

Terraprobe

Consulting Geotechnical & Environmental Engineering

Construction Materials Inspection & Testing

**PRELIMINARY
FOUNDATION INVESTIGATION REPORT
DECEPTION CREEK BRIDGE REPLACEMENT
HIGHWAY 668
ASSIGNMENT No. 5013-E-0018
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. No. 5267-11-00, SITE 39E-169
GEOCRES NO. 42H-64**

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FOUNDATION INVESTIGATION REPORT

**DECEPTION CREEK BRIDGE REPLACEMENT, SITE 39E-169
HIGHWAY 668
TOWNSHIP OF CLUTE, DISTRICT OF COCHRANE, ONTARIO
ASSIGNMENT No. 5013-E-0018, G.W.P. 5267-11-00**



1.0 INTRODUCTION

Terraprobe Inc. (Terraprobe) has been retained by MMM Group Limited (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of preliminary designs for the rehabilitation of structures identified in MTO's Request for Proposal (RFP) titled *"Preliminary Design, Rehabilitation/Replacement of Twelve Structures on Highway 11, 101, 577, 579, 634 & 668, in New Liskeard Area"*, Contract Number. 5013-E-0018.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's RFP, and in Section 5.7 of MMM's *Technical Proposal* for this assignment. This report presents the factual data on subsurface conditions at the Deception Creek Bridge, Site 39E-169 on Highway 668, Township of Clute, District of Cochrane, Ontario.

2.0 SITE DESCRIPTION

The site is located on Highway 668 (Latitude 49.113°, Longitude – 81.272°), approximately 6 km north of the highway's south junction with Trans-Canada Highway 11 in the Township of Clute, Ontario. Cochrane is located south-east of the site and the village of Huntla is located approximately 1.4 km south of the site. The key plan on the Borehole Locations and Soil Strata Drawing, (Drawing 1) provides an overview of the site location and photographs of the site are also provided.

The existing structure is a seven-span timber bridge that is 33± m long and 9± m wide, supported on timber piles. This bridge carries Highway 668 north bound and south bound traffic over Deception Creek. Deception Creek flows from west to east meandering within a well-defined flood plain.

The terrain at the bridge site and surrounding area is generally gently rolling. Vegetation within the flood plain area consists primarily of grass and shrubs. Beyond the flood plain, the area is vegetated with mature stands of deciduous and coniferous trees.

3.0 INVESTIGATION PROCEDURES

The field work for this project was carried out between September 14 and September 17, 2015 and consisted of drilling and sampling three boreholes to depths ranging from 18.9 m to 21.1 m below ground surface. The approximate borehole locations are shown on Drawing 1.

Based on borehole locations plans provided by Terraprobe, MTO Geomatics staked out the boreholes in the field. Terraprobe's staff surveyed the boreholes for coordinates and geodetic elevations by referring to Control Point HCP 101. This data is summarized in the following table.

Borehole No.	Local Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH1	5 441 652.1	284 923.2	265.4	21.1
BH2	5 441 691.7	284 919.6	265.8	20.0
BH3	5 441 584.6	284 922.9	265.7	18.9

The boreholes were drilled with a truck-mounted CME 55 drill rig supplied and operated by a specialist drilling contractor after the borehole locations were cleared for underground utilities. Samples of the overburden soils were generally obtained at intervals of 0.75 m and 1.5 m depth using a 50 mm outer

diameter (O.D.) split-spoon sampler in conjunction with the Standard Penetration Testing (SPT) procedures as specified in ASTM Method D 1586¹. Relatively undisturbed samples of the clay soils were also collected with thin-walled Shelby Tube samplers. In the clay deposits an MTO 'N' vane was used to perform in-situ field vane tests, in order to determine the undrained shear strength of the soil. Terraprobe's staff observed the drilling, sampling and in situ testing operations and logged the boreholes on a full-time basis.

Ground water conditions in the open boreholes were observed during the drilling operations and standpipe piezometers were installed in Boreholes 2 and 3 to permit longer term ground water level monitoring. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The recovered soil and rock samples were subjected to Visual Identification (VI) and select soil samples were also subjected to a laboratory testing programme consisting of natural moisture content, grain size distribution analyses, Atterberg limits determinations and one-dimensional consolidation testing in accordance with MTO and/or ASTM Standards as appropriate. The bedrock core samples were subjected to point load index tests.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The study area is located north of the Great Lakes-Hudson Bay drainage divide. All surface drainage flows northwards into James Bay. The major river system located close to the site is the Abitibi river. Surficial geology of the study area indicates the presence of clays, silts, organic deposits and glaciofluvial ice-contact deposits such as gravels, sands and minor till.

The study area lies within the Abitibi Greenstone Belt of the Superior structural province of the Canadian Shield. The Abitibi Greenstone Belt consists of both volcanic and sedimentary rocks though typically dominated by mafic metavolcanic rocks. Several felsic and alkaline intrusions occur throughout the area.

4.2 Subsurface Conditions

Reference is made to the Record of Borehole Sheets in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the "Borehole Locations and Soil Strata" drawings. An overall description of the stratigraphy is given in the following paragraphs.

The stratigraphic boundaries shown on the Record of Boreholes and on the interpreted stratigraphic section are inferred from non-continuous soil sampling and therefore represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

In summary, the highway pavement is generally underlain by fill material consisting of loose sand and firm to stiff silty clay. The fill soils are further underlain by deposits of peat, firm to stiff silty clay, loose silt, firm clayey silt, very loose to very dense sand and silt, inferred very dense sand and loose to dense silty sand

¹ ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

till. These overburden soils are further underlain by greywacke bedrock. A more detailed description of the subsurface conditions is provided in the following sections.

4.2.1 Flexible Pavement

The boreholes were drilled through a flexible pavement consisting of 15 mm to 65 mm thick asphaltic concrete, underlain by granular fill varying in composition from sand and gravel to gravelly sand. The locations, thicknesses and base elevations of the granular base fill are summarized in the following table.

Borehole No.	Fill Thickness (mm)	Fill Base Elevation (m)
BH1	615	264.7
BH2	605	265.1
BH3	590	265.1

Standard Penetration tests carried out in the sand and gravel and gravelly sand fill measured SPT N-values of 23 to 56 blows for 0.3 m of penetration indicating a compact to very dense relative density. The natural water content of samples of the sand and gravel and gravelly sand fill range from 3% to 5% by weight.

The grain size distribution curve of a sample of the gravelly sand fill is presented in Figure B1 in Appendix B. The results show a grain size distribution consisting of 24% gravel, 58% sand, 12% silt and 6% clay size particles.

4.2.2 Fill – Sand

A 0.7 m thick layer of sand fill was encountered in Borehole 1 extending to a depth of 1.4 m (elevation 264.0 m). A Standard Penetration test carried out in this sand fill measured a SPT N-value of 10 blows for 0.3 m of penetration suggesting a loose relative density.

The grain size distribution curve of a sample of the sand fill is illustrated in Figure B2 in Appendix B. The results show a grain size distribution consisting of 13% gravel, 63% sand, 14% silt and, 10% clay size particles.

4.2.3 Fill – Silty Clay

Silty clay fill material was encountered in the boreholes. The locations, thicknesses, depths and base elevations of the silty clay fill are summarized in the following table.

Borehole No.	Fill Thickness (m)	Fill Depth (m)	Fill Base Elevation (m)
BH1	2.5	3.9	261.5
BH2	2.2	2.9	262.9
BH3	1.3	1.9	263.8

Standard Penetration tests performed in the silty clay fill measured SPT N-values ranging from 6 to 12 blows for 0.3 m of penetration indicating a firm to stiff consistency. The moisture content (by weight) of samples of the silty clay fill varies between 17% and 25% by weight.

The grain size distribution plot of a sample of the silty clay fill is depicted in Figure B3 in Appendix B. The results show a grain size distribution consisting of 1% gravel, 15% sand, 54% silt and 30% clay size particles.

An Atterberg limits test was also carried out on a sample of the silty clay fill and the results are presented in Figure B4 in Appendix B. These values indicate that the fill is a cohesive soil (CL) with low plasticity. The Atterberg limits test results are summarized below:

Liquid Limit:	25 %
Plastic Limit:	16 %
Plasticity Index:	9 %
Natural Moisture Content:	17 %

4.2.4 Peat

Amorphous peat was encountered below the silty clay fill in Boreholes 1 and 3. The locations, thicknesses, depths and base elevations of the peat deposit are summarized in the following table.

Borehole No.	Silty Clay to Clay Thickness (m)	Silty Clay to Clay Depth (m)	Silty Clay to Clay Base Elevation (m)
BH1	1.3	5.2	260.2
BH3	0.2	2.1	263.6

The N-values of Standard Penetration tests carried out in the peat deposit measured 3 blows per 0.3 m of penetration and the moisture content (by weight) of two samples of the peat are 49% and 44%.

4.2.5 Silty Clay

The site is underlain by a silty clay deposit. The locations, thicknesses, depths and base elevations of the silty clay deposit are summarized in the following table.

Borehole No.	Silty Clay Thickness (m)	Silty Clay Depth (m)	Silty Clay Base Elevation (m)
BH1	0.7	5.9	259.5
BH2	1.5	4.4	261.4
BH3	7.0	9.1	256.6

The N-values of Standard Penetration tests carried out in the silty clay deposit range from 0 blows (weight of rods) to 8 blows per 0.3 m of penetration and, field vane tests measured in-situ undrained shear strengths ranging from 32 kPa to 64 kPa. A plot of undrained shear strength versus elevation is shown in Figure B5 in Appendix B. Based on the undrained shear strength values, the consistency of the silty clay is described as firm to stiff. The sensitivity of the silty clay ranges from 4.3 to 8.7, indicating a sensitive to extra-sensitive soil class (Canadian Foundation Engineering Manual [CFEM], 2006).

Samples of the silty clay were subjected to grain size distribution tests and the grain size distribution curves are illustrated in Figure B6 in Appendix B. The test results show a grain size distribution consisting of 0% to 1% gravel, 0% to 9% sand, 26% to 53% silt and, 40% to 73% clay size particles.

Atterberg limits tests were carried out on samples of the silty clay and the results are plotted on the plasticity chart, Figure B7 in Appendix B. The results indicate a cohesive deposit of low to medium plasticity (CL to CI).

The Atterberg limits test results are summarized below.

Liquid Limit:	30% to 46 %
Plastic Limit:	15% to 20 %
Plasticity Index:	13% to 26 %
Natural Moisture Content:	22% to 46 %

The Atterberg Limits test results of the silty clay deposit are also plotted against elevation in Figure B8. The moisture content of samples of the silty clay varies between 22% and 46% and the unit weight of a tested sample is 19.3 kN/m³.

A one-dimensional consolidation test was performed on a sample of the silty clay and the results are presented in Figures B9 to B11 in Appendix B. The results of the one-dimensional consolidation test are summarized below.

Borehole/Sample No.	Sample Depth/Elevation (m)	σ'_{vo} (kPa)	σ'_p (kPa)	C_c	C_r	e_o
BH3, TW9	6.4 / 259.3	72	130	0.26	0.04	0.83

Where: σ'_{vo} = effective overburden pressure;
 σ'_p = Preconsolidation pressure;
 C_c = Compression index;
 C_r = Recompression index; and
 e_o = Initial void ratio.

The preconsolidation pressure derived from the consolidation test data is higher than the effective overburden pressure suggesting that the silty clay deposit is overconsolidated.

4.2.6 Silt

Boreholes 1 and 2 encountered silt layers. The locations, thicknesses, depths and base elevations of the silt layers are summarized in the following table.

Borehole No.	Silt Thickness (m)	Silt Depth (m)	Silt Base Elevation (m)
BH1	4.5	10.4	255.0
BH2	1.5	5.9	259.9
	3.4	10.1	255.7

Standard Penetration tests performed in the silt deposits measured SPT N-values that range from 6 blows to 9 blows for 0.3 m of penetration indicating a loose relative density. The moisture content (by weight) of samples of the silt varies between 24% and 35%.

The grain size distribution plots of samples of the silt are depicted in Figure B12 in Appendix B. The results show a grain size distribution consisting of 0% gravel, 0% to 3% sand, 81% to 93% silt and, 7% to 18% clay size particles.

4.2.7 Clayey Silt

In Borehole 2 the silt deposit is divided by a 0.8 m thick layer of clayey silt, encountered at a depth of 6.7 m (elevation 259.1 m) below ground surface. A Standard Penetration test performed in the clayey silt

deposit measured a SPT N-value of 5 blows for 0.3 m of penetration indicating a firm consistency. The moisture content (by weight) of a sample of the clayey silt is 28%.

A grain size distribution test was carried out on a sample of the clayey silt and the results are shown on the grain size distribution curve in Figure B13 in Appendix B. The test results show a grain size distribution of 0% gravel, 1% sand, 76% silt and, 23% clay size particles.

An Atterberg limits test was also carried out on a sample of the clayey silt and the results are plotted on the plasticity chart, Figure B14 in Appendix B. The results indicate a cohesive deposit with low plasticity (CL-ML). The Atterberg limits test results are summarized below.

Liquid Limit:	23 %
Plastic Limit:	18 %
Plasticity Index:	5 %
Natural Moisture Content:	28 %

4.2.8 Sand and Silt

A sand and silt deposit was encountered at this site. The locations, thicknesses, depths and base elevations of the sand and silt deposit are summarized in the following table.

Borehole No.	Sand and Silt Thickness (m)	Sand and Silt Depth (m)	Sand and Silt Base Elevation (m)
BH1	5.3	15.7	249.7
BH2	1.6	11.7	254.1
BH3	2.6	11.7	254.0

The N-values of Standard Penetration tests carried out in the sand and silt deposit range from 0 blows (weight of rods) to 22 blows and more than 100 blows per 0.3 m of penetration. Based on these N-values the sand and silt deposit is described as very loose to compact with very dense zones. The moisture content (by weight) of samples of the sand and silt varies between 12% and 16%.

The grain size distribution plots of two samples of the sand and silt are depicted in Figure B15 in Appendix B. The results show a grain size distribution consisting of 4% and 5% gravel, 47% and 59% sand, 33% and 43% silt and, 4% and 5% clay size particles.

In Borehole 1 the matrix of the sand and silt deposit contains cobbles and boulders below a depth of 12.5 m± (elevation 252.9 m±) and, NQ-size diamond coring techniques were implemented to extend the boring through the cobbles and boulders. The recovered cobble and boulder core samples are illustrated in Figure B16 in Appendix B.

4.2.9 Sand

Borehole 1 encountered a 1.3 m thick layer of sand at a depth of 17.0 m (elevation 248.4 m) below ground surface. Frequent cobbles and boulders were encountered in the sand layer and NQ size coring techniques were implemented to extend the boring through the cobbles and boulders. The recovered cobble and boulder core samples are illustrated in Figure B16 in Appendix B. Standard Penetration Tests were not performed in the sand deposit because of the frequency of cobble and boulder inclusions and the sand deposit is inferred to have a very dense relative density.

The moisture content (by weight) of a sample of the sand is 18%. The grain size distribution plot of a sample of the sand is depicted in Figure B17 in Appendix B. The results show a grain size distribution consisting of 13% gravel, 75% sand and 12% silt and clay size particles.

4.2.10 Silty Sand Till

Silty sand till deposits were encountered in Boreholes 2 and 3. The locations, thicknesses, depths and base elevations of the silty sand till are summarized in the following table.

