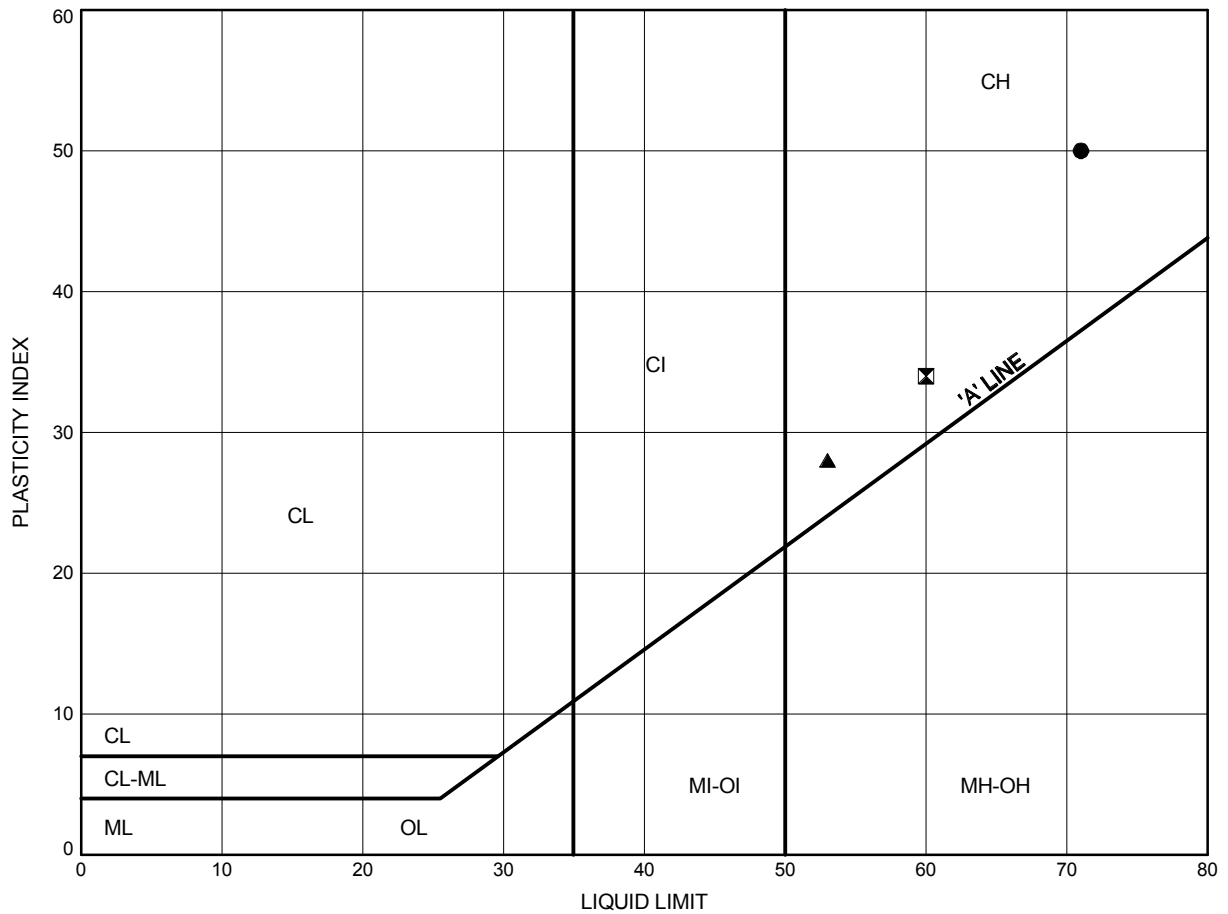
Date May 2017  
GWP# 4017-16-00



Prep'd KE  
Chkd. KP

Casselman Commercial Vehicle Inspection Facility  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE 3



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	3.35	62.37
⊠	17-1	7.92	57.80
▲	17-1	14.02	51.71

Date May 2017  
 GWP# 4017-16-00



Prep'd KE  
 Chkd. KP

**APPENDIX D**  
**NONSTANDARD SPECIAL PROVISION - AUGURED CAISSON CONSTRUCTION FOR TRAFFIC**  
**CONTROL SIGN FOUNDATION SUPPORT**  
**LIST OF REFERENCED SPECIFICATIONS**

## **RECOMMENDED WORDING FOR "NSSP – "AUGURED CAISSON CONSTRUCTION FOR TRAFFIC CONTROL SIGN FOUNDATION SUPPORT"**

The Contractor is advised that the soil conditions observed at the site suggest that where the augured hole extends into the fill material below the groundwater level and further into the native sensitive firm clay, the hole is not expected to remain open. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

For bidding purposes, the Contractor shall assume the following:

1. The subsurface conditions at an augured caisson location are the same as those encountered in the borehole closest to the subject caisson location.
2. Water seepage and/or soil sloughing into the caisson hole will occur from existing fill. The sidewall stability would be susceptible to disturbance under conditions of unbalanced hydrostatic head or disturbance of the sensitive clay. Temporary liners shall be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required.
3. All concrete should be placed in the dry. Should it be impractical to remove accumulated water in the caisson hole, tremie techniques should be used to place the concrete.

The Contractor is responsible for constructing the foundation without disturbing the material at the sides or bases of the foundation.

## **LIST OF REFERENCED SPECIFICATIONS**

OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 903	Construction Specification for Deep Foundations
Sign Support Manual	Ministry of Transportation – Provincial Highway Management Division Highway Standards Branch Office; April 2011