



**THURBER** ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
LOW BAY INSPECTION BAY  
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-257**

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

**JUNE 2017  
15193**

## Table of Contents

### PART 1: FACTUAL INFORMATION

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

### PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6	GENERAL.....	6
6.1	Proposed Structure .....	6
6.2	Geotechnical Assessment.....	7
7	FOUNDATION RECOMMENDATIONS .....	7
7.1	Subgrade Preparation.....	8
7.2	Structural Slab-on-Grade .....	8
7.3	Concrete Bollard Foundations.....	8
7.4	Frost .....	9
7.5	Excavations .....	9
7.6	Dewatering .....	9
7.7	Erosion Protection.....	9
8	CONSTRUCTION CONSIDERATIONS .....	10

8.1	Construction Concerns .....	10
9	CLOSURE .....	11

## APPENDICES

Appendix A	Borehole Locations and Soil Strata Drawings
Appendix B	Record of Borehole Sheets
Appendix C	Laboratory Test Results
Appendix D	Selected Site Photographs of the Inspection Facility
Appendix E	List of Referenced Specifications

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
LOW BAY INSPECTION BAY  
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-257**

**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 a low bay inspection bay 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 9 of Agreement No. 4015-E-0015.

General Arrangement (GA) drawings and base plan mapping were 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 boreholes, 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 three at-grade inspection bays separated by concrete barriers. Each bay is approximately 31 m long and 6.0 wide with an asphalt surface. The inspection bays are located in the middle of the facility to the northeast of the buildings and scales. The lands surrounding the site are flat, poorly drained and consist of agriculture fields to the north and south of Highway 417. Site photographs showing the general conditions at the site, are presented in Appendix D.

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**

GEOCRES 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. 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.

### 3.2 Field Investigation

The field investigation was carried out on November 24, 2016, and included advancing two boreholes. The approximate locations and elevations of the boreholes are shown on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1.

**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>
101	5021390.5	186617.4	65.7	14.3
102	5021400.2	186649.8	65.8	11.4

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call and MTO Electrical to provide utility locates/clearances for the intended borehole locations. The proposed locations were also reviewed with the operation staff from the CVIF.

The boreholes were advanced with a CME, truck mounted drill rig equipped with hollow stem augers. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes 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 boreholes were placed in moisture-proof containers and the samples were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing.

Groundwater was measured in the open boreholes prior to backfilling. The boreholes were backfilled with a low-permeability combination of auger cuttings and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903. All boreholes were capped with 150 mm of cold patch asphalt.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber on November 25, 2016. The temporary benchmark (TBM) used was the top of the manhole cover located approximately 3.5 m west of the existing inspection building. 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 65.914 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.

The laboratory test results are presented on the Record of Borehole sheets 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 sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. 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 Boreholes governs any interpretation of the site conditions.

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.

More detailed descriptions of the individual strata are presented below.

### **4.2 Asphalt**

The thickness of the asphalt measured at the borehole locations was 250 mm and 350 mm.

### **4.3 Fill – Silty Gravel with Sand**

A fill layer consisting predominantly of gravel and sand with varying amounts of silt was encountered below the asphalt surface in both boreholes. The top of this layer has an elevation of 65.4 m. The thickness of this layer is 1.8 m. The SPT 'N' values ranged from 10 to 30 indicating a compact condition.

The moisture content of the samples tested ranged from 8% to 12%. The results of a grain size analysis completed on a sample of this material indicated a gravel content of 40%, sand content of 31%, and fines content (combined silt and clay size particles) of 29%. The results indicate the this material is low to moderately susceptible to frost heave. The results of the grain size analysis are illustrated on Figure 1 in Appendix C.

### **4.4 Clay**

#### **Clay Crust**

A mottled grey and brown clay crust deposit was encountered below the granular fill layer in both boreholes. The top of this layer was identified at elevation 63.6 m. The thickness of this layer ranged from 0.5 m to 0.7 m. The SPT 'N' values were 5 and 6.

The moisture content of the samples tested were 30% and 31%. The results of grain size analysis testing completed on samples of this material indicated a gravel content of 0%, sand content of 1% and 3%, silt content of 34% and 35%, and clay content of 62% and 65%. The results of the grain size analysis 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 58 and 62, a plastic limit of 22 and 23, and plasticity index of 36 and 39, indicating a clay of high plasticity (CH). Atterberg Limits analysis results are illustrated on Figure 3 in Appendix C.

## **Clay**

A grey clay deposit was encountered below the clay crust stratum in both boreholes. The top of this layer ranged from elevation 63.1 m to 62.9 m. The thickness of this layer ranged from 8.5 m to 9.7 m. In-situ shear vane test results indicated an undrained shear strength ranging from 17 kPa to 60 kPa; indicating a soft to stiff consistency, but typically firm.

The moisture content of the samples tested ranged from 48% to 83%. The results of grain size analysis completed on samples of this material indicated a gravel content of 0%, sand content ranging from 0% to 3%, silt content ranging from 26% to 47%, and clay content ranging from 51% to 74%. 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 ranging from 45 to 68, a plastic limit ranging from 20 to 24, and plasticity index ranging from 23 to 44, indicating a clay of intermediate to high plasticity (CI to CH). Atterberg Limits analysis results are illustrated on Figure 3 in Appendix C.

## **4.5 Glacial Till**

A stratum of glacial till consisting predominantly of gravel and sand with varying amounts of fines was encountered beneath the clay stratum in Borehole 101. The top of this layer was identified at elevation 53.3 m. The SPT 'N' values were greater than 100 indicating a very dense condition.

The moisture content of a sample tested was 11%. The results of grain size analysis completed on a sample of this material indicated a gravel content of 48%, sand content of 23%, silt content of 24%, and clay content of 5%. The results of the grain size analysis testing are illustrated on Figure 4 in Appendix C.

