Foundation Investigation and Design Report

Bass Creek Bridge Replacement

GWP 476-00-00

Highway 585
14 km north of the 585 and 11/17 Highway Intersection

Prepared for
Ministry of Transportation, Northwestern Region

Prepared By:

TBT Engineering
200-101 Syndicate Ave. N
Thunder Bay, Ontario
P7C 3V4

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Part A - **FOUNDATION INVESTIGATION REPORT**

1 Introduction

TBT Engineering has been retained by the Ministry of Transportation to provide foundation investigation services for the bridge replacement at Bass Creek.

The site is located on Highway 585, approximately 14 km north of the Highway 11/17 intersection, within Booth Township, Ontario.

The foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of five boreholes drilled in the vicinity of the proposed bridge replacement, and laboratory testing. This report provides a summary of that work and of the conditions encountered.

2 Site Description

The site is located on Highway 585, approximately 14 km north of the Highway 11/17 intersection. At this location Highway 585 runs generally in a north-south direction.

The existing bridge is a single lane “Bailey” type structure supported on timber cribs and is approximately 40 m long. The side embankments along the approaches have side slopes of approximately 1.5 horizontal to 1 vertical or flatter as the Highway approaches the Bass Creek ravine. The existing bridge abutment and approaches have been built up from the original ground in order to cross the creek.

The site is within Ontario’s boreal forest region. Highway 585 at the bridge location is generally level with the surrounding area. Bass Creek flows easterly in a ravine below the bridge, with approximately 7 m from the bridge deck to the top of water.

Bass Creek - Existing Bridge

3 Investigation Procedures

A site investigation was undertaken on July 24, 25, 28 and August 25, 2008. Five boreholes were drilled for this project, two along the approach, two near the existing abutments (one of each for either side of the creek), and the remaining one on the north end approximately 10 m east of the centerline.

The investigation was carried out using a CME drill rig equipped for geotechnical testing. The boreholes were drilled to depths ranging between 8.3 and 21.5 m below existing ground surface. Borehole locations and depths were determined through consultation with the client during an onsite meeting. Borehole BC08-02 was located in a potential detour route away from the road and bridge alignment. The remaining proposed detour boreholes were deleted upon cancellation of the detour. Refer to the Record of Borehole drawings (Appendix C) for specific depths and comments concerning each borehole.

Soil samples were obtained at the boreholes with a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m, known as the SPT blow count (N), was recorded. In addition to SPTs, field shear vane testing was conducted within cohesive soils. Thin walled tube samples were taken within cohesive materials to obtain relatively undisturbed samples. Bedrock was sampled utilizing diamond core techniques.

Borehole location and elevations were surveyed in the field by Cook Engineering and referenced to the benchmark Number 302, located on the RR spike in a 0.45 m diameter poplar, at station 10+334.988 23.16 Left. A reference elevation of 100.000 m was assigned to the benchmark.

A summary of the borehole location data is provided on the enclosed Borehole Location Plan and Soil Strata Drawing 1 (Appendix C).

The borehole characteristics and drill techniques utilized are summarized for the various borehole locations in the following table.

Table 1 - Drill Summary
Bass Creek
Booth Township

Location	Borehole Elevations m			Comments
	Surface	1st SPT Refusal*	Termination	
BC08-01	97.9	80.6	76.4	Hollow Stem Augers, BW Casing
BC08-02	96.4	80.2	80.2	Hollow Stem Augers
BC08-03	98.5	80	77.1	Hollow Stem Augers, Diamond Coring
BC08-04	97.9	-	88.1	Hollow Stem Augers
BC08-05	97.8	-	89.5	Hollow Stem Augers

*Refusal has been defined as a SPT test with an "N" value which exceeds 100 blows per 0.3 m

The boreholes were backfilled to ensure the environmental integrity of the site, utilizing appropriate bentonite mixtures for the soils encountered (at individual locations) and complying with the amended Ontario Regulation 903.

Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content and grain size analysis. In addition, consolidation testing was conducted on select samples. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

4 General Site Geology and Sub-Surface Conditions

4.1 Site Geology

The Bass Creek flows easterly through an area of high land to the north west of the bridge site, reporting to the Nipigon River just downstream of the bridge. The Nipigon River flows generally south and reports to Lake Superior near the town site of Red Rock.

Bedrock in the area of Bass Creek is of the Archean-aged Quetico geological subprovince. Available mapping (OGS Map 2232 – Nipigon-Schreiber Compilation) shows paragneiss and metasedimantary-derived migmatite underlying the area of the bridge. Associated granitic units may also be present nearby. Regional deformation is generally aligned east-west; however, faulting is locally aligned approximately north-south. A Proterozoic-aged Nipigon diabase sill is exposed approximately 500 m to the west and northwest of the bridge site.

Available surficial geology mapping (OGS NOEGTS Map 5052 – Frazer Lake) shows generally low and wet local relief with coarse-sand lacustrine plain and delta deposits fringing the Nipigon River, associated with the former Nipigon spillway.

4.2 Subsurface Conditions

Details of the subsurface conditions are provided on the Borehole Logs, Appendix A, and on the Borehole Location Plan and Strata Drawing 1.

4.2.1 General

In general, the subsurface stratigraphy consists of various mixtures of fill, overlying layered lacustrine deposits which are further underlain by a glacial till. At all boreholes the upper strata consist of sands and/or silts followed by a thick clay deposit and a second silt stratum. A deposit of sand and gravel till exists below the silt stratum (overlying bedrock).

The subsurface stratigraphy has been interpreted based on the results of the boreholes and has been illustrated on the Borehole Location Plan and Soil Strata Drawing 1.

4.2.1.1 Topsoil

Topsoil was encountered off of the driving surface, at Borehole BC08-02. The topsoil extended to a depth of 0.1 m (elevation 96.3 m).

4.2.1.2 Roadway Fill

Fill consisting of various mixtures of sand, gravel and silt were encountered below the road surface at Boreholes BC08-01, 03, 04, and 05. Based on four grain size tests samples the fill can consist of 0 - 6 % gravel, 23 - 91% sand, and 9 - 77 % silt/clay sized particles. There is no record of fill placement and differing conditions may be present in the fill. This material does not meet Granular "B" Type 1 specifications. The fill varies in thickness from 2.1 to 2.9 and extended to a depth ranging from 2.1 to 2.9 m (elevation 95.8 to 95.0 m). The material is very loose to compact as indicated by "N" values ranging from 1 to 15 blows per 0.3 m. The fill material is considered to be frost susceptible.

4.2.1.3 Discontinuous Upper Sand

A discontinuous sand layer is present beneath the roadway fill at Borehole BC08-01. The sand layer can consist of 0 % gravel, 98 % sand, and 2 % silt/clay sized particles. The sand is 1.5 m thick and extends to a depth of 3.6 m (elevation 94.3 m). The material is loose as indicated by "N" values ranging from 4 to 9 blows per 0.3 m. This stratum is not considered to be frost susceptible.

4.2.1.4 Silt and Sand

Silt and sand was encountered beneath the fill at Boreholes BC-08-03 and 04, and beneath the topsoil at Borehole BC08-02. Based on a sample from Borehole BC08-04 the silt can consist of 0 % gravel, 39 % sand, and 61 % silt/clay sized particles. The silt and sand varies in thickness from 0.9 to 2.1 m in thickness and extends to a depth

ranging from 2.2 to 4.6 m (elevation 94.7 to 93.3 m). The deposit is very loose to loose as indicated by "N" values ranging from 3 to 8 blows per 0.3 m. This material is considered to be frost susceptible.

4.2.1.5 Clay

Silty clay is found beneath the silt and sand at all borehole locations. This stratum varies in thickness from 4.0 to 10.0 m in thickness and extends to depths ranging from 8.3 to 12.2 m (elevation 89.5 to 84.3 m). The silty clay varies from CL-ML to low and medium plastic (CL to CI) with natural moisture contents at or above the liquid limit. (Atterberg Limit Testing Appendix B).

The clay is soft to very stiff as indicated by field vane tests ranging from 22 to 110 kPa, although generally the clay has a firm consistency.

A consolidation test carried out on a low plastic silty clay sample from Borehole BR08-01 at a depth of 6.1 m indicates the clay is slightly over consolidated with an estimated over consolidation ratio (OCR) of 1.8. The calculated compression index is 0.15 and the coefficient of consolidation varies from 0.2 to 1.4 mm^2/min. The hydraulic conductivity within the design stress range as interpreted from the consolidation testing varies from 10^{-9} to 10^{-8} cm/sec.

A consolidation test carried out on a medium plastic clay sample from Borehole BR08-03 at a depth of 7.6 m indicates the clay is normally consolidated to slightly over consolidated with an estimated over consolidation ratio (OCR) of 1.5. The calculated compression index is 0.15 and the coefficient of consolidation varies from 2.5 to 5.4 mm^2/min. The hydraulic conductivity within the design stress range as interpreted from the consolidation testing varies from 10^{-8} to 10^{-7} cm/sec.

A discontinuous one metre thick layer of non plastic silt is bedded within the clay at Borehole BC08-04, 7 .0 m below grade (Elev. 91.9)

4.2.1.6 Lower Silt

A layer of silt with trace to some sand was encountered below the clay at all boreholes with the exception of BC08-05 in which the borehole was terminated within the silty clay above. Based on samples from Boreholes BC08-02, and 03 the silt can consist of 0 - 15 % gravel, 5 -13 % sand, and 72 - 95 % silt/clay sized particles. The silt varies in thickness from 3.0 to 9.2 m in thickness and extends to a depth ranging from 15.2 to 18.2 m (elevation 81.4 to 80.3 m). The material is loose to compact as indicated by "N" values ranging from 4 to 26 blows per 0.3 m.

4.2.1.7 Sand and Gravel (Till)

Heterogeneous mixtures of sand, gravel and silt were encountered below the lower silt at Boreholes BC08-01, 02, and 03, Borehole BC08-04 was terminated above this within the lower silt stratum. Based on two samples, the sand and gravel can consist of 7 - 89 % gravel, 9 – 73 % sand, and 3 - 20 % silt/clay sized particles. This stratum is likely of glacial till origin. This material varies in thickness from 0.6 to 5.0 and extended to a depth ranging from 16.2 to 21.5 m (elevation 80.3 to 76.4 m). The till is dense to very dense as indicated by "N" values ranging from 46 blows to blows greater than 100 per 0.3 m.

4.2.1.8 Bedrock

Bedrock was sampled at Borehole BC08-03 from 18.8 to 21.4 m below grade (elevation 79.7 to 77.1 m). The bedrock can be described as a migmatite, with zones of gneiss and fine and medium-grained granitic material. The granitic zones are mostly massive, grey to pink. The gneissic zones have a strong foliation/schistosity.

