



**DRAFT  
ADDENDUM NO. 1  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
for  
TEMPORARY MODULAR BRIDGE FOR  
SMITH CREEK BRIDGE REPLACEMENT  
SITE NO. 39E-0014/B0  
HIGHWAY 668 – 10+284  
TOWN OF COCHRANE, ONTARIO  
G.W.P. 5267-11-00  
W.P. 5368-11-01  
LATITUDE AND LONGITUDE: 49.157440, -81.272080**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
Fax: (416) 785-5120  
Email:toronto@petomaccallum.com

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PML Ref.: 18TF002A  
Index No.: 054DIR and 055DDR  
GEOCRES No.: Not Assigned  
June 5, 2020



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**DRAFT**  
**ADDENDUM NO. 1**  
**PART A - FOUNDATION INVESTIGATION REPORT**  
Temporary Modular Bridge for Smith Creek Bridge Replacement  
Site No. 39E-0014/B0  
Highway 668 – 10+284  
Town Of Cochrane, Ontario  
G.W.P. 5267-11-00, W.P. 5368-11-01

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## **1. INTRODUCTION**

The Ministry of Transportation Ontario (MTO) has retained Parsons Corporation (Parsons) as the Prime Consultant, to provide detail design services for the replacement of two (2) bridges on Highway 668 and one (1) bridge on Highway 579. Parsons retained Peto MacCallum Ltd. (PML) on behalf of MTO to provide geotechnical engineering services for the assignment. This assignment involves two (2) contracts and the foundation investigation and design reports were submitted as follows:

### Contract Package 1:

1. Replacement of Deception Creek Bridge (Site No. 39E-169) – Issued under GEOCREs No.: 42H-82, dated August 21, 2019.
2. Smith Creek Bridge (Site 39E-014) on Highway 668 – Issued under GEOCREs No.: 42H-83, dated August 19, 2019.

### Contract Package 2:

1. Replacement of Gilles Creek Bridge (Site No. 39E-006) on Highway 579 - Issued under GEOCREs No.: 42H-82, dated August 21, 2019.

The foundation investigation work reported herein is part of Contract Package 1, for the detail design of the proposed Temporary Modular Bridge (TMB) at the crossing of Smith Creek along Highway 668.

Pavement investigations were also carried out in conjunction with the foundation investigation and the pavement investigation report for the proposed structure locations was issued under a separate cover.

The Terms of Reference and Scope of Work for the Foundation Engineering services are outlined in MTO Assignment No. 5017-E-0030, dated August 2017.



The initial scope of work for Smith Creek Bridge included the installation of a TMB. During the initial site visit on February 27 and 28, 2019, PML staff marked out the TMB boreholes, designated as Boreholes ED-1 to ED-4, along the proposed alignment. Prior to the May 2019 field investigation for the Smith Creek Bridge, in a meeting with MTO and Parsons on March 21, 2019, an alternative with full road closure of Highway 668 with detour on local roads was considered instead of the installation of the TMB. As a result, the field work for the TMB was not conducted during the initial time.

Upon completion of the initial investigations and submission of the final foundation investigation and design report, dated August 19, 2019 (GEOCREC No. 42H-83), the staging for the replacement bridge was revised to reinstate the installation of a TMB located approximately 11.5 m easterly in relation to the proposed alignment, to accommodate detour vehicular and traffic flow. The decision to revert to the original scope of work was communicated to PML by Parsons via e-mail, dated July 12, 2019. The original fieldwork for the TBM programmed consisted of four (4) boreholes, designated as Boreholes ED-1 to ED-4, located along the proposed TMB alignment. Boreholes ED-2 and ED-3 were to advanced 3.0 m into bedrock based on the Terms of Reference.

This addendum report presents the findings from the foundation investigation carried out for the proposed TMB at the crossing of Smith Creek (Station 10+284) in the Town of Cochrane, Ontario.

The purpose of the investigation was to explore the subsurface conditions to facilitate the design of the proposed TMB for the replacement Smith Creek bridge and to aid the designer in selecting the suitable type of foundation to support the TMB.

## **2. SITE DESCRIPTION**

The location of the existing Smith Creek bridge is approximately 11 km north of Highway 11 on Highway 668. Highway 668 in the area of the bridge site is slightly elevated from the natural topography, and accommodates two (2) lanes of vehicular traffic. The site is generally a flat area, with the exception of the highway embankments. Smith Creek flows from west to east, almost perpendicular to Highway 668. The proposed bridge site is located within farm lands and are surrounded by long grass and forestation with mature trees and shrubs.



### **3. FIELD INVESTIGATION PROCEDURES**

The field work for the foundation investigation involved advancing four (4) boreholes at the Smith Creek bridge site. The boreholes were drilled to depths ranging from 10.4 m to 22.1 m below the existing ground surface.

During the initial site visit on February 27 and 28, 2019, PML staff visited the site to mark out the TMB boreholes (ED-1 to ED-4). PML staff used a portable GPS device to establish the location of boreholes in the field. Subsequently, Rugged Geomatics Inc. of Timmins, Ontario, under contract to PML, carried out the survey of the as drilled borehole locations and elevations, and provided the co-ordinates for locations in MTM Northing and Easting (MTM Zone – ON12). PML used the survey data provided by Rugged Geomatics Inc. for the preparation of this report. All elevations reported in this report are referred to Geodetic datum and expressed in meters.

The equipment used for drilling was owned and operated by Landcore Drilling of Chelmsford, Ontario and PML FS of Hamilton, Ontario. Landcore Drilling and PML FS are specialist drilling contractors and worked under the full time supervision of a PML field supervisor. Boreholes ED-1 to ED-4 were drilled on December 16 and 17, 2019 and between January 16 and 23, 2020. The boreholes were advanced using a CME 55 track-mounted drilling rig equipped with 200 mm diameter hollow stem augers and rotary coring.

Due to the existing terrain and overhead bell line along the proposed TMB alignment, the boreholes had to be relocated from the planned locations at the site to facilitate safe drilling operation.

Refer to Drawings ED-1 in Appendix A for borehole location details for the Smith Creek TMB.

Representative soil samples were recovered from the boreholes at 0.75 m intervals to a depth of 6.0 m and at 1.5 m to the depth of termination, using a conventional 51 mm OD split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In addition, the in-situ vane shear strength of clayey soil at depths where SPT 'N' values were below about 8 blows/300 mm was measured using a N- size (MTO) vane.



The groundwater conditions at the borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in the open boreholes upon completion of drilling. Water levels were measured using a Solinst flat tape water level reader.

The water level in Smith Creek was observed at approximate EL. 257.6 during the May 2019 fieldwork. During the January 2020 fieldwork, the surface of the creek was frozen, however, the top of the frozen creek surface was measured at approximately the same elevation (EL. 257.6).

Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and O.Reg. 903 for borehole abandonment procedures.

The recovered soil samples were returned to the PML laboratory for detailed visual examination and index tests.

#### **4. LABORATORY TEST PROCEDURES**

Laboratory tests were conducted at PML's laboratory, located in Toronto, on representative SPT samples recovered during the fieldwork. The laboratory testing program included the following:

- Natural moisture content determinations (52)
- Grain size distribution analysis (18)
- Atterberg limits tests (15)

All laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow the American Society for Testing Materials (ASTM) standards, with the exception of hydrometer tests (LS-702). The results of the grain size distribution analyses are presented on Figures ED-GS-1 to ED-GS-5. The results of the Atterberg limits tests are presented on Figures ED-PC-1 to ED-PC-3. All of the test results are summarized on the attached Record of Borehole Logs provided in Appendix A.



## **5. SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **5.1 Site Geology**

In general, the project area is located within the Abitibi Uplands of the James physiographic region of the Canadian Shield. The Quaternary Geology map published by the Ontario Ministry of Northern Development and Mines (MNDM), indicates that the surface conditions in the area of the culvert site consist of fine grained till deposits; predominantly silty clay to silt matrix. Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the project area mainly consists of metasedimentary supercrustal rocks of the Superior Province.

### **5.2 Subsurface Conditions**

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations and stratigraphic profile section are shown on Drawings ED-1. The boundaries between soil strata have been established at the borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and may vary from location to location.

In general, the subsoil conditions immediately below the ground surface along the alignment of proposed TMB consists of fill 2.3 m to 3.8 m thick, composed of layers of clayey silt and sand, which is followed by firm to stiff clayey silt. The clayey silt layer is underlain by compact to very dense sand. In Boreholes ED2 and ED3, the sand deposit is underlain by bedrock by which extends to the maximum borehole termination depth of 22.1 m below the existing ground surface. For classification purposes, the subsurface stratigraphy encountered at this site can be divided into five (5) distinct zones:

- a) Clayey Silt, Trace/Some Sand, Trace/Some Gravel (Fill)
- b) Sand Trace/Some Silt, Trace/Some Gravel (Fill)
- c) Clayey Silt/Silty Clay, Trace/Some Sand, Trace Gravel
- d) Sand, Trace Silt
- e) Bedrock





#### 5.2.1 Clayey Silt, Trace/Some Sand, Trace/Some Gravel (Fill)

A 900 mm to 2.3 m thick clayey silt fill layer was encountered immediately below the ground surface in all of the boreholes (ED1 to ED4).

The SPT 'N' values in the clayey silt fill ranged from 10 blows to 30 blows, indicating stiff to hard consistency. Generally, the moisture content of the samples tested from this layer ranged from 10.3% to 26.5%, with an average value of 21.1%. However, a moisture content of one (1) sample was found to be 42.3% in Borehole ED1.

#### 5.2.2 Sand Trace/Some Silt, Trace/Some Gravel (Fill)

A 800 mm to 1.4 m thick sand fill layer was encountered immediately below the clayey silt fill in Boreholes ED3 and ED4, located south of Smith Creek. This silty sand fill layer extends to 2.3 m (EL. 259.1 to EL. 258.5) below the existing ground surface.

The SPT 'N' values in the silty sand/sandy silt fill layer varied between 9 blows and 14 blows, indicating compactness condition ranging from loose to compact.. The moisture content of the samples tested ranged from 4.0% to 9.7%, with an average value of 6.1%.

#### 5.2.3 Clayey Silt/Silty Clay, Trace/Some Sand, Trace Gravel

The fill layer in all of the boreholes is underlain by clayey silt/silty clay deposit. This deposit extends to depths ranging from 16.8 m to 18.3 m (EL. 244.0 to EL. 242.6) below the existing ground surface, in Boreholes ED1 to ED3, where it was fully penetrated. This deposit was not fully penetrated in Borehole ED4 and extended to the termination depth of 10.4 m (EL. 251.1) below the existing ground surface.