Based on the results of Atterberg Limits testing the fines content is classified as non-plastic.

## **4.6 Refusal and Inferred Bedrock**

Auger refusal was encountered beneath the glacial till in Borehole 101 and beneath the clay stratum in Borehole 102. The auger refusal has been inferred to be probable bedrock. The inferred bedrock surface ranges from elevation 51.4 m to 54.4 m in Boreholes 101 and 102 respectively.

## **4.7 Groundwater**

The groundwater level was measured in the open boreholes at the time of drilling at depths of 7.0 m and 5.2 m; corresponding to elevations 58.7 m and 60.6 m in Boreholes 101 and 102 respectively. These observations are considered short-term readings. 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.

Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.



## 5 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and provided the ground surface elevations 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. Jeff Morrison 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.



Kenton C. Power, P.Eng.  
Geotechnical Engineer



Paul Carnaffan, P.Eng.  
Principal, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
LOW BAY INSPECTION BAY  
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-257**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**6 GENERAL**

This report presents the interpretation of the factual data obtained from a foundation investigation conducted by Thurber for the design and construction of a low bay inspection bay at the existing Highway 417 CVIF, in the United Counties of Prescott and Russell, Ontario. 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 of the replacement and conversion to a low bay inspection bay. The discussions and recommendations presented in this report are based on the information provided by MPCE-LEA and on the factual data obtained during the course of this investigation.

**6.1 Proposed Structure**

It is understood that the Ministry wants to construct a low bay inspection bay at the existing Casselman CVIF. The new low bay is to be located at the location of the existing middle at-grade inspection bay (Bay 2). Based on information provided by MPCE-LEA, it is understood that the low bay structure will have a width of 6.0 m and a length of 31.0 m. The low bay is to be constructed as a reinforced concrete slab-on-grade structure with a 0.225 m deep recessed area extending down the middle of its length to allow for easier access for the inspection of the underside of the commercial vehicles. The remainder of Bay 2 will be at-grade. Bay 2 is also to include in-slab heating and a 150 mm diameter pipe subdrain beneath the middle of the bay which will connect to a catchbasin and outlet. The adjacent inspection bays (Bays 1 and 3) are to be reconstructed with concrete pavement.

The existing pre-cast concrete barriers along the sides of all three inspection bays are to be replaced with new concrete lighting bollards. The bollards will be rectangular concrete pedestals 600 mm wide by 760 mm long by 1500 mm tall. The bollards between the new low bay and the adjacent bays will be supported directly on the edge of the low bay slab. The bollards on the

outside edges of Bay 1 and Bay 3 will be supported on strip footings. It is understood that the bollards are not designed to resist traffic loading; the loading is from the self-weight of the concrete.

## **6.2 Geotechnical Assessment**

In general, the stratigraphy identified in the boreholes is characterized by an asphalt surface, overlying gravel and sand fill that extends to a depth of approximately 2.1 m and which is underlain by native clay, overlying glacial till, and underlain by inferred bedrock.

Based on the results of the field and laboratory investigation and the information provided by MPCE-LEA with regards to the proposed project requirements, the geotechnical foundation design considerations include the following:

- The clay at the site is compressible. A surcharge program was carried out during construction of the existing CVIF to help manage post construction settlements. No grade raise is proposed for the construction of the low bay and the new bollards are lightly loaded (similar to existing concrete jersey barriers that they will replace). Since there is virtually no increase in loading, settlement is not a concern for the proposed work. If changes to the finished grades are proposed a review of the settlement across the site would be required.
- The inspection bays are located within a paved area with an asphalt surface. Trucks will drive from the asphalt pavement onto the new low bay slab. Differential movement between the asphalt pavement and low-bay slab is not desirable.
- The concrete pavement for the surface of Bays 1 and 3 will be confined on both sides by foundation elements: strip footings supporting bollards on the outsides and the low bay slab on the insides. Compatibility of the foundation design elements and concrete pavement structure must be considered to ensure proper drainage of the pavement structure and to minimize differential movement between the asphalt pavement, concrete pavement, bollard footings and low bay slab.
- The fill and clay subgrades are susceptible to softening in the presence of excess moisture and/or construction traffic. Surface water should be diverted away from the excavation and not allowed to pond over the exposed subgrade. Also, construction equipment should not be permitted to travel on the exposed subgrades.

Based on the lightly loaded nature of the bollard footings and low bay slab and performance requirements of both these foundation elements and pavement elements, it is recommended to support all elements of the three inspection bays on a compacted pad of Granular O with a minimum thickness of 400 mm. Subdrains are to be installed at the subgrade level and connected to a drainage outlet.

## **7 FOUNDATION RECOMMENDATIONS**

The following sections provide foundation recommendations for subgrade preparation and design of the proposed low bay facility.

## 7.1 Subgrade Preparation

The low bay slab, bollard footings and concrete pavement in Bays 1 and 3 should be supported on a compacted pad of Granular O. The granular pad should extend full width beneath these elements and a minimum of 1 m beyond the outside edge of the concrete footings and slabs (measured at the base of the granular pad). The thickness of the granular pad should be a minimum of 400 mm beneath the bollard footings and low bay slab.

Excavations should be in accordance with OPSS 902 and must be dewatered prior to construction of the granular pad. All asphalt, existing conduits and existing fill material must be removed to a minimum depth of 400 mm below the underside of the low bay slab and bollard footings. Existing granular fill material remaining at the subgrade elevation may remain in place provided it is free of organic material, debris, boulders and is in a compact state.

The subgrade surface shall be sloped at 2% toward subdrains connected to a drainage outlet.

A Class 1, non-woven geotextile meeting the requirements of OPSS 1860 and with a maximum filtration opening size (FOS) of 212  $\mu\text{m}$  should be placed over the subgrade prior to placing the Granular O pad.