Borehole No.	Sand and Silt Thickness (m)	Sand and Silt Depth (m)	Sand and Silt Base Elevation (m)
BH2	2.9	14.6	251.2
BH3	4.5	16.2	249.5

The N-values of Standard Penetration tests carried out in the silty sand till deposit range from 8 blows to 32 blows per 0.3 m of penetration indicating a loose to dense relative density. The moisture content (by weight) of samples of the silty sand till varies from 10% to 16%.

The grain size distribution plot of a sample of the silty sand till is depicted in Figure B18 in Appendix B. The results show a grain size distribution consisting of 29% gravel, 37% sand, 28% silt and, 6% clay size particles. Till soils can also be expected to contain random cobbles and boulders.

4.2.11 Bedrock

The overburden soils are underlain by greywacke bedrock. Summarized below are the depths to bedrock and the bedrock surface elevations.

Borehole No.	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
BH1	17.0	248.4
BH2	14.6	251.2
BH3	16.2	249.5

The greywacke bedrock is described as unweathered to slightly weathered, thickly bedded and its colour is light grey to grey. Photographs of the bedrock core samples are provided in Figures B19 to B22 in Appendix B. Summarized below are the Rock Quality Designation, Rock Mass Quality, Total Core Recovery and Solid Core Recovery.

Borehole No.	Rock Quality Designation (RQD)	Rock Mass Quality ²	Total Core Recovery (TCR)	Solid Core Recovery (SCR)
BH1	73% to 89%	Fair to Good	97% to 100%	95% to 100%
BH2	48% to 87%	Poor to Good	81% to 100%	77% to 93%
BH3	83% and 89%	Good	99% and 100%	99% and 100%

Point Load Index Tests were carried out on the bedrock core samples and the interpreted unconfined compressive strength (UCS) results range from 88 MPa to 303 MPa. The laboratory test data is provided in Figures B23 to B25. These UCS results classify the tested portions of the bedrock as strong to

² Deere et al., 1967.

extremely strong (R4, R5 and R6 grade, 50 MPa to more than 250 MPa); according to the rock strength classification in Table 3.5 of the *Canadian Foundation Engineering Manual 2006*.

4.3 Ground Water Levels

The ground water conditions were observed in the boreholes during and upon completion of drilling and standpipe piezometers were installed in Boreholes 2 and 3. The ground water levels measured in the piezometer are summarized in the following table.

Borehole No.	Date	Water Levels	
		Depth (m)	Elevation (m)
BH2	October 1, 2015	1.7	264.1
	October 7, 2015	1.8	264.0
BH3	September 28, 2015	1.2	264.5
	October 9, 2015	1.3	264.4

The ground water level at this site is estimated to vary from Elevation 264.0 m to 264.5 m, based on the ground surface topography, soil moisture conditions, measured ground water levels and creek water levels. The ground water level is expected to fluctuate seasonally, will rise during wet periods of the year, and will also be controlled by the free water level in the creek.




5.0 MISCELLANEOUS

The investigation was carried out using drilling equipment supplied and operated by Landcore Drilling of Chelmsford, Ontario. The field operations were supervised by Ms. Sepideh D-Monfared, MEng. and the routine laboratory and one-dimensional consolidation testing was carried out at Terraprobe's Brampton laboratory.

This report was prepared by Ms. Sepideh D-Monfared, MEng. and reviewed by Mr. Rehman Abdul, P.Eng., a Senior Geotechnical Engineer and Principal with Terraprobe. Mr. Michael Tanos, P.Eng., Terraprobe's Designated MTO Contact conducted an independent quality control review.

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REFERENCES

Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Deere et al., 1967. *Design of Surface and Near Surface Construction in Rock*. Society of Mining Engineers of AIME, New York.



LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

Changes In Site And Scope

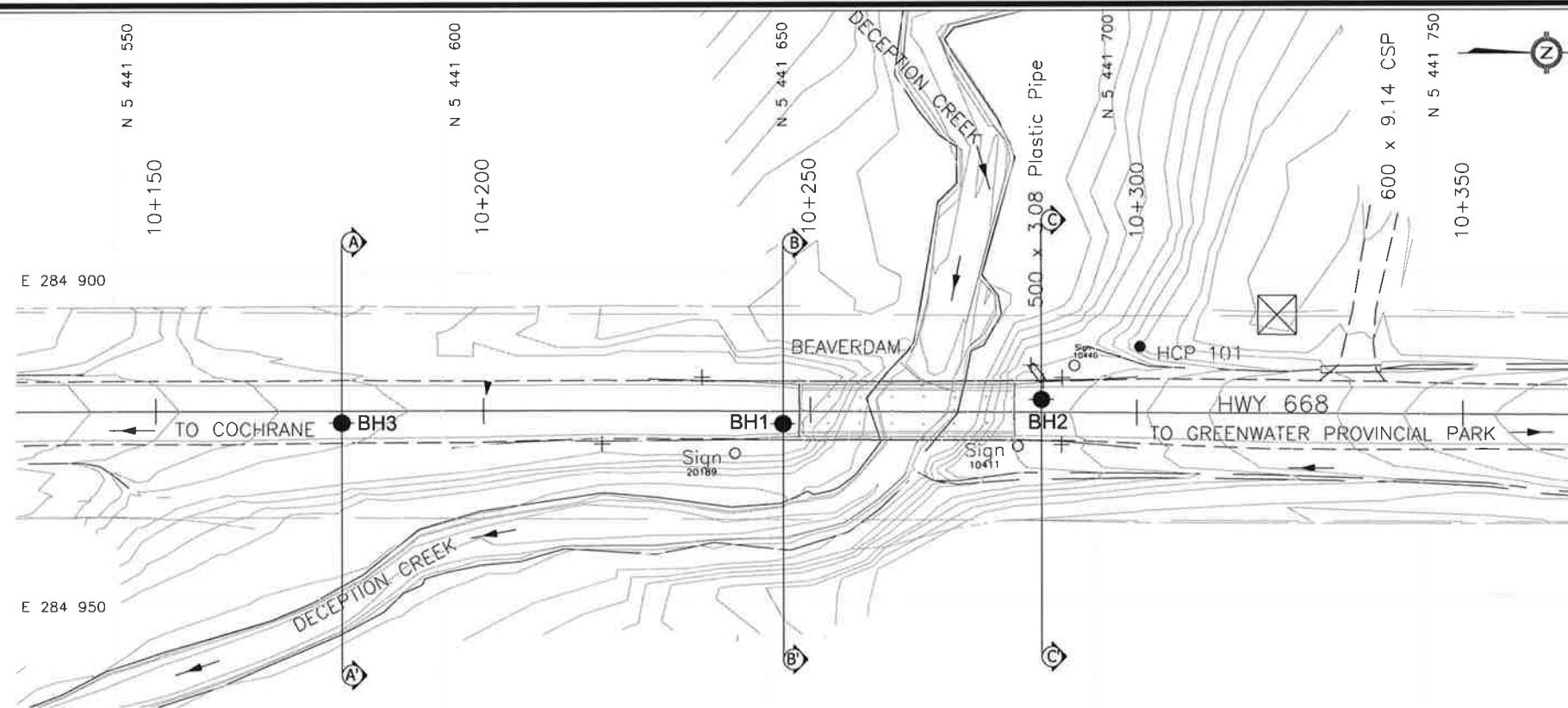
It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of the Ministry of Transportation, its retained design consultants and MMM Group Limited. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. The Ministry of Transportation, its retained design consultants and MMM Group Limited, are authorized users.

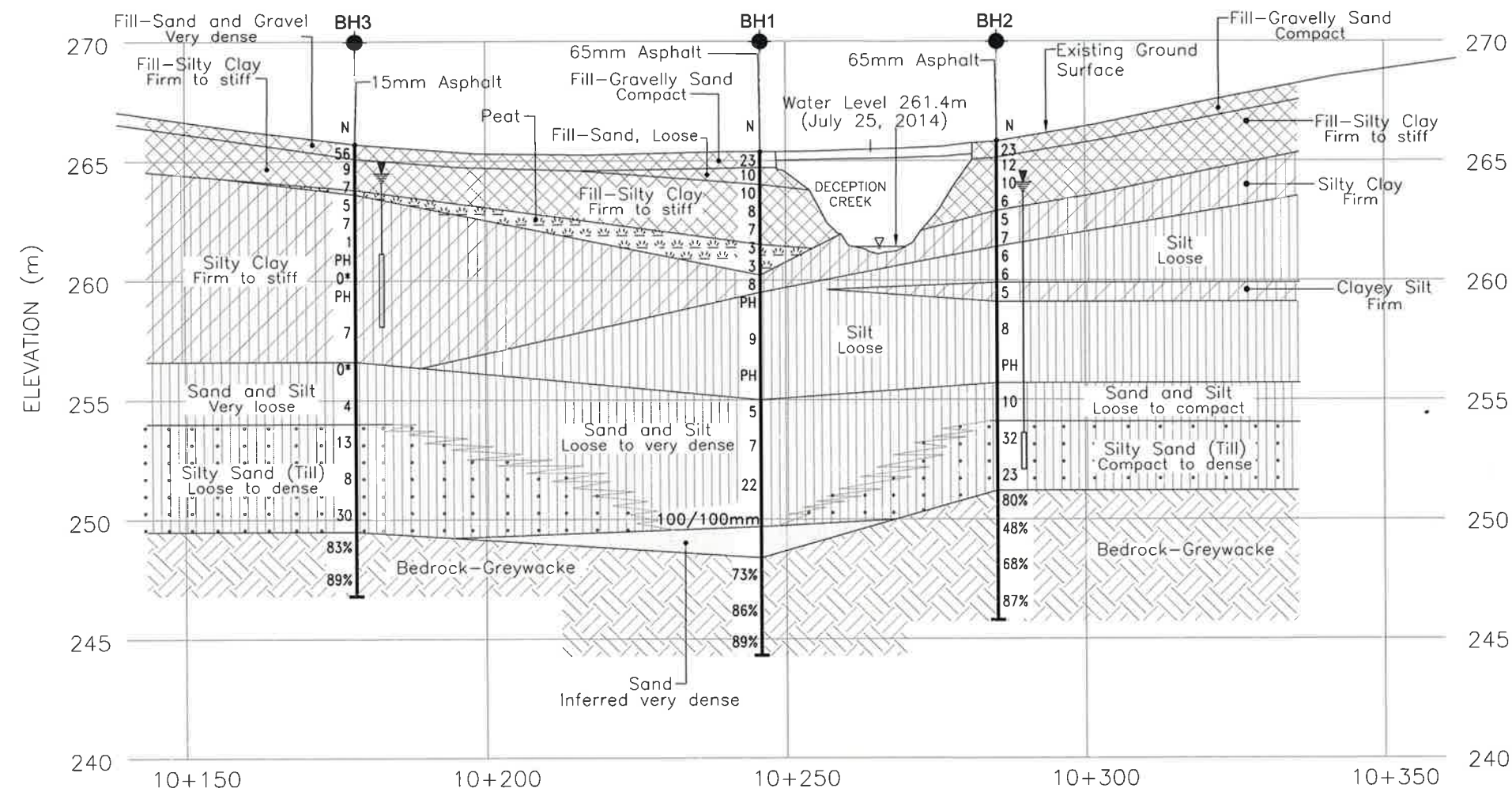
DRAWINGS & SITE PHOTOGRAPHS





PLAN

SCALE 10 0 10 20m



Q PROFILE OF HWY 668

HORIZ. SCALE 10 5 0 5 10 15 20m
VERT. SCALE 2.5 0 2.5 5m

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

GWP No.: 5267-11-00

HWY 668
DECEPTION CREEK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1 OF 2



KEY PLAN

LEGEND			
	Bore Hole		
	Dynamic Cone Penetration Test		
	Bore Hole And Cone		
	Blows/0.3m (Std Pen Test, 475 J/blow)		
	Blows/0.3m (60' Cone, 475 J/blow)		
	WL at Time of Investigation		
	WL in Piezometer		
	Piezometer		
	Rock Quality Designation		
	Auger Refusal		

No	ELEV.	LOCAL COORDINATES	
		NORTHING	EASTING
1	265.4	5 441 652.1	284 923.2
2	265.8	5 441 691.7	284 919.6
3	265.7	5 441 584.6	284 922.9

NOTE

This drawing is for subsurface information only. The proposed structure details/works if shown are for illustration purposes only and may not be consistent with final design configuration as shown elsewhere in the contract documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents are specifically excluded in accordance with Section GC 2.01 of GPS General Conditions.

REFERENCE

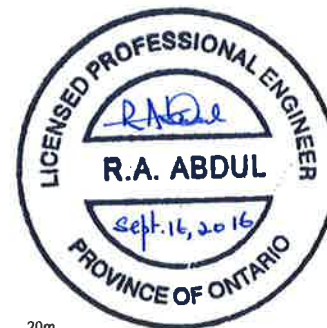
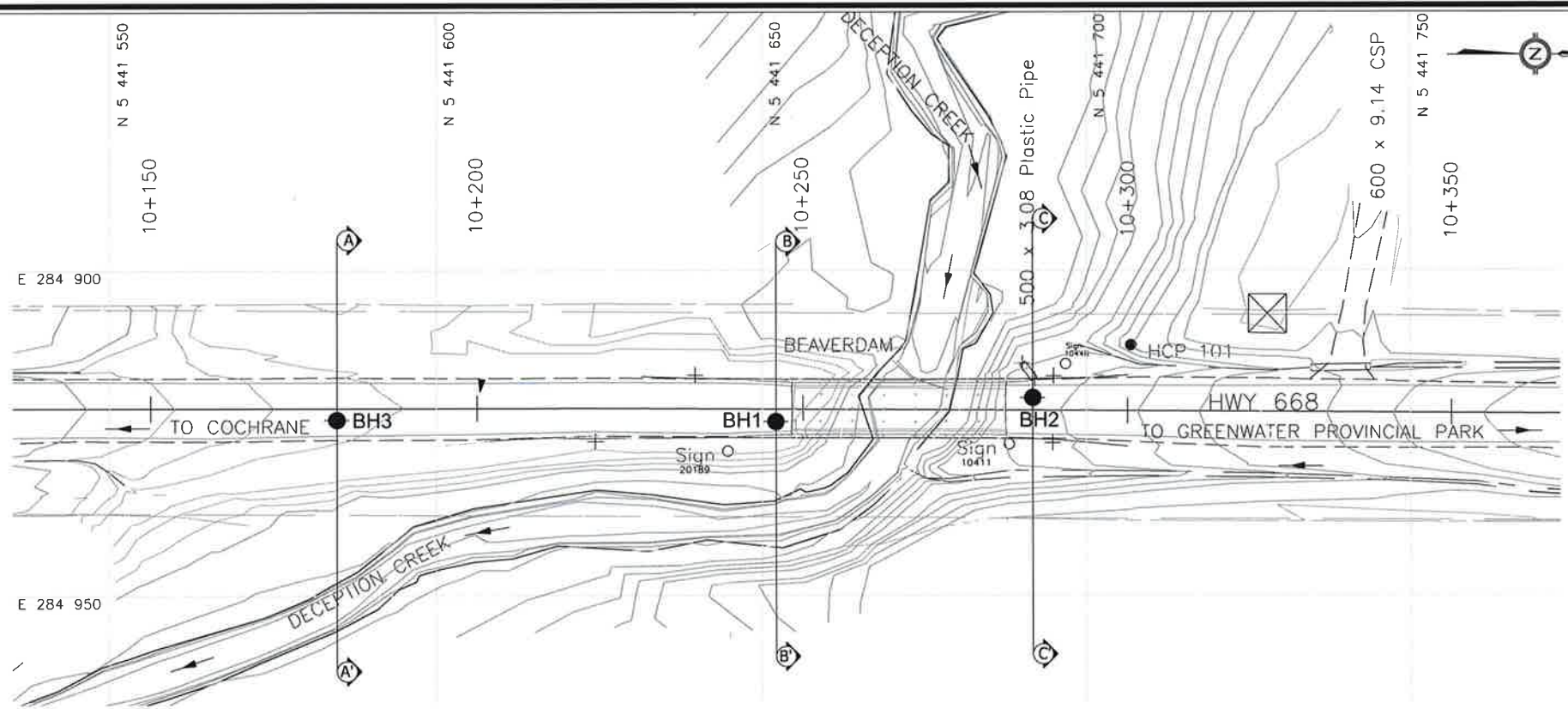
Drawings provided in digital format by MMM Group Ltd. by CD (Assignment 5013-E-0018 Preliminary Design for Rehab/Replacement of 12 Structures on Highways in New Liskeard Area) drawing files B5280668001, DTM5280668001, received September 11, 2014

