



**ADDITIONAL INVESTIGATION TECHNICAL MEMORANDUM**

**for**

**UNNAMED CREEK CULVERT REPLACEMENT**

**SITE NO. 39W-119/C**

**HIGHWAY 11 - STA. 11+917**

**TOWNSHIP OF CLAVET, DISTRICT OF NEW LISKEARD**

**HEARST, ONTARIO**

**ASSIGNMENT NO. 5015-E-0009**

**GWP 5130-13-00**

**WP 5292-14-01**

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**ADDITIONAL INVESTIGATION TECHNICAL MEMORANDUM**

for  
Unnamed Creek Culvert Replacement,  
Site No. 39W-119/C  
Highway 11 - Sta. 11+917  
Township of Clavet, District of New Liskeard  
Hearst, Ontario  
GWP 5130-13-00, WP 5292-14-01

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**1. INTRODUCTION**

The Ministry of Transport of Ontario (MTO) is currently planning to replace the culvert (MTO Site No. 39W-119/C) and associated structures located at the crossing of an unnamed creek and Highway 11, about 120 km west of Hearst, Sta. 11+917, in the Township of Clavet, District of New Liskeard. Peto MacCallum Ltd (PML) prepared the following foundation investigation and design report for the culvert and submitted it to GHD.

- *Foundation Investigation and Design Report for Unnamed Creek Culvert Replacement, Site No. 39W-119/C, Highway 11 –Sta. 11+917, Township of Clavet, District of New Liskeard, Hearst, Ontario, Geocres No. 42F-042, March 6, 2017.*

The report was prepared based on the foundation investigation program consisted of four (4) boreholes (16-119-01, 16-119-02, 16-119-03, and 16-119-04) drilled during the period between July 6, 2016 and July 20, 2016.

Boreholes 16-119-01 and 16-119-02 were drilled on the shoulders of Highway 11, on the west and east approaches, and Borehole 16-119-04 was located at the northwest end of the culvert, near the toe of the embankment. However, access for the drill rig to the southeast end of the culvert was difficult at the time of drilling because of steep slope and proximity of Pagwachan River in relation to the culvert. Borehole 16-119-03 was drilled on the shoulder of the road at the nearest location to the culvert.

After the draft report was submitted, comment was received from MTO suggesting that the location of Borehole 16-119-03 was far from the southeast end of the culvert and an additional borehole should be advanced using a suitable drill rig. Following this comment, PML attempted to drill this borehole immediately, but the area was covered with snow and drilling was postponed to summer, 2017. This technical memorandum summarizes the subsurface and groundwater conditions encountered, based on the foundation investigation carried out on July 24, 2017 at the



southeast end of the culvert. Drilling at the site was conducted using a portable tripod rig, owned and operated by Tatry Drilling of Timmins, Ontario, is a specialist drilling contractor, worked under the full time supervision of a PML field technician.

Photographs A1 to A4 provided in Appendix A, present the general site conditions at the time of drilling. The location of the new borehole is shown on Drawing 119/C-1 provided in Appendix B.

Soil samples were retrieved at selected intervals using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures described in ASTM D1586. Samples were visually examined as they were retrieved and stored in moisture-proof bags. The groundwater conditions at borehole locations were observed during drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved.

Upon completion of drilling, the boreholes were backfilled with drill cuttings and sealed with a bentonite/cement mixture in accordance with the MTO guidelines.

All the soil samples were transported to PML laboratory in Toronto for detailed visual examination and laboratory testing. The laboratory tests included the following:

- Natural Moisture Content Determination (9)
- Atterberg Limit Tests (3)
- Grain Size Distribution (2)

Laboratory tests were performed on representative samples, and results are provided on the Record of Borehole Sheet, provided in Appendix B. The grainsize distribution curves are shown on Figures GS-119-3A-1 and GS-119-3A-2, and the plasticity charts are provided on Figure PC-119-3A-1.

## **2. SUBSURFACE CONDITIONS**

In summary, the subsurface stratigraphy at the borehole location consisted of 750 mm thick organic silt underlain by about 2.3 m thick silty sand with varying proportions of gravel. The sand is underlain by clayey silt deposit to the maximum depth of drilling of 6.9 m. For classification purposes, the soils encountered at this location can be divided into three distinct zones.