The Granular O material should meet the specifications of OPSS.PROV 1010 Granular O and should be placed and compacted in accordance with OPSS.PROV 501.

Construction of the proposed pipe subdrain and outlet should be in accordance with OPSS 405.

## 7.2 Structural Slab-on-Grade

The slab-on-grade founded on the granular pad prepared as described in Section 7.1 may be designed using an unfactored modulus of sub-grade reactions of 25 MPa/m.

## 7.3 Concrete Bollard Foundations

The concrete bollards may be supported on concrete strip footing foundations. It is understood that the proposed width of the footings is not governed by bearing resistance requirements and will be 2.0 m. The depth of the footings will be 0.5 m.

The foundations for the new bollards may be constructed directly on the Granular O material placed as outlined in Section 7.1 above.

The factored geotechnical resistances for the 2.0 m wide by 0.5 m deep bollard footings founded on the Granular O pad are the following:

- Factored vertical geotechnical resistances at ULS 100 kPa
- Factored vertical geotechnical resistance at SLS 75 kPa

The factored geotechnical resistances provided include the following factors:

- Consequence factor ( $\Psi$ ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
  - $\phi_{gu} = 0.5$ , ULS (static analysis; typical degree of understanding)
  - $\phi_{gs} = 0.8$ , SLS (static analysis; typical degree of understanding)

The geotechnical resistances are for vertical concentric loading and will need to be adjusted for the effects of inclined or eccentric loading, if applicable. The geotechnical resistance should be calculated as illustrated in the CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces and sliding resistance between concrete and compacted Granular O material should be evaluated using an unfactored coefficient of 0.45 for cast-in-place concrete.

#### **7.4 Frost**

The design frost penetration depth at this site is estimated to be 1.8 m based on OPSD 3090.101.

While the provision of OPSS Granular O beneath the slab will help to mitigate frost action some seasonal movement of the slab should be expected.

#### **7.5 Excavations**

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fills and native materials within 3 m of ground surface at the site are classified as Type 3 soil in accordance with OHSA.

#### **7.6 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 excavation. Water from either surface flow and/or groundwater must be diverted away or removed from the excavation at all times. Groundwater perched within the pavement structure, or surface runoff will tend to seep into, and accumulate in proposed excavations.

Dewatering design and decisions regarding dewatering, must be carried out by the Contractor. Due to the shallow excavation depths being considered and the depth to groundwater at the site it is anticipated that conventional sump and pump techniques should be sufficient, however initial pumping rates may be high until water trapped within the existing granular fill has been removed.

#### **7.7 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:

- Confirmation that proper subgrade preparation has been carried out prior to constructing the slab-on-grade and the subgrade is uniformly competent. Final subgrade must not be disturbed by construction traffic.
- Effectiveness of the under-slab drainage will be critical to performance of the low bay structure.

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.