REVISIONS	DATE	BY	DESCRIPTION

HWY: 668	PROJECT No.: 1-15-0509	Geocres No. 42H-64
SUBM'D.SD	CHKD. RA	DATE: Sept. 2016
DRAWN: KC	CHKD. RA	APPD: MT

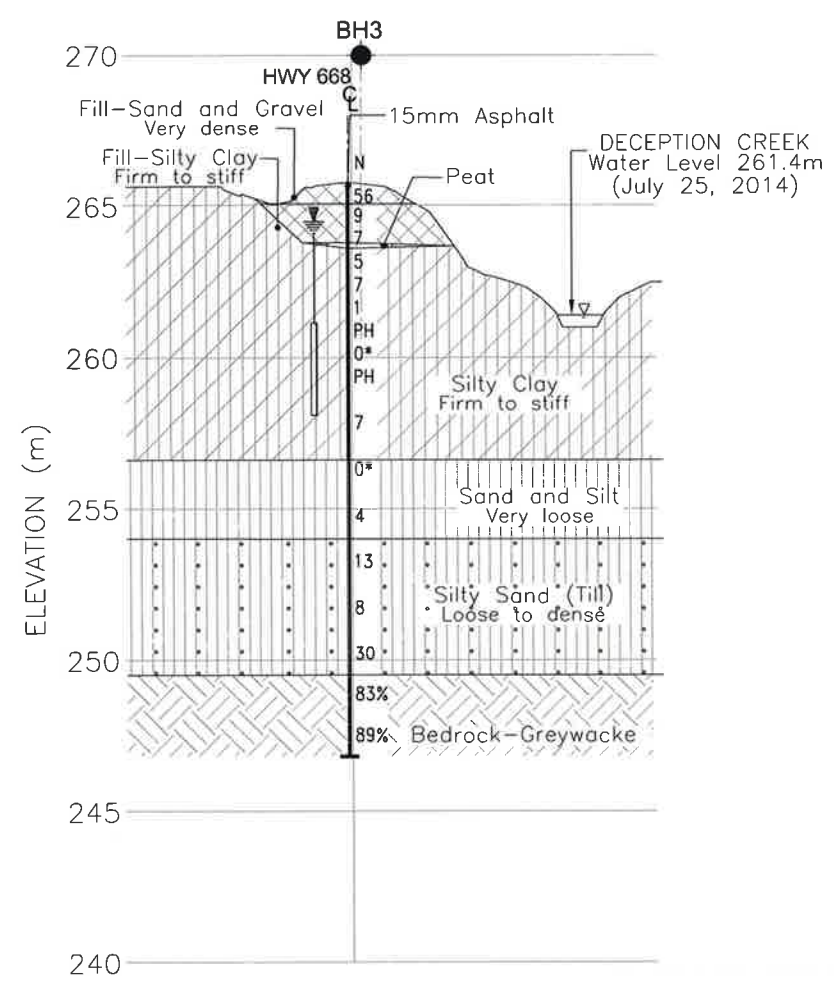
SITE: 39E-169	DWG: 1
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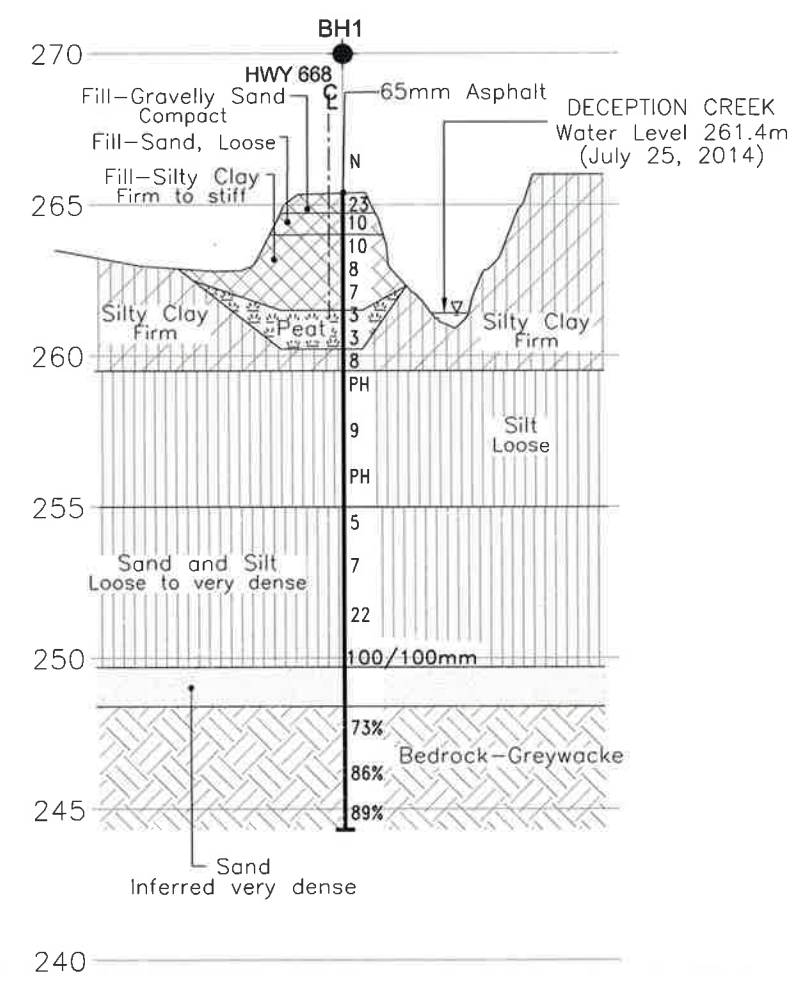


PLAN

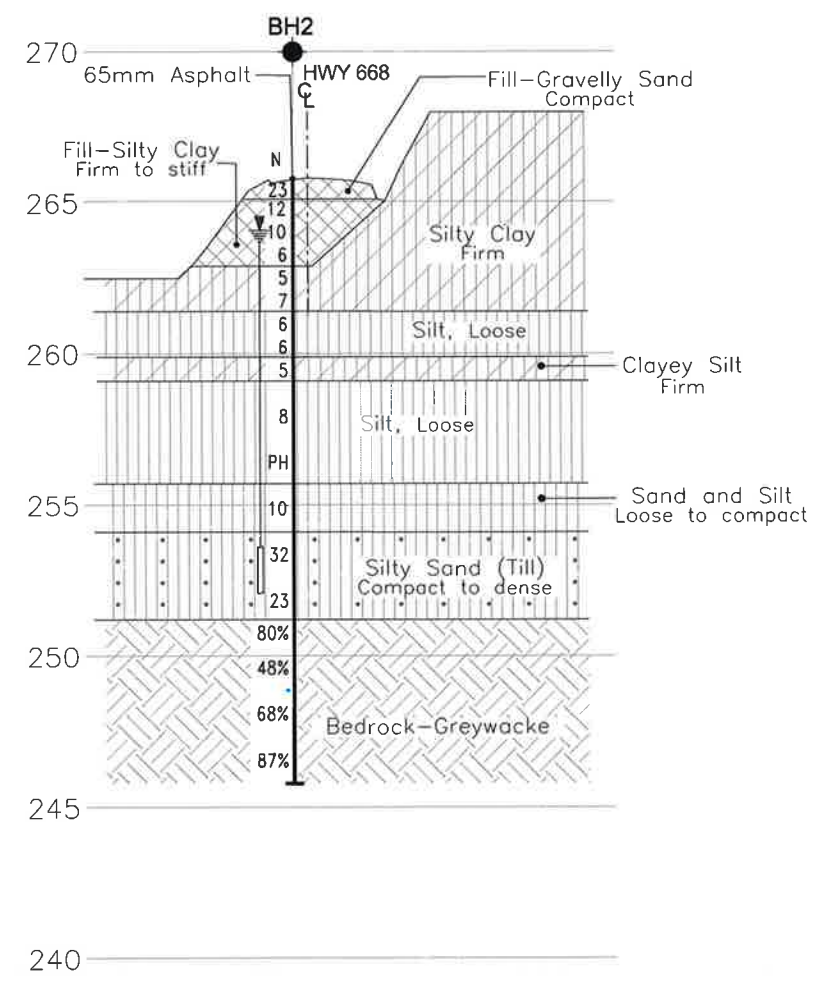
SCALE 10 0 10 20m



SECTION A-A'



SECTION B-B'



SECTION C-C'

HORIZ. SCALE 10 5 0 5 10 15 20m
VERT. SCALE 2.5 0 2.5 5m

GWP No.: 5267-11-00

HWY 668
DECEPTION CREEK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
11 Indell Lane - Brampton Ontario L6T 3Y3 (905) 796-2650

REGISTERED PROFESSIONAL ENGINEER
M. Tanos
M. TANOS
16.09.2016
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
R.A. Abdul
R.A. ABDUL
Sept. 16, 2016
PROVINCE OF ONTARIO

KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60" Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer
- Piezometer
- 90% Rock Quality Designation
- Auger Refusal

No	ELEV.	LOCAL COORDINATES	
		NORTHING	EASTING
1	265.4	5 441 652.1	284 923.2
2	265.8	5 441 691.7	284 919.6
3	265.7	5 441 584.6	284 922.9

NOTE

This drawing is for subsurface information only. The proposed structure details/works if shown are for illustration purposes only and may not be consistent with final design configuration as shown elsewhere in the contract documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents are specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Drawings provided in digital format by MMM Group Ltd. by CD (Assignment: 5013-E-0018 Preliminary Design for Rehab/Replacement of 12 Structures on Highways in New Liskeard Area) drawing files B5280668001, DTMS280668001, received September 11, 2014

REVISIONS	DATE	BY	DESCRIPTION
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HWY.	668	PROJECT No.	1-15-0509	Geocres No.	42H-64
SUBM'D. SD	CHKD. RA	DATE:	Sept. 2016	SITE:	39E-169
DRAWN: KC	CHKD. RA	APPD: MT		DWG:	2

DECEPTION CREEK SITE PHOTOGRAPHS



Photo 1: Hwy 668 , Looking South



Photo 2: Looking South at Deception Creek Bridge

Project No. : 1-15-0509

Date : September, 2016



Prepared by : SD

Checked by : RA

APPENDIX A

Record of Borehole Sheets



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{u} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J 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.

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 (RQD), FOR MODIFIED RECOVERY IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_{α}	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	- °	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	- °	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_r	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL






ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1.0%	VOID RATIO	e_{\min}	1.0%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1.0%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1.0%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_S	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(w_L - w)/I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1.0%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 of 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: E:284923.2 N:5441652.1 ORIGINATED BY SD
 DIST HWY 668 BOREHOLE TYPE SOLID STEM AUGERS / NW CASING AND WASH BORING / NQ CORING COMPILED BY SD
 DATUM GEODETIC DATE 2015-9-15 - 2015-9-16 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)					WATER CONTENT (%)				
								20	40	60	80	100	W _P	W	W _L		
265.4	GROUND SURFACE																
264.7	65mm ASPHALTIC CONCRETE		1	SS	23		265							○		13 63 14 10	
0.7	615mm FILL, gravelly sand, some silt, trace clay, compact, brown, moist		2	SS	10		264										
264.0	FILL, sand, some gravel, some silt, trace clay, loose, brown, moist						263								○		
1.4	FILL, silty clay, trace gravel, some sand, firm to stiff, brown to 2.9m, grey below, moist		3	SS	10		262										
			4	SS	8												
		5	SS	7													
261.5	PEAT, amorphous and wood pieces, black		6	SS	3		261										
3.9			7	SS	3		260										
260.2	SILTY CLAY, frequent silt seams and partings, firm, grey, moist		8	SS	8		259										
5.2							258										
259.5	SILT, trace to some clay, loose, grey, wet			9	TW		PH	257									
5.9								256									
				10	SS		9	255									
							254										
							253										
			11	TW	PH	252											
255.0	SAND AND SILT, trace to some gravel, trace clay, with cobbles and boulders, loose, grey, wet		12	SS	5	251											
10.4																	
				13	SS	7											
				14	RC												
			15	SS	22												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

file: 1-15-0509-01 deception creek bh logs.gpj

RECORD OF BOREHOLE No 1

2 of 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: E:284923.2 N:5441652.1 ORIGINATED BY SD
 DIST HWY 668 BOREHOLE TYPE SOLID STEM AUGERS / NW CASING AND WASH BORING / NQ CORING COMPILED BY SD
 DATUM GEODETIC DATE 2015-9-15 - 2015-9-16 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
								20 40 60 80 100										10 20 30		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	(continued)																			
249.7	SAND AND SILT, trace to some gravel, trace clay, with cobbles and boulders, very dense, grey, wet		16	SS	100/100mm		250													
15.7	SAND, trace to some gravel, frequent cobbles and boulders, inferred very dense, black, wet		17	RC			249													
248.4			18	WS																
17.0	BEDROCK - GREYWACKE containing quartz veins, slightly weathered, thickly bedded, light grey to grey, strong to extremely strong		1	RUN			248									13 75 (12)				
																Run #1 TCR: 97% SCR: 95% RQD: 73% UCS*= 196 - 303 (MPa)				
			2	RUN			247									Run #2 TCR: 100% SCR: 100% RQD: 86% UCS*= 88 - 253 (MPa)				
			3	RUN			246									Run #3 TCR: 100% SCR: 96% RQD: 89% UCS*= 141 - 230 (MPa)				
244.3							245													
21.1																				

END OF BOREHOLE

Borehole filled with drill water upon completion of drilling.

Soil heaved into casings after completing RC17.

Borehole grouted and sealed with bentonite slurry after drilling was completed.

Atterberg Limits test attempted on TW9, SS10 and TW11. Samples are non-plastic.

*Uniaxial Compressive Strength determined from Point Load Strength Index values.