- a) Organic Silt, Trace Sand
- b) Silty Sand (Alluvium)
- c) Clayey Silt, Some Sand



## **2.1 Organic Silt, Trace Silt**

An organic silt mixed with topsoil was encountered immediately below the ground surface (approximate El. 194 m). The thickness of this deposit was about 750 mm, extending to El. 193.25 m. The SPT “N”-value was none (weight of a hammer), indicating very soft consistency.

Moisture content test result of only sample of this material indicated a moisture content of 54.4%.

## **2.2 Silty Sand, Alluvium**

A silty sand (alluvium) layer was encountered below the organic silt. This silty sand layer contained trace clay and varying proportions of gravel, and was found to be wet to very wet. The thickness of this silty sand layer was approximately 2.3 m, extending to El. 191 m). SPT “N” values ranged from 5 to 12 blows/300 mm, indicating loose to compact state of compaction.

The moisture content of this silty sand layer decreased from 24.6% in the upper part to 4.7% in the lower part where this layer contains a higher proportion of gravel content.

Grainsize analysis of a sample taken at a depth of 2 m indicates the presence of 82% sand and 18% of fines passing 75 µm sieve. The grain size distribution curve is presented on Figure GS-119-3A-1, in Appendix B.

## **2.3 Clayey Silt, Some Sand**

Clayey silt deposit was encountered at a depth of about 3 m. This clayey silt deposit contained some sand, and was found to be wet to very wet. The SPT “N”-values ranged from 2 to 8 blows/300 mm, indicating soft to firm consistency. The low SPT blow count corresponds to a layer of silt where extremely wet conditions were observed. This clayey silt deposit extends to the full depth of investigation of 6.9 m, extending to El. 187.1 m. Soil caved-in at a depth of 6.9 m and borehole could not be advanced further as a result of refusal to SPT spoon sampler.

Laboratory test results indicated that the moisture content of the clayey silt deposit was in the range of 32% to 41.8%. The liquid limit ranged from 29 to 40 and the corresponding plastic limits varied between 19 and 29, resulting in plasticity index of 10 to 11. Based on the results of the Atterberg limit



tests, the soil may be classified as clay of low plasticity (CL) in the Unified Soil Classification System (USCS). The plasticity chart is provided on Figure PC-119-3A-1, in Appendix B.

The grainsize analyses carried out on sample taken at a depth of about 4 m indicated 2.5% gravel, 24.5% sand, 58% silt and 15% clay. The grain size distribution curve is presented on Figure GS-119-3A-2, in Appendix B.

### **3. GROUNDWATER**

During drilling, groundwater was not encountered. However, samples were wet to very wet. The depth of the water in the creek was estimated to be about 10 mm.

### **4. DISCUSSION**

The final report submitted on March 6, 2017 indicated that the subsurface conditions at the proposed culvert location consists of sand and gravel fill, followed by loose to compact silt, which in turn is underlain by soft to firm clayey silt deposit that extends to about El. 185.3 m. The factual information given above is consistent with this summary of the subsurface information provided in report. Hence, the discussions on culvert replacement options and the recommendations for the preferred precast concrete box culvert, headwall and wing walls, backfill and cover material, approach embankment, foundation frost depth, staged construction, temporary excavation, subgrade preparation, and groundwater control, provided in the report do not require an update.

An updated stratigraphic profile is provided on Drawing 119/C-1 in Appendix B.



## 5. CLOSURE

The drilling work was supervised by Mr. Shane Aziz, under the direction of Mr. M. Khorsand, B.Sc. P.Eng. The drilling equipment was supplied and operated by Tatry Drilling of Timmins, Ontario. The laboratory tests were conducted at the PML laboratory in Toronto

This technical memorandum was prepared by Mr. L. Yimam, PhD. P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review.

Yours very truly,

Peto MacCallum Ltd.