The SPT 'N' values in this deposit vary from none to 14 blows, indicating very soft to stiff consistency, with the exception of Sample SS8 in Borehole ED1 of 25 blows, indicating very stiff consistency.

Vane shear tests were attempted at depths where low SPT 'N' values were observed. The test was performed at 21 locations within this deposit and the vane shear strength measured ranged from 28 kPa to over 120 kPa. The vane shear test results indicate firm to very stiff consistency, compared to typically very soft to stiff consistency based on SPT 'N' values.



The grain size distribution results of selected samples from this deposit are provided on Figures ED-GS-1 to ED-GS-2, and the results of Atterberg limits for the same samples are provided on Figures ED-PC-1 and ED-PC-2 in Appendix A.

The moisture content of the samples ranged from 8.5% to 45.5%, with an average value of 22.0%. However, the moisture content of two (2) samples containing organics was found to be 50.7% and 58.9%. Sieve and hydrometer tests were performed on 14 representative samples and the test results indicate that this deposit consists of none to 1% gravel, none to 16% sand, 20% to 76% silt, and 24% to 80% clay. Atterberg limits were performed on the same 14 representative samples and the test results indicate liquid limit values range from 22 to 55, plastic limit values range from 13 to 26, and corresponding plasticity index values range from 8 to 29. Based on the test results, the soil may be classified as clay of low to medium plasticity (CL/CI) in the Unified Soil Classification System (USCS), i.e., clayey silt/silty clay.

The result of the sieve analysis test performed on one (1) sample from the silty sand seam is provided on Figure ED-GS-3. The test results indicate that the soil consists of 1% gravel, 74% sand, 20% silt, and 5% clay sized particles.

The result of the sieve analysis test performed on one (1) sample from the gravelly seam is provided on Figure ED-GS-4. The test results indicate that the soil consists of 56% gravel, 29% sand, 15% silt and clay sized particles. Atterberg limits were performed on the same sample (Results shown in Figure ED-PC-3) and the test results indicate a liquid limit value of 27, a plastic limit value of 15, and a corresponding plasticity index value of 12. Based on the test results, the soil may be classified as clayey gravel (GC) in accordance with the USCS.

#### 5.2.4 Sand, Trace Silt

A 300 mm and 1.6 m thick sand layer was encountered immediately below the clayey silt/silty clay deposit in Boreholes ED2 and ED3.

The SPT 'N' values in this deposit vary from 24 blows to 100 blows, indicating compactness condition ranging from compact to very dense.



The results of grain size distribution of selected two (2) representative samples from this deposit are provided on Figure ED-GS-5 in Appendix A. The test results indicate that this deposit consists of no gravel, 94% to 99% sand, 1% to 6% silt and clay sized particles. The moisture content of one (1) sample tested from this deposit was 14.8%.

#### 5.2.5 Bedrock

Borehole ED1 was terminated on probable bedrock at 18.9 m, EL. 242.2. Bedrock was encountered in Boreholes ED2 and ED3, immediately below the sand deposit at approximate elevations of EL. 242.3 and EL. 242.4, respectively. The presence of bedrock was confirmed by obtaining 3.3 m and 3.7 m of rock core from Boreholes ED2 and ED3, respectively. Rock coring was advanced using an HQ sized core barrel and wash boring with a 75 mm diameter NW casing. The rock core recovery ranged from 67% to 100% and the Rock Quality Designation (RQD) of the rock cores ranged from 29% to 95%. The quality of the bedrock at this site may be described as poor to excellent based on the RQD values ranging from 29% to 95%. The bedrock was identified as Diabase. For complete description of the bedrock, refer to the Rock Core Photographs and the Rock Core Description logs provided in Appendix A.

#### 5.2.6 Groundwater

Groundwater was encountered at 16.8 m (EL. 244.0) and 3.8 m (EL. 257.6) below the existing ground surface during drilling in Boreholes ED3 and ED4, respectively. Groundwater was not encountered in Boreholes ED1 and ED2 during drilling. Groundwater was measured at 16.8 m (EL. 244.1) and 15.2 m (EL. 245.6) below the existing ground surface upon completion of drilling in Boreholes ED2 and ED3, respectively. Boreholes ED1 and ED4 were dry upon completion of drilling. The water level in the creek was observed at approximate elevation of EL. 257.6 during the fieldwork.

Groundwater levels may fluctuate due to the influence of precipitation and seasonal change. The groundwater levels were observed and measured prior to backfilling the boreholes. Groundwater levels are shown on the Borehole Logs in Appendix A.



## 6. CLOSURE

Mr. M. Mohamed and Mr. F. Meng carried out the field investigations under the supervision of Mr. N. Rahman, P.Eng., Project Engineer, and Ms. N. Leong-Sem, EIT. Landshark Drilling Ltd. of Brantford, Ontario supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Ms. N. Leong-Sem, B.Eng., EIT, Geotechnical Services and reviewed by Mr. N. Rahman, P.Eng., Project Engineer, and Geoffrey Uwimana, MEng, P.Eng. Senior Engineer, Geotechnical Services. Mr. R. Ng, MBA, PhD, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

A handwritten signature in blue ink, reading "Natasha Leong-Sem".

Natasha Leong-Sem  
EIT  
Geotechnical Services

A handwritten signature in blue ink, reading "Nazibur Rahman".

Nazibur Rahman, P.Eng.  
Project Engineer  
Geotechnical Services

A handwritten signature in blue ink, reading "Geoffrey Uwimana".

Geoffrey Uwimana, MEng, P.Eng.  
Senior Engineer  
Geotechnical Services

A handwritten signature in blue ink, reading "Robert Ng".

Robert Ng, MBA, PhD, P.Eng.  
Project Manager and  
MTO Designated Principal Contact

NL/NR:nl-nr-nk

**NOTE:** The Final Report will be signed and stamped by two Professional Engineers licensed by PEO, one of whom shall be the Designated Principal Contact for MTO foundation projects



## **APPENDIX A**

Borehole Locations Plan and Soil Strata Drawing ED-1

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures ED-GS-1 to ED-GS-5

Results of Atterberg Limit Tests – Figures ED-PC-1 to ED-PC-3

Rock Core Descriptions and Photographs

GWP No 5267-11-00  
WP No 5368-11-01



SMITH CREEK TEMPORARY MODULAR BRIDGE  
HIGHWAY 668  
BOREHOLE LOCATIONS

SHEET



- LEGEND**
- Foundation Borehole for Structure
  - N Blows/0.3m (Std. Pen Test, 475 J/blow)
  - WH Penetration Due to Weight of Hammer and Rods
  - \* Water Level Not Encountered Upon Completion of Drilling
  - Water Level Measured Upon Completion of Drilling
  - JAN. 2020 Smith Creek Water Level

BH No	ELEVATION	NORTHINGS	EASTINGS
ED1	261.1	5 446 643.6	284 954.3
ED2	260.9	5 446 628.1	284 955.9
ED3	260.8	5 446 605.1	284 955.0
ED4	261.4	5 446 583.0	284 954.6

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

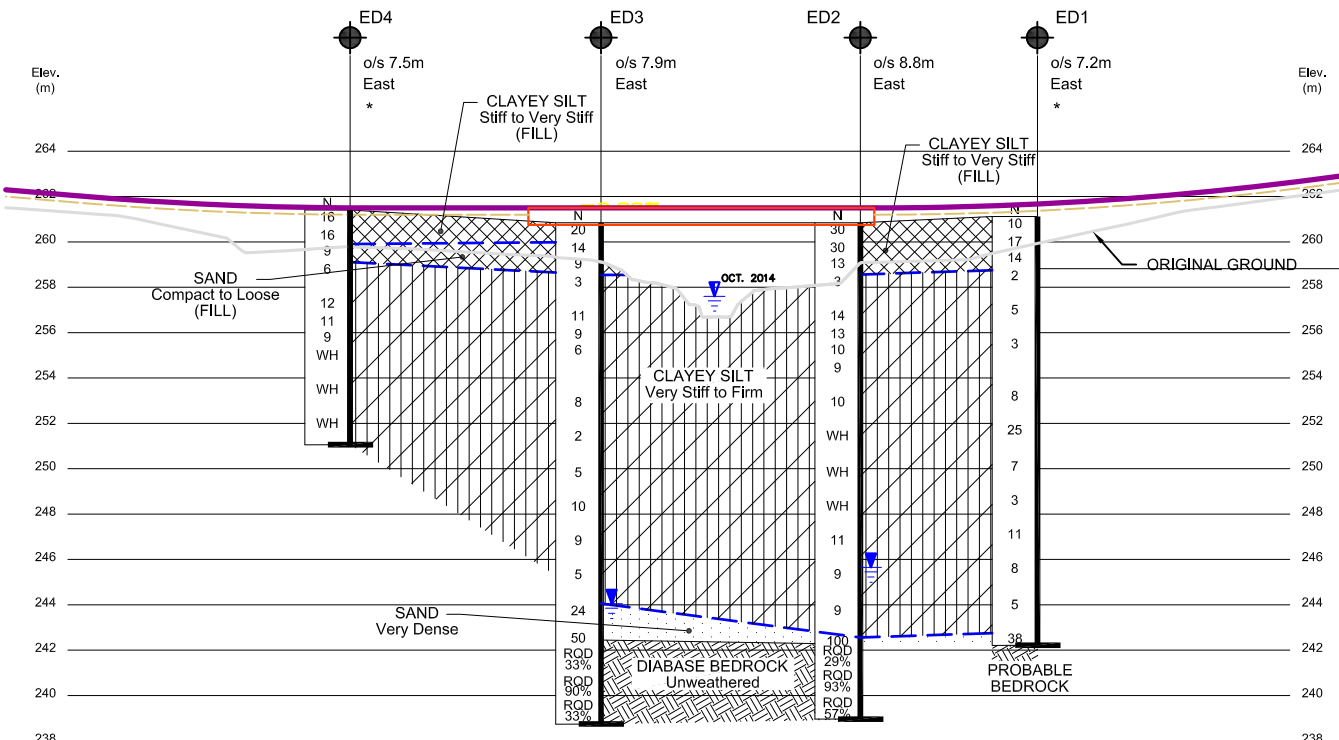
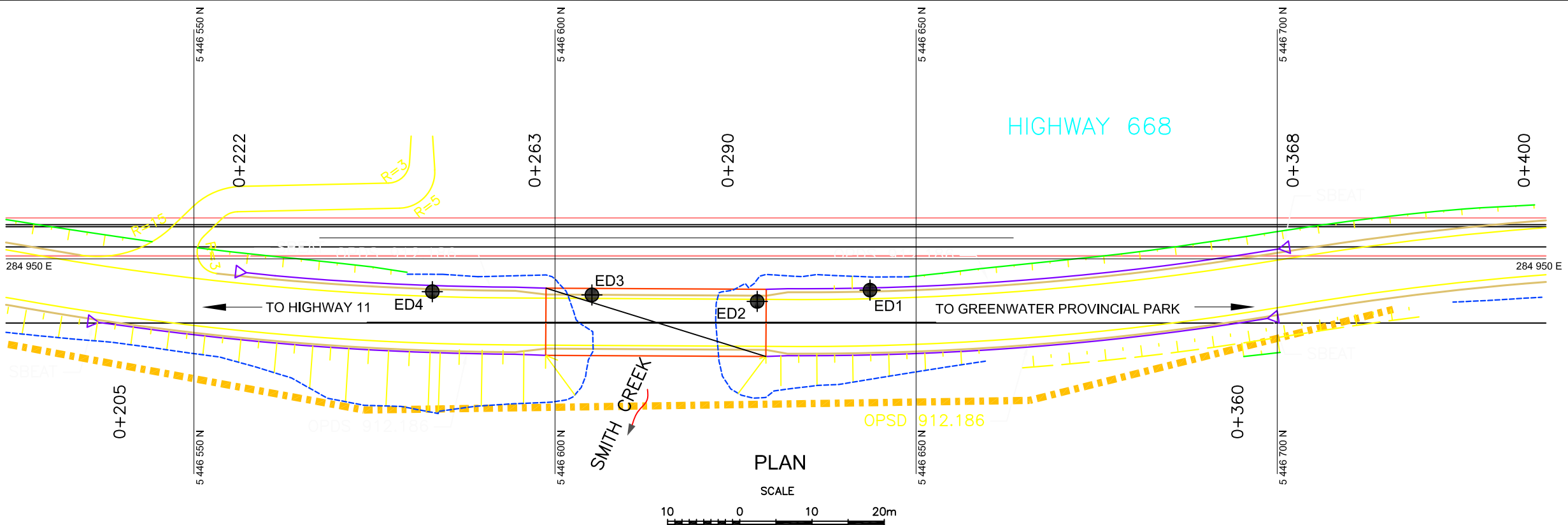
DATE	BY	DESCRIPTION