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 100 mm) to the total length cored. The RQD index is used to provide a classification for the rock quality according to the following limits.

Table 2 – RQD Index

RQD %	Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

The RQD for the two core lengths at Borehole BC08-03 were 47 % and 58 %, indicating poor to fair quality.

The bedrock surface grades are known to vary considerably in this region. Significant rock surface elevation changes and steeply sloping bedrock surfaces are common within short distances.

4.2.1.9 Ground Water

The water level of the creek at the time of the investigation was at elevation 90.9 m. The ground water table was measured in the boreholes at depths ranging from 2.2 to 4.4 m from ground surface (elevation 95.8 to 93.5). Ground water levels will be highly dependant on the water level within the creek, and will generally rise in elevation away from the creek. Ground water levels will also fluctuate with precipitation events.

5 Miscellaneous

The field drilling services for this project were provided by TBT Engineering. Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The field operations were supervised by H. Finke. This report was prepared by S. Seller, P.Eng. and G. Maki, P.Eng., and reviewed by W. Hurley, P.Eng.

Part B FOUNDATION DESIGN RECOMMENDATIONS

6 Introduction

The current Bass Creek Bridge was constructed in 1971 and is a single span Bailey structure supported on timber cribs. The proposed replacement structure will be a single span single lane “Bailey” type structure. A detour will not be utilized during the construction of the replacement bridge.

The foundation investigation as described in Part A, was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes advanced in the vicinity of the new structure, laboratory testing and geotechnical analysis of the data.

The purpose of this section of the report (Part B) is to provide geotechnical design recommendations for the project. These are based on the conditions encountered at the test locations and interpretation of the subsurface conditions at the site.

7 Bridge Foundations

The foundation system for the proposed structure must support the design loads within acceptable settlement tolerances, stability, and bearing resistance to accommodate all anticipated loadings.

The preliminary design concepts for the bridge and abutment involve the use of a “Bailey” type bridge structure. The bridge may be founded on timber cribs or on a pile foundation. Both options are discussed below.

7.1 Timber Crib Foundation

A timber crib foundation will consist of wood timbers assembled to form a crib and rock filled for mass. A single crib will be used at each abutment, acting as a large spread footing.

7.1.1 Factored Geotechnical Resistance at ULS and Geotechnical Reactions at SLS

The following (Table 3) geotechnical resistances at ULS and geotechnical reactions at SLS are valid for the proposed timber crib subject to the following conditions.

1. A minimum 1.0 m depth of cover to underside of the timber crib shall be provided.
2. Cribs will be placed at or below an elevation of 95.5 m
3. A minimum distance of 2 times the width (dimension parallel with the centreline of the roadway) of the crib shall be provided from the top of the crib to the edge of the embankment fore slope
4. The crib shall be vertically and concentrically loaded.

A resistance factor of 0.5 has been applied for the calculation of factored geotechnical resistance at ULS and the geotechnical reaction at SLS has been computed for maximum settlements of 25, 50 and 100 mm.

Applicable ULS and SLS values for timber cribs with widths of 3 and 4 m are provided in Table 3.

Table 3 –Geotechnical Factored Resistance and Reaction for Timber Cribs

Timber Crib Dimensions m	Factored Geotechnical Resistance at ULS kPa	Geotechnical Reactions at SLS kPa		
		25 mm	50 mm	100 mm
3 x (5 to 7)	85	20	40	90
4 x (5 to 7)	85	20	35	70

7.1.2 Lateral Pressures

Lateral earth pressure distributions along the crib should be computed as per Section 6.9. of the Canadian Highway Bridge Design Code (CHBDC). Compaction surcharge as per Section 6.9.3 should be included.

Granular “A” or “B”, Type 1 backfill should be in accordance with Ontario Provincial Specifications (OPSS 1010). The following parameters are recommended when calculating earth pressures.

Table 4 - Soil Parameters (unfactored) Level Backfill

Material	Unit Weight γ kN/m³	Effective Angle of Friction φ’ º
Compacted Granular "A"	22	35
Compacted Granular “B”	21	33
Upper Silts and Sand	20	30

The above properties are unfactored.

The design of the timber crib must also consider sloping ground effects (behind the crib) and any surcharge loads.

Sufficient drainage should be provided behind the crib to alleviate potential hydrostatic pressures. Frost susceptible materials should not be placed within 3 m of the face of the retaining wall to avoid lateral pressures from frost action.

7.2 Driven Piles

Driven piles consisting of HP 310 x 110 may be founded within the sand and gravel till or on bedrock. The actual depth of pile penetration will depend on localized till conditions and thickness, and the underlying bedrock condition and elevation.

7.2.1 Factored Geotechnical Axial Resistance at ULS and Geotechnical Resistance at SLS

For the anticipated design loads and with the presence of compressible overburden soils over till, the most feasible foundation will consist of piles driven into the underling till. A heavy steel pile such as a HP 310 x 110 piles is recommended. H-piles are expected to

penetrate the till to varying depths. Piles are to be driven under the requirements of Special Provision 903.S01.

Table 5 - Pile Design Capacities

Pile Designation	ULS Factored Geotechnical Axial Resistance	SLS Geotechnical Resistance for 25 mm
HP 310 x110	1800 kN	1450 kN

For refusal within the sand and gravel till material geotechnical axial resistance (ULS) verification shall be determined through the use of the Hiley Formula (Standard drawing SS1030-11) as per Section 903.08.01.02 of SSP903S01.

Table 6 – Estimated Pile Tip Elevation

Abutment	Estimated Effective Pile Tip m		Comments
	Depth*	Elevation	
North	21	76	Based on Borehole BC08-01 approx. 6 m from abutment location
South	17	80	Based on Borehole BC08-03 approx. 8 m from abutment location

* For top of pile at 97 m

Pile set should be verified in the field for the specific pile and pile driver combination in use. The depth to refusal should be expected to vary and the contractor should be prepared to drive piles of variable lengths.

Due to the presence of boulders in the sand and gravel stratum, and high stresses induced during driving through very dense sand and gravel and potentially into bedrock, the piles should be equipped with a driving shoe to prevent damage to the pile tip, such as a Titus Standard “H” Bearing Pile Point. The behaviour of the piles should be monitored during driving for any signs indicative of pile damage.

The presence of numerous cobbles and boulders within the sand and gravel and/or sloping bedrock, may cause the piles to “walk” during driving. Displaced piles will require review and potential replacement.

Piles should be spaced at least 2.5 pile widths apart (centre to centre).

Drag loads caused by negative skin friction are not anticipated at this site since no sustained wide spread and/or heavy concentrated surface loads are anticipated.

8 Stability Considerations

The existing approach embankments were constructed with side and fore slopes approaching the natural angle of repose. As such, the existing theoretical factor of safety is expected to be slightly above unity. This was confirmed using stability analysis methods (SLOPE/W software (Version 4.0, by Geo-Slope International Ltd.) and the following properties.

Table 7 – Stability Analyses - Soil Properties

Soil	Unit Weight (kN/m^3)	Undrained Shear Strength Parameters	Effective Strength Parameters
Existing Fill	20	N/A	c’ = 0 kPa, ϕ’ = 30°
Upper Silt	19	N/A	c’ = 0 kPa, ϕ’ = 29°
Clay	18	Cu at elev. 95 m = 20 kPa and increases linearly to 26 kPa at elev. 90.5 m and further increases linearly 50 kPa at elev. 84.0 m	c’ = 0 kPa, ϕ’ = 29°
Lower Silt	19	N/A	c’ = 0 kPa, ϕ’ = 30°
Sand and Gravel	20	N/A	c’ = 0 kPa, ϕ’ = 38°

Embankment loading conditions such as traffic loads have been considered for slope stability analysis. Traffic loads on the embankment have been modeled with a 12 kPa uniformly distributed pressure. Where the timber crib was analyzed, the foundation loads were included as provided by Cook Engineering.

To improve the stability of the embankment side and fore slopes, modification to the configuration of the embankment would be required. However, it is understood that embankment modifications are outside of the scope of this project. It is also understood that no historical stability related issues have been reported.

Stability analysis was carried out for the cribs located at the proposed locations (understood to be at Stations 10+279 and 10+320). Factors of safety of 1.1 and 1.0 are calculated when analysed using undrained strength parameters and effective strength parameters, respectively. These analyses were conducted without any alteration to the embankment fore slope extending to the river.

Stability conditions generally improve with an increase of distance from the embankment fore slope. Foundation elements were located at different stations in order to calculate a minimum theoretical factor of safety in terms of stability of a minimum of 1.3. Analysis was conducted with both the construction of a bench and without a bench for comparison purposes. The bench was modeled (in front of the foundation element) at an elevation 96.5 m from the foundation location to the embankment fore slope available soils data.

Table 8 – Foundation Element Locations Which Satisfy a Minimum Calculated Factor of Safety of 1.3

Foundation Element	Excavated Bench	Foundation Station		Estimated Span Between Foundations m
		North	South	
Piles	No	10+271.1	10+329.0	58
	Yes	10+273.1	10+327.0	54
Timber Crib	No	10+270.4	10+329.7	59
	Yes	10+274.4	10+325.7	51

The embankment fore slope inside of these locations (towards river) will continue to have a potential for sloughing and slope displacements, factors of safety less than 1.3.

9 Frost Protection

Based on the Ontario Provincial Standard Drawing 3090.1 “Foundation Frost Depth for Northern Ontario” the design frost depth is 2.6 m.

The soils within the frost depth at the abutment locations are considered to be of low to moderate frost susceptibility (MTO Pavement Design and Rehabilitation Manual).

10 Scour Protection

Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated creek levels. Scour protection should be designed in accordance with Section 1.10.5 of the Canadian Highway Bridge Design Code

11 Dewatering and Excavations

Excavations for the timber crib installations should be carried out and sloped in accordance with the requirements of the Occupational Health and Safety act.

Based on anticipated construction configurations, excavations are anticipated to go slightly below current groundwater levels. It is anticipated any seepage encountered should be handled using conventional sump and pump dewatering methods.

12 Backfill

Backfill below the pavement structure should consist of materials meeting OPSS specifications for Granular A or Granular B, Type 2 or Type 3.

13 Red Flag Issues

The embankment is constructed of fill materials of unknown consistency. There is a possibility that a zone of debris or very soft soils may be encountered.

The above comments are not intended to include all critical issues that may become apparent during the construction of this project. The responsibility to deliver acceptable construction quality remains with the contractor.