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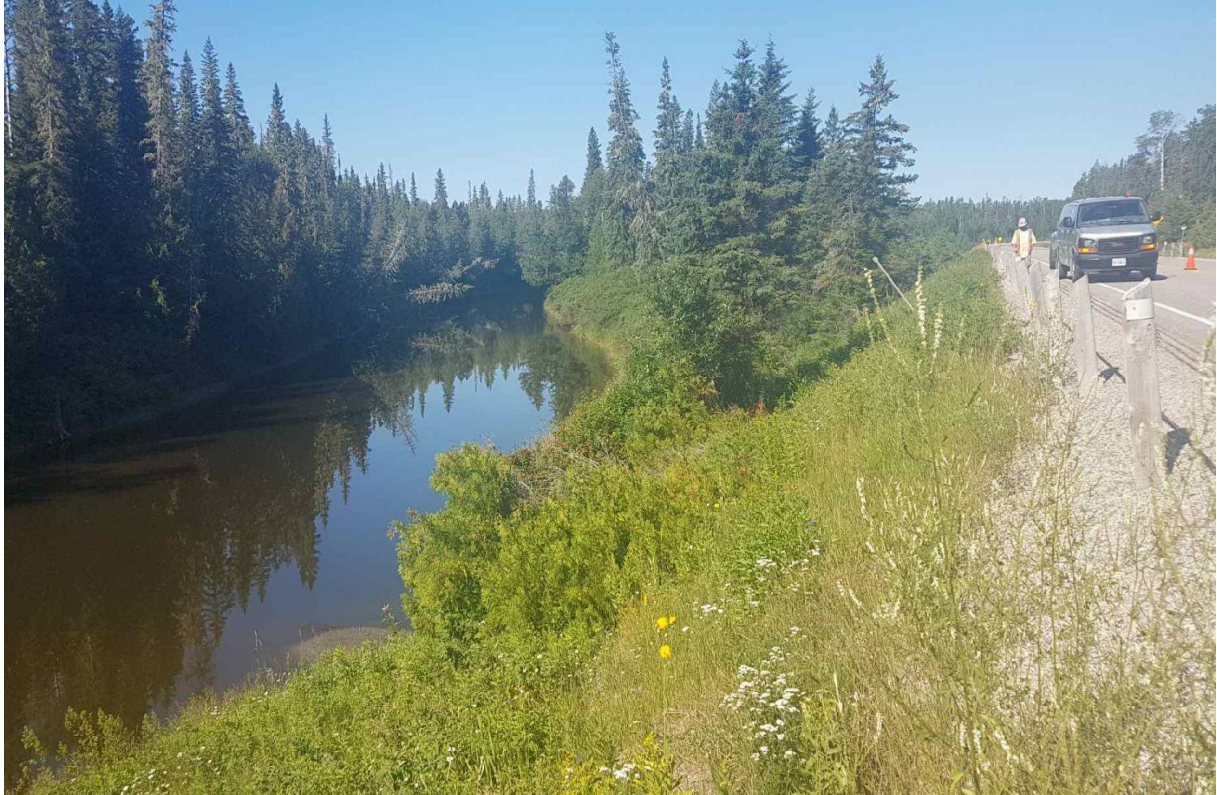
Carlos M.P. Nascimento, P.Eng.  
Project Manager and  
MTO Designated Principal Contact