RECORD OF BOREHOLE No 2

1 of 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: E:284919.6 N:5441691.7 ORIGINATED BY SD
 DIST HWY 668 BOREHOLE TYPE SOLID STEM AUGERS / NW CASING AND WASH BORING / NQ CORING COMPILED BY SD
 DATUM GEODETIC DATE 2015-9-14 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100										
								SHEAR STRENGTH (kPa)										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE										
								PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT W _P W W _L		WATER CONTENT (%)								
265.8	GROUND SURFACE																	
265.1	65mm ASPHALTIC CONCRETE		1	SS	23										24 58 12 6			
0.7	605mm FILL, gravelly sand, some silt, trace clay, compact, brown, moist		2	SS	12													
	FILL, silty clay, trace sand, firm to stiff, brown, moist		3	SS	10													
			4	SS	6													
262.9																		
2.9	SILTY CLAY, trace sand, firm, grey, wet		5	SS	5										0 8 38 54			
			6	SS	7													
261.4																		
4.4	SILT, occasional clay seams and partings, loose, grey, wet		7	SS	6										0 0 86 14			
			8	SS	6													
259.9																		
5.9	CLAYEY SILT, trace sand, firm, grey, wet		9	SS	5										0 1 76 23			
259.1																		
6.7	SILT, trace to some clay, loose, grey, wet																	
			10	SS	8													
			11	TW	PH										0 3 82 15			
255.7																		
10.1	SAND AND SILT, trace to some gravel, loose to compact, grey, wet		12	SS	10													
254.1																		
11.7	SILTY SAND, trace to some gravel, occasional cobbles, compact to dense, grey, wet (GLACIAL TILL)		13	SS	32													
			14	SS	23													
251.2																		
14.6			1	RUN											Run #1 TCP: 100%			

Continued Next Page

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

file: 1-150509-01 deception creek bh logs.gpj

RECORD OF BOREHOLE No 2

2 of 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: E:284919.6 N:5441691.7 ORIGINATED BY SD
 DIST HWY 668 BOREHOLE TYPE SOLID STEM AUGERS / NW CASING AND WASH BORING / NQ CORING COMPILED BY SD
 DATUM GEODETIC DATE 2015-9-14 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
	(continued)		1	RUN			20	40	60	80	100				kN/m ³	GR SA SI CL				
	BEDROCK - GREYWACKE containing quartz veins, unweathered, thickly bedded, light grey to grey, strong to extremely strong		2	RUN												SCR: 82% RQD: 80% UCS*= 97 - 248 (MPa) Run #2 TCR: 81% SCR: 77% RQD: 48% UCS*= 150 - 257 (MPa)				
		3	RUN													Run #3 TCR: 100% SCR: 93% RQD: 68% UCS*= 112 - 225 (MPa)				
		4	RUN													Run #4 TCR: 94% SCR: 92% RQD: 87% UCS*= 90 - 195 (MPa)				
245.8																				

END OF BOREHOLE

Piezometer installation consists of a
50mm diameter PVC pipe with a 1.5m
slotted screen.

Unable to push vane below 7.0m.

Atterberg Limits test attempted on
SS7 and TW11. Samples are non-
plastic

*Uniaxial Compressive Strength
determined from Point Load
Strength Index values.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Oct 1, 2015	1.7	264.1
Oct 7, 2015	1.8	264.0

METRIC

SOIL PROFILE						DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS					ELEVATION SCALE	
			NUMBER	TYPE							SPT 'N' VALUE
265.7	GROUND SURFACE										
	15mm ASPHALTIC CONCRETE	[Pattern]	1	SS	56						
265.1	590mm FILL, sand and gravel, trace silt, very dense, brown, dry	[Pattern]	2	SS	9						
263.8	FILL, silty clay, trace sand, trace gravel, firm to stiff, brown, moist	[Pattern]	3	SS	7						
263.6	PEAT, amorphous, black	[Pattern]	4	SS	5						
263.6	SILTY CLAY, trace sand, trace gravel, firm to stiff, brown to 4.1m, grey below, occasional silt seams and partings, moist to wet	[Pattern]	5	SS	7						
		[Pattern]	6	SS	1						
		[Pattern]	7	TW	PH						
		[Pattern]	8	SS	0*						
		[Pattern]	9	TW	PH						
		[Pattern]	10	SS	7						
256.6	SAND AND SILT, trace gravel, trace clay, very loose, grey, wet	[Pattern]	11	SS	0*						
		[Pattern]	12	SS	4						
254.0	SILTY SAND, trace to some gravel, occasional cobbles, loose to dense, grey, wet (GLACIAL TILL)	[Pattern]	13	SS	13						
		[Pattern]	14	SS	8						

+³, ×³: Numbers refer to Sensitivity **○^{3%}** STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

2 of 2

METRIC

G.W.P. 5267-11-00 LOCATION Coords: E:284922.9 N:5441584.6 ORIGINATED BY SD
 DIST HWY 668 BOREHOLE TYPE HOLLOW STEM AUGERS / NW CASING AND WASH BORING / NQ CORING COMPILED BY SD
 DATUM GEODETIC DATE 2015-9-16 - 2015-9-17 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100							
								SHEAR STRENGTH (kPa)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE							
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L WATER CONTENT (%)							
								20 40 60 80 100 10 20 30							
	(continued)														
249.5 16.2	SILTY SAND, trace to some gravel, occasional cobbles, loose to dense, grey, wet (GLACIAL TILL)		15	SS	30		250								29 37 28 6
	BEDROCK - GREYWACKE containing quartz veins, unweathered, thickly bedded, light grey to grey, strong to extremely strong		1	RUN			249								Run #1 TCR: 99% SCR: 99% RQD: 83% UCS**= 99 - 285 (MPa)
			2	RUN			248								Run #2 TCR: 100% SCR: 100% RQD: 89% UCS**= 90 - 156 (MPa)
						247									
246.8															

END OF BOREHOLE

*Sampler sinking under weight of hammer and/ or rods.

Piezometer installation consists of a 50mm diameter PVC pipe with a 3.0m slotted screen.

Piezometer installed 0.3m east and 1.8m north of this borehole on September 17, 2015.

Consolidation test performed on TW9.

**Uniaxial Compressive Strength determined from Point Load Strength Index values.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Sep 28, 2015	1.2	264.5
Oct 9, 2015	1.3	264.4