Geocres No. Not Assigned			
HWY No 668			DIST Northern
SUBM'D NL	CHECKED NR	DATE APR. 22, 2020	SITE 39E-0014/B0
DRAWN NL	CHECKED	APPROVED RN	DWG. ED-1

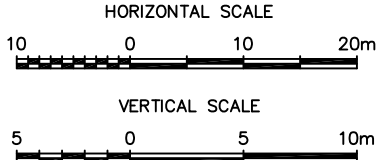
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REF Drawing: 476617- Smith Detour New Construction & Profile.dwg, Received March 2020.



PROFILE ALONG PROPOSED TMB CENTERLINE WITH OFFSETS FROM HIGHWAY 668 CENTERLINE



- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
  - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	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
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No ED1

1 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 643.6 N; 284 954.3 E ORIGINATED BY M.M.  
 DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
 DATUM Geodetic DATE 2020.01.16 - 2020.01.17 LATITUDE 49.157580 LONGITUDE -81.272110 CHECKED BY N.R.

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 (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)				GR	SA	SI	CL
261.1	Ground Surface							20	40	60	80	100											
0.0	CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Grey, Moist (FILL)		1	SS	10		261																
			2	SS	17		260																
			3	SS	14		259																
258.8	CLAYEY SILT, trace sand, trace gravel Very stiff to stiff, Grey, Moist		4	SS	2		258																
2.3				VANE			257																
			5	SS	5		256																
				VANE			255																
			6	SS	3		254																
				VANE			253																
			7	SS	8		252																
			8	SS	25		251																
			9	SS	7		250																
				VANE			249																
			10	SS	3		248																
				VANE			247																
			11	SS	11																		
246.1																							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE




RECORD OF BOREHOLE No ED1

2 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 643.6 N; 284 954.3 E ORIGINATED BY M.M.  
DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
DATUM Geodetic DATE 2020.01.16 - 2020.01.17 LATITUDE 49.157580 LONGITUDE -81.272110 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W <sub>P</sub> W                      W <sub>L</sub>							
								20   40   60   80   100				20   40   60							
								○ UNCONFINED                      + FIELD VANE											
								● QUICK TRIAXIAL                      × LAB VANE				WATER CONTENT (%)							
								20   40   60   80   100				20   40   60			kN/m <sup>3</sup>	GR   SA   SI   CL			
246.1 15.0	CLAYEY SILT, trace sand, trace gravel  Stiff, Grey, Moist						246												
			12	SS	8														
				VANE					245										
			13	SS	5														
				VANE					244										
						243													
242.2 18.9	Borehole terminated on probable bedrock		14	SS	38											56   29   (15)			
NOTES: 1.        Groundwater level was not encountered during or upon completion of drilling. 2.        No cave-in was noted upon extraction of hollow stem augers.																			

RECORD OF BOREHOLE No ED2

1 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 628.1 N; 284 955.9 E ORIGINATED BY M.M.  
DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
DATUM Geodetic DATE 2020.01.22 - 2020.01.23 LATITUDE 49.157440 LONGITUDE -81.272080 CHECKED BY N.R.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
260.9 0.0	Ground Surface													
	CLAYEY SILT, some sand, trace gravel		1	SS	30									
	Very stiff to stiff, Brown to grey, Moist													
	_____ sandy		2	SS	30									
	_____ (FILL)		3	SS	13									
258.6 2.3	CLAYEY SILT/SILTY CLAY, trace/some sand, trace gravel		4	SS	3									
	Stiff to firm, Grey, Wet to moist			VANE										
			5	SS	14									
			6	SS	13									
			7	SS	10									
			8	SS	9									
			9	SS	10									
			10	SS	0									
				VANE										
			11	SS	0									
				VANE										
			12	SS	0									
				VANE										
			13	SS	11									
245.9														

Continued Next Page

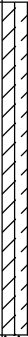



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No ED2

2 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 628.1 N; 284 955.9 E ORIGINATED BY M.M.  
DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
DATUM Geodetic DATE 2020.01.22 - 2020.01.23 LATITUDE 49.157440 LONGITUDE -81.272080 CHECKED BY N.R.

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 (%)	
245.9 15.0	CLAYEY SILT, trace sand, trace gravel  Stiff, Grey, Moist																		
			14	SS	9		245												
								244											
								243											
242.6 18.3	SAND, trace silt Very dense, Grey, Moist Unweathered, fine grained to medium grained  Dark grey to black, Hard, Crystalline Diabase Bedrock		16	SS	100													0 99 (1)	
242.3 18.6			RUN 1	RC	REC 100%		242											RQD = 29%	
			RUN 2	RC	REC 100%		241												RQD = 93%
								240											
			RUN 3	RC	REC 100%														RQD = 87%
239.0 21.9	End of borehole																		
	 Groundwater level measured upon completion of drilling  NOTE: No cave-in was noted upon extraction of hollow stem augers.																		

RECORD OF BOREHOLE No ED3

1 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 605.1 N; 284 955.0 E ORIGINATED BY M.M.  
DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
DATUM Geodetic DATE 2020.01.20 - 2020.01.21 LATITUDE 49.157240 LONGITUDE -81.272100 CHECKED BY N.R.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
260.8 0.0	Ground Surface													
	CLAYEY SILT, trace sand, trace gravel		1	SS	20		260							
	Very stiff, Brown to grey, Moist													
	SAND, some gravel, trace silt		2	SS	14									
	Compact to loose, Grey, Moist													
	(FILL)		3	SS	9		259							
258.5 2.3	CLAYEY SILT, trace sand, trace gravel		4	SS	3		258							
	CLAYEY SILT/SILTY CLAY, trace sand, trace gravel			VANE										
	Stiff to firm, Grey, Moist to wet													
			5	SS	11		257							
			6	SS	9		256							1 10 58 31
			7	SS	6		255							
				VANE										
							254							
			8	SS	8		253							0 9 54 37
				VANE			252							
			9	SS	2		251							
				VANE			250							0 0 27 73
			10	SS	5		249							
				VANE			248							
			11	SS	10		247							0 0 74 26
			12	SS	9		246							

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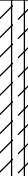


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No ED3

2 OF 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 605.1 N; 284 955.0 E ORIGINATED BY M.M.  
DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
DATUM Geodetic DATE 2020.01.20 - 2020.01.21 LATITUDE 49.15724 LONGITUDE -81.2721 CHECKED BY N.R.

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 (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
245.8						▽		20	40	60	80	100							
15.0	CLAYEY SILT, trace sand, trace gravel Stiff, Grey, Moist		13	SS	5	▽	245							○			-		
				VANE										>>					
244.0							244								○			0 94 (6)	
16.8	SAND, trace silt Compact to very dense, Grey, Moist		14	SS	24		243												
242.4			15	SS	50		242												
18.4	Unweathered, fine grained to medium grained Dark grey to black, Hard, Crystalline Diabase Bedrock		RUN 1	RC	REC 81%		241										RQD = 33%		
			RUN 2	RC	REC 100%		240										RQD = 95%		
			RUN 3	RC	REC 67%		239										RQD = 33%		
238.7																			
22.1	End of borehole																		
	▽ Groundwater level observed during drilling ▼ Groundwater level measured upon completion of drilling NOTE: No cave-in was noted upon extraction of hollow stem augers.																		

▽ Groundwater level observed  
during drilling  
▼ Groundwater level measured  
upon completion of drilling

NOTE: No cave-in was noted upon  
extraction of hollow stem  
augers.

ONTARIO MTO 18TF002A-SMITH CREEK TMB REV.GPJ ONTARIO MTO.GDT 20-6-4

# RECORD OF BOREHOLE No ED4

1 OF 1

METRIC

G.W.P. 5267-11-00 LOCATION Coords: 5 446 583.0 N; 284 954.6 E ORIGINATED BY M.M.  
 DIST Northern HWY 668 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M.  
 DATUM Geodetic DATE 2020.01.21 LATITUDE 49.157040 LONGITUDE -81.27210 CHECKED BY N.R.