Kenton C. Power, P.Eng.  
Geotechnical Engineer



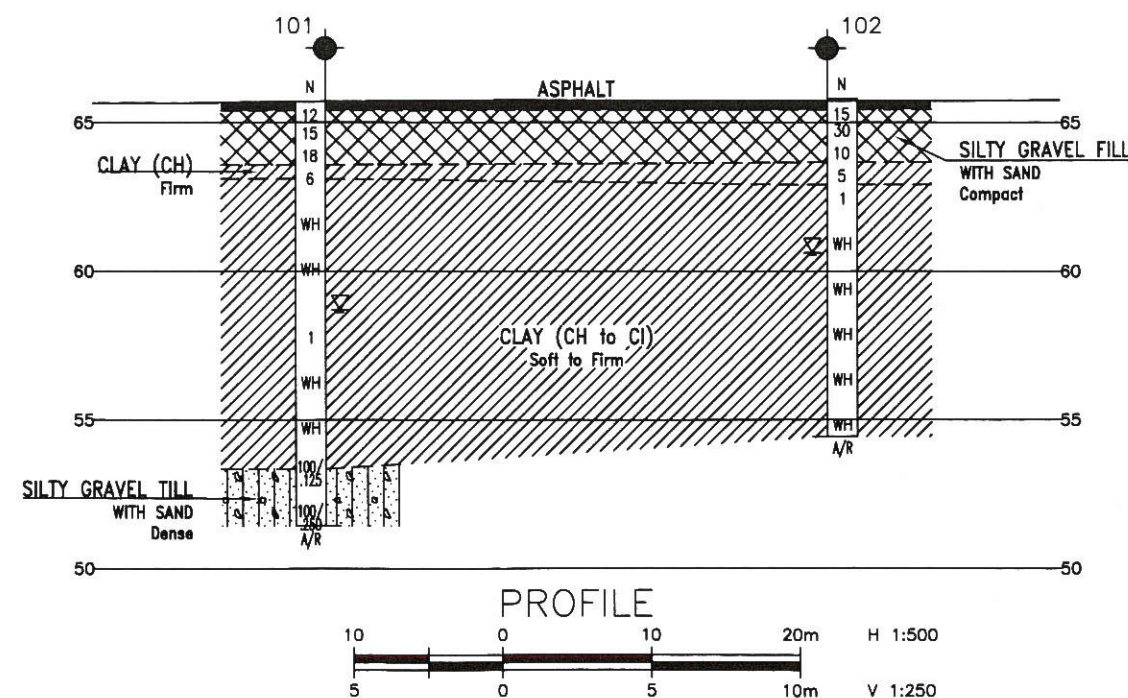
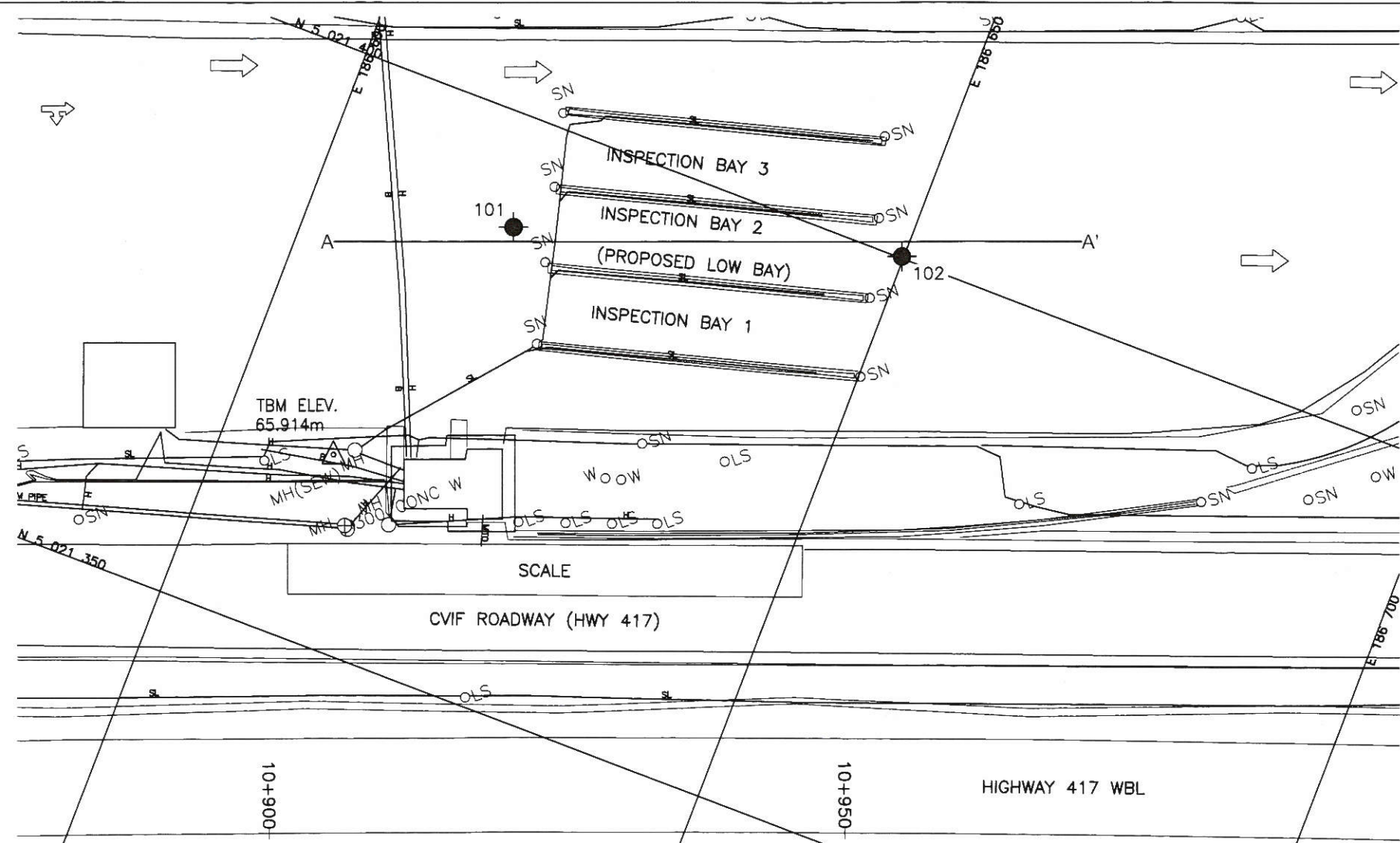
Paul Carnaffan, P.Eng.  
Principal, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact

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





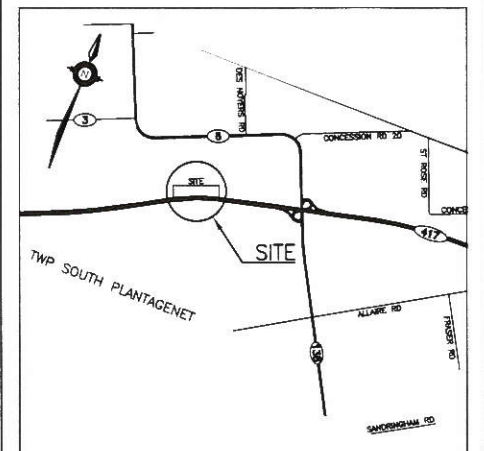
MILTRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CGNT No  
GWP No 4017-16-00

HIGHWAY 417  
CASSELMAN VEHICLE  
INSPECTION FACILITY  
BOREHOLE LOCATIONS AND SOIL STRATA








**THURBER ENGINEERING LTD.**



## 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                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

[illegible]

-NOTES-

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

GEOCRES No. 31D-257

LICENSED PROFESSIONAL ENGINEER  
 K. T. C. POWER  
 100130652  
 June 23, 17  
 PROVINCE OF ONTARIO

DATE		BY		DESCRIPTION	DATE	APP	1017
D	SIGN	JM	CHK	LOAD			
D	RAWN	MI	A	CHK	AC	SP	
				SERVICE	LOW		

**APPENDIX B**  
**RECORD OF BOREHOLE SHEETS**

## 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 101

1 OF 2

METRIC

GWP# 4017-16-00 LOCATION Casselman CVIF N 5 021 390.5 E 186 617.4 ORIGINATED BY JM  
 HWY 417 BOREHOLE TYPE HSA COMPILED BY JM  
 DATUM Geodetic DATE 2016.11.24 - 2016.11.24 CHECKED BY KP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  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	250 mm ASPHALT															
65.4																
0.3	Silty gravel with sand Compact Brown FILL		1	SS	12											
			2	SS	15											40 31 29 (SI+CL)
			3	SS	18											
63.6																
2.1	CLAY (CH) Firm Mottled grey and brown		4	SS	6											0 1 34 65
63.1																
2.6	CLAY (CH to Cl) Soft to firm Grey															
			5	SS	WH											
			6	SS	WH											0 0 26 74
			7	SS	1											
			8	SS	WH											