## **APPENDIX A**

### Site Photographs





**Photograph A1:** View of the Embankment Slope and the Pagwachan River (July 24, 2017).



**Photograph A2:** View of the Southeast End of the Culvert and the Pagwachan River (July 24, 2017).





**Photograph A3:** The Drilling Location (July 24, 2017).





**Photograph A4:** Drilling Operation and the Soil Condition (July 24, 2017).



## **APPENDIX B**

Borehole Location Plan and Soil Strata

Explanation of Terms Used in the Report

Record of Borehole Sheet

Grain Size Distribution Curves – Figures GS-119-3A-1 and GS-119-3A-2

Plasticity Charts – Figure PC-119-3A-1

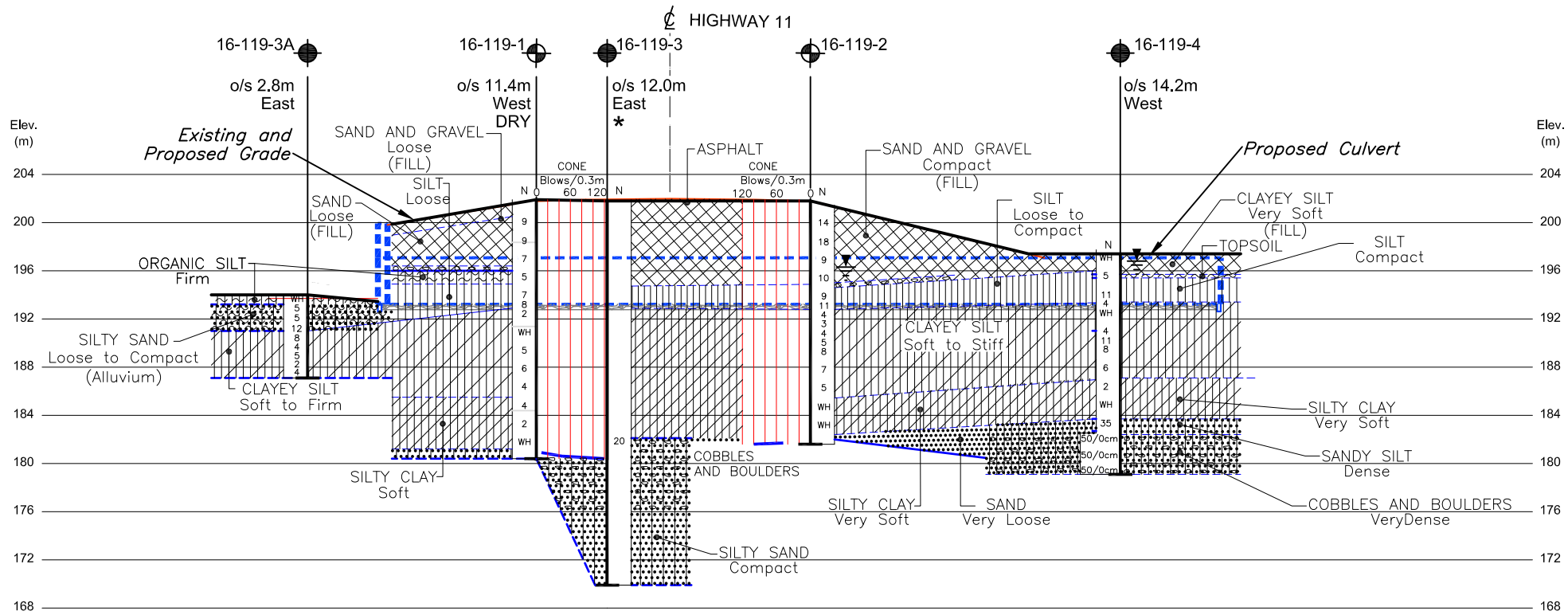
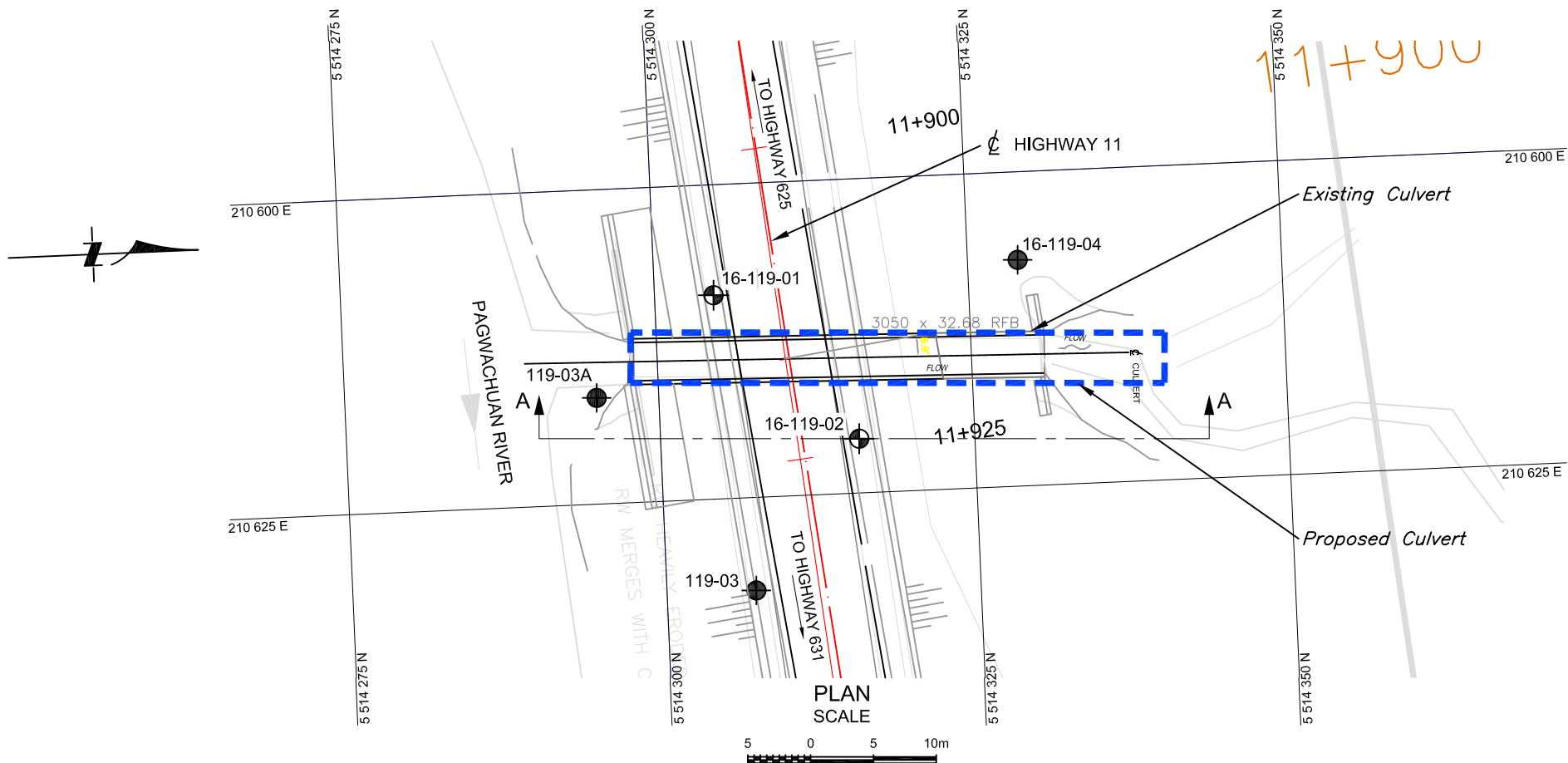
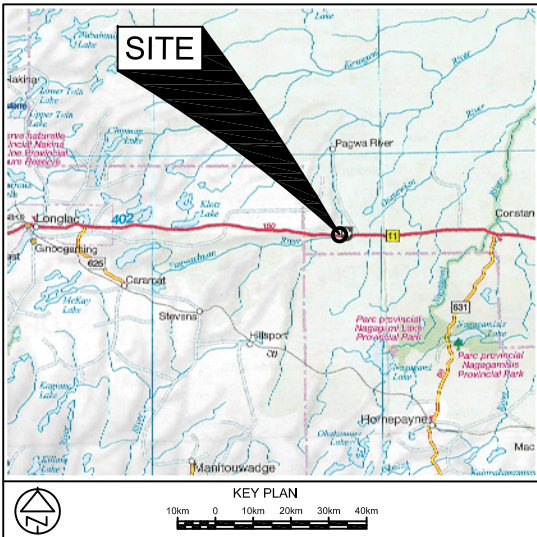
CONT No  
GWP No 5130-13-00  
WP No 5153-08-01