14 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

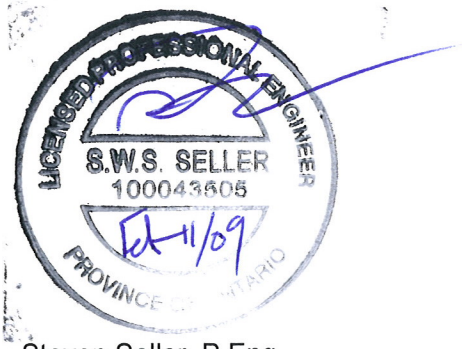
Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

15 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING



Steven Seller, P.Eng
Geotechnical Engineering

Wayne Hurley, P. Eng
Vice-President, Engineering

Gordon Maki, P.Eng.
Manager of Foundation Engineering

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MTO Special Provisions and Drawings

Special Provision 903.S01 (Pile Installations)

OPSS 1010 (Material Specifications)

APPENDIX A

BOREHOLE LOGS

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.

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

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

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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

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RECORD OF Borehole No BC08-01 1 OF 2 METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+325.2 o/s 4.0 m Lt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 23, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.9								
0.0	FILL - SAND - Silty, trace gravel, brown, loose		1	AS				Water level @ 2.6 m on completion. Cave @ 14.5 m. 6 68 (27)
			2	SS	7			
			3	SS	9			
95.8								
2.1	SAND - trace silt, brown, loose		4	SS	9	▼		
			5	SS	4			0 98 (2)
94.3								
3.6	CLAY - Silty, grey, firm		6	SS	1			
			7	SS	1			
			8	TW				
			9	SS	1			
			10	SS	4			
			11	SS	5			
86.1								
11.8	SILT - trace sand, occasional cobbles, grey, loose		12	SS	4			
			13	SS	9			

ELEVATION SCALE: 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

Continued Next Page

×³, ★³: Numbers refer to Sensitivity
NP Non Plastic
○ 3% STRAIN AT FAILURE

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RECORD OF Borehole No BC08-01 2 OF 2 METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+325.2 o/s 4.0 m Lt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 23, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.4			14	SS	4		82				
16.5	GRAVEL - trace sand, trace silt, numerous cobbles, brown, dense to very dense		15	SS	46		81				88 9 (3)
			16	SS	100+		80	>>			Auger refusal @ 17.3 m. BH advanced with casing.
			17	SS	100+		79	>>			
76.4			18	SS	100+		78	>>			
21.5	End of Borehole @ 21.5 m.						77				

$\times^3$, $\star^3$: Numbers refer to Sensitivity
NP Non Plastic
$\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH-10 08-085 BASS CREEK BRIDGE.GPJ ON_MOT.GDT 1/22/09

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RECORD OF Borehole No BC08-02

1 OF 2

METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+319.7 o/s 9.0m Rt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 24, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.4								
96.0 / 0.1	TOPSOIL - 75 mm							Water level @ 2.6 m on completion. Cave @ 5.8 m.
	SILT & SAND - brown, loose to very loose		1	AS				
			2	SS	8			
			3	SS	3			
94.2								
2.2	CLAY - brown, soft to firm		4	SS	2	▼		
	- - - - -		5	TW				
	- grey		6	SS	1			
			7	TW				
			8	SS	2			
	- - - - -		9	SS	4			
	- Silty		10	SS	1			
	- - - - -		11	SS	4			
	- stiff							
84.6								
11.8	SILT - some gravel, some sand, trace clay, occasional cobbles, loose to compact		12	SS	8			
			13	SS	26			15 13 (72)
81.4								

ELEVATION SCALE: 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

Continued Next Page

×³, ★³: Numbers refer to Sensitivity

NP Non Plastic

○ 3% STRAIN AT FAILURE

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RECORD OF Borehole No BC08-02

2 OF 2 **METRIC**

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+319.7 o/s 9.0m Rt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 24, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L WATER CONTENT (%) 20 40 60	γ kN/m³	GR SA SI CL
15.0	SAND - some silt, trace gravel, grey, very dense		14	SS	63		81				7 73 (20)
80.2			15	SS	100+			>>			
16.2	End of Borehole @ 16.2 m. Auger Refusal.										

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE

$\times^3$, $\star^3$: Numbers refer to Sensitivity
NP Non Plastic
$\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF Borehole No BC08-03

1 OF 2

METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+272.0 o/s 3.0m Lt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 28, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
98.5							
0.0	FILL - SAND - Silty, trace gravel, brown, very loose to compact		1	AS			98
			2	SS	1		
			3	SS	10		97
			4	SS	9	▼	96
95.6							
2.9	SILT & SAND - brown, very loose		5	SS	4		95
94.7							
3.8	CLAY - brown, firm		6	SS	5		
	- 150 mm sand layer		7	SS	1		94
	- - - - -		8	SS	1		93
	- grey		9	TW			92
89.8							91
8.7	SILT - trace sand, grey, loose to compact		10	SS	10		90
			11	SS	9		89
			12	SS	10		88
			13	SS	11		87
							86
							85
							84

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ✕ FIELD VANE
■ SPT (N) ★ LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Water level @ 2.7 m 1 hr after completion. Cave @ 15.0 m on completion.

3 76 (21)

0 7 (94)

Continued Next Page

✕³, ★³: Numbers refer to Sensitivity
NP Non Plastic
○ 3% STRAIN AT FAILURE

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RECORD OF Borehole No BC08-03

2 OF 2 **METRIC**

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+272.0 o/s 3.0m Lt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **July 28, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	- 10 mm clay layer		14	SS	15		83				
			15	SS	10		82				0 5 (95)
80.8							81				
17.7	SAND & GRAVEL - some silt, grey, very dense		16	SS	100+		80	>>			
79.7											
18.8	BEDROCK - Meta Sedimentary from a migmatite-gneiss suite of the Quetico Sub-province		1	RC			79				Auger Refusal @ 18.5 m. RC # 1 REC = 100% RQD = 47%
			2	RC			78				RC # 2 REC = 100% RQD = 58%
77.1											
21.4	End of Borehole @ 21.4 m.										

$\times^3$, $\star^3$: Numbers refer to Sensitivity
NP Non Plastic

$\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH-10 08-085 BASS CREEK BRIDGE.GPJ ON_MOT.GDT 1/22/09

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RECORD OF Borehole No BC08-04

1 OF 1

METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+278.4 o/s 2.0m Rt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **August 25, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
97.9						
0.0	FILL - SAND - Gravelly, trace silt, occasional cobbles, brown, loose		1	AS		
			2	SS	6	
			3	SS	6	
			4	SS	4	
95.0						
2.9	SILT & SAND - brown, loose		5	SS	5	
			6	SS	8	
93.3						▼
4.6	CLAY - Silty, very stiff		7	SS	2	
91.9						
6.0	SILT - trace organics, brown, loose		8	SS	7	
90.9						
7.0	CLAY - Silty, brown, stiff		9	SS	3	
89.3						
8.6	SILT - trace sand, grey, loose		10	SS	7	
88.1						
9.8	End of Borehole @ 9.8 m.					

ELEVATION SCALE: 97, 96, 95, 94, 93, 92, 91, 90, 89

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100
- ○ UNCONFINED
- ■ SPT (N)
- × FIELD VANE
- ★ LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
Water level @ 4.4 m on completion.				
	29	64		(7)
	0	39		(61)
Non Plastic				

$\times^3$, $\star^3$: Numbers refer to Sensitivity
NP Non Plastic
$\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH-10 08-085 BASS CREEK BRIDGE.GPJ ON_MOT.GDT 1/22/09

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RECORD OF Borehole No BC08-05

1 OF 1

METRIC

W.P. **476 00 00** PROJECT **Bass Creek Bridge** SITE NO. **48C-043** ORIGINATED BY **HF**

DIST **61** HWY **585** LOCATION **10+321.9 o/s 2.0m Rt Booth Twp** TBTE JOB# **08-085** COMPILED BY **TB**

DATE **August 25, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Local** CHECKED BY **SS**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
97.8						
0.0	FILL - SILT- Sandy, brown, compact		1	AS		
			2	SS	15	
			3	SS	10	
	- - - - -					
	- SAND - trace silt, compact, brown		4	SS	11	
95.0						
2.8	CLAY - Silty, grey, soft to firm		5	SS	1	
			6	SS	1	
			7	SS	1	
			8	SS	1	
			9	SS	2	
89.5						
8.3	End of Borehole @ 8.3 m.					

ELEVATION SCALE: 97, 96, 95, 94, 93, 92, 91, 90

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

	GR	SA	SI	CL
No water observed.				
	0	23		(77)
	0	91		(9)

$\times^3$, $\star^3$: Numbers refer to Sensitivity

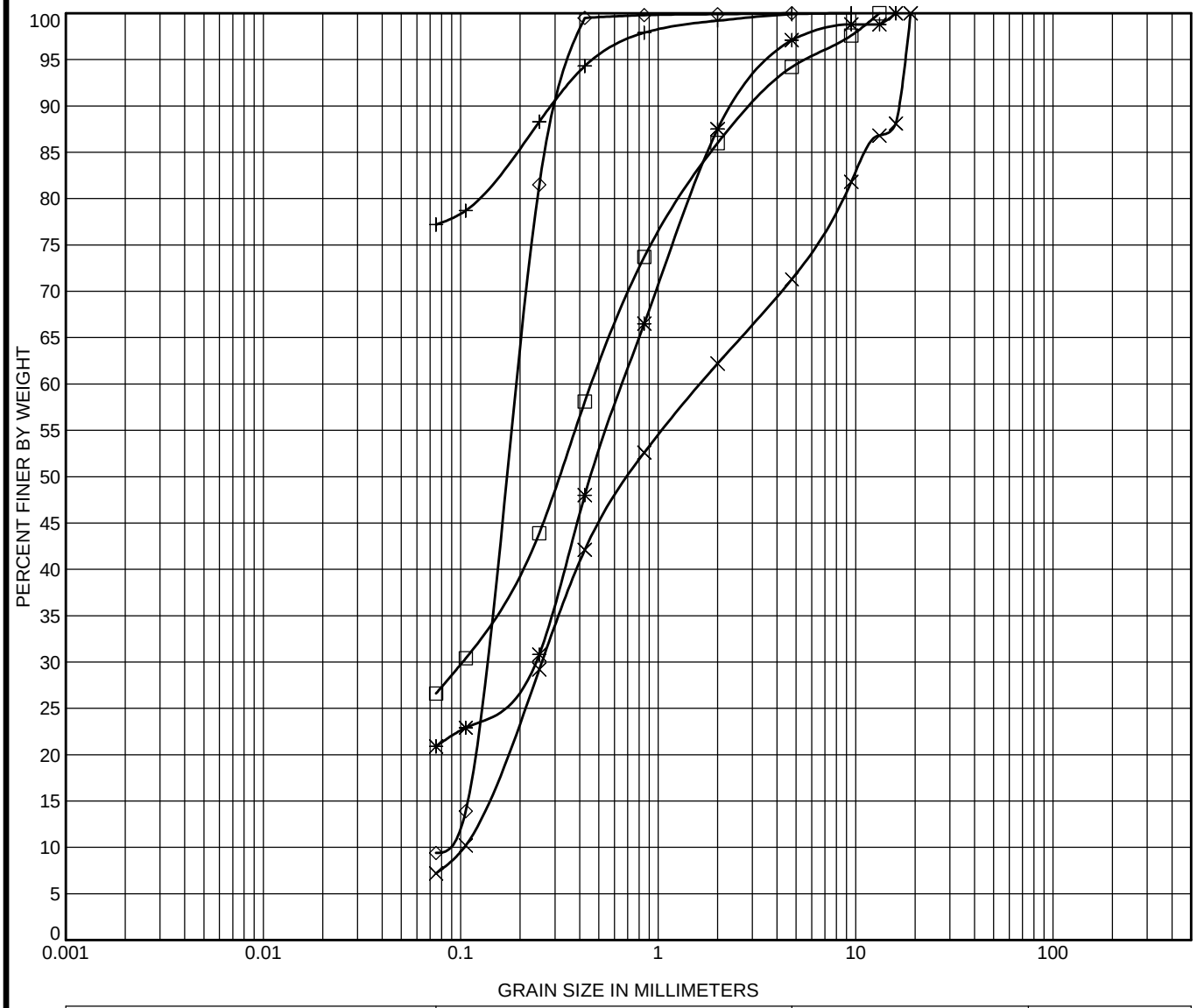
NP Non Plastic

$\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT_BH-10 08-085 BASS CREEK BRIDGE.GPJ ON_MOT.GDT 1/22/09