Continued Next Page

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




# RECORD OF BOREHOLE No 101

2 OF 2

METRIC

GWP# 4017-16-00 LOCATION Casselman CVIF N 5 021 390.5 E 186 617.4 ORIGINATED BY JM  
HWY 417 BOREHOLE TYPE HSA COMPILED BY JM  
DATUM Geodetic DATE 2016.11.24 - 2016.11.24 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						
	Continued From Previous Page						20 40 60 80 100	PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT W <sub>P</sub> W                      W <sub>L</sub> WATER CONTENT (%)						
53.3	<b>CLAY (CH to CI)</b> Soft to firm Grey		9	SS	WH		55	8.0 +						0 1 38 61
	- base of the borehole rose 0.6 m inside the augers when the till layer was penetrated						54	3.2 +      4.7 +						
12.3	<b>Silty GRAVEL (GM)</b> with sand <b>TILL</b> Dense Grey		10	SS	100 / 125mm		53							
51.4			11	SS	100/ 250mm		52							48 23 24 5
14.3	End of Borehole Auger refusal on probable bedrock Groundwater level was measured in open borehole at 7 m BGS (elev. 58.7 m) on 2016/11/24													

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

# RECORD OF BOREHOLE No 102

1 OF 2

METRIC

GWP# 4017-16-00 LOCATION Casselman CVIF N 5 021 400.2 E 186 649.8 ORIGINATED BY JM  
HWY 417 BOREHOLE TYPE HSA COMPILED BY JM  
DATUM Geodetic DATE 2016.11.24 - 2016.11.24 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 (%)				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT					
				20 40 60 80 100				W P      W      W L					
65.8													
0.0	350 mm ASPHALT												
65.4													
0.4	Silty gravel with sand Compact Brown FILL		1	SS	15								
			2	SS	30								
			3	SS	10								
63.6													
2.1	CLAY (CH) Firm Mottled grey and brown		4	SS	5								
62.9													
2.9	CLAY (CH to CI) Soft to firm Grey		5	SS	1								
			6	SS	WH								
			7	SS	WH								
			8	SS	WH								
			9	SS	WH								

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 102

2 OF 2

METRIC

GWP# 4017-16-00 LOCATION Casselman CVIF N 5 021 400.2 E 186 649.8 ORIGINATED BY JM  
 HWY 417 BOREHOLE TYPE HSA COMPILED BY JM  
 DATUM Geodetic DATE 2016.11.24 - 2016.11.24 CHECKED BY KP

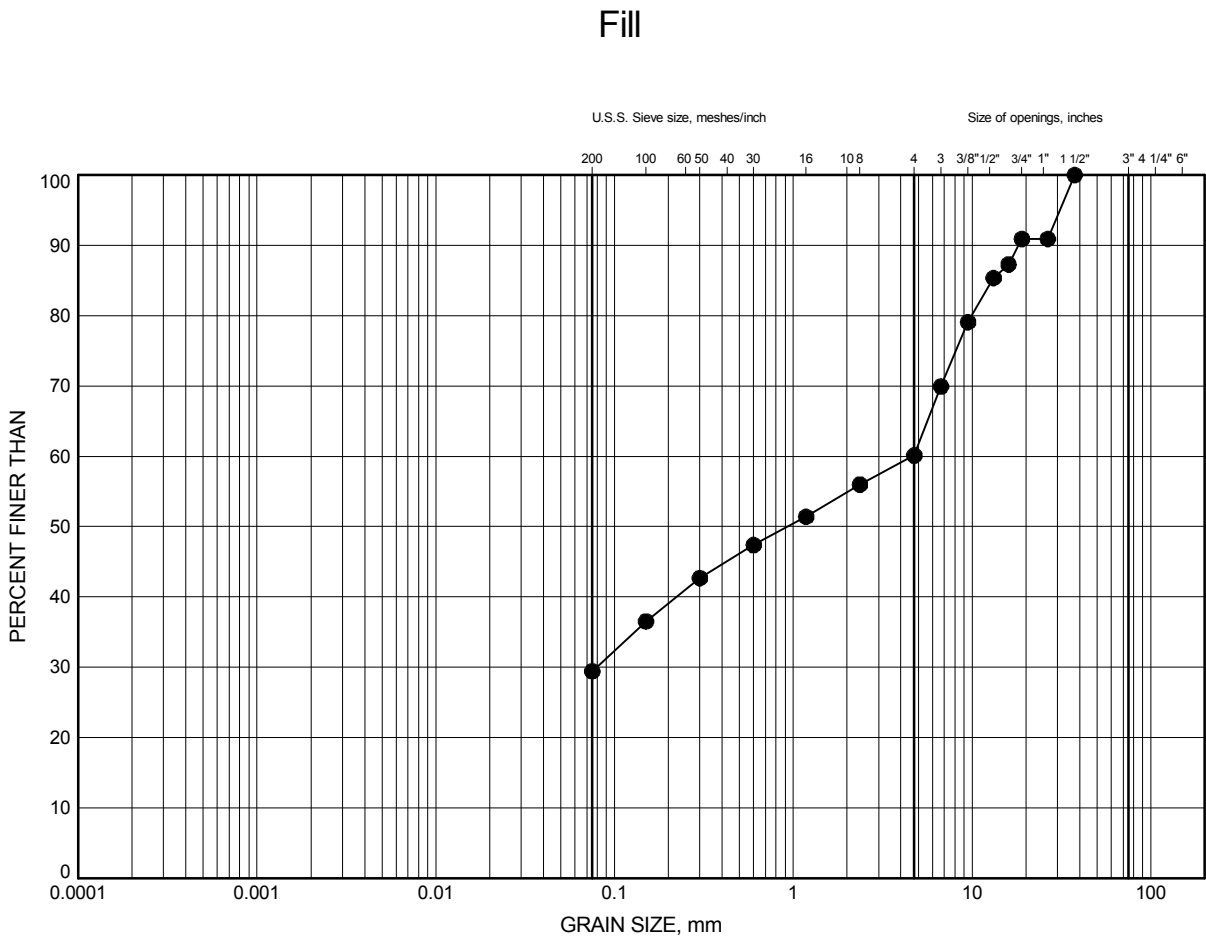
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
54.4	CLAY (CH to CI) Soft to firm Grey		10	SS	WH		55							
11.4	End of Borehole Auger refusal on inferred till Groundwater level was measured in open borehole at 5.2 m BGS (elev. 60.6 m) on 2016/11/24													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