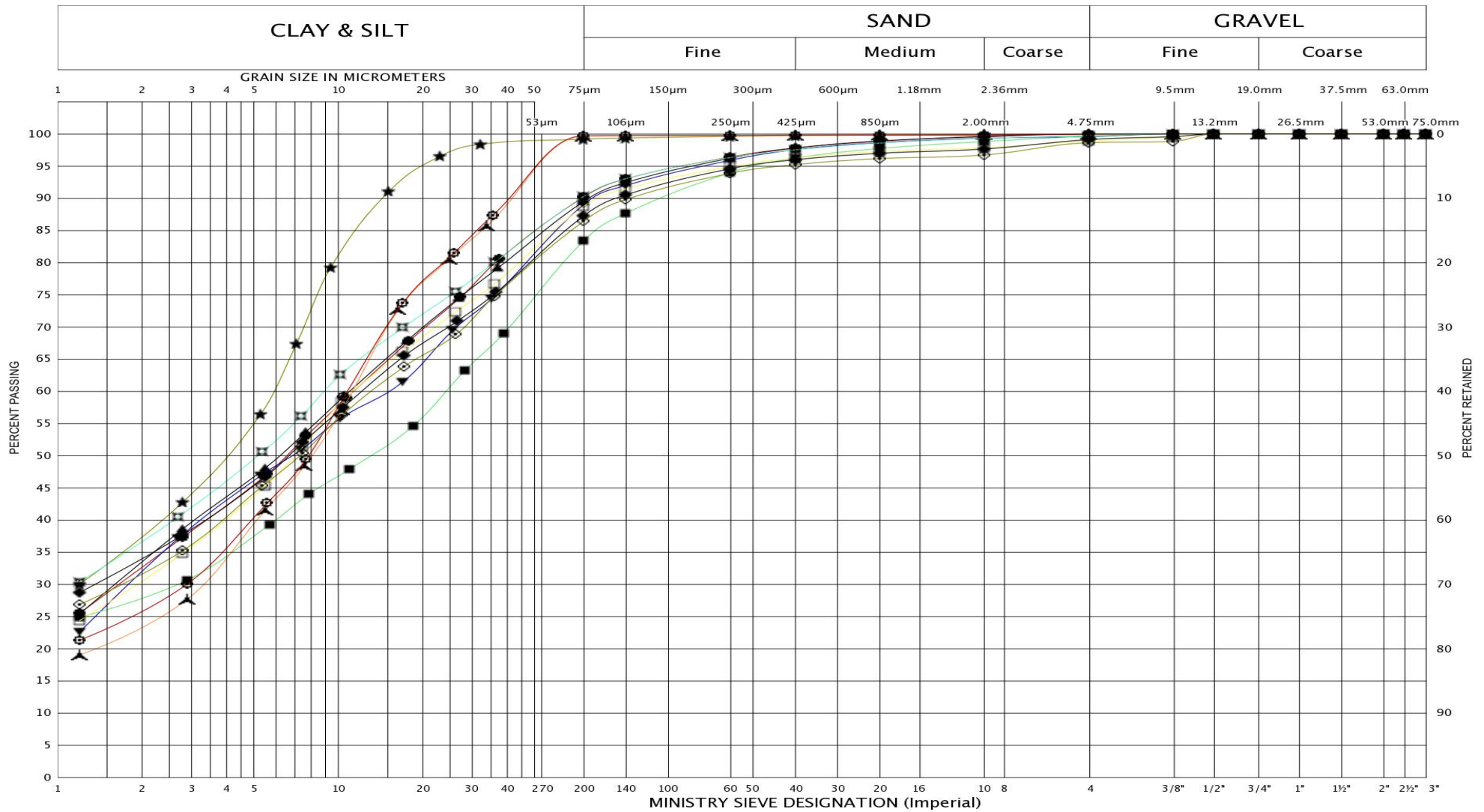
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
261.4	Ground Surface							20	40	60	80	100		
0.0	CLAYEY SILT, some sand, some gravel		1	SS	16									
	Very stiff, Grey, Moist													
			2	SS	16									
	Sand, some silt													
	Loose, Brown, Moist		3	SS	9									
	(FILL)													
259.1	organics		4	SS	6									
2.3	CLAYEY SILT/SILTY CLAY, trace/some sand, trace gravel			VANE										
	Stiff to firm, Grey, Moist													
			5	SS	12									
			6	SS	11									
			7	SS	9									
			8	SS	0									
				VANE										
			9	SS	0									
				VANE										
			10	SS	0									
				VANE										
251.1	End of borehole													
10.4														
	▽ Groundwater level observed during drilling													
	NOTES:													
	1. Groundwater level was not encountered upon completion of drilling.													
	2. No cave-in was noted upon extraction of hollow stem augers.													

Groundwater level observed during drilling

NOTES:

- Groundwater level was not encountered upon completion of drilling.
- No cave-in was noted upon extraction of hollow stem augers.

# UNIFIED SOIL CLASSIFICATION SYSTEM



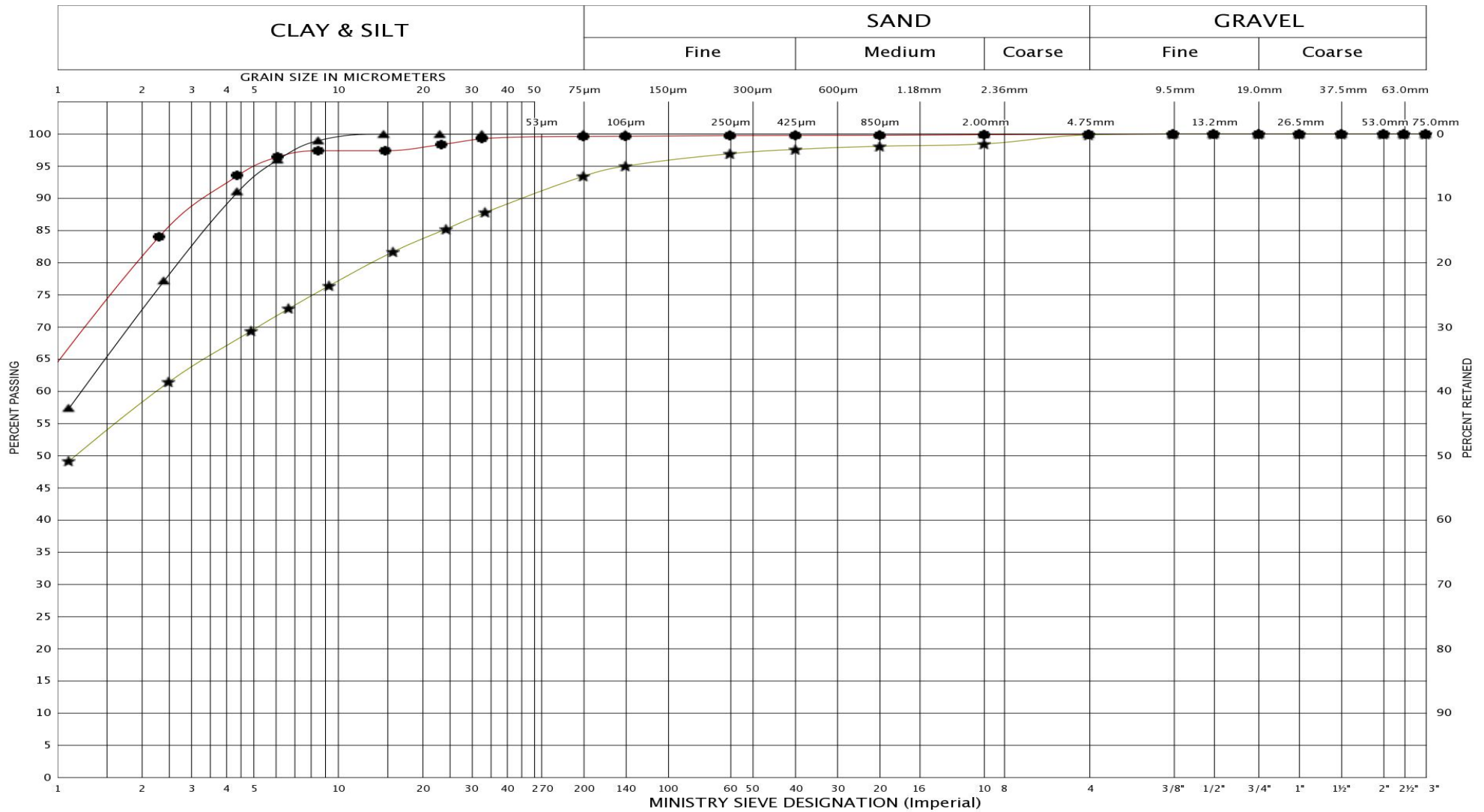
LEGEND	BH	ED1	ED1	ED1	ED2	ED2	ED2	ED3	ED3	ED3	ED4	ED4
	SAMPLE	5	6	11	5	8	13	6	8	12	5	7
	SYMBOL	●	▲	★	▼	■	△	□	⊠	⊕	◆	◇



**GRAIN SIZE DISTRIBUTION**  
CLAYEY SILT, Trace/Some Sand, Trace Gravel

FIG No.: ED-GS-1  
HWY : 668  
GWP 5267-11-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	ED2	ED3	ED4
	SAMPLE	10	10	9
	SYMBOL	●	▲	★