APPENDIX B

Laboratory Test Data



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
FILL

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**BC08-01**	**0.75**	**13.2**	**0.462**	**0.102**		**5.8**	**67.6**	**26.6**	
✳	**BC08-03**	**1.50**	**16**	**0.666**	**0.229**		**2.9**	**76.2**	**20.9**	
×	**BC08-04**	**0.70**	**19**	**1.644**	**0.258**	**0.104**	**28.7**	**64.1**	**7.2**	
+	**BC08-05**	**1.50**	**9.5**				**0.1**	**22.7**	**77.2**	
◇	**BC08-05**	**2.30**	**4.75**	**0.19**	**0.13**	**0.079**	**0.0**	**90.6**	**9.4**	

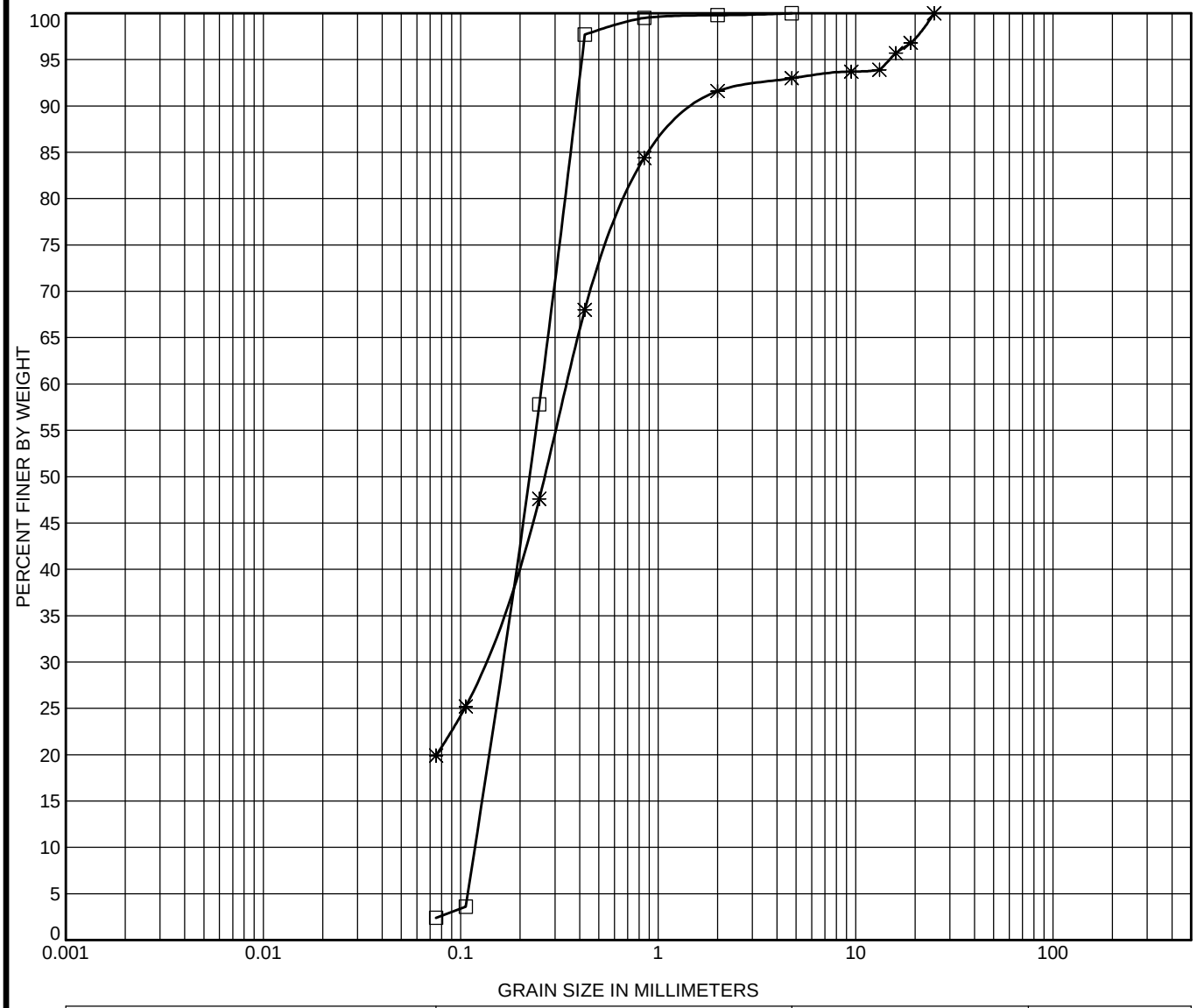
TBT Engineering Consulting Group
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Bass Creek Bridge

W P: 476 00 00

DIST: 61 HWY: 585



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
SAND

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**BC08-01**	**3.00**	**4.75**	**0.257**	**0.161**	**0.117**	**0.0**	**97.6**	**2.4**	
✳	**BC08-02**	**15.20**	**25**	**0.345**	**0.127**		**7.0**	**73.1**	**19.9**	

TBT Engineering Consulting Group
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Bass Creek Bridge

W P: 476 00 00

DIST: 61 HWY: 585

SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
SILT & SAND

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
☐ **BC08-04**	**3.00**	**9.5**				**0.4**	**38.7**	**60.9**	

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101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Bass Creek Bridge

W P: 476 00 00

DIST: 61 HWY: 585

SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
SILT

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ **BC08-02**	**13.70**	**37.5**				**15.2**	**12.5**	**72.3**	
✳ **BC08-03**	**10.70**	**2**				**0.0**	**6.5**	**93.5**	
× **BC08-03**	**16.70**	**2**				**0.0**	**5.1**	**94.9**	

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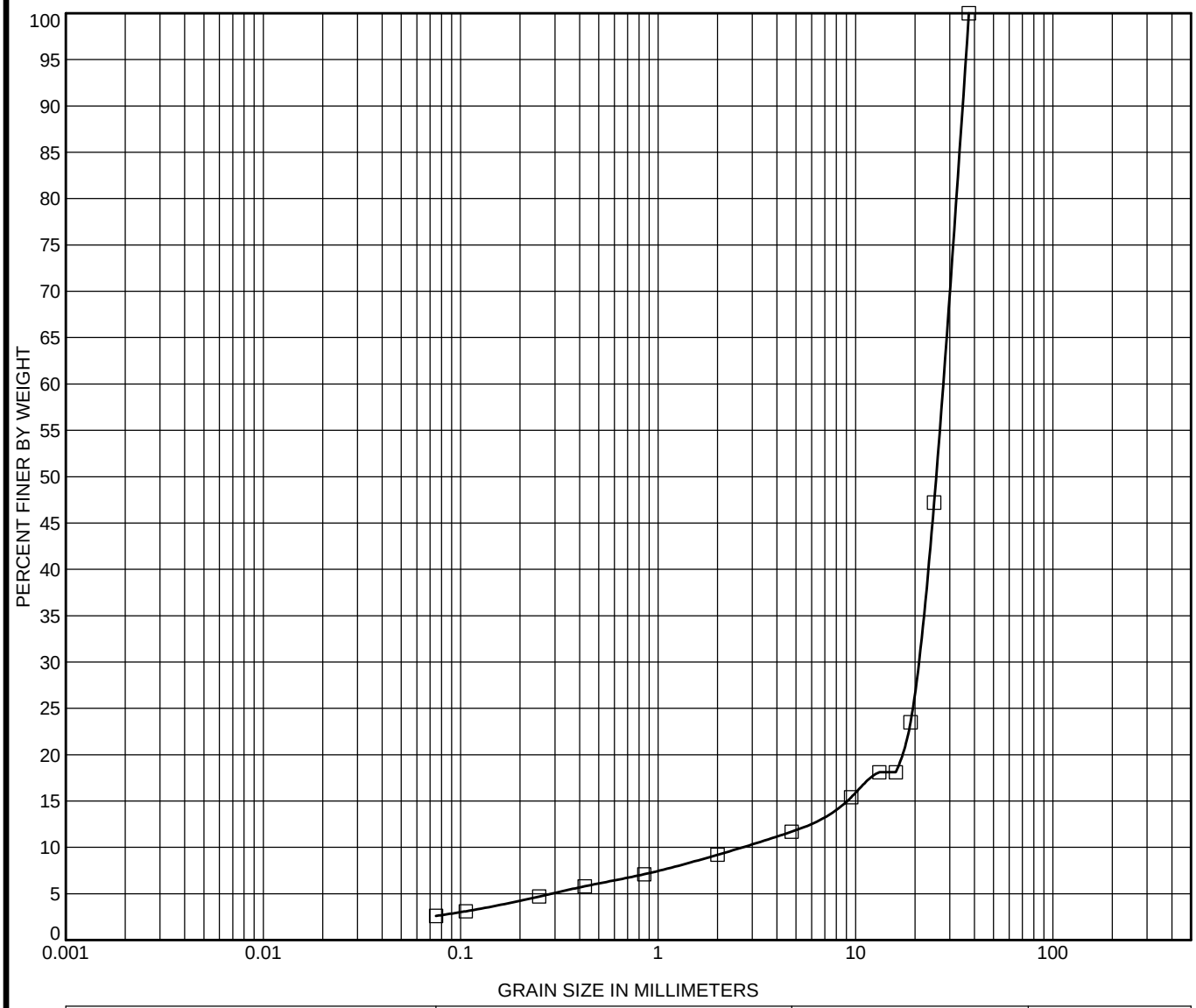
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Bass Creek Bridge