## **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)
●	101	1.07	64.63

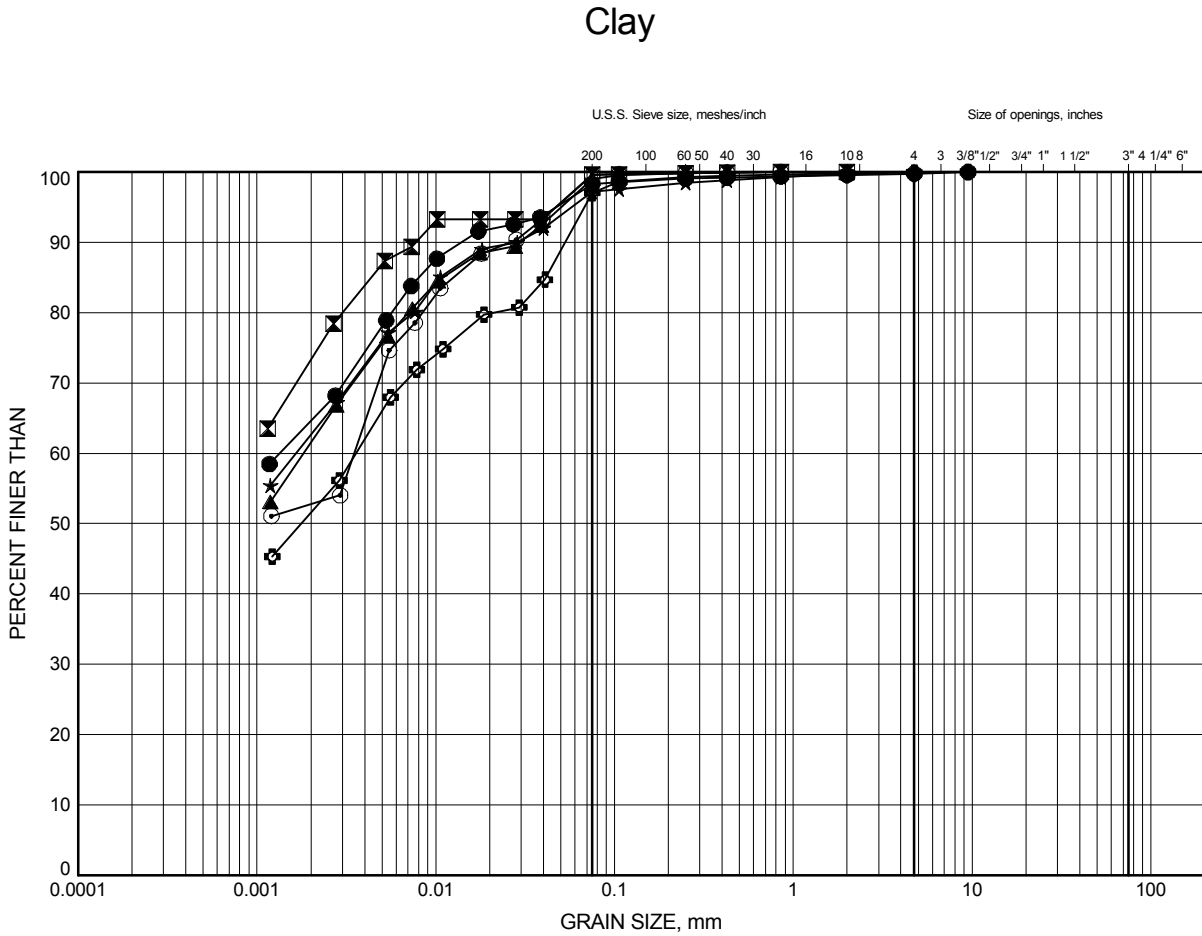
Date January 2017  
 GWP# 4017-16-00



Prep'd KCP  
 Chkd. PC

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)
●	101	2.44	63.26
⊠	101	5.64	60.06
▲	101	10.97	54.72
★	102	2.59	63.17
⊙	102	4.88	60.88
⊕	102	9.45	56.31