## GRAIN SIZE DISTRIBUTION

SILTY CLAY, Trace Sand

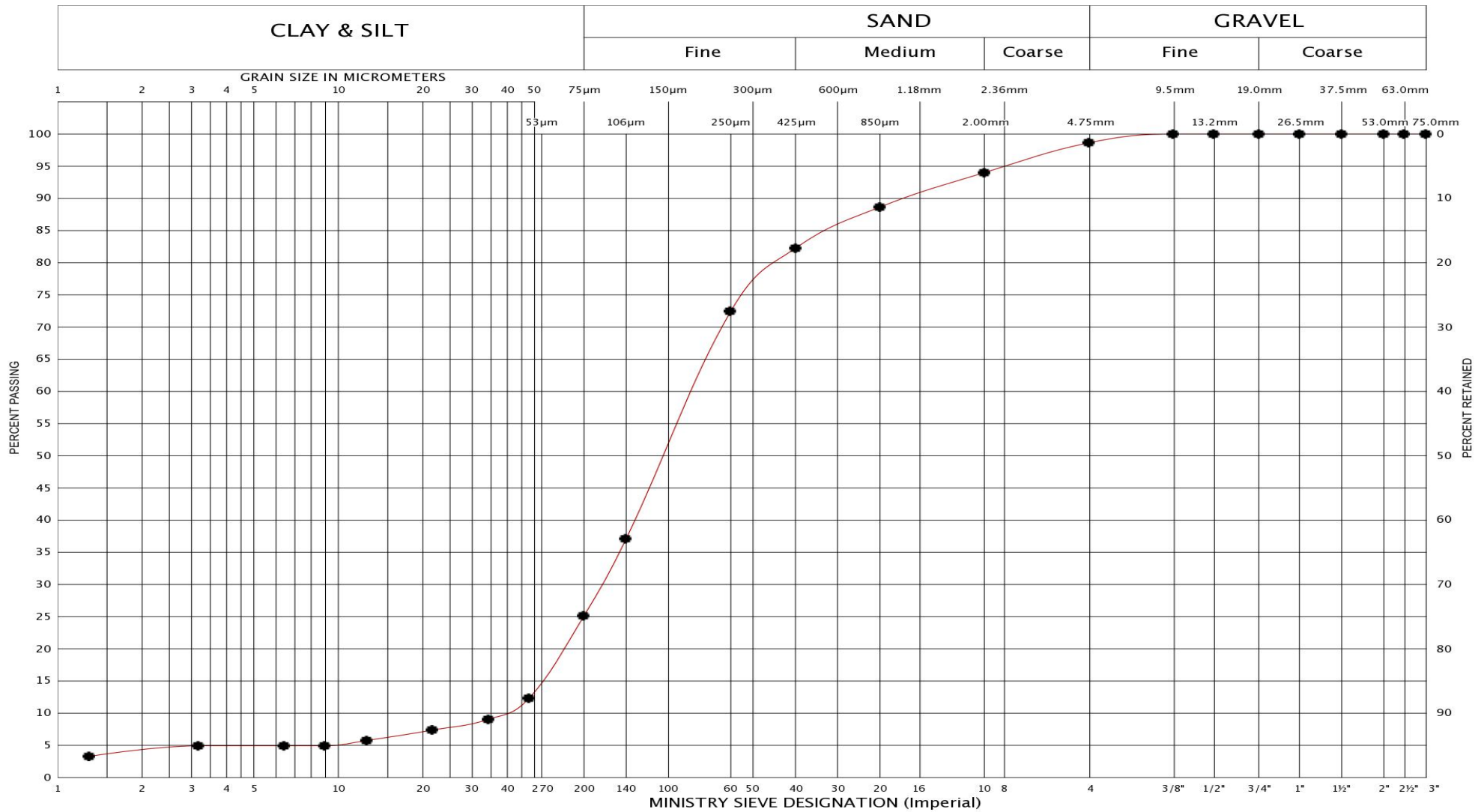
FIG No.: ED-GS-2

HWY : 668

GWP 5267-11-00



# UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	ED1
	SAMPLE	8
	SYMBOL	•



## GRAIN SIZE DISTRIBUTION

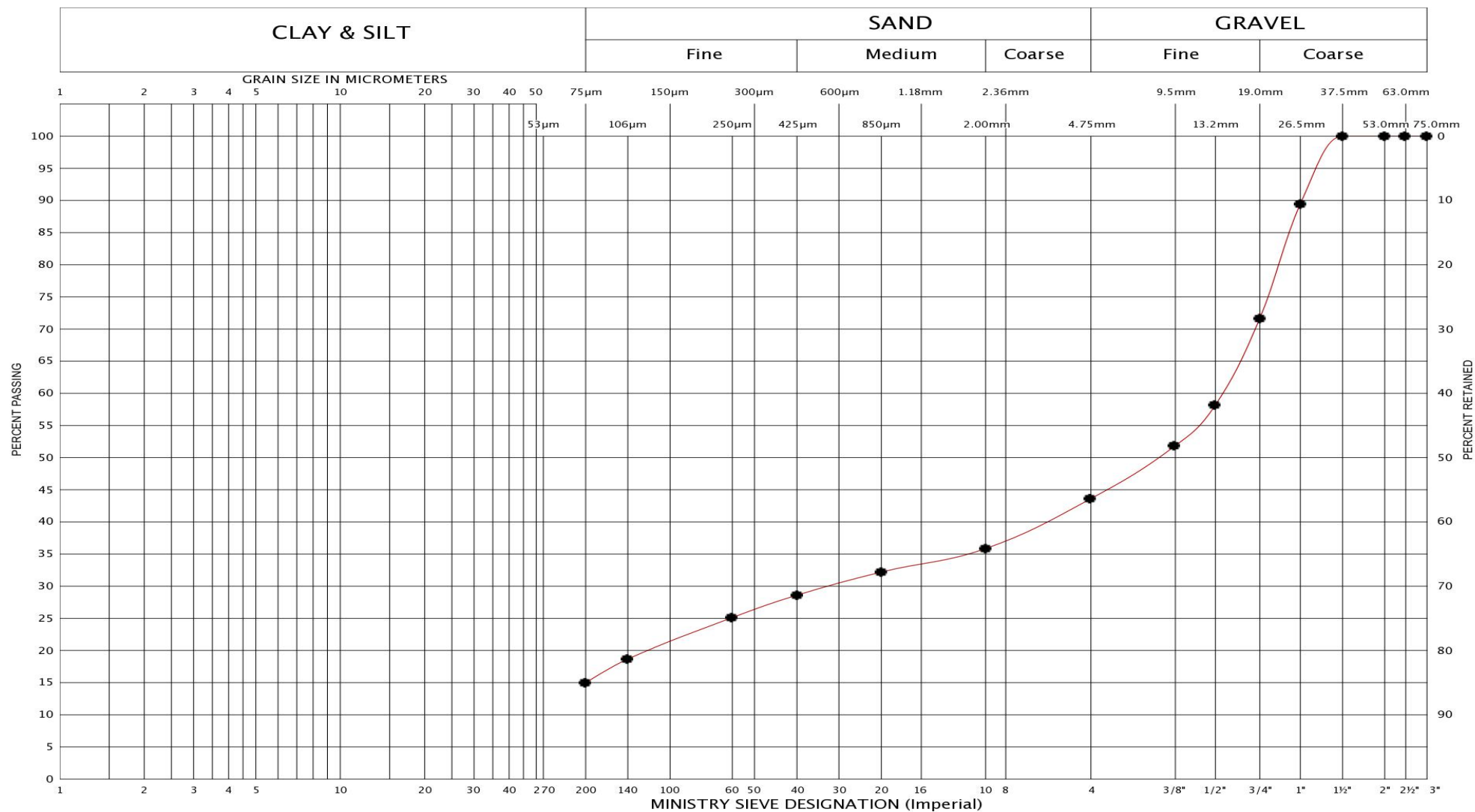
SILTY SAND, Trace Gravel


FIG No.: ED-GS-3

HWY : 668

GWP 5267-11-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



<b>LEGEND</b>	<b>BH</b>	ED1
	<b>SAMPLE</b>	14
	<b>SYMBOL</b>	



## GRAIN SIZE DISTRIBUTION

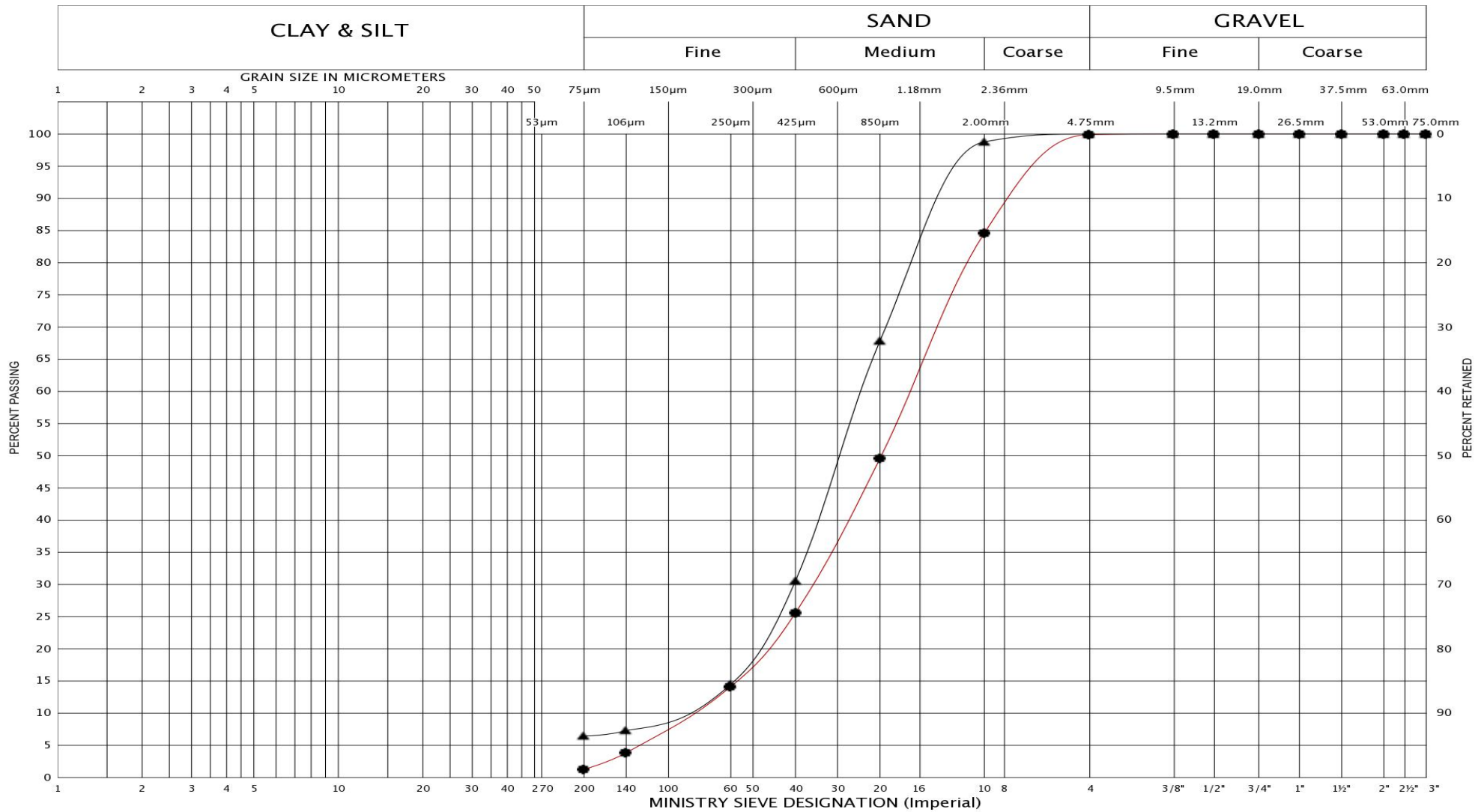
CLAYEY GRAVEL

FIG No.: ED-GS-4

HWY :	668
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GWP	5267-11-00
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# UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	ED2	ED3
	SAMPLE	16	14
	SYMBOL	●	▲