UNNAMED CREEK CULVERT REPLACEMENT  
STA. 11+917 HIGHWAY 11  
CLAVET TWP  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET

**PML Peto MacCallum Ltd.**  
CONSULTING ENGINEERS



PROFILE A - A

SCALE  
HORIZONTAL

2.5 0 2.5 5m

VERTICAL

5 0 5 10m

NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LEGEND

- Borehole
- Cone
- Borehole and Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation July 2016
- WH Penetration due to weight of hammer and rod
- \* Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
16-119-01	201.9	5 514 304.7	210 608.8
16-119-02	201.8	5 514 315.8	210 620.7
16-119-03	201.8	5 514 307.1	210 632.4
16-119-03A	194.0	5 514 295.1	210 616.6
16-119-04	197.4	5 514 329.0	210 607.0

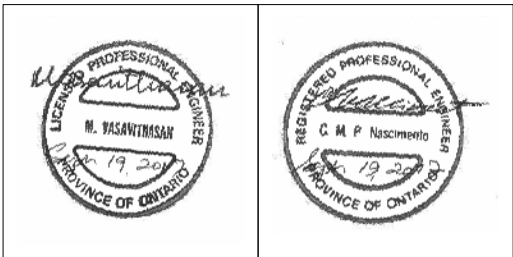
NOTE

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. 042-042a

HWY No	11	DIST NEW LISKEARD
SUBM'D	NA	CHECKED LY DATE SEPT. 19, 2017 SITE 39W-119
DRAWN	NA	CHECKED MV APPROVED CN DWG 119/C-1R