APPENDIX B

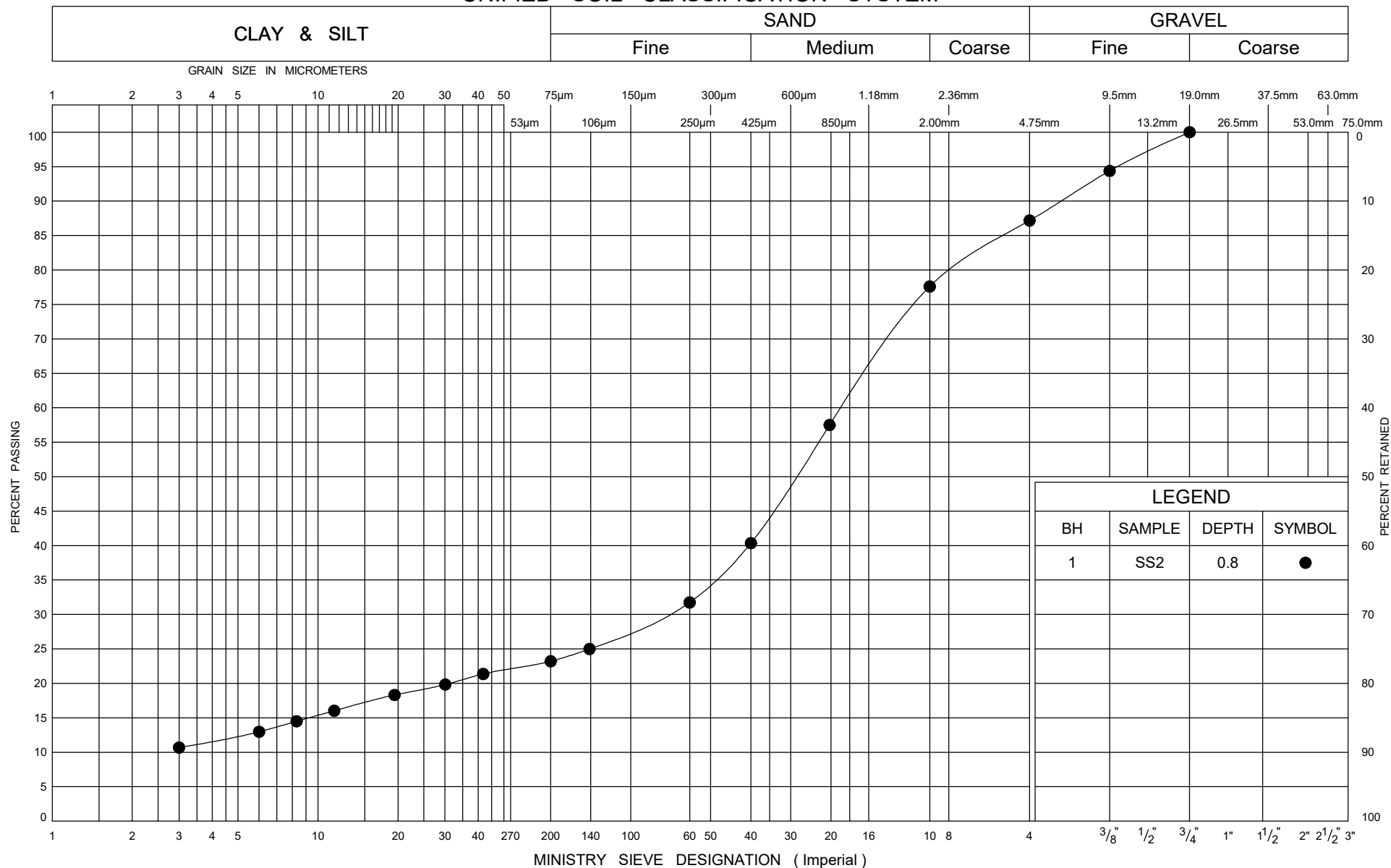
Field & Laboratory Test Results

&

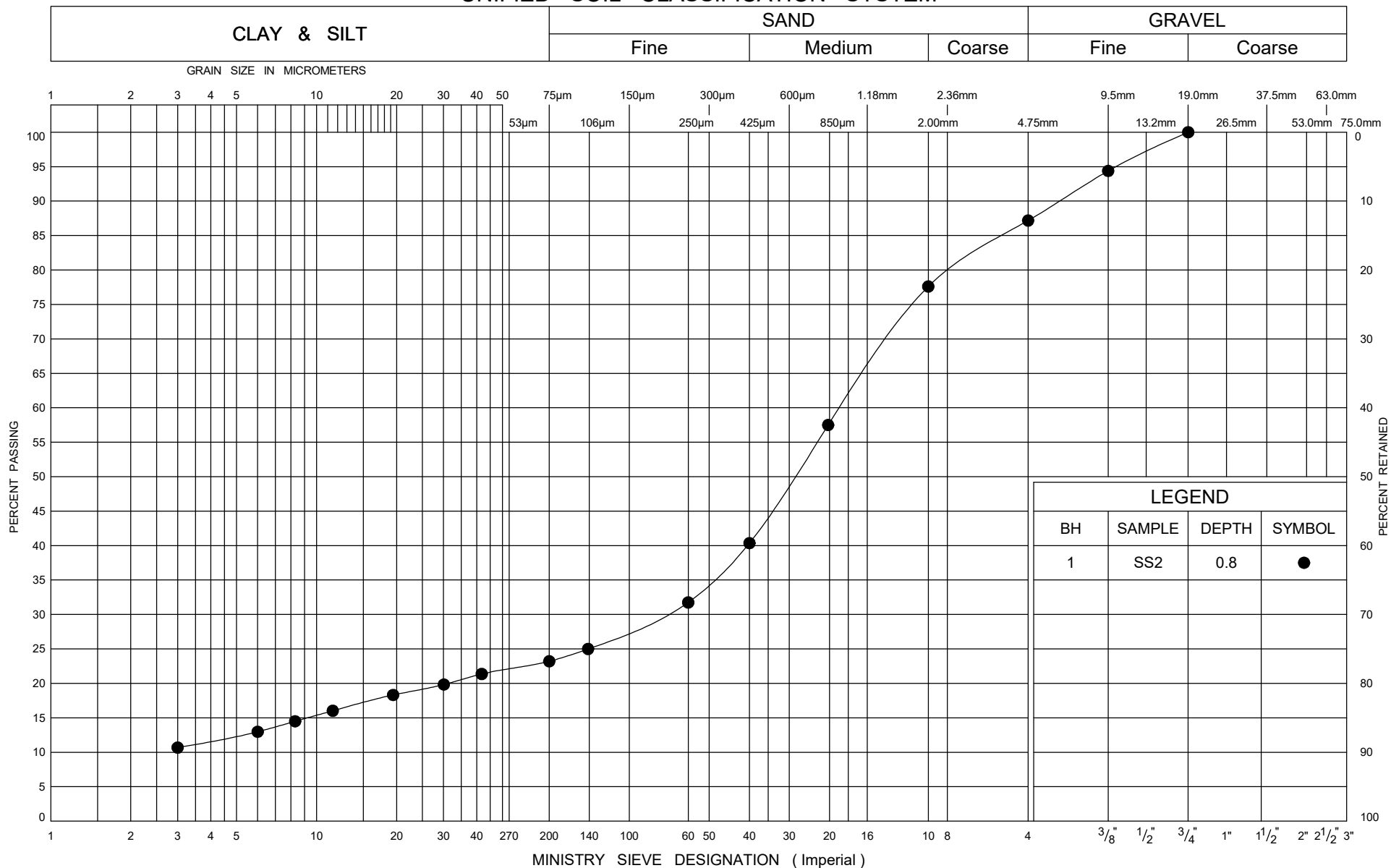
Photographs



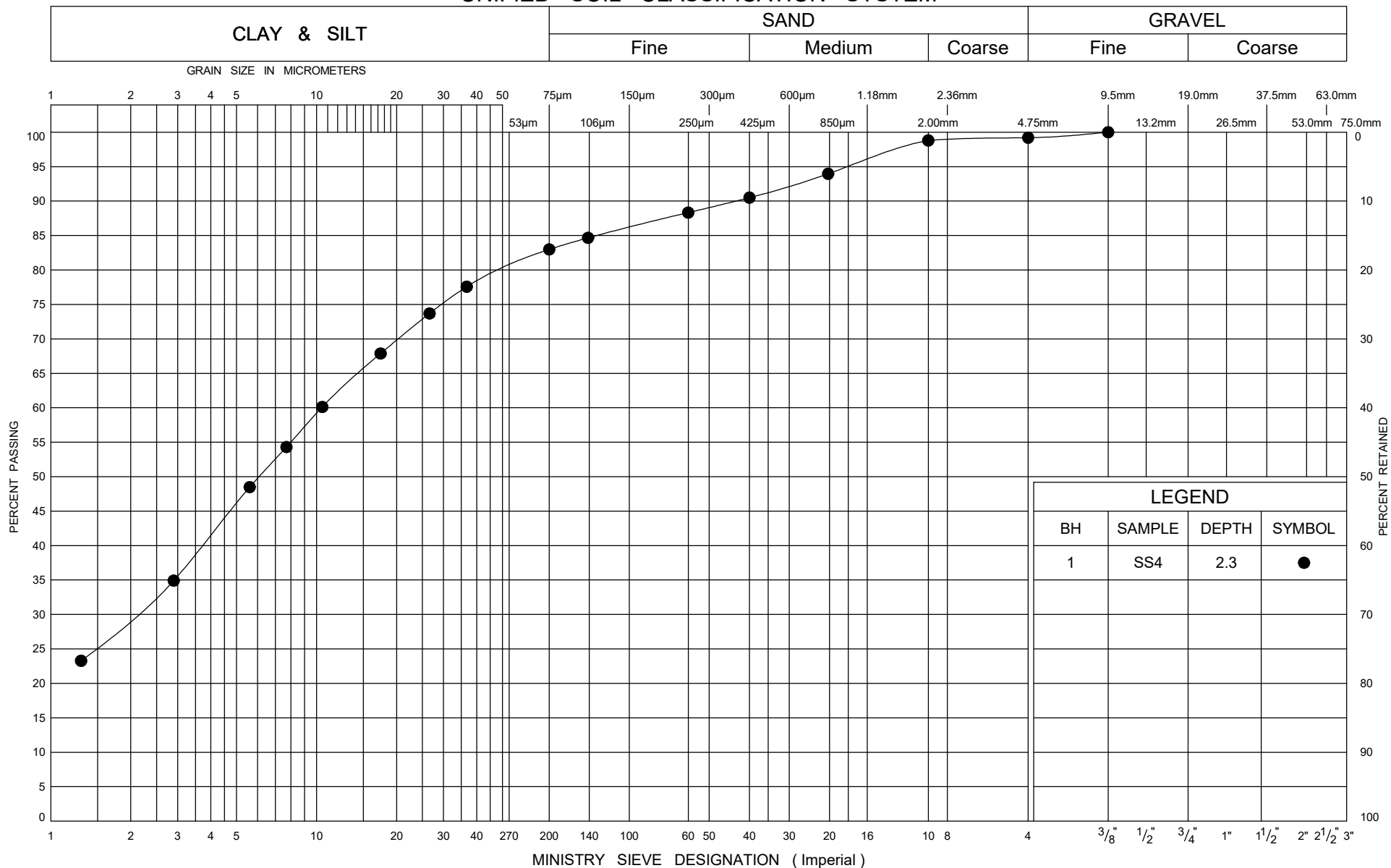
UNIFIED SOIL CLASSIFICATION SYSTEM

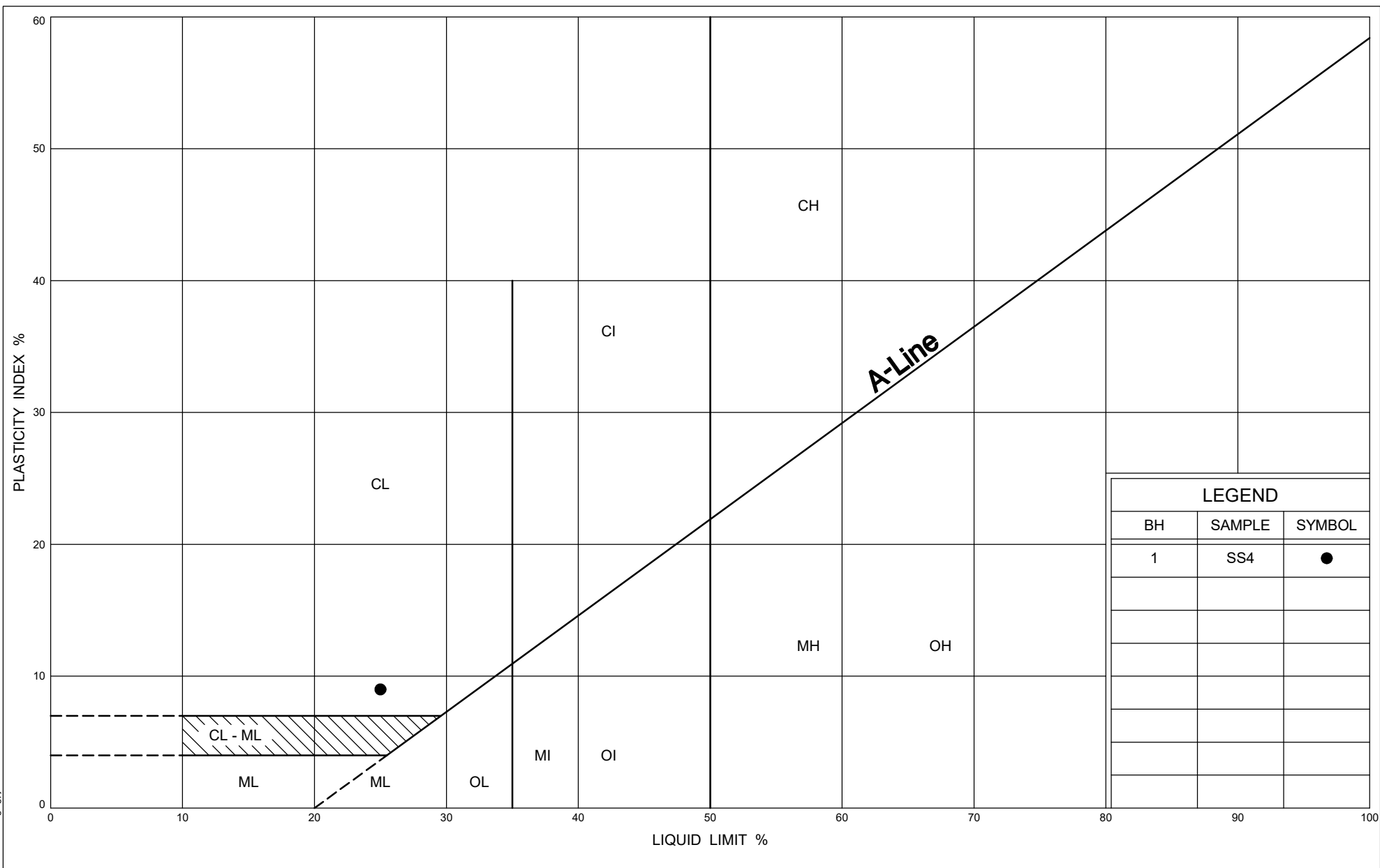


UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

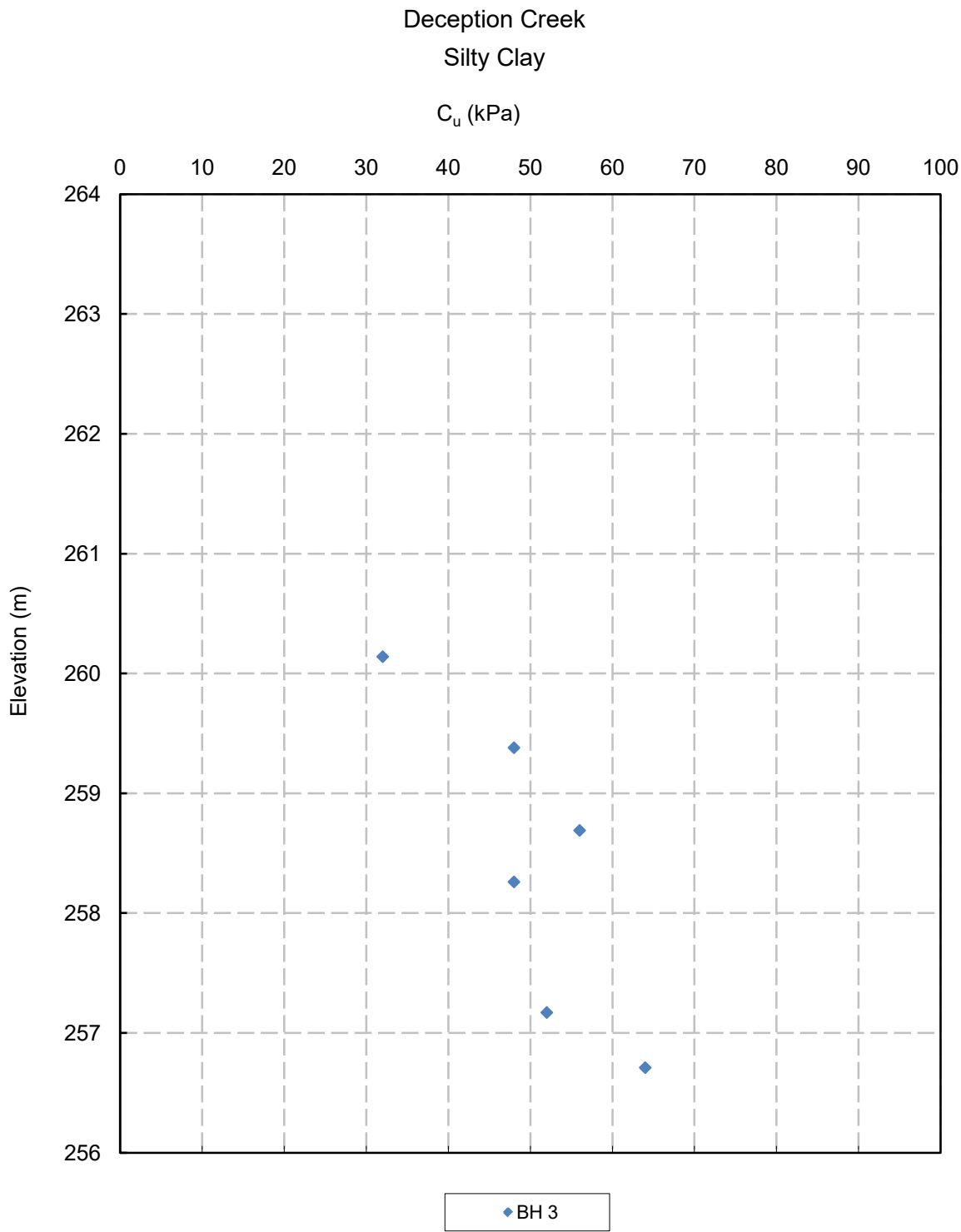




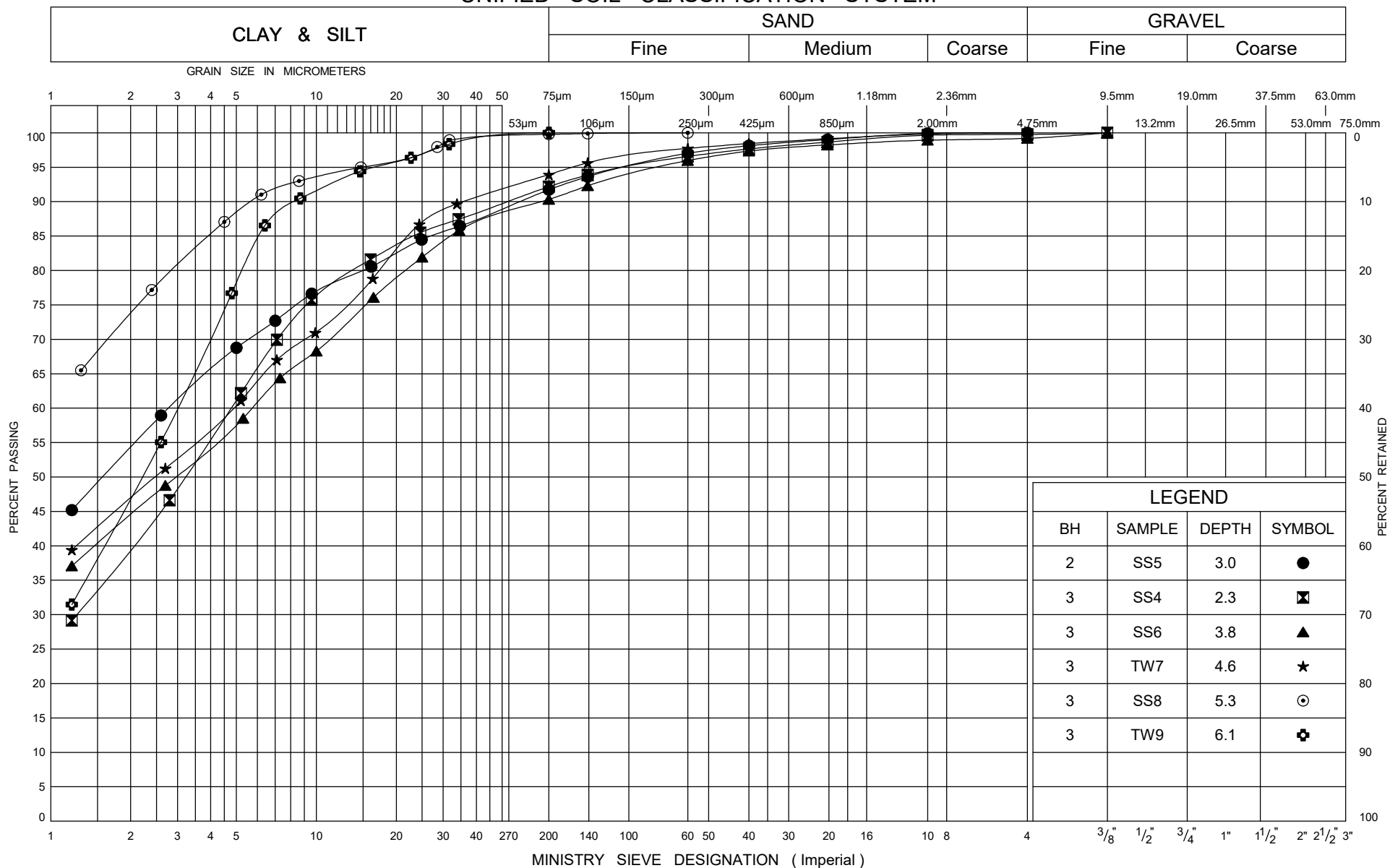
file: 1-15-0509-01 deception creek bh logs.gpj