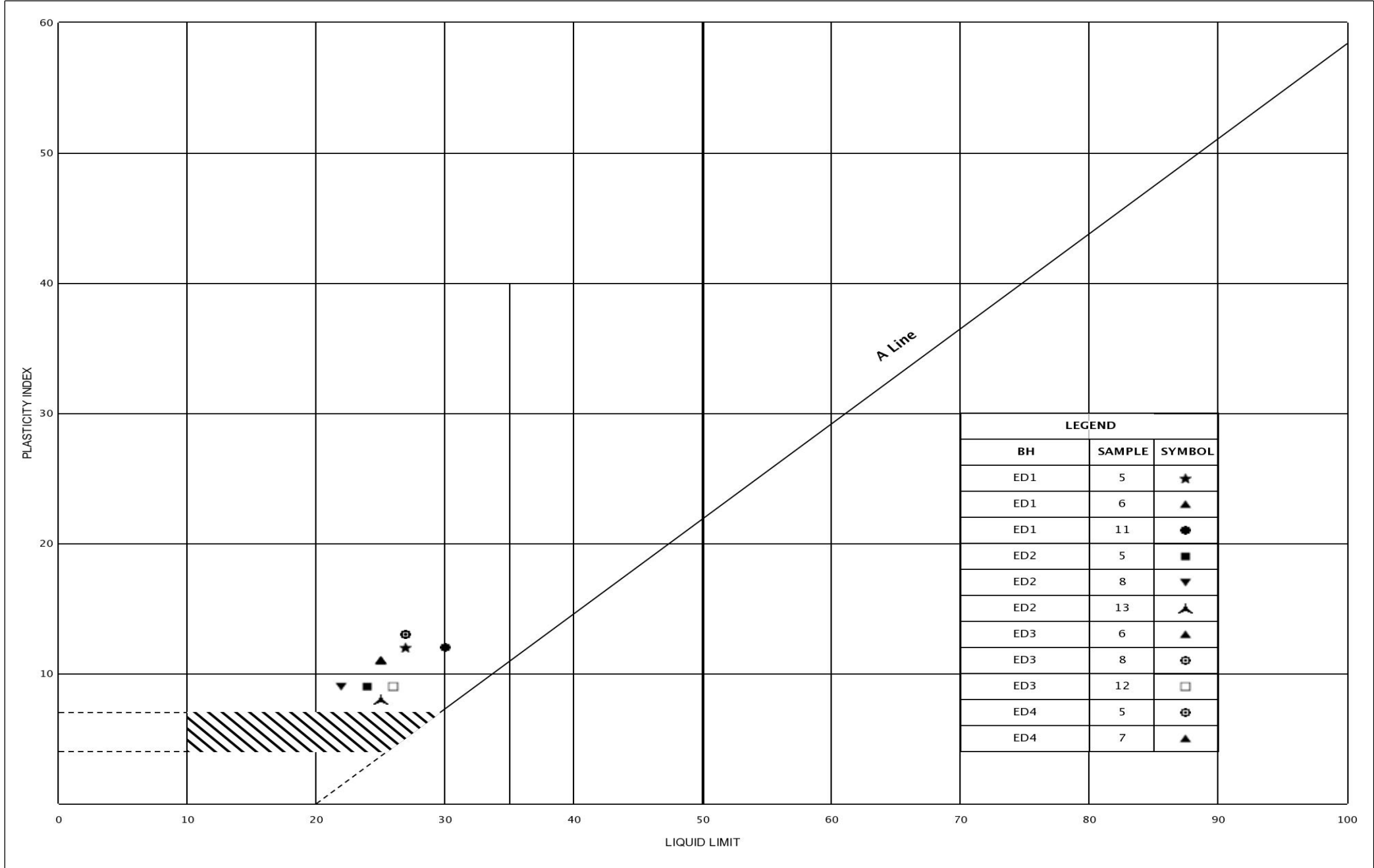
## GRAIN SIZE DISTRIBUTION

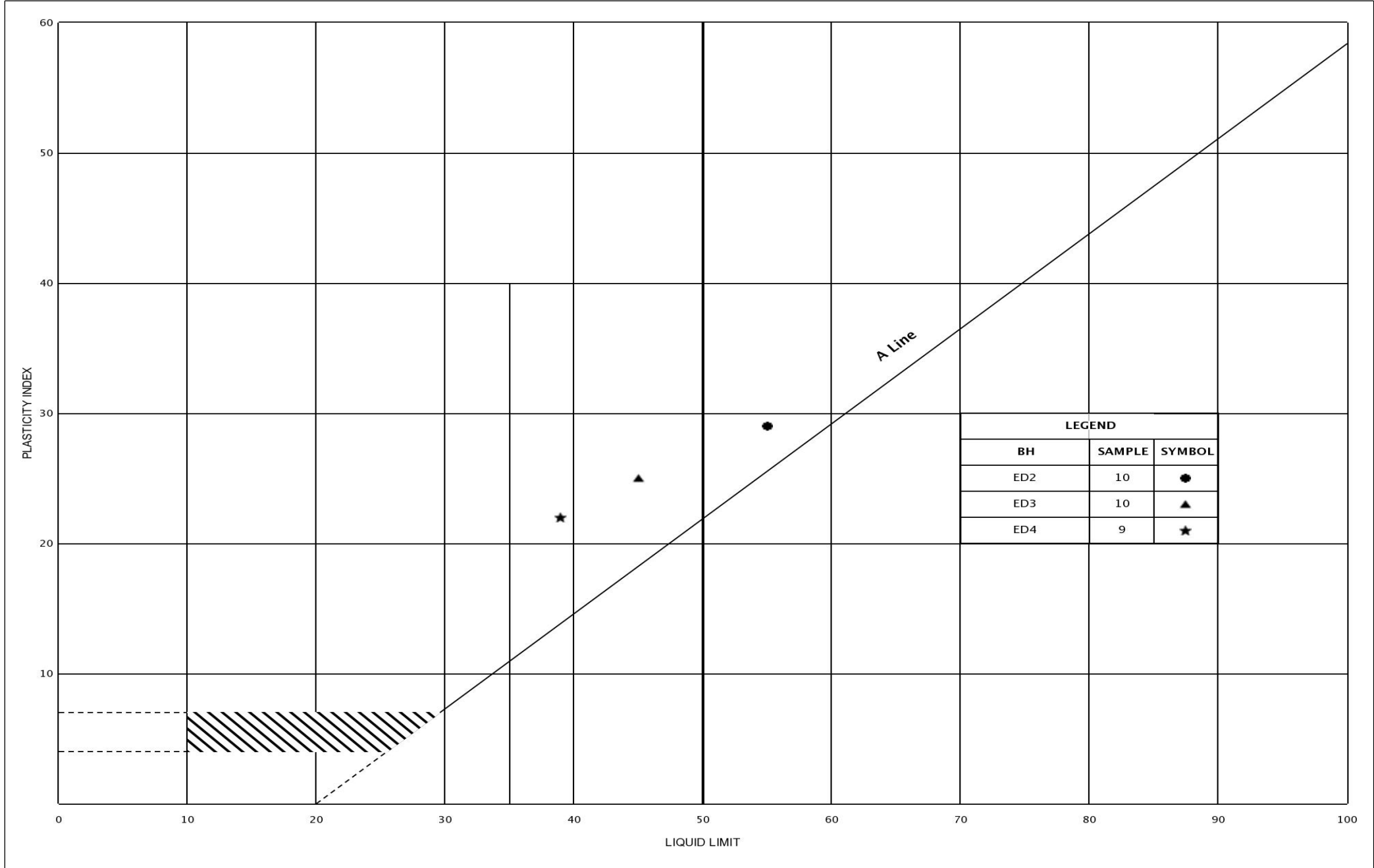
SAND

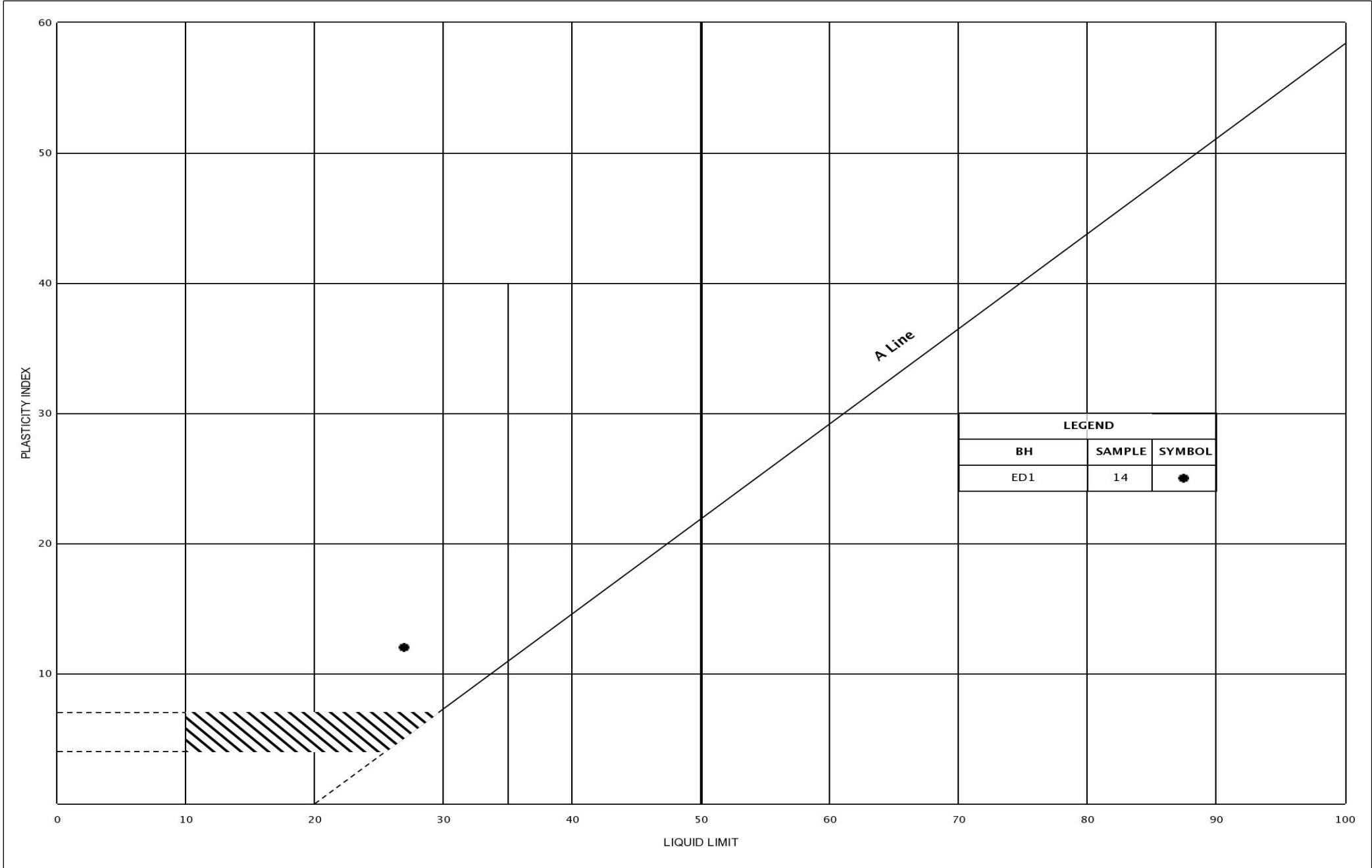
FIG No.: ED-GS-5

HWY : 668

GWP 5267-11-00







**PLASTICITY CHART**  
CLAYEY GRAVEL

FIG No.:	ED-PC-3
HWY.:	668
GWP	5267-11-00



## ROCK CORE DESCRIPTION

**Location:** Smith Creek, Cochrane, ON  
**Site Name:** TMB for Smith Creek Bridge Replacement, Hwy 668

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	RC No.	DEPTH (m)	% CR*	% RQD**	DEPTH (m)	DESCRIPTION
ED 2	1	18.59	+100.0% (1.04 m)	28.7% (0.25 m)	19.46	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, fine to medium grained, massive, dark grey to black, hard, crystalline; <b>DIABASE</b> with white; translucent quartz veins (8.0 mm thick) and unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Occasional features: Presence of sulphides (stringers/nodules).
ED 2	2	19.46	+100.0% (1.63 m)	93.4% (1.42)	20.98	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, fine to medium grained, massive, dark grey to black, hard, crystalline; <b>DIABASE</b> with white; translucent quartz veins (3.0 mm thick) and unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Occasional features: Presence of sulphides (stringers/nodules). Sample taken at 19.69-19.94 m.
ED 2	3	20.98	+100.0% (0.94 m)	86.8% (0.76 m)	21.89	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, fine to medium grained, massive, dark grey to black, hard, crystalline; <b>DIABASE</b> with white; translucent quartz veins (8.0 mm thick) and unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Occasional features: Presence of sulphides (stringers/nodules). Sample taken at 21.72-21.89 m.

**CR\*** - Core Recovery

Logged by: Heather Racher, M.Sc.

**RQD\*\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).



## ROCK CORE DESCRIPTION

**Location:** Smith Creek, Cochrane, ON  
**Site Name:** TMB for Smith Creek Bridge Replacement, Hwy 668

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	RC No.	DEPTH (m)	% CR*	% RQD**	DEPTH (m)	DESCRIPTION
ED 3	1	18.44	81.0% (1.32 m)	32.5% (0.53 m)	20.07	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, fine to medium grained, massive, dark grey to black, hard, crystalline; <b>DIABASE</b> with white; translucent quartz veins (6.0 mm thick) and unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Sample taken at: 19.41-19.65
ED 3	2	20.07	100.0% (1.52 m)	95.4% (1.45)	21.59	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, fine to medium grained, massive, dark grey to black, hard, crystalline; <b>DIABASE</b> with white; translucent quartz veins (5.0 mm thick) and unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Sample taken at 20.07-20.29 m.
ED 3	3	21.59	67.2% (0.41 m)	32.8% (0.20 m)	22.20	<b>NEO-MESOARCHEAN (2.5-3.4 GA) MAFIC TO INTERMEDIATE METAVOLCANIC</b> Unweathered, coarse grained, black/white, hard, crystalline <b>DIORITE</b> . Sample taken at 21.59-21.79 m.

**CR\*** - Core Recovery

Logged by: Heather Racher, M.Sc.

**RQD\*\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).

**Note:** Depths are approximated where core recovery is less than 100%. RQDs are calculated according to core recovery (less than designated 1.52 m runs).



**DRAFT** Addendum No. 1, Part A - Foundation Investigation Report

Temporary Modular Bridge for Smith Creek Bridge Replacement, Site No. 39E-0014/B0, Highway 668

Town of Cochrane, Ontario, G.W.P. 5267-11-00, W.P. 5368-11-01, Index No.: 054DIR

PML Ref.: 18TF002A, June 5, 2020



Photograph 1: Borehole ED-2; Runs 1, 2, and 3.



Photograph 2: Borehole ED-3; Runs 1, 2, and 3.



**DRAFT  
ADDENDUM NO. 1  
PART B – FOUNDATION DESIGN REPORT  
for  
TEMPORARY MODULAR BRIDGE FOR  
SMITH CREEK BRIDGE REPLACEMENT  
SITE NO. 39E-0014/B0  
HIGHWAY 668 – 10+284  
TOWN OF COCHRANE, ONTARIO  
G.W.P. 5267-11-00  
W.P. 5368-11-01  
LATITUDE AND LONGITUDE: 49.157440, -81.272080**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
Fax: (416) 785-5120  
Email:toronto@petomaccallum.com

Distribution:  
1 cc: Electronic Copy to Parsons for  
Distribution to MTO Foundations  
1 cc: Electronic Copy to Parsons for  
Distribution to MTO PM  
1 cc: Electronic Copy to Parsons  
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Appendix B – List of Standard Specifications and Non-Standard Special Provision Relevant to Report

**DRAFT**

**ADDENDUM NO. 1**

**PART B - FOUNDATION DESIGN REPORT**

Temporary Modular Bridge for Smith Creek Bridge Replacement

Site No. 39E-0014/B0

Highway 668 – Station 10+284

Town of Cochrane, Ontario

G.W.P. 5267-11-00, W.P. 5267-11-01 and 5363-01

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## **7. INTRODUCTION**

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

## **8. PROJECT DESCRIPTION**

### **8.1 General**

This report provides recommendations for foundation design based on interpretation of the geotechnical data presented in the factual report (Part A) and the details provided on the General Arrangement (GA) drawing for the proposed replacement of bridge on Highway 668 at the crossing of Smith Creek in the Town of Cochrane, Ontario.

Based on the GA drawing, it is proposed to construct the replacement bridge with a single-span structure supported on integral abutments.

PML understands that the traffic flow during the construction of the replacement bridge across Smith Creek will be diverted through a local detour, which includes a TMB.