REF GHD Drawing: 39W-119.dwg undated



## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

**RECORD OF BOREHOLE No 16-119-03A**

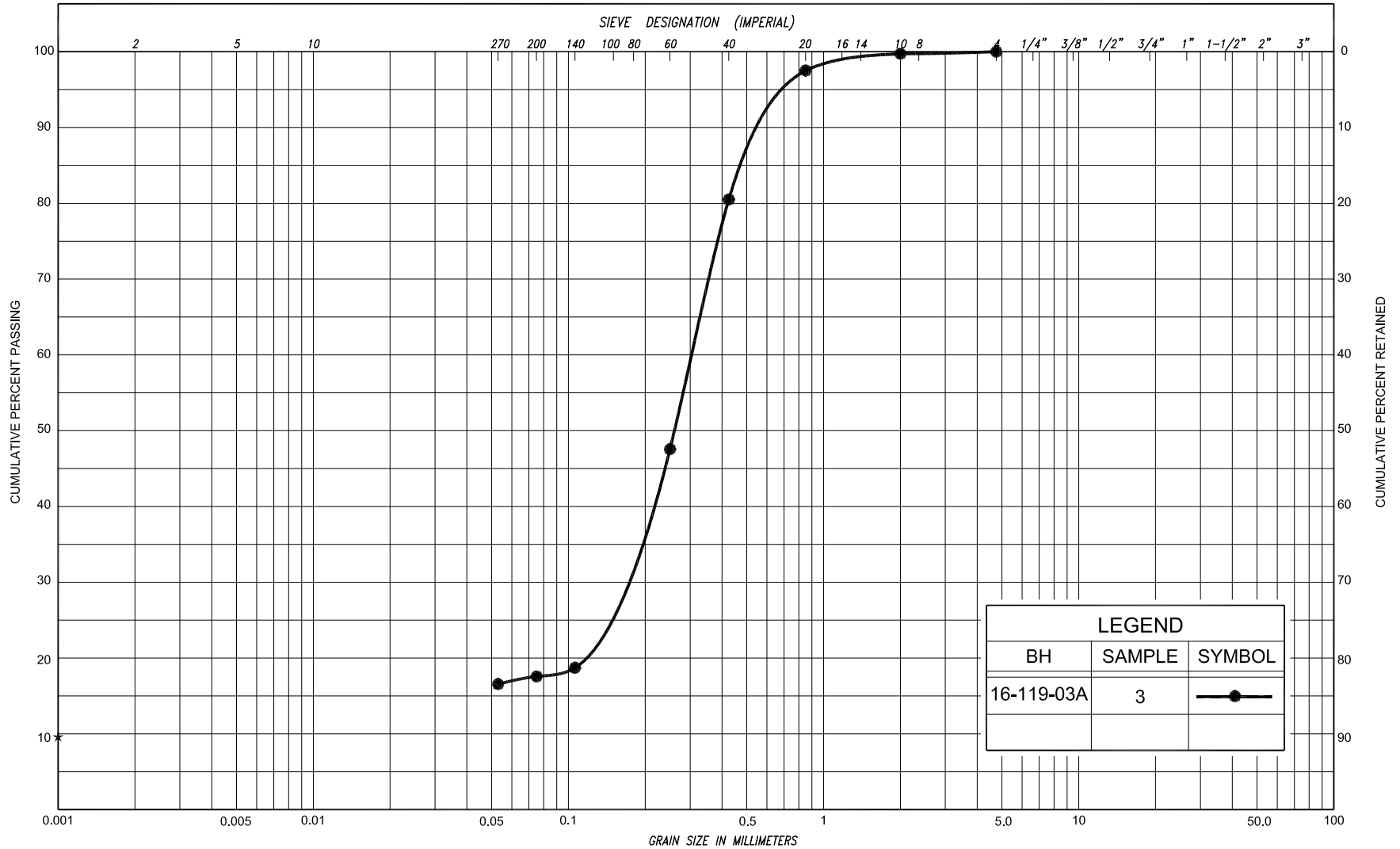
1 of 1

**METRIC**

G.W.P. 5130-13-00 LOCATION Co-ords: 5 514 295.1 N ; 210 616.6 E ORIGINATED BY S.A.  
DIST New Liskeard HWY 11 BOREHOLE TYPE Continuous Sampling with Tripod rig COMPILED BY L.Y.  
DATUM Geodetic DATE July 24, 2017 CHECKED BY M.V.