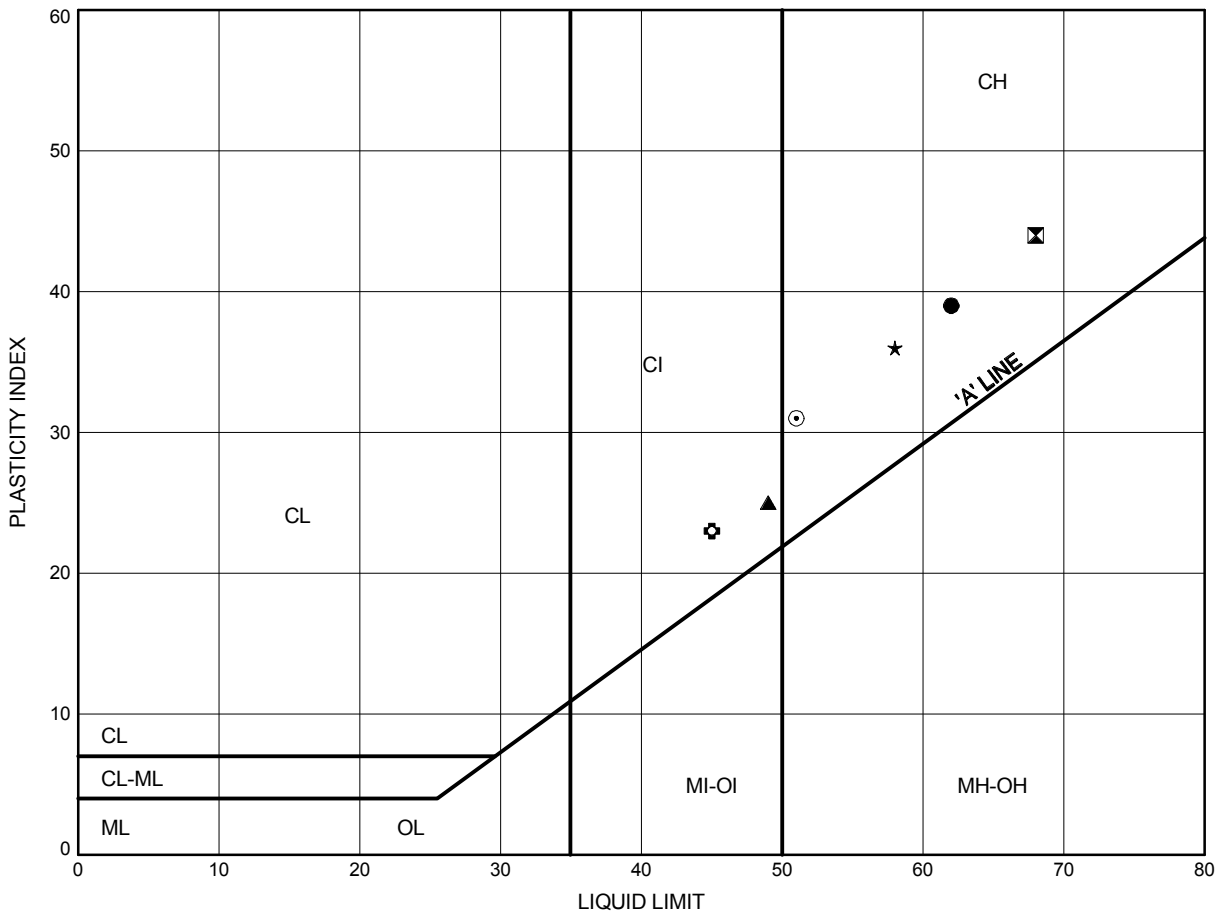
Date January 2017  
GWP# 4017-16-00



Prep'd KCP  
Chkd. PC

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

FIGURE 3



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	2.44	63.26
⊠	101	5.64	60.06
▲	101	10.97	54.72
★	102	2.59	63.17
⊙	102	4.88	60.88
⊕	102	9.45	56.31