The discussions and recommendations presented in this report are based on the information provided by Parsons and the factual data obtained during the geotechnical investigation carried out by PML.



## **8.2 Proposed Detour Structure**

Based on the GA drawing, the construction of replacement bridge will be carried out by transferring the traffic onto a TMB located east of the existing bridge.

## **8.3 Foundation For Detour Structure**

In summary, the subsoil conditions immediately below the ground surface along the alignment of proposed TMB consists of 2.3 m thick fill, composed of layers of clayey silt and sand, overlying very stiff to firm clayey silt. The clayey silt layer is underlain by compact to very dense sand. In Boreholes ED2 and ED3, the sand deposit is underlain by bedrock, which extends to the maximum borehole termination depth of 22.1 m below the existing ground surface.

Groundwater was encountered at 16.8 m (EL. 244.0) and 3.8 m (EL. 257.6) below the existing ground surface during drilling in Boreholes ED3 and ED4, respectively. Groundwater was not encountered in Boreholes ED1 and ED2 during drilling. Groundwater was measured at 16.8 m (EL. 244.1) and 15.2 m (EL. 245.6) below the existing ground surface in Boreholes ED2 and ED3, respectively, upon completion of drilling. Boreholes ED1 and ED4 were dry upon completion of drilling. The water level in the creek was observed at approximate elevation of EL. 257.6 during the fieldwork.

It is our understanding that construction of the detour is planned in 2021 and removal is planned for 2022. Based on the contour map provided by Parsons, the approximate existing ground surface elevation within the proposed south abutment footprint ranges from EL. 260.0 to EL. 258.0 and within the proposed north abutment footprint, the approximate existing ground surface elevation ranges from EL. 260.0 to EL. 258.5.

### **Option 1: Shallow Foundation**

The foundation may be placed on stiff clayey silt approximately at EL. 257.5 at the south and north abutments. The geotechnical resistances provided on Table 8.3 are recommended for the design of the TMB, assuming 2.5 m wide by 9.0 m long footing, supported on conventional timber crib or equivalent abutments founded at a level not higher than the elevations provided in Table 8.3.



**Table 8.3: Founding Elevation and Geotechnical Resistance for Shallow Foundation**

LOCATION	FOUNDING ELEVATION (m)	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	FACTORED GEOTECHNICAL RESISTANCE AT SLS (kPa)	SUBGRADE SOIL
South Abutment	257.5	205	110	Stiff Clayey Silt
North Abutment	257.5			

In case the TMB is required to be maintained throughout the winter months, the depth of frost should be taken into consideration and an adequate earth cover should be maintained.

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.10.4 of the CHBDC (2014). The total settlement under a Serviceability Limit State (SLS) loads recommended is expected to be in the order of 25 mm and the associated differential settlement may be expected to be in the order of 20 mm.

The sliding resistance of footings against lateral loads between the concrete footing and subgrade should be calculated in accordance with Section 6.10.5 of the CHBDC (2014). For cast in place concrete footings constructed on concrete working slabs and on top of stiff clayey silt:

- Cast-In-Place footing on concrete working slab: = 0.6
- Cast-In-Place concrete working slab on stiff clayey silt: = 0.4

#### Option 2: Granular 'A' Pad

Alternatively, based on the subsoil and groundwater conditions encountered at the site, it is considered geotechnically feasible to place the TMB on a shallow foundation design comprising a Granular 'A' pad.

A minimum thickness of 2.0 m may be considered for the Granular 'A' pad. The Granular 'A' should meet the requirements of OPSS.PROV 1010.



The factored geotechnical resistances of 100 kPa at ULS and 75 kPa at SLS at the top of the granular pad may be assumed based on a recent TMB design at Gilles Creek site (on the same assignment contract) with similar detour conditions. A minimum 1.0 m offset from the edge of footing (cribbing) to the top edge of the granular pad should be provided.

With regards to serviceability performance of using a granular pad as the TBM foundation, as considered for TMB at Gilles Creek, it is understood that the MTO Contract may relax the usual maximum 25 mm settlement serviceability limits because of the temporary nature of the structure and would allow the contractor to jack and shim the temporary bridge as required during its service life.

It is recommended that surficial topsoil, organic, deleterious and/or otherwise unsuitable materials be removed from the subgrade on which the Granular 'A' pad is constructed. The subgrade should be inspected and approved prior to placing Granular 'A'. The Granular 'A' should be placed in lifts not exceeding 200 mm in thickness and compacted to 100% of the Standard Proctor Maximum Dry Density (SPMDD) according to OPSS.PROV 501.

Where the slope of existing ground is steeper than 3H:1V, benching should be carried out in accordance with OPSD 208.010. The forward and side slopes of the Granular 'A' pad for the TMB could be constructed no steeper than 1.75H:1V. The slopes of the pad adjacent to the Smith Creek shall be protected against erosion with rock protection in accordance with OPSS.PROV 511.