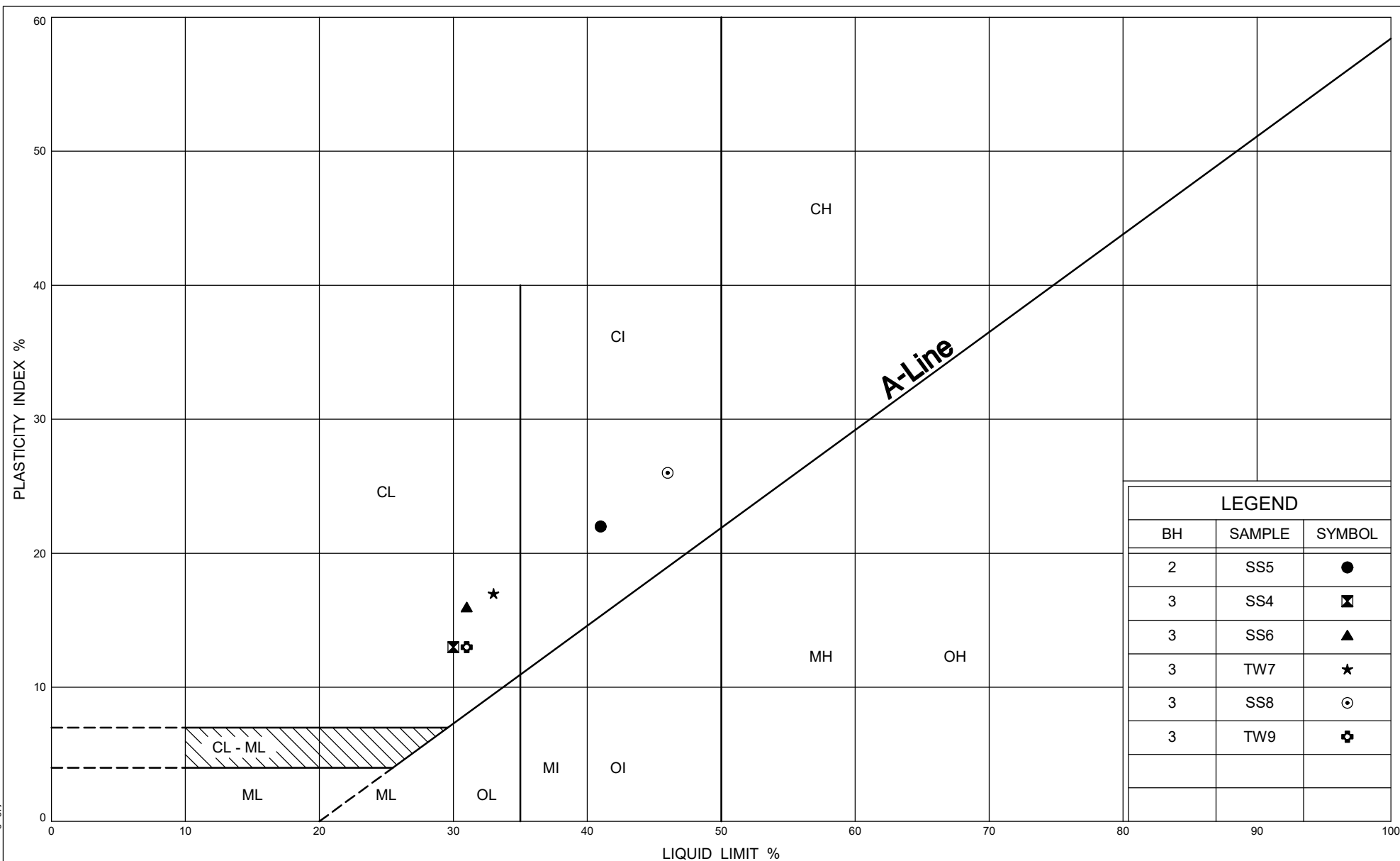
UNDRAINED SHEAR STRENGTH

FIGURE B5



UNIFIED SOIL CLASSIFICATION SYSTEM





PLASTICITY CHART SILTY CLAY

FIG No B7

G W P 5267-11-00

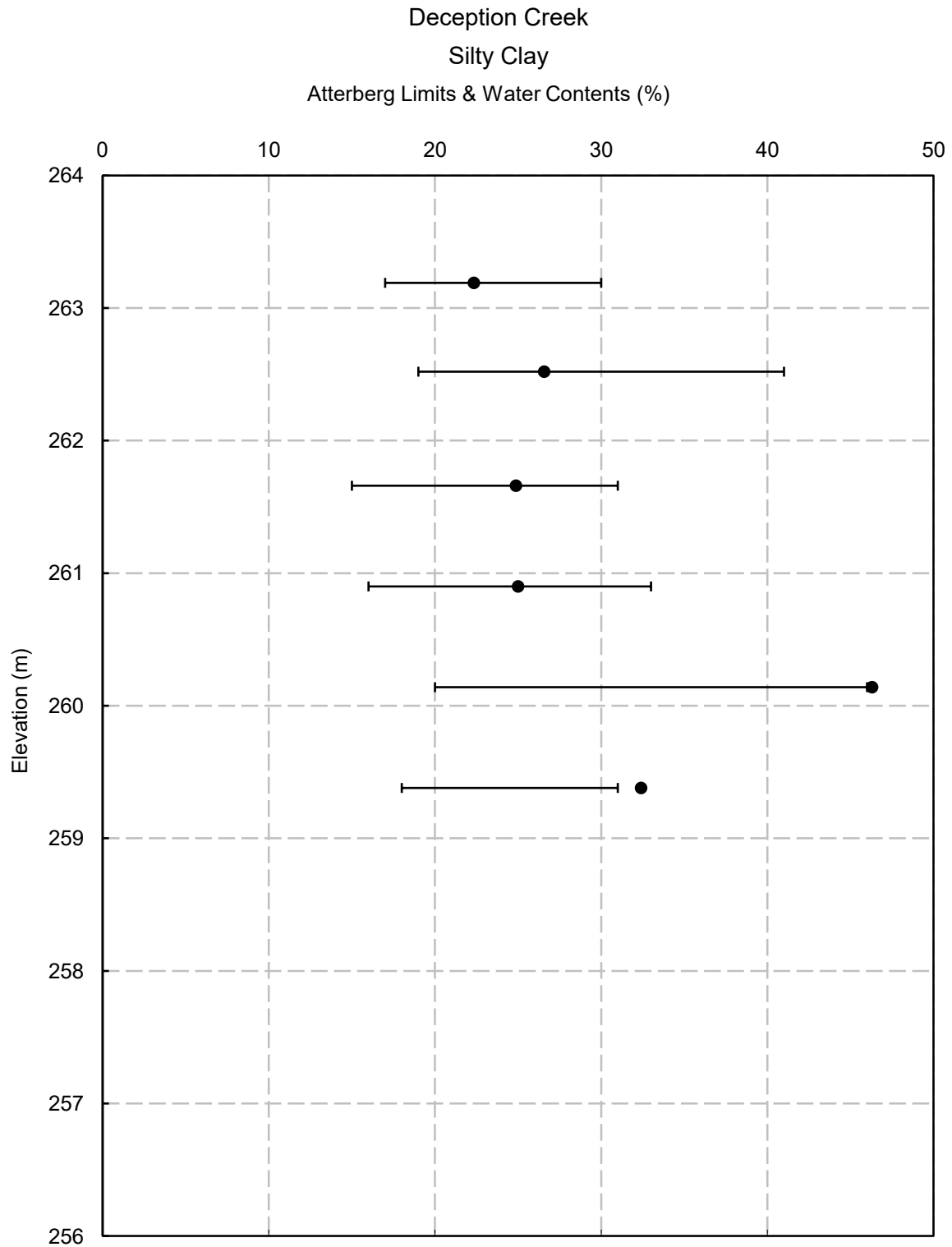
New Liskeard Area



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Transportation

ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B8




F:\2015\1-15-0509\Deception Creek Bridge\0-Pc-Cc-Cr-Cu - Deception Creek.xlsx

Project No. : 1-15-0509
Date : August, 2016



Prepared by : SD
Checked by : RA

CONSOLIDATION TEST SUMMARY				FIGURE B9			
SAMPLE IDENTIFICATION							
Borehole No. :		3		Sample No. :		TW9	
				Sample Depth (m) :		6.1 - 6.6	
TEST CONDITIONS							
Test Type :		Laboratory Standard		Date Started :		5-Jan-16	
Load Duration (hr) :		24		Date Completed :		18-Jan-16	
SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL							
Sample Height (mm) :		19.04		Unit Weight (kN/m ³) :		19.26	
Sample Diameter (mm) :		63.44		Dry Unit Weight (kN/m ³) :		14.55	
Area (cm ²) :		31.61		Specific Gravity :		2.72	
Volume (cm ³) :		60.18		Solid Height (mm) :		10.4	
Water Content (%) :		32.4%		Volume of Solids (cm ³) :		32.88	
Wet Mass (g) :		118.17		Volume of Voids (cm ³) :		27.31	
Dry Mass (g) :		89.30		Degree of Saturation (%) :		105.73	
TEST COMPUTATIONS							
Stress (kPa)	Initial Height (mm)	Final Height (mm)	Void Ratio	t ₉₀ (min)	C _v (cm ² /s)	m _v (m ² /kN)	k (cm/s)
1.566	19.04	19.04	0.831				
18.7	19.04	18.82	0.810	16.00	7.84E-04	6.62E-04	5.10E-08
35.83	18.82	18.79	0.806	9.00	1.39E-03	1.18E-04	1.60E-08
70.09	18.79	18.58	0.787	16.00	7.64E-04	3.14E-04	2.35E-08
138.6	18.58	18.25	0.755	7.56	1.56E-03	2.61E-04	4.00E-08
275.7	18.25	17.60	0.692	9.00	1.22E-03	2.62E-04	3.15E-08
549.8	17.60	16.84	0.619	12.25	8.25E-04	1.57E-04	1.27E-08
1098.0	16.84	16.22	0.559	5.06	1.85E-03	6.74E-05	1.22E-08
2194.4	16.22	15.60	0.500	4.00	2.17E-03	3.50E-05	7.43E-09
275.7	15.60	15.67	0.506				
70.09	15.67	15.89	0.528				
18.7	15.89	16.19	0.556				
SAMPLE DIMENSIONS AND PROPERTIES _ FINAL							
Sample Height (mm) :		16.19		Unit Weight (kN/m ³) :		20.75	
Sample Diameter (mm) :		63.44		Dry Unit Weight (kN/m ³) :		16.63	
Area (cm ²) :		31.61		Specific Gravity :		2.72	
Volume (cm ³) :		51.18		Solid Height (mm) :		7.73	
Water Content (%) :		24.90		Volume of Solids (cm ³) :		31.95	
Wet Mass (g) :		108.30		Volume of Voids (cm ³) :		19.23	
Dry Mass (g) :		86.77					
Project No. : 1-15-0509				 Terraprobe Inc.		Prepared By : SD	
Date : August 2016						Checked By : RA	

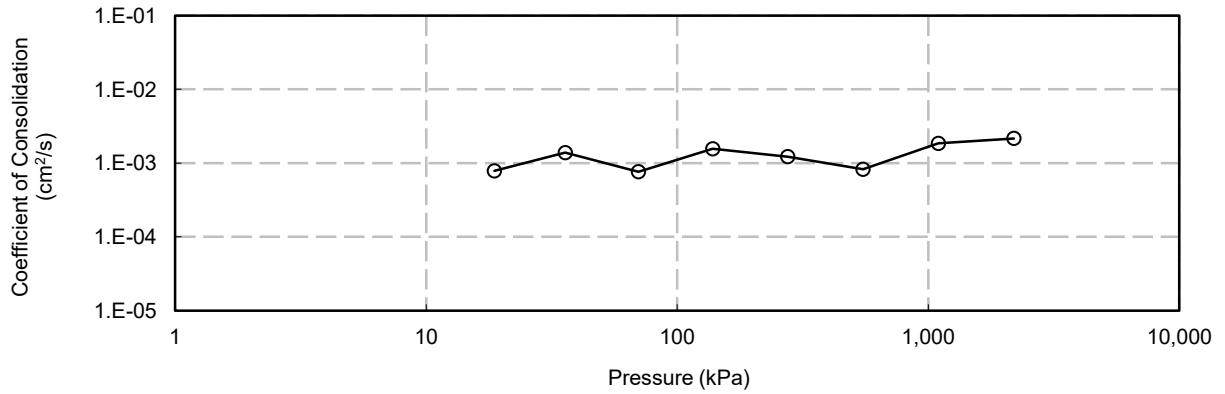
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CONSOLIDATION TEST

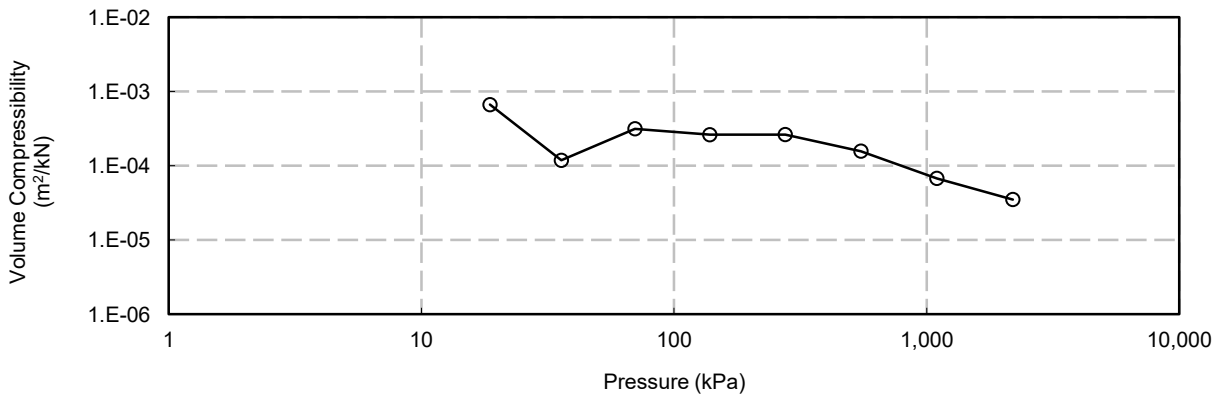
FIGURE B10

Site: Deception Creek
Sample # : BH3 TW9

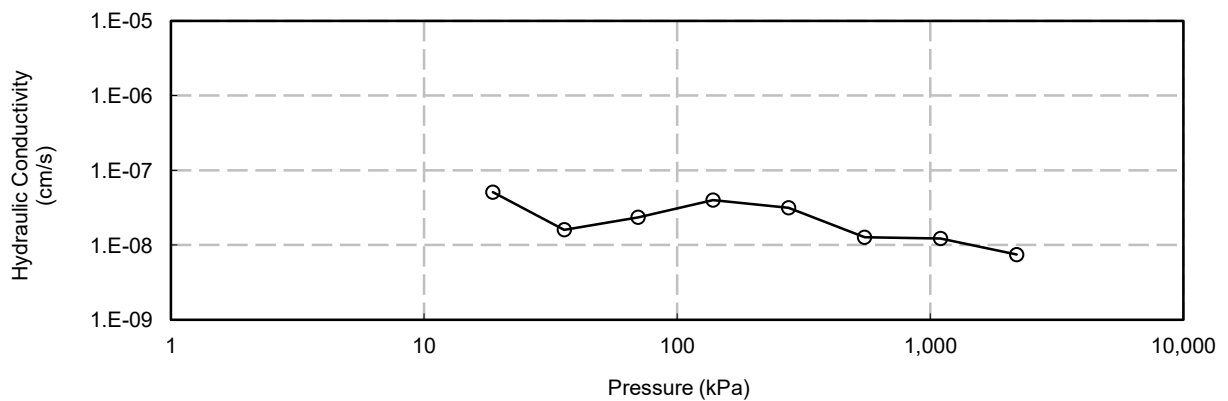
C_v vs Pressure



m_v vs Pressure



k vs Pressure



F:\2015\1-15-0509\Deception Creek Bridge\Consolidation Results - Deception Creek.xlsx