Date January 2017  
 GWP# 4017-16-00

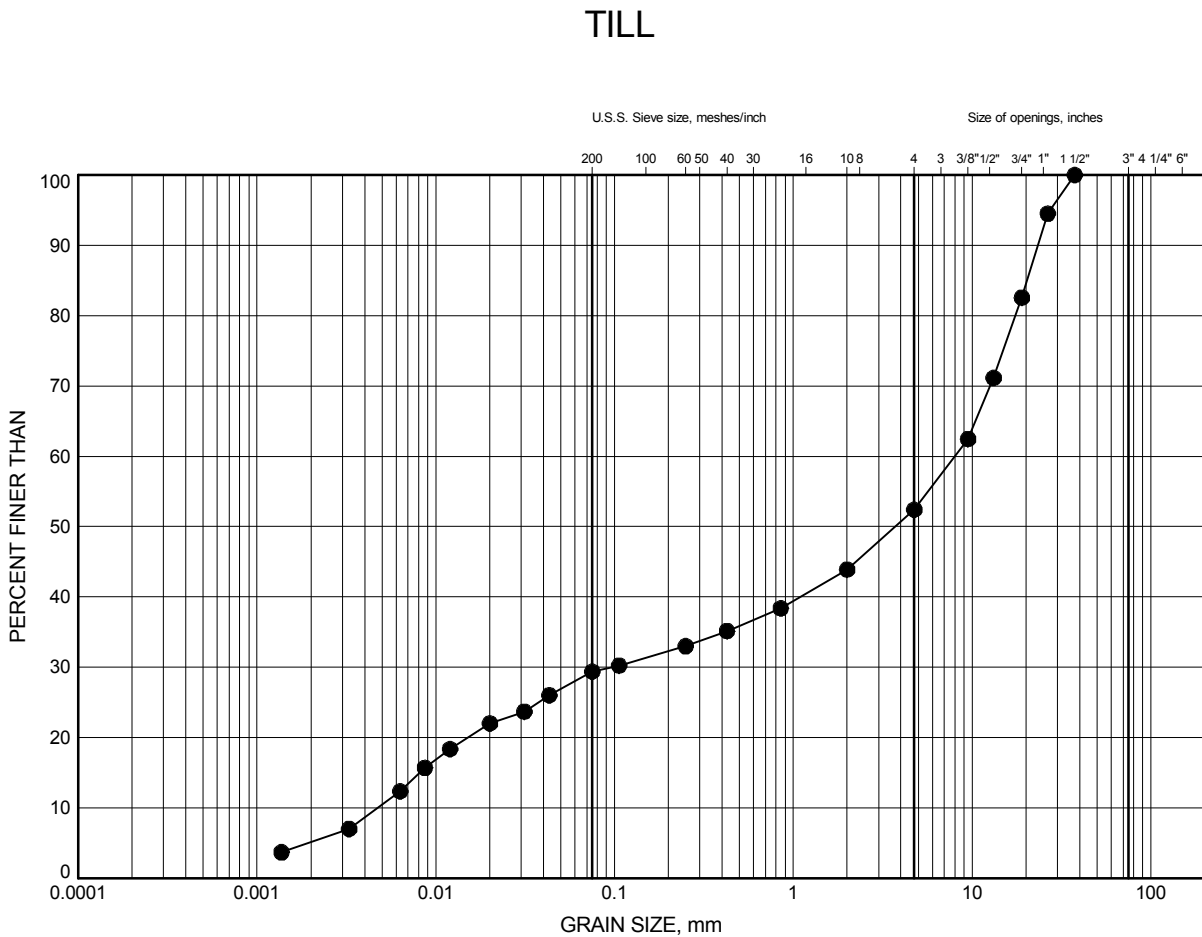


Prep'd KCP  
 Chkd. PC



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

FIGURE 4



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	14.02	51.67

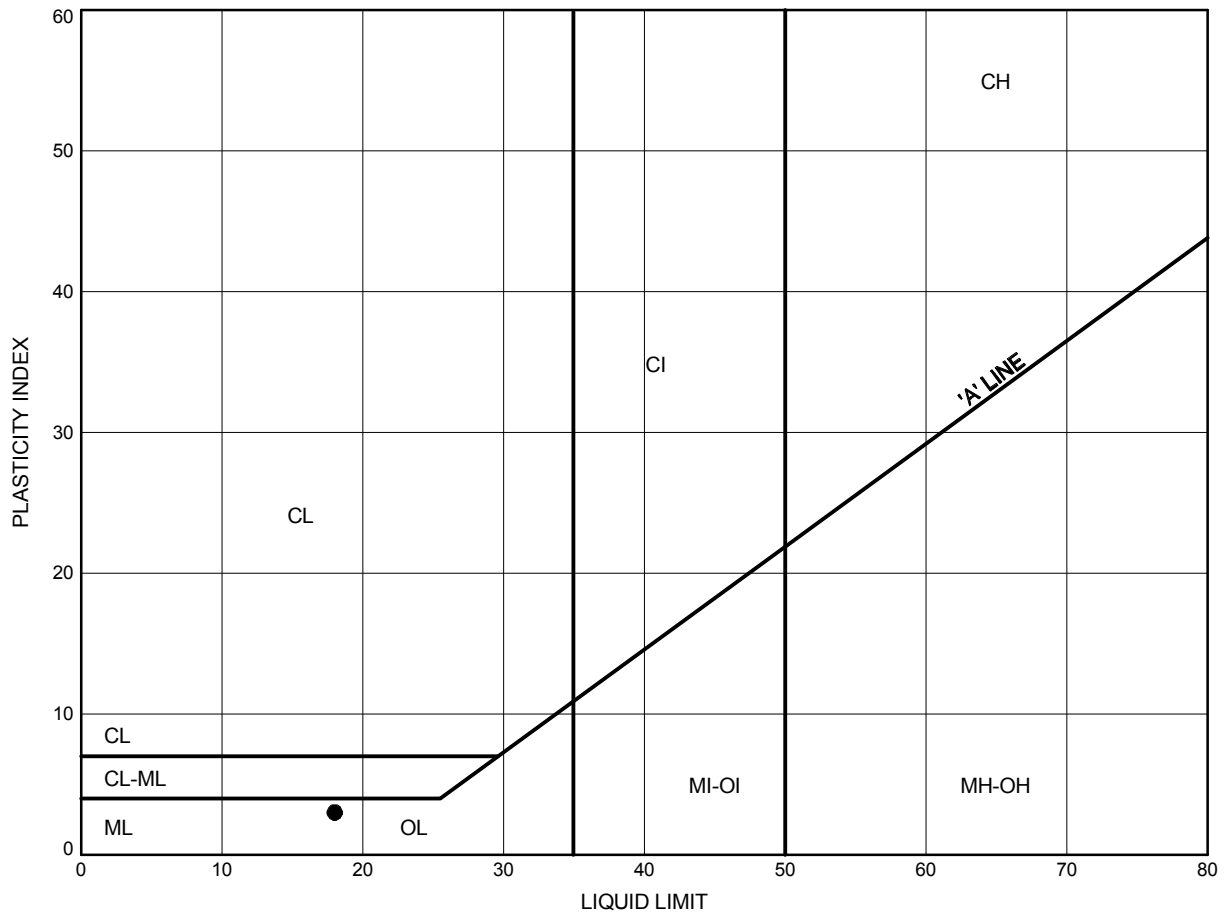
Date January 2017  
 GWP# 4017-16-00



Prep'd KCP  
 Chkd. PC

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

FIGURE 5



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	14.02	51.67

Date January 2017  
 GWP# 4017-16-00



Prep'd KCP  
 Chkd. PC

**APPENDIX D  
SELECTED PHOTOGRAPHS**



**Figure 1: Casselman CVIF inspection bays looking southeast**



**Figure 2: Bay 2, the location of the new low bay inspection bay looking east**

**APPENDIX E**  
**LIST OF REFERENCED SPECIFICATIONS**

## **LIST OF REFERENCED SPECIFICATIONS**

OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSS 405	Construction Specification for Pipe Subdrains
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 510	Construction Specification for Removal
OPSS 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavating and Backfilling-Structures
OPSS.PROV 1010	Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1860	Material Specification for Geotextiles