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									
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
194.0	Ground Surface																
0.0	Organic silt, trace sand topsoil inclusions		1	SS	WH**												
193.2	Very soft Wet																
0.8	Silty sand, trace clay		2	SS	5		193										
	Compact Dark grey Wet																
			3	SS	5		192										
	Gravelly																
	(ALLUVIUM)		4	SS	12		191										
191.0	Clayey silt, some sand																
3.0	Soft to Grey Wet to firm		5	SS	8		190										
			6	SS	4												
			7	SS	5		189										
			8	SS	2												
			9	SS	4		188										
187.1	End of borehole																
6.9	Spoon refusal due to cave-in																
NOTES: 1. No ground water was encountered during and after completion of drilling 2 Borehole caved-in after sample SS-9																	





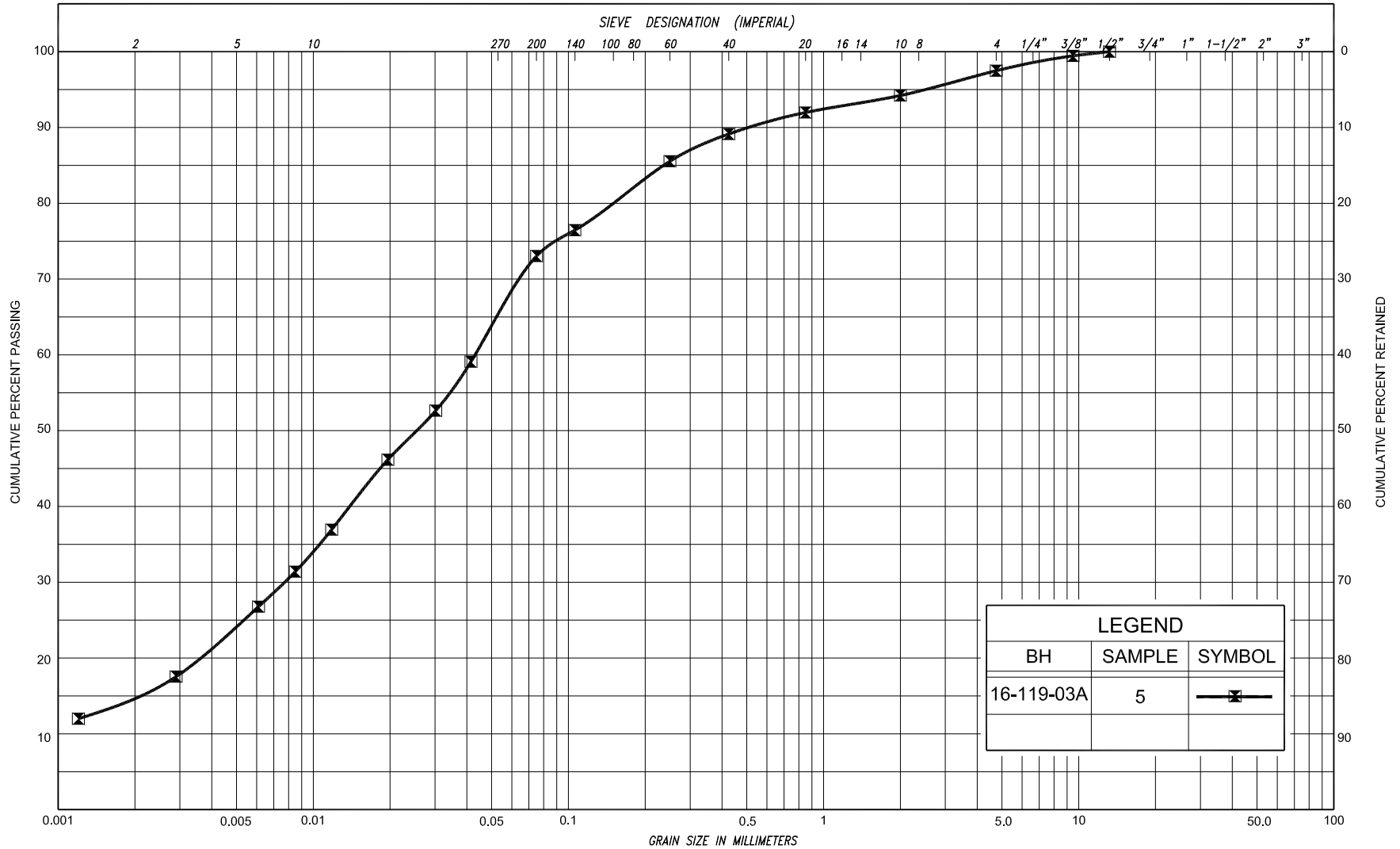
LEGEND		
BH	SAMPLE	SYMBOL
16-119-03A	3	—●—