For better stabilization of the pad, it is recommended to provide biaxial geogrid at vertical spacing of 0.5 m to the full extent of the Granular 'A' pad. It should be noted that geogrid products are proprietary products and should be designed by the proprietor design engineer. A non standard special provision for geogrid, similar to that for Gilles Creek TMB, is included in Appendix B.

The final design alternative should be determined by the designer considering the site conditions, constructability and economics.



## **9. FOUNDATION FROST DEPTH**

In accordance with OPSD 3090.100, a minimum of 2.5 m earth cover is required to protect against the frost penetration in the area where the site is located.

Frost tapers within the granular backfill should be constructed in accordance with OPSD 3101.150. The frost penetration depth,  $f$ , is measured from the top of the grade to the bottom of the footing.

## **10. SEISMIC CONSIDERATIONS**

The Spectral ( $S_a(T)$ , where  $T$  is in seconds) and Peak Ground Acceleration (PGA) for the project site is 0.217 ( $S_a(0.2)$ ) and 0.142 (2%/50 years) based on the longitude and latitude coordinates of the proposed structure (National Building Code of Canada, 2015). The soil below the founding level at this site for seismic design purposes is classified as Type C in accordance with Clause 4.4.3.2, CHBDC 2014.

The Seismic Performance Category should be determined by the Regulatory Authority (MTO) and no information was provided in the RFP with regards to the category. In the absence of any information, it was assumed that the proposed replacement bridge is located on a Major Route and classified as Seismic Performance Category 2.

## **11. EXCAVATION AND GROUNDWATER CONTROL**

Approximately, up to 2.5 m depth of excavation is expected at the south and north abutment locations to El. 257.5. All the excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects. In accordance with Ont. Reg. 213/91, S. 226. The fill soils may be classified as Type 3 soils. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. Therefore, temporary cut slopes over the full depth of excavation inclined at 1H:1V should be provided assuming adequate drainage measures are in place. Temporary shoring systems may be required if such slopes inclination cannot be provided.





Excavating and backfilling of structures should be in accordance with OPSS 902. All excavated surfaces should be kept free of frost and water during the period of construction. Runoff shall be directed away from open excavations and should not be allowed to flow into the excavation. Excavated material shall not be stockpiled adjacent to the top of the excavation.

Prior to excavation, the locations and depths of existing underground utilities should be verified. All underground utilities that might be exposed and become unsupported as a result of the excavation should be properly supported to avoid potential damage.

Considering the depth of groundwater level (EL. 245.6 to EL. 244.1) at this site, no major dewatering problems are anticipated for footings placed at the recommended elevation of EL. 257.5. However, the groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

It is considered that seepage from soil fissures or surface run-off that enters the excavations can be handled by conventional sump pumping techniques. The groundwater level should be lowered to a minimum of 0.5 m below the base of excavation, where anticipated. It is suggested that construction of the TMB should be carried out during the drier season.

Nevertheless, the contractor shall be responsible for the selection, performance and detailed design of the dewatering control system.



## 12. CLOSURE

This Foundation Investigation and Design Report was prepared by Ms. N. Leong-Sem, E.I.T., Geotechnical Services, and reviewed by Mr. N. Rahman P.Eng., and Geoffrey Uwimana, MEng, P.Eng., Senior Engineer. Mr. R. Ng, MBA, PhD, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

A handwritten signature in blue ink, reading "Natasha Leong-Sem".

Natasha Leong-Sem  
EIT  
Geotechnical Services

A handwritten signature in blue ink, reading "Nazibur Rahman".

Nazibur Rahman, P.Eng.  
Project Engineer  
Geotechnical Services

A handwritten signature in blue ink, reading "Geoffrey Uwimana".

Geoffrey Uwimana, MEng, P.Eng.  
Senior Engineer  
Geotechnical Services

A handwritten signature in blue ink, reading "Robert Ng".

Robert Ng, MBA, PhD, P.Eng.  
Project Manager and  
MTO Designated Principal Contact

NL/NR:nl-nr-nk

**NOTE:** The Final Report will be signed and stamped by two Professional Engineers licensed by PEO, one of whom shall be the Designated Principal Contact for MTO foundation projects



## **APPENDIX B**

### List of Standard Specifications and Non-Standard Special Provision Relevant to Report



## **LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT**

<b>DOCUMENT</b>	<b>TITLE</b>
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS 902	Excavation and Backfilling of Structures
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
OPSD 208.010	Benching of Earth Slopes
OPSD 3090.100	Foundation, Frost Penetration depths for Northern Ontario
OPSD 3101.150	Walls, Abutment, Backfill, Minimum Granular Requirement



## **GEOGRID – Item No.**

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### **Special Provision**

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#### **1.0 SCOPE**

This special provision covers the requirements for the supply, delivery, storage, handling and installation of geogrid bedding reinforcement.

#### **REFERENCES**

This special provision refers to the following standards, specifications or publications:

##### **Ontario Provincial Standard Specifications, Construction**

OPSS 314      Construction Specification for Untreated Granular, Subbase, Base, Surface, Shoulder and Stockpiling

##### **American Society for Testing and Materials (ASTM)**

D 1388      Standard Test Method for Stiffness of Fabrics, Option A  
D 4759      Practice for Determining the Specification Conformance of Geosynthetics  
D 6637      Standard Test Method for Determining Tensile Properties of Geogrid by the Single or Multi-rib Tensile Method

##### **Geosynthetic Research Institute (GRI)**

GRI-GG2-87 Standard Test Method for Geogrid Junction Strength

#### **3.0 DEFINITIONS**

For the purpose of this special provision, the following definitions apply:

**Flexural Rigidity** means the resistance to bending force measured via ASTM D1388-96, Option A, using specimen dimensions of 864 mm in length by 1 aperture width. Values shown are MARVs.

**Geogrid** means a biaxial polymeric grid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth to function primarily as reinforcement.

**Minimum Average Roll Value (MARV)** means a value based on testing and determined in accordance with ASTM D 4759-92.



**True Initial Modulus in Use** means the ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM D6637 at a strain rate of 10%/min. Values shown are MARVs.

#### 4.0 DESIGN AND SUBMISSION REQUIREMENTS

##### Submission Requirements

At least 20 Days prior to the installation of the geogrid, the Contractor shall provide the Contract Administrator with the following:

- a) a geogrid product sample measuring 10 x 20 cm or larger;
- b) a certificate from the manufacturer stating the name of the manufacturer, product name, style number, chemical composition, and other pertinent information to fully describe the geogrid as evaluated under the manufacturer's Quality Control (QC) program; and,
- c) a copy of the manufacturer's storage, handling and installation instructions and general recommendations.

The Contractor shall also provide separate documentation certifying that the geogrid meets the requirements of Table 1 of this special provision.

The Contract Administrator shall review the Contractor's submission. The geogrid shall not be placed until the Contract Administrator has provided written confirmation to the Contractor of the conformance to the Contract requirements for the geogrid. The Owner shall bear no responsibility for the rejection of any materials which do not conform to the Contract requirements.

Confirmation of conformance to the Contract requirements for the geogrid does not relieve the Contractor of the responsibility for ensuring the specified quality of Materials and workmanship.

#### 5.0 MATERIALS

The geogrid supplied shall be an integrally formed biaxial geogrid having the characteristics specified in Table 1.

**TABLE 1  
GEOGRID PROPERTY REQUIREMENTS**

Property	Test Method	Units	Requirements <sup>1</sup>
Aperture Size	Callipered	mm	25 to 33
Tensile Strength @ 2% Strain	ASTM D6637-01	kN/m	6.0 (Machine Direction) 9.0 (Cross-machine Direction)
Tensile Strength @ 5% Strain	ASTM D6637-01	kN/m	11.8 (Machine Direction) 19.6 (Cross-machine Direction)
Flexural Rigidity	ASTM D1388-96	mg-cm	750,000
Junction Efficiency	GRI-GG2-87	%	93



**Notes:**

1. All values are Minimum Average Roll Values (MARV), unless a range or characteristic is indicated.

## **6.0 CONSTRUCTION**

### **6.01 Storage and Handling**

The Contractor shall store and handle the geogrid in a manner to prevent excessive mud, wet concrete, epoxy or other deleterious materials from coming into contact with and affixing to the geogrid materials as recommended by the manufacturer.

Rolls shall not be left exposed to direct sunlight for periods longer than recommended by the manufacturer.

### **6.02 Examination**

The Contractor shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the Contractor to be free of flaws or damage occurring during manufacturing, shipping or handling.

### **6.03 Preparation**

The subgrade soil shall be graded to provide positive drainage as indicated in the Contract Drawings, and shall be cleared of any sharp objects that might damage the geogrid.

### **6.04 Installation**

The geogrid shall be placed longitudinally (parallel to the direction of traffic flow) to the lines and dimensions in the Contract Drawings. The material shall be free of tears and folds. Edges and ends shall be overlapped by 500 mm and securely tied to make one continuous mat. The ends of the rolls shall be overlapped in the direction that the fill will be spread; the edges of the rolls shall be overlapped in the direction of the subgrade cross-fall.

The geogrid may be temporarily secured in place with ties, staples, pins or small piles of the granular fill to aid in the placement and smoothing of the geogrid mat.

### **6.05 Granular Placement Over Geogrid**

Granular material shall be placed by end dumping, spread over the geogrid mat with a with a crawler type tractor bulldozer having a maximum net flywheel power of 60 kW.

The granular material shall be compacted in a manner that minimizes the development of wrinkles and/or movement of the geogrid mat. Compaction shall be carried out such that the subgrade material is not damaged or disturbed. At no time shall any vehicles be allowed directly on any portion of the



geogrid mat.

Granular material shall be placed to the lines and grades shown on the plans, in accordance with OPSS 314.

The Contractor shall take all necessary precautions to avoid rutting during the backfilling operations.

#### **6.06 Inspection**

The Contract Administrator shall randomly inspect the geogrid before and during construction operations and may randomly inspect after installation using test pits.

Any damaged or defective geogrid (i.e. frayed coating, separated junctions, separated layers, tears, etc.) shall be repaired/replaced in accordance with Clause 6.07.

#### **6.07 Repair**

Geogrid damaged before, during or after installation shall be replaced with new material.

Proper replacement shall consist of replacing the damaged geogrid material, within the affected area, as recommended by the manufacturer.

### **7.0 MEASUREMENT FOR PAYMENT**

#### **7.01 Actual Measurement**

Measurement for payment shall be in square metres of the installed geogrid product, with no allowance for overlap.

### **8.0 BASIS FOR PAYMENT**

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and materials necessary to do the work.

Replacement geogrid materials used for repairs shall be at no additional cost to the Owner.