Project No. : 1-15-0509
Date : August 2016



Prepared By : SD
Checked By : RA

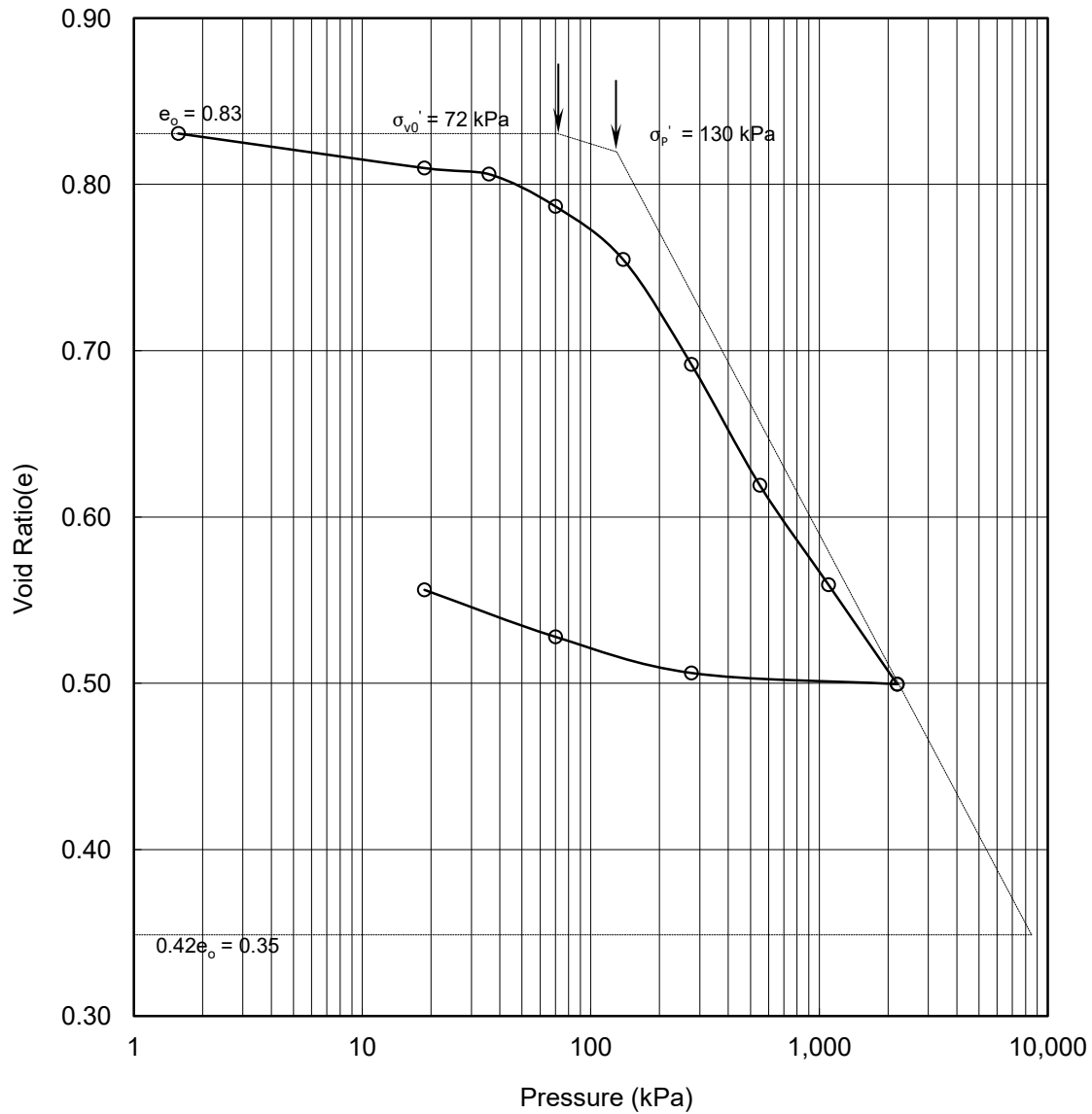
CONSOLIDATION TEST

FIGURE B11

Site: Deception Creek

Sample # : BH3 TW9

Void Ratio vs Pressure



Soil Type : Silty Clay to Clay

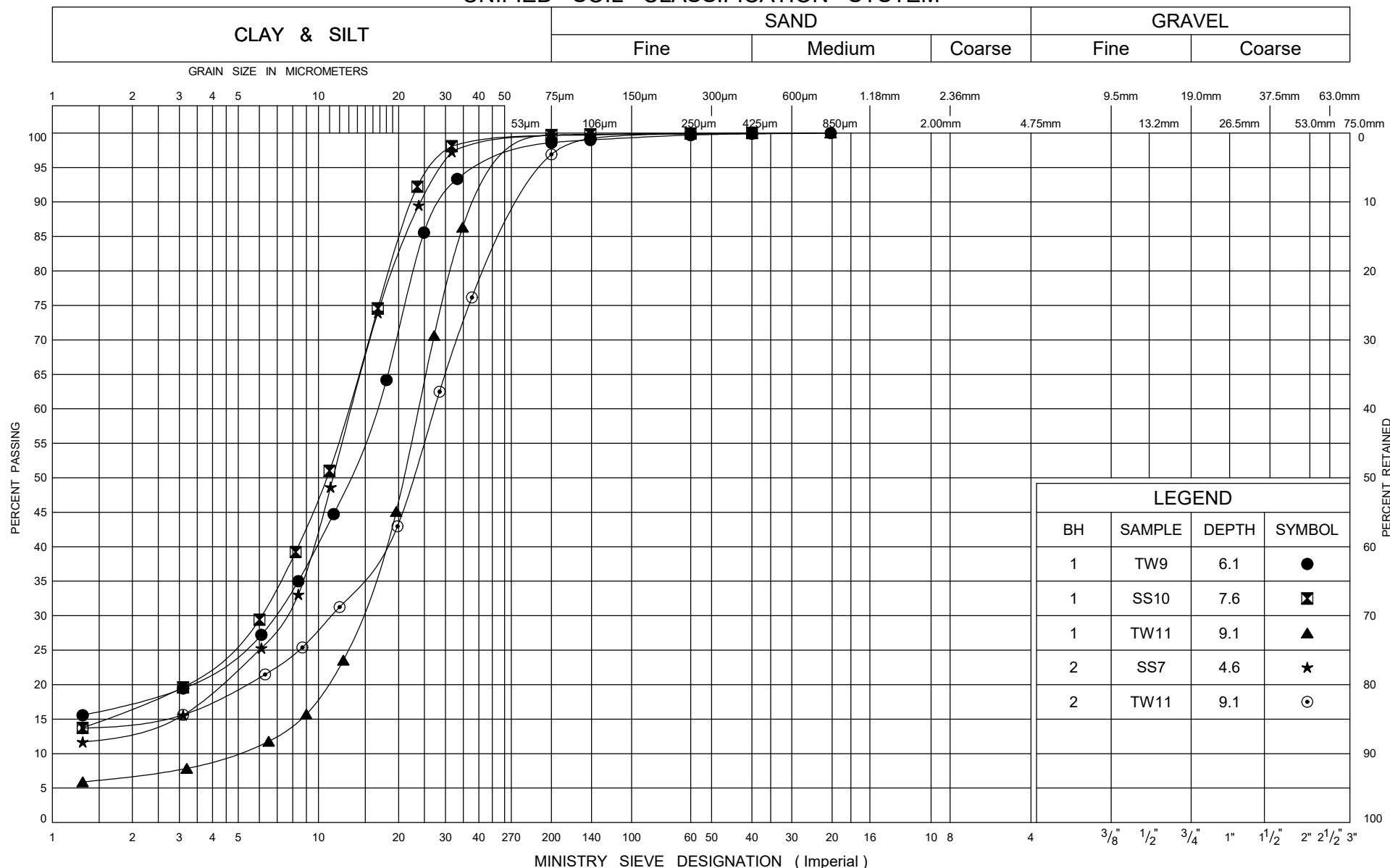
$e_0 =$	0.83	$\omega_L =$	31%	$\sigma_{v0}' =$	71.7 kPa
$\omega =$	32%	$\omega_P =$	18%	$\sigma_P' =$	130.0 kPa
$\gamma =$	19.3 kN/m ³	PI =	13%	$C_c =$	0.259
Gs =	2.72			$C_r =$	0.043

Project No. : 1-15-0509
Date : August 2016



Prepared By : SD
Checked By : RA

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION SILT

FIG No B12

G W P 5267-11-00

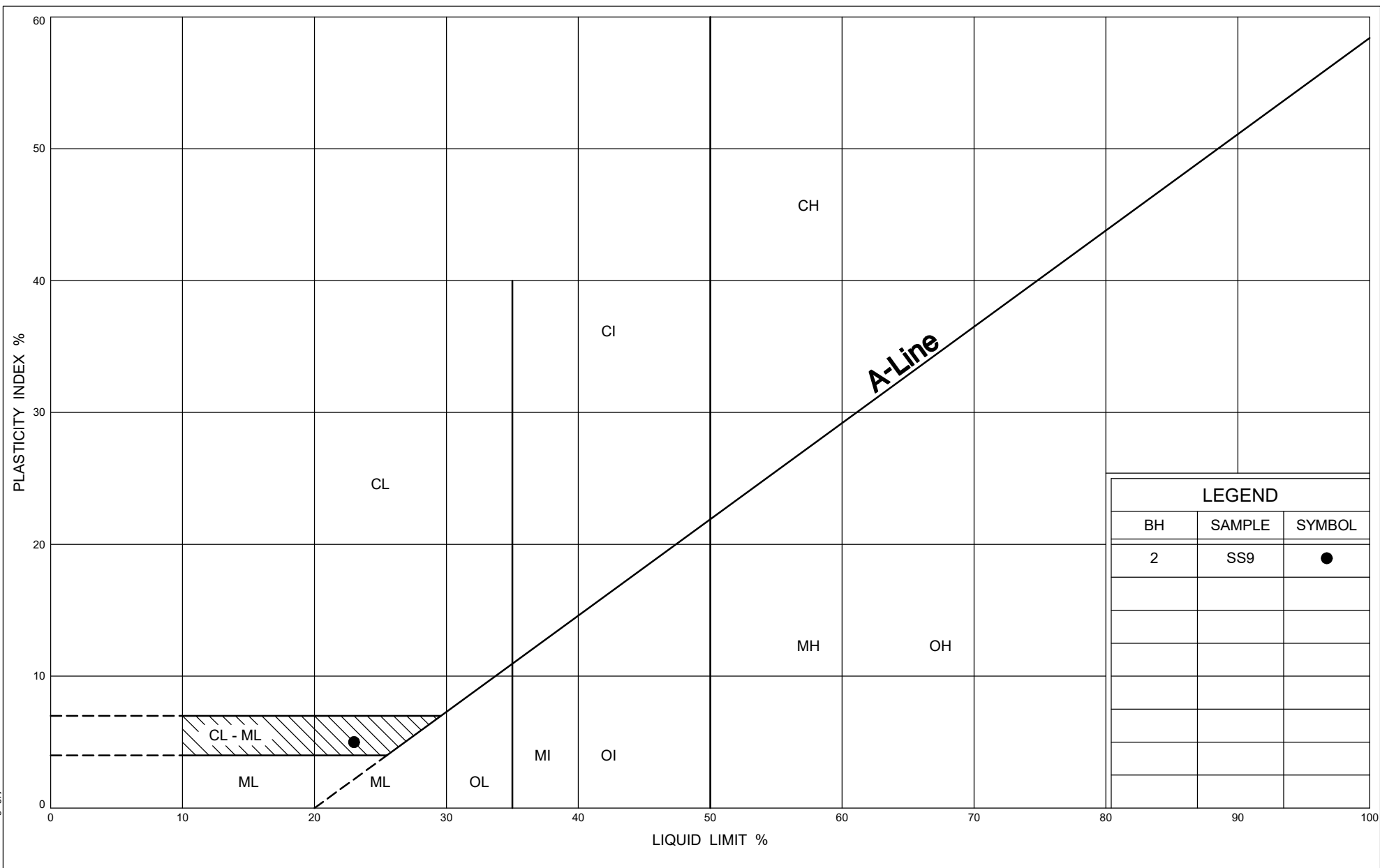
New Liskeard Area



Ministry of
Transportation

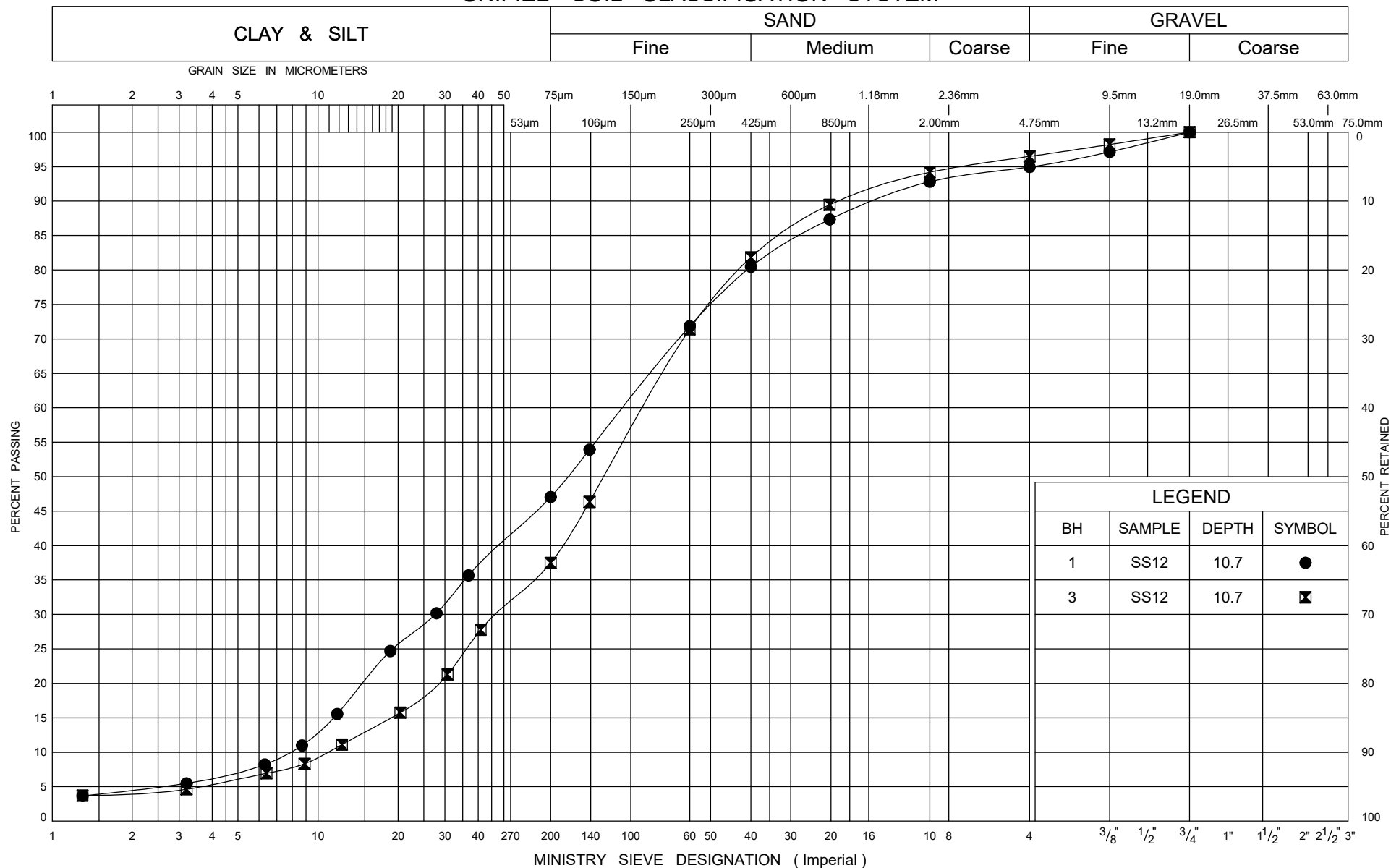


New Liskeard Area



file: 1-15-0509-01 deception creek bh logs.gpj

UNIFIED SOIL CLASSIFICATION SYSTEM



PHOTOGRAPH OF COBBLES AND BOULDERS

FIGURE B16

NEW LISKEARD AREA

Deception Creek Bridge

Borehole No.1



Z:\1-Project Files\2015\1-15-0509 -New Liskeard Area, MTO Northern Region\01-Preliminary FID\2 Deception Creek Bridge\B_Photos\1-15-0509-1 Sept-22-2015 (Rock Cores)\Rock Photos.xls