W P: 476 00 00

DIST: 61 HWY: 585



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
GRAVEL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
☐ **BC08-01**	**16.70**	**37.5**	**27.582**	**20.485**	**2.638**	**88.3**	**9.1**	**2.6**	

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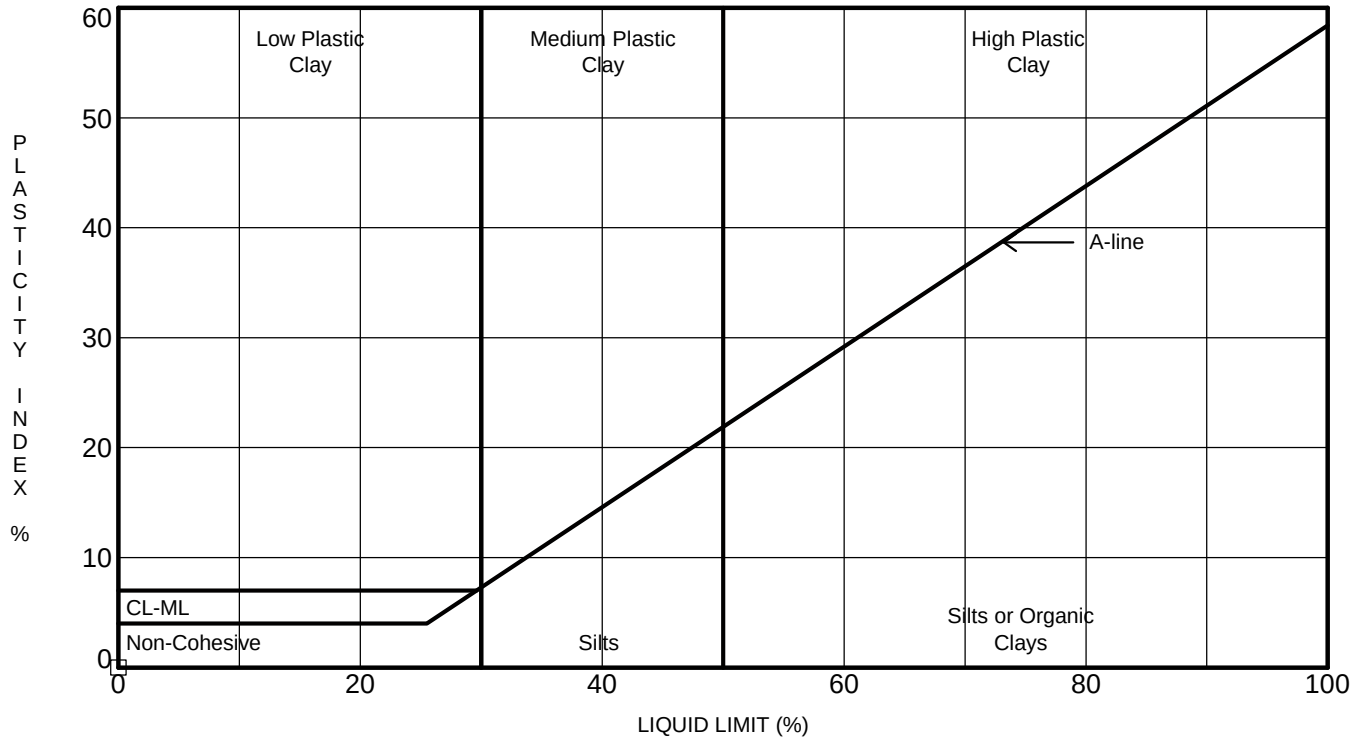
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-624-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Bass Creek Bridge

W P: 476 00 00

DIST: 61 HWY: 585



Remarks:
NON-PLASTIC

	Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
☐	**BC08-04**		**6.10**	**NP**	**NP**	**NP**	**41**

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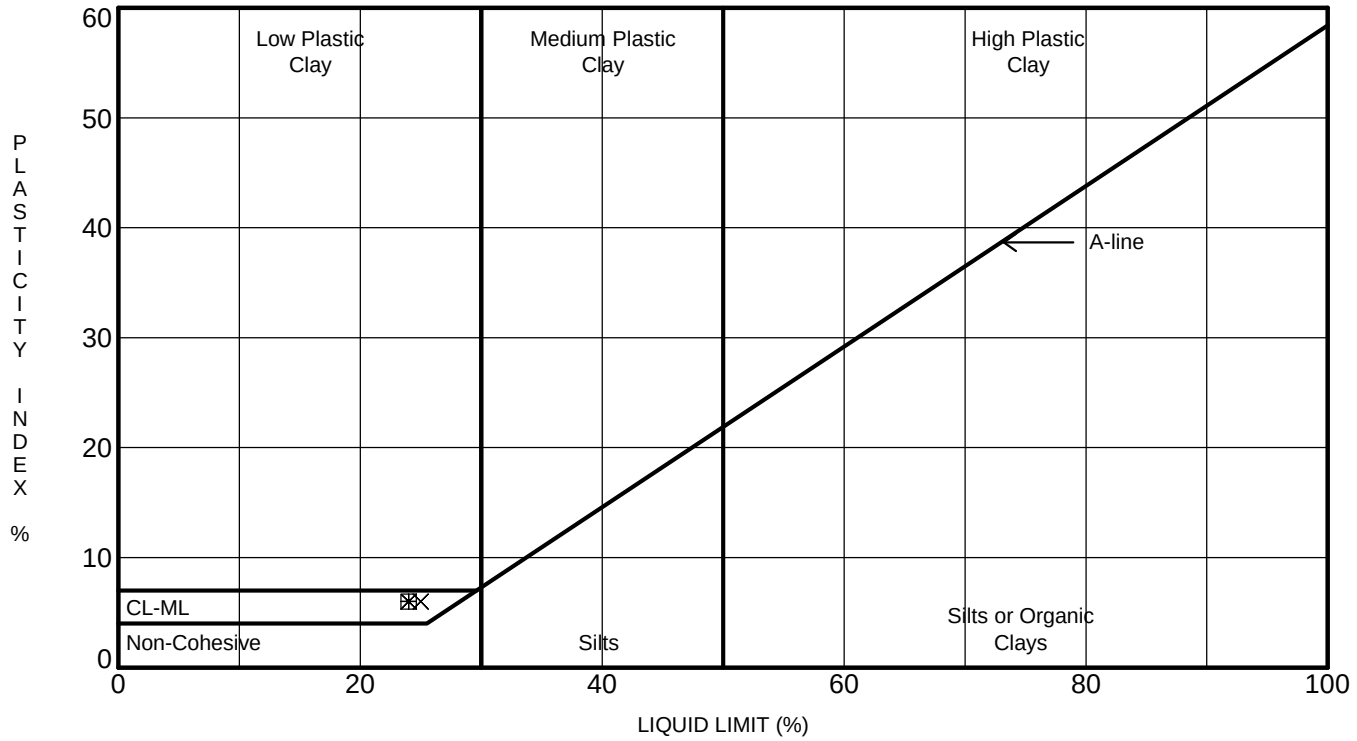
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

ATTERBERG LIMIT RESULTS

W P: 476 00 00

District: 61

Highway: 585



Remarks:
Silty CLAY

	Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
□	**BC08-02**		**7.60**	**24**	**18**	**6**	**30**
✳	**BC08-04**		**4.60**	**24**	**18**	**6**	**29**
×	**BC08-05**		**6.10**	**25**	**19**	**6**	**32**

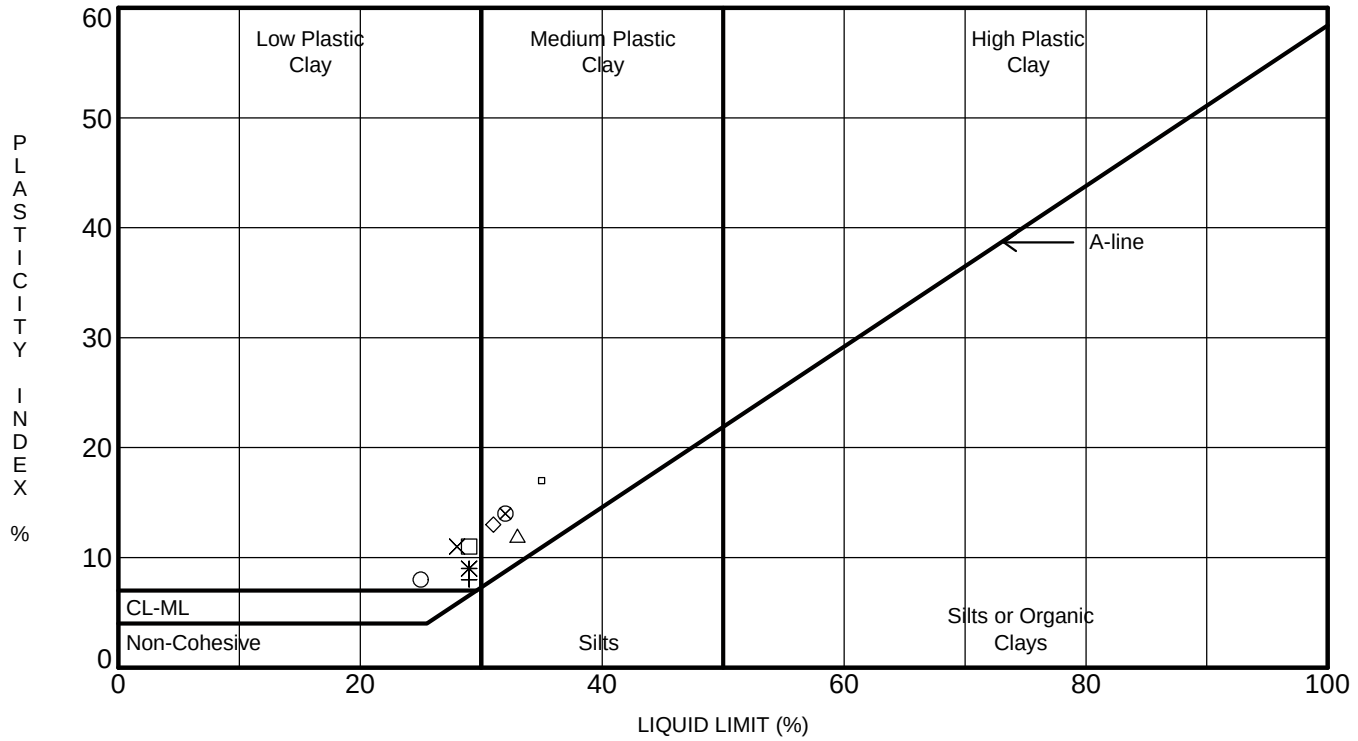
TBT Engineering Consulting Group
101 Syndicate Avenue North
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