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



# GRAIN SIZE DISTRIBUTION SILTY SAND, trace clay (ALLUVIUM)

FIG No.	GS-119-3A-1
HWY	11
G.W.P.	5130-13-00

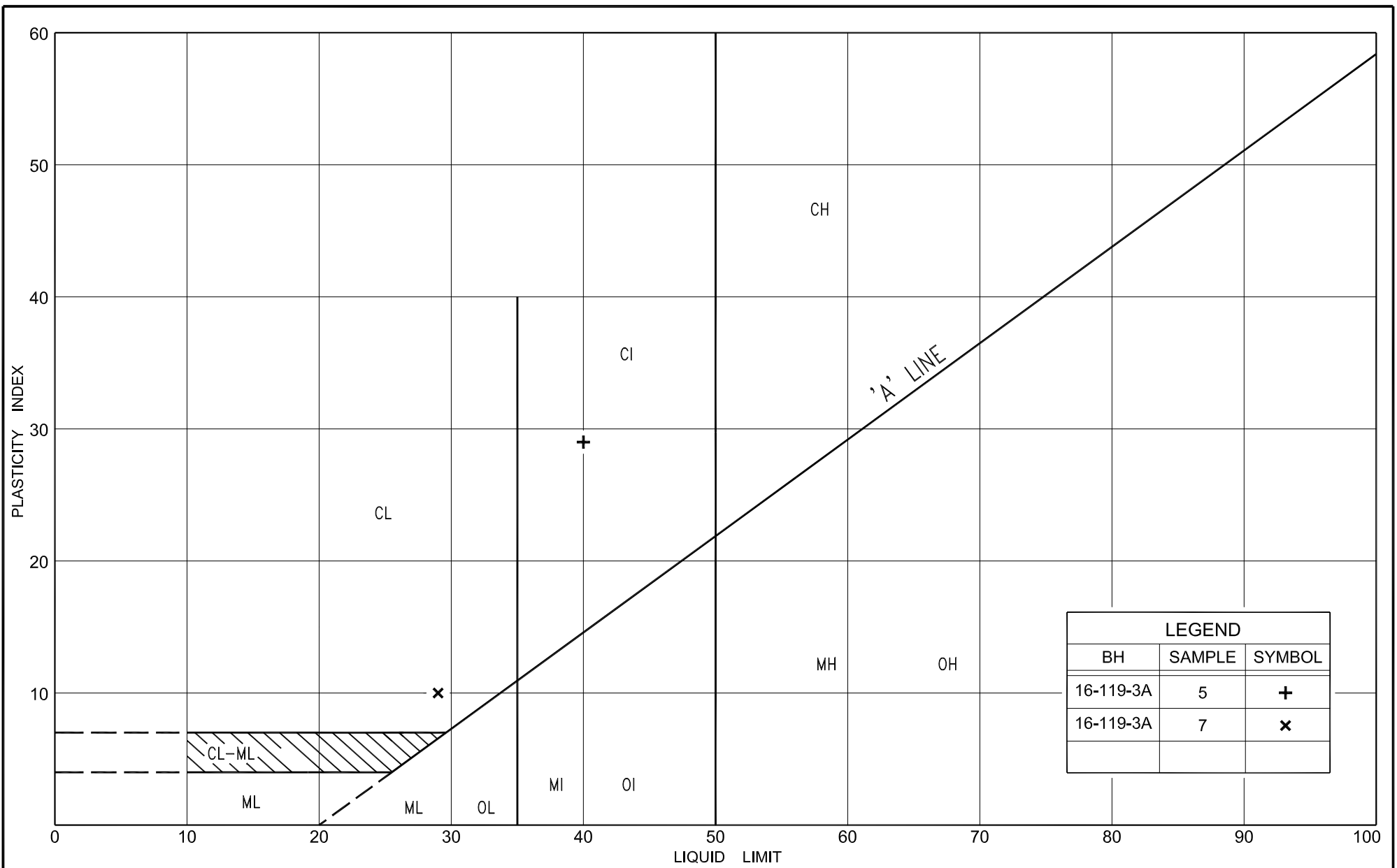


SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED	
				SAND										
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.
	SILT				SAND									
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL					U.S. BUREAU
				SAND										



**GRAIN SIZE DISTRIBUTION**  
CLAYEY SILT, some sand, trace gravel

FIG No.	GS-119-3A-2
HWY	11
G.W.P.	5130-13-00



## PLASTICITY CHART

CLAYEY SILT, some sand, trace gravel

FIG No.	PC-119-3A-1
HWY	11
G.W.P.	5130-13-00