Project No. : 1-15-0509

Date : August, 2016

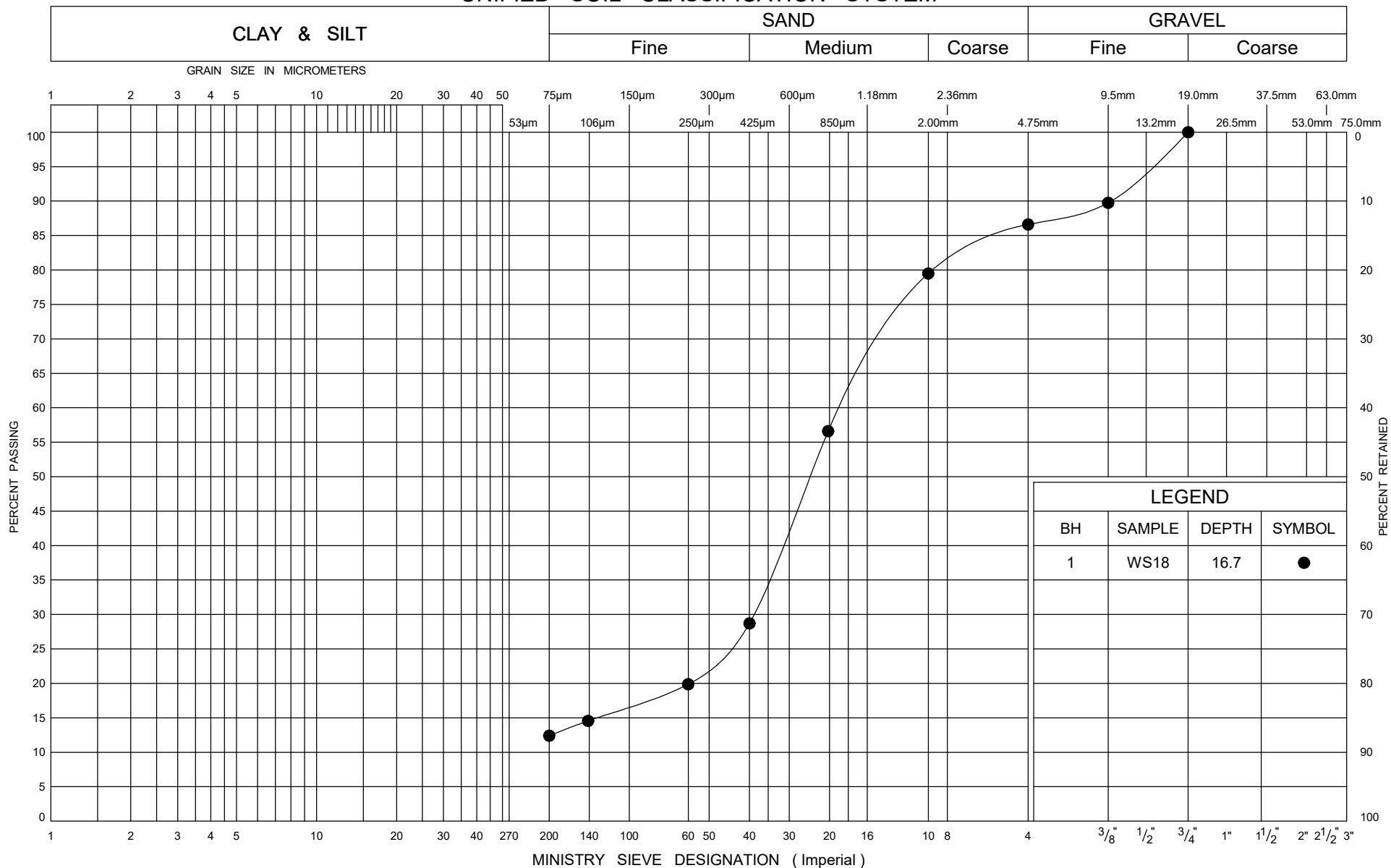


Terraprobe Inc.

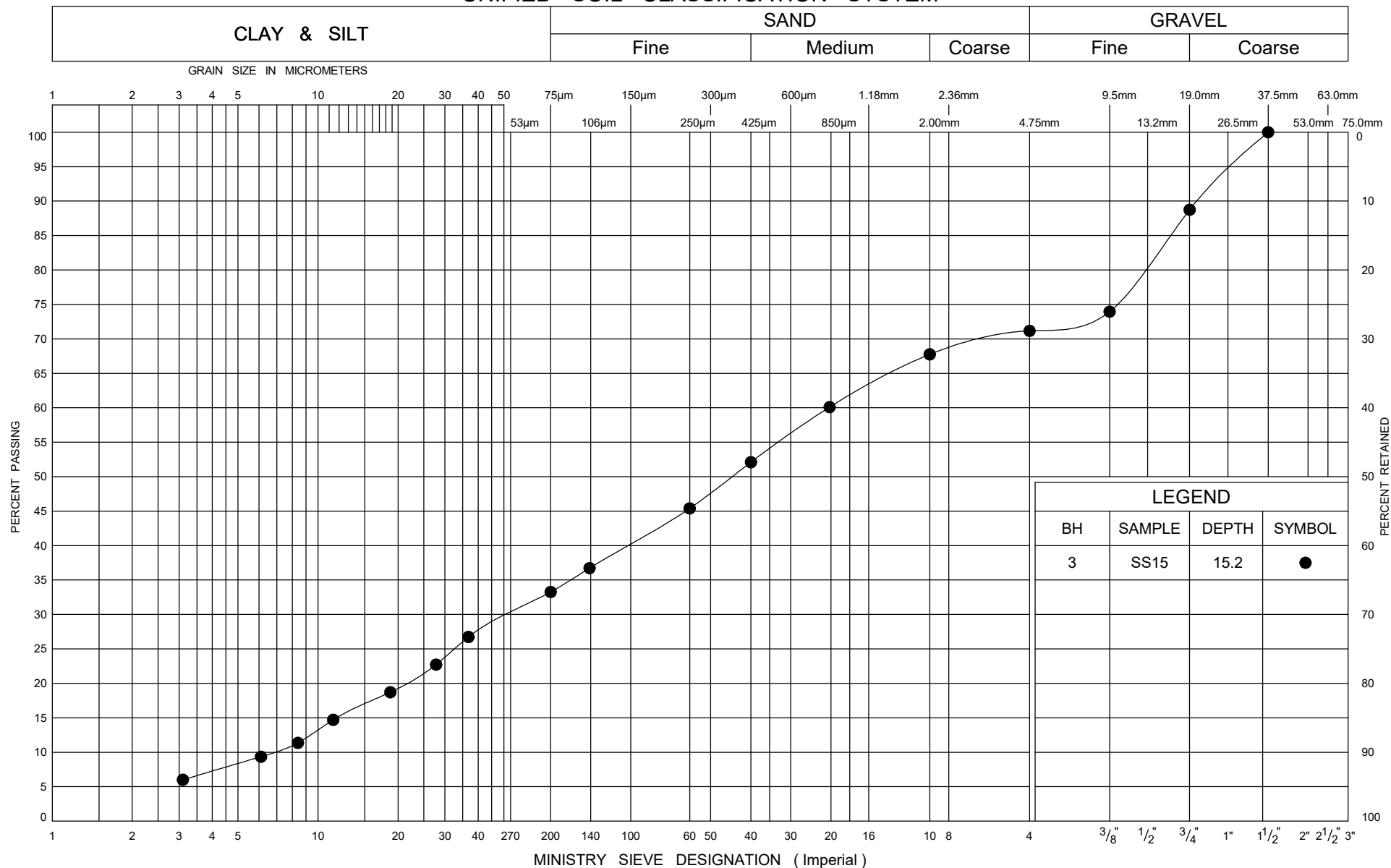
Prepared by : SD

Checked by : RA

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



PHOTOGRAPHS OF BEDROCK CORE SAMPLES

FIGURE B19

NEW LISKEARD AREA

Deception Creek Bridge

Borehole No.1



Borehole No.1



Project No. : 1-15-0509

Date : August, 2016



Prepared by : SD

Checked by : RA

PHOTOGRAPHS OF BEDROCK CORE SAMPLES

FIGURE B20

NEW LISKEARD AREA

Deception Creek Bridge

Borehole No.2



Borehole No.2



Project No. : 1-15-0509

Date : August, 2016



Prepared by : SD

Checked by : RA

PHOTOGRAPHS OF BEDROCK CORE SAMPLES

FIGURE B21

NEW LISKEARD AREA

Deception Creek Bridge

Borehole No.2



Z:\1-Project Files\2015\1-15-0509 -New Liskeard Area, MTO Northern Region\01-Preliminary FID\2 Deception Creek Bridge\B_Photos\1-15-0509-1 Sept-22-2015 (Rock Cores)\Rock Photos.xls

Project No. : 1-15-0509

Date : August, 2016



Prepared by : SD

Checked by : RA

PHOTOGRAPHS OF BEDROCK CORE SAMPLES

FIGURE B22

NEW LISKEARD AREA

Deception Creek Bridge

Borehole No.3



Z:\1-Project Files\2015\1-15-0509 -New Liskeard Area, MTO Northern Region\01-Preliminary FID\2 Deception Creek Bridge\B. Photos\1-15-0509-1 Sept-22-2015 (Rock Cores)\Rock Photos.xls

Project No. : 1-15-0509

Date : August, 2016



Prepared by : SD

Checked by : RA

POINT LOAD INDEX TEST RESULTS

Figure B23



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 10123
 Client: Terraprobe
 Project Name: Deception Creek
 Core Size: NQ BH No : BH 1

Date Drilled: 15-Sep-15
 Date Tested: 13-Nov-15
 Tester: GA
 Reviewed by: JPL

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_s(50)$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	17.1	D	20.3	47.3	277.5	8.4	201.2	Greywacke	Very Strong
2	1	17.4	D	20.8	47.3	256.0	8.6	206.1	Greywacke	Very Strong
3	1	17.8	D	19.8	47.3	249.5	8.2	195.8	Greywacke	Very Strong
4	1	18.1	D	30.6	47.4	151.0	12.6	302.9	Greywacke	Extremely Strong
5	1	18.3	D	20.2	47.4	176.0	8.3	199.6	Greywacke	Very Strong
6	2	18.5	D	23.9	47.4	178.5	9.8	236.4	Greywacke	Very Strong
7	2	18.8	D	15.2	47.4	227.0	6.3	150.4	Greywacke	Very Strong
8	2	19.2	D	8.9	47.4	462.0	3.7	88.2	Greywacke	Strong
9	2	19.5	D	15.1	47.4	229.0	6.2	149.6	Greywacke	Very Strong
10	2	19.8	D	25.5	47.3	294.5	10.5	252.5	Greywacke	Extremely Strong
11	3	20.2	D	14.2	47.3	126.3	5.9	141.3	Greywacke	Very Strong
12	3	20.5	D	23.2	47.3	326.0	9.6	229.5	Greywacke	Very Strong
13	3	20.8	D	20.2	47.3	228.5	8.3	199.9	Greywacke	Very Strong
14	3	21.1	D	14.2	47.3	125.0	5.9	140.9	Greywacke	Very Strong
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- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
- * Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

Note: Point Load Index Tests were performed by Thurber Engineering Ltd.

Project No. : 1-15-0509

Date : September, 2016



Terraprobe Inc.

POINT LOAD INDEX TEST RESULTS

Figure B24



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 10123
 Client: Terraprobe
 Project Name: Deception Creek
 Core Size: NQ BH No : BH 2

Date Drilled: 14-Sep-15
 Date Tested: 13-Nov-15
 Tester: GA
 Reviewed by: JPL

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.7	D	16.7	47.3	98.5	6.9	165.7	Greywacke	Very Strong
2	1	15.0	D	9.8	47.3	375.0	4.0	97.2	Greywacke	Strong
3	1	15.3	D	25.0	47.3	174.5	10.3	247.5	Greywacke	Very Strong
4	2	15.5	D	15.1	47.3	152.0	6.2	149.7	Greywacke	Very Strong
5	2	15.8	D	25.9	47.3	370.5	10.7	256.7	Greywacke	Extremely Strong
6	2	16.1	D	23.0	47.4	178.5	9.5	227.4	Greywacke	Very Strong
7	2	16.5	D	21.5	47.4	202.0	8.9	213.0	Greywacke	Very Strong
8	2	16.8	D	23.2	47.4	89.1	9.5	228.7	Greywacke	Very Strong
9	3	17.1	D	22.6	47.4	301.0	9.3	223.4	Greywacke	Very Strong
10	3	17.3	D	22.7	47.4	200.5	9.4	224.8	Greywacke	Very Strong
11	3	17.5	D	11.3	47.4	270.0	4.7	111.8	Greywacke	Very Strong
12	3	17.7	D	15.6	47.5	210.5	6.4	153.7	Greywacke	Very Strong
13	3	18.1	D	11.5	47.5	151.0	4.7	112.7	Greywacke	Very Strong
14	4	18.6	D	15.2	47.5	322.5	6.2	149.4	Greywacke	Very Strong
15	4	18.9	D	19.8	47.6	250.0	8.1	194.5	Greywacke	Very Strong
16	4	19.3	D	10.2	47.6	347.5	4.2	99.6	Greywacke	Strong
17	4	19.9	D	9.2	47.6	152.0	3.7	89.9	Greywacke	Strong
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- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
- * Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

Note: Point Load Index Tests were performed by Thurber Engineering Ltd.

Project No. : 1-15-0509

Date : September, 2016



Terraprobe Inc.

Z:\1-Project Files\2015\1-15-0509 -New Liskeard Area, MTO Northern Region\01-Preliminary FID\2 Deception Creek Bridge\Lab Results\Point Load Test\Sep 14, 2016\Point Load Test Results.xls

POINT LOAD INDEX TEST RESULTS

Figure B25



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 10123
 Client: Terraprobe
 Project Name: Deception Creek
 Core Size: NQ BH No : BH 3

Date Drilled: 16-Sep-15
 Date Tested: 13-Nov-15
 Tester: GA
 Reviewed by: JPL

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hook & Brown, 1997)
1	1	16.3	D	10.0	47.3	327.0	4.1	99.2	Greywacke	Strong
2	1	16.5	D	19.3	47.3	324.5	8.0	191.4	Greywacke	Very Strong
3	1	16.8	D	13.0	47.3	124.0	5.4	128.8	Greywacke	Very Strong
4	2	17.1	D	18.9	47.3	423.5	7.8	187.4	Greywacke	Very Strong
5	2	17.3	D	28.8	47.4	178.0	11.9	285.2	Greywacke	Extremely Strong
6	2	17.6	D	9.1	47.4	349.5	3.8	90.4	Greywacke	Strong
7	2	17.9	D	15.8	47.4	279.5	6.5	156.3	Greywacke	Very Strong
8	2	18.1	D	14.5	47.4	278.0	6.0	143.4	Greywacke	Very Strong
9	3	18.4	D	9.1	47.4	264.5	3.8	90.2	Greywacke	Strong
10	3	18.8	D	15.6	47.4	152.5	6.4	154.4	Greywacke	Very Strong
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- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
- * Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have 0.7 x D on either side of test point.
- * Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

Note: Point Load Index Tests were performed by Thurber Engineering Ltd.

Project No. : 1-15-0509

Date : September, 2016



Terraprobe Inc.

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