ATTERBERG LIMIT RESULTS

W P: 476 00 00

District: 61

Highway: 585



Remarks:
CLAY

	Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
□	**BC08-01**		**4.50**	**29**	**18**	**11**	**37**
✳	**BC08-01**		**6.10**	**29**	**20**	**9**	**47**
×	**BC08-01**		**10.70**	**28**	**17**	**11**	**34**
+	**BC08-02**		**2.30**	**29**	**21**	**8**	**32**
◇	**BC08-03**		**6.10**	**31**	**18**	**13**	**38**
△	**BC08-03**		**7.60**	**33**	**21**	**12**	**42**
○	**BC08-04**		**7.60**	**25**	**17**	**8**	**24**
▫	**BC08-05**		**3.00**	**35**	**18**	**17**	**40**
⊗	**BC08-05**		**7.60**	**32**	**18**	**14**	**30**

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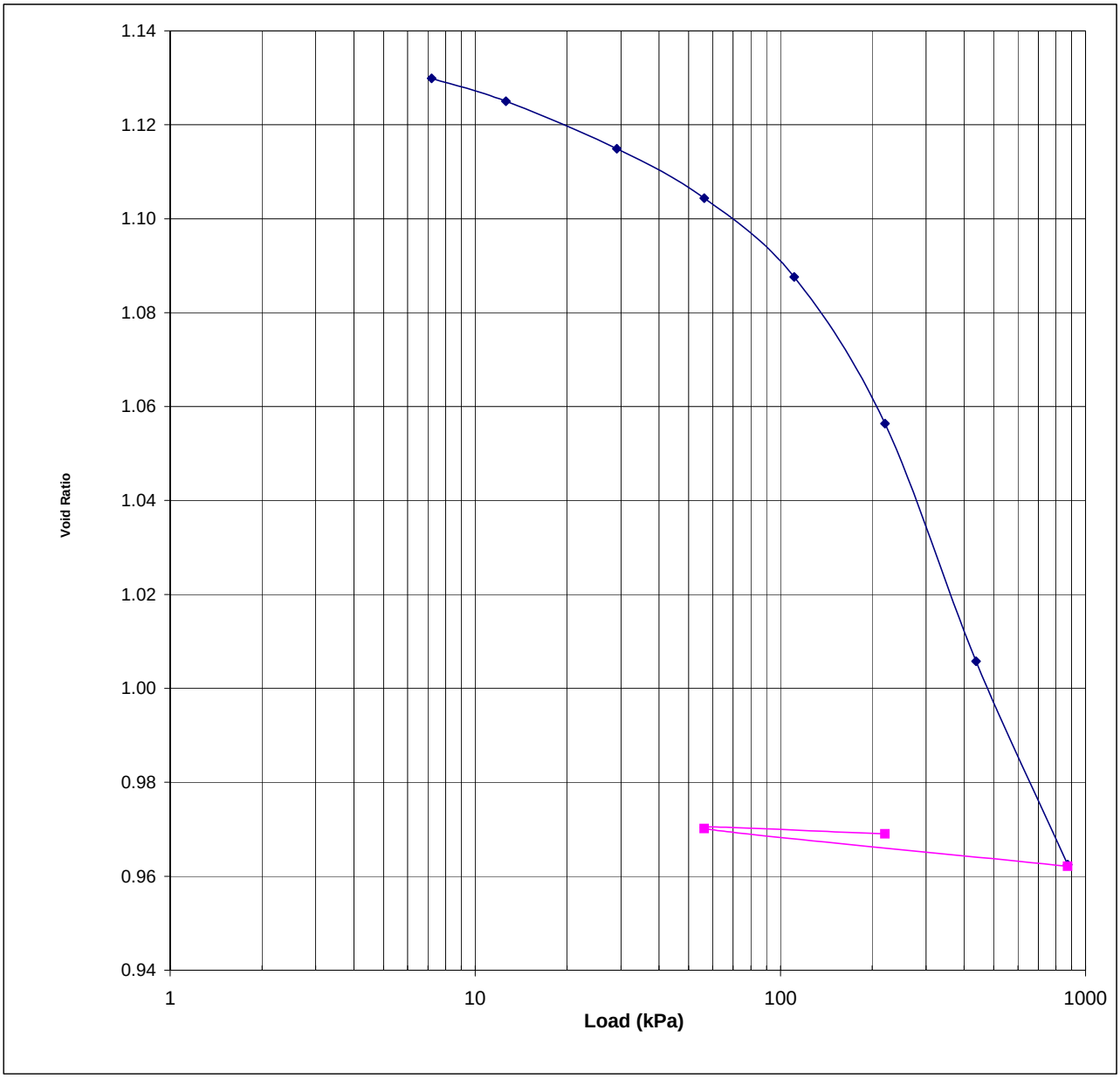
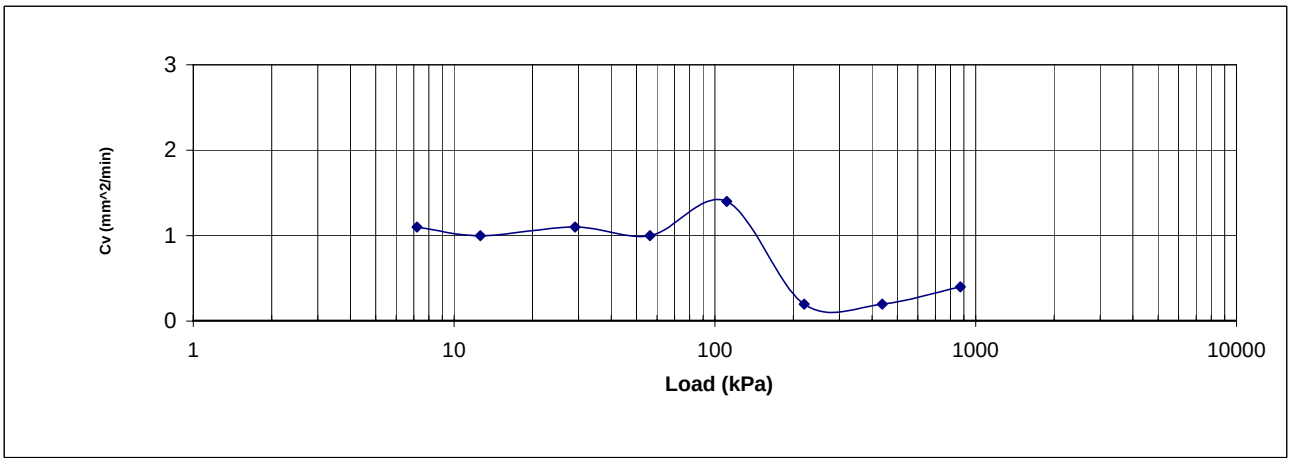
ATTERBERG LIMIT RESULTS

W P: 476 00 00

District: 61

Highway: 585



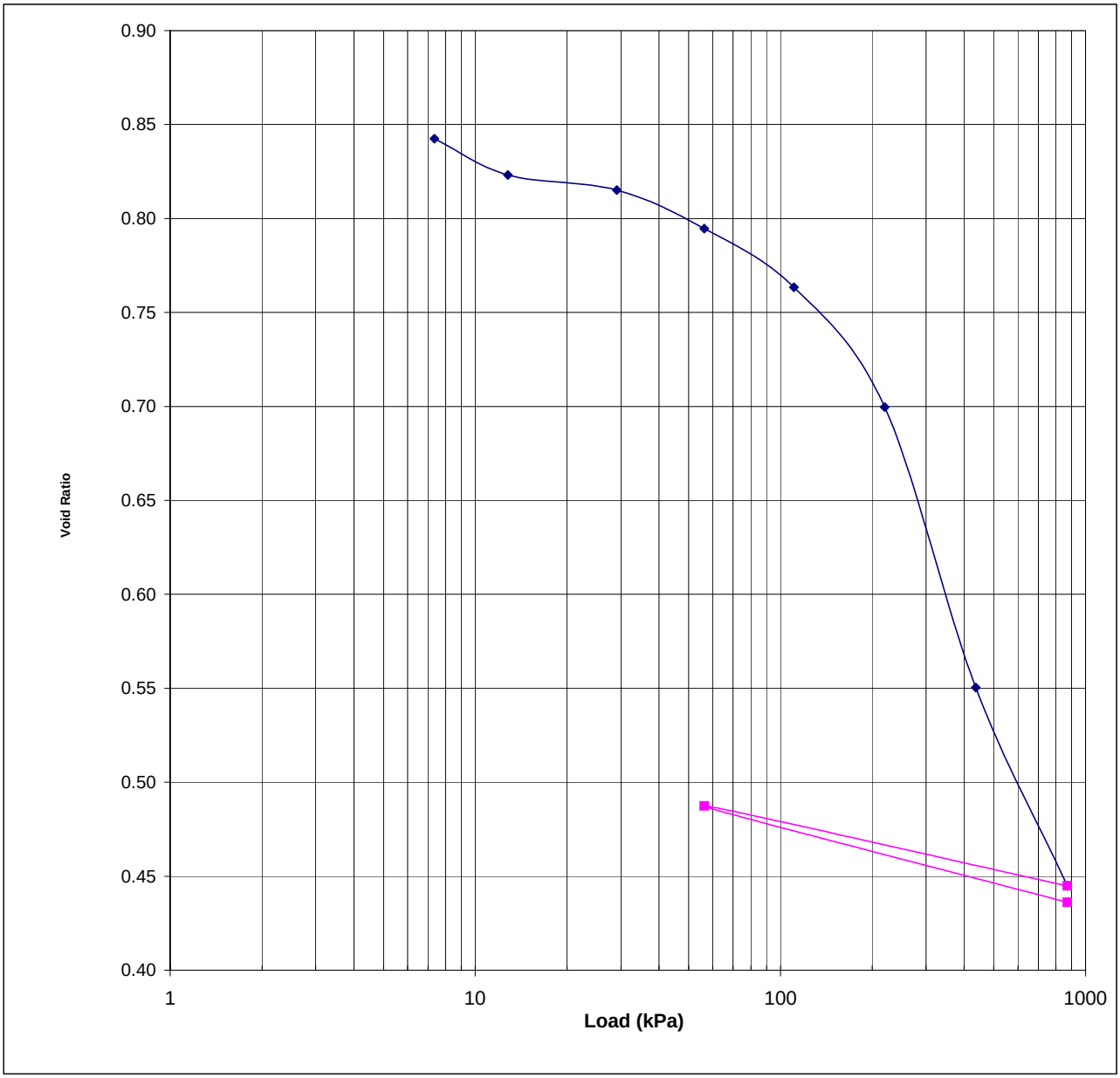


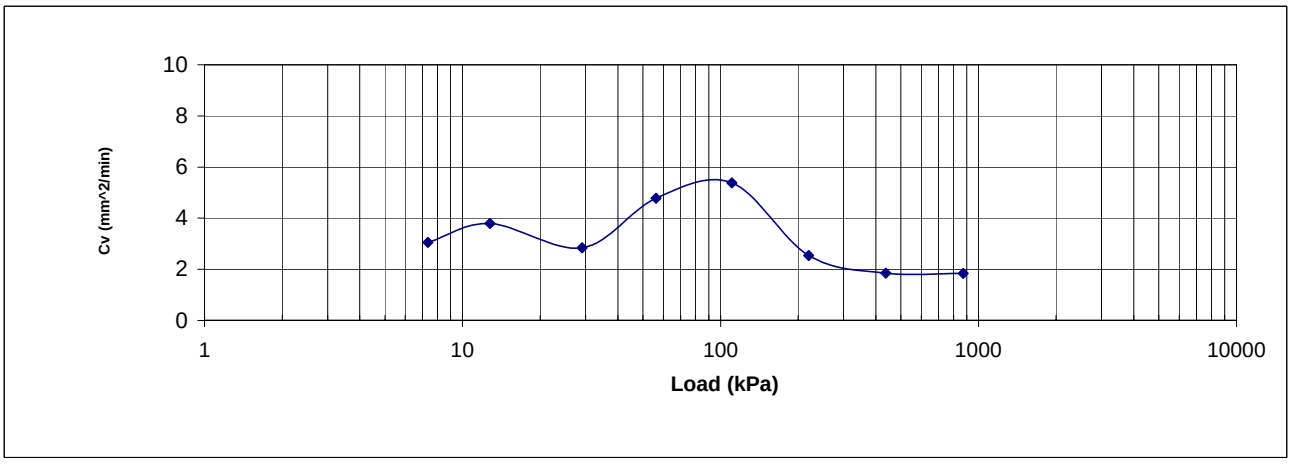
CONSOLIDATION TEST
MTO - Bass Creek Highway 585

Borehole: BC08-01 TW8 Depth: 6.1 Lab No. 08-594

Project No.: 08-085

GWP 476-00-00





CONSOLIDATION TEST
MTO - Bass Creek Highway 585

Borehole: BC08-03 TW 9 Depth: 7.6 m Lab No. 08-640

Project No.: 08-085

GWP 476-00-00

APPENDIX C

Borehole Locations and Soil Strata Drawings

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

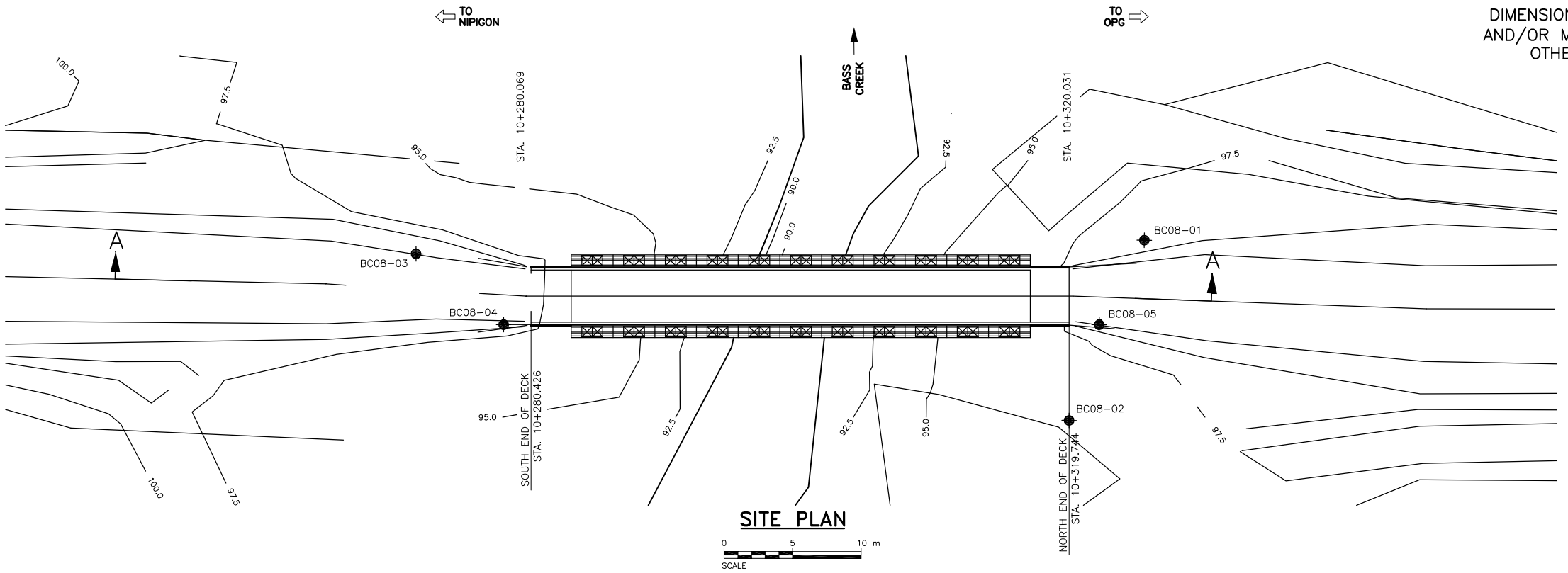
DIST	No. 61	HWY No. 585	
CONT	No. 200x–xx		
WP	No. 476 00 00		

BASS CREEK BRIDGE
HWY 585
STRUCTURE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

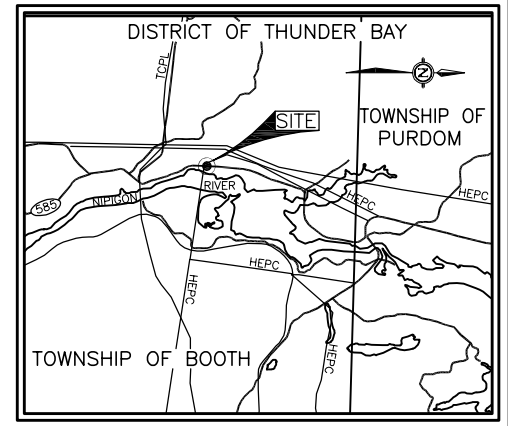
Ontario — Ministry of Transportation, Northwestern Region, Structural Section

TBT ENGINEERING CONSULTING GROUP



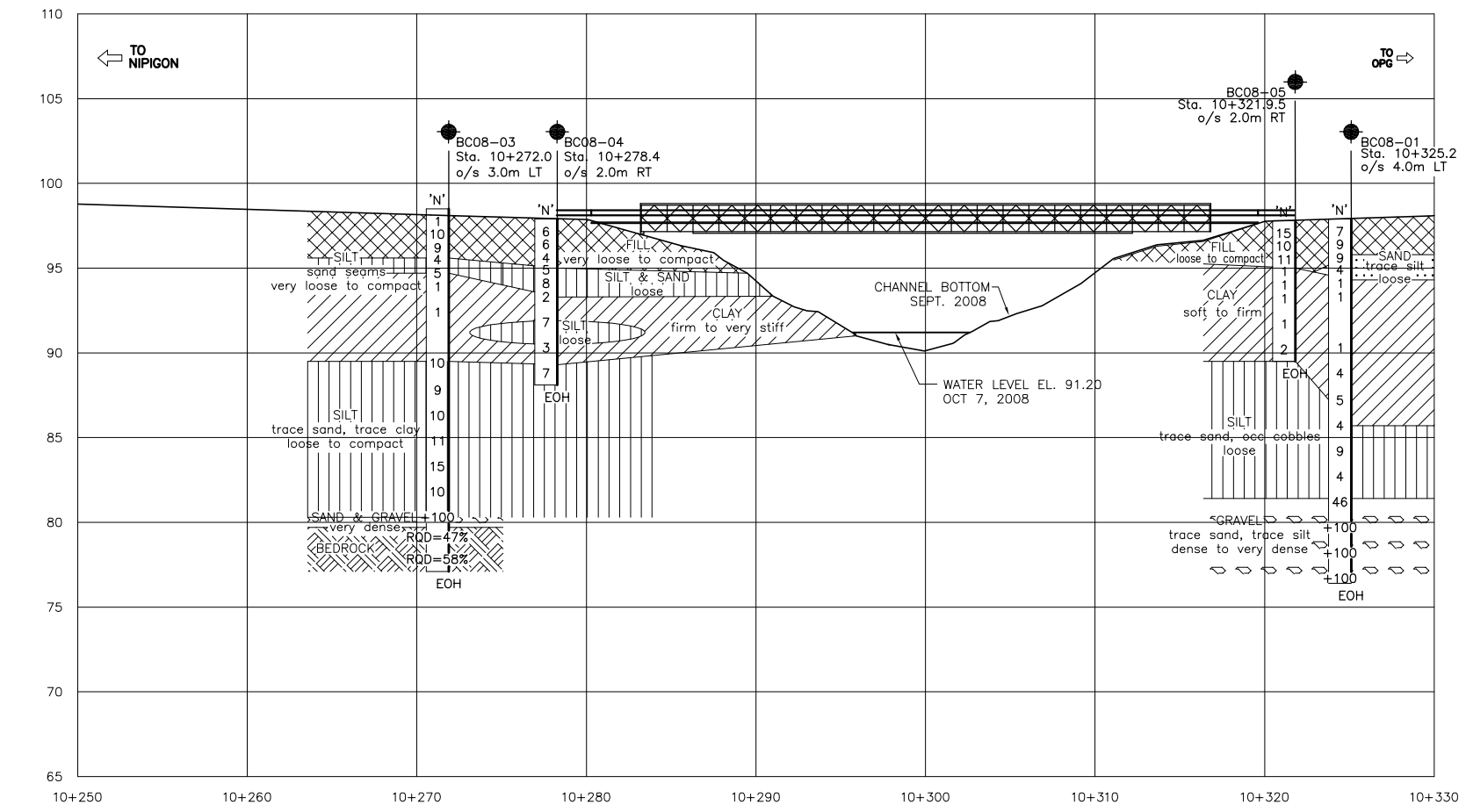
SITE PLAN

SCALE 0 5 10 m



KEY PLAN

2.0 km 0 2.0 km



SECTION A–A

SCALE 0 5 10 m

B.M. 302 – EL.100.000
RR SPIKE IN 0.45 POPLAR
STA. 10+334.988 23.160 RT.

SOIL STRATA SYMBOLS

TOPSOIL · SAND · FILL · SAND & GRAVEL · GRAVEL · BEDROCK · SILT

LEGEND

- Borehole
- 'N' Std Pen Test (Blows/0.3m)
- Water Level
- NFP No Further Progress
- EOH End of Hole

No	ELEVATION	STATION	OFFSET
BC08–01	97.9	10+325.2	4.0 LT
BC08–02	96.4	10+319.7	9.0 RT
BC08–03	98.5	10+272.0	3.0 LT
BC08–04	97.9	10+278.4	2.0 RT
BC08–05	97.8	10+321.9	2.0 RT

REFERENCE DRAWING SUPPLIED BY COOK ENGINEERING LTD.

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

REVISIONS			
11/02/09	SS	ISSUED FOR REPORT	
22/01/09	TB	REVIEW	
		DESCRIPTION	

DESIGN		CHK		CODE XXXXX–XX	LOAD XX–XXX–XXX	DATE XXXXXXX	
DRAWN	TB	CHK	SS	SITE 48C–04B		DWG	X

APPENDIX D

Slope Stability Models

Title: Bass Creek Centerline
Comments: Crib Location at 10+274.4 Bench Included
Name: DN NS CL Bass LT 10+274.4 Bench.gsz
Method: Morgenstern-Price
Horz Seismic Load: Horz Seismic Load: 0
PWP Option: PiezometricLine
Factor of Safety: 1.3

Material #: 1
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 1

Material #: 2
Description: Existing Fill
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Upper Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 29
Piezometric Line: 1

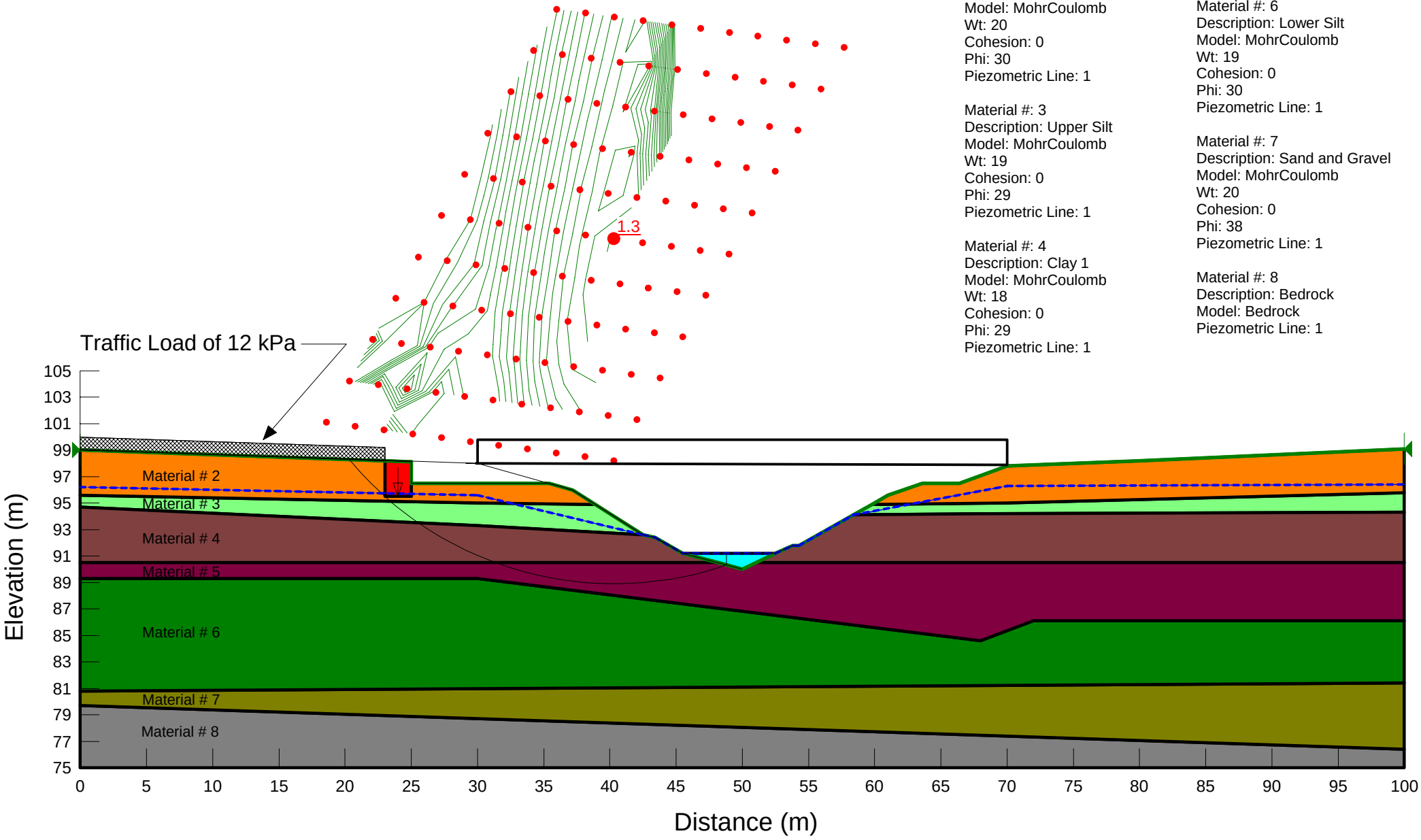
Material #: 4
Description: Clay 1
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 29
Piezometric Line: 1

Material #: 5
Description: Clay 2
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 29
Piezometric Line: 1

Material #: 6
Description: Lower Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 7
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 38
Piezometric Line: 1

Material #: 8
Description: Bedrock
Model: Bedrock
Piezometric Line: 1



Title: Bass Creek Centerline
Comments:
Name: UN NS CL Bass LT 10+270.4No Bench.gsz
Method: Morgenstern-Price
Horz Seismic Load: Horz Seismic Load: 0
PWP Option: PiezometricLine
Factor of Safety: 1.3

Material #: 1
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 1

Material #: 2
Description: Existing Fill
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Upper Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 29
Piezometric Line: 1

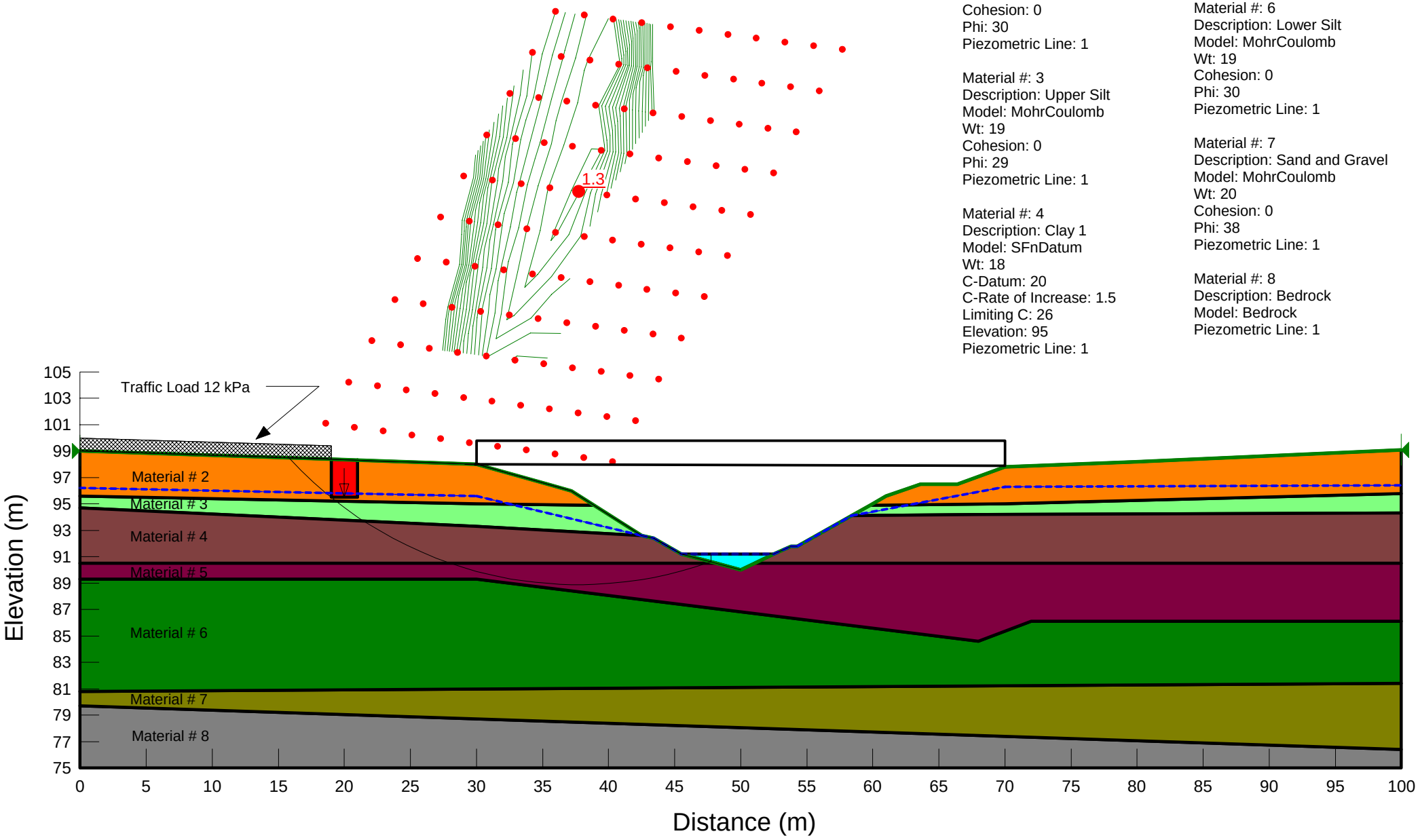
Material #: 4
Description: Clay 1
Model: SFnDatum
Wt: 18
C-Datum: 20
C-Rate of Increase: 1.5
Limiting C: 26
Elevation: 95
Piezometric Line: 1

Material #: 5
Description: Clay 2
Model: SFnDatum
Wt: 18
C-Datum: 26
C-Rate of Increase: 3.7
Limiting C: 50
Elevation: 90.5
Piezometric Line: 1

Material #: 6
Description: Lower Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 7
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 38
Piezometric Line: 1

Material #: 8
Description: Bedrock
Model: Bedrock
Piezometric Line: 1



Title: Bass Creek Centerline
Comments:
Name: DN NS CL Bass LT 10+270.4 No Bench.gsz
Method: Morgenstern-Price
Horz Seismic Load: Horz Seismic Load: 0
PWP Option: PiezometricLine
Factor of Safety: 1.4

Material #: 1
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 1

Material #: 2
Description: Existing Fill
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Upper Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 29
Piezometric Line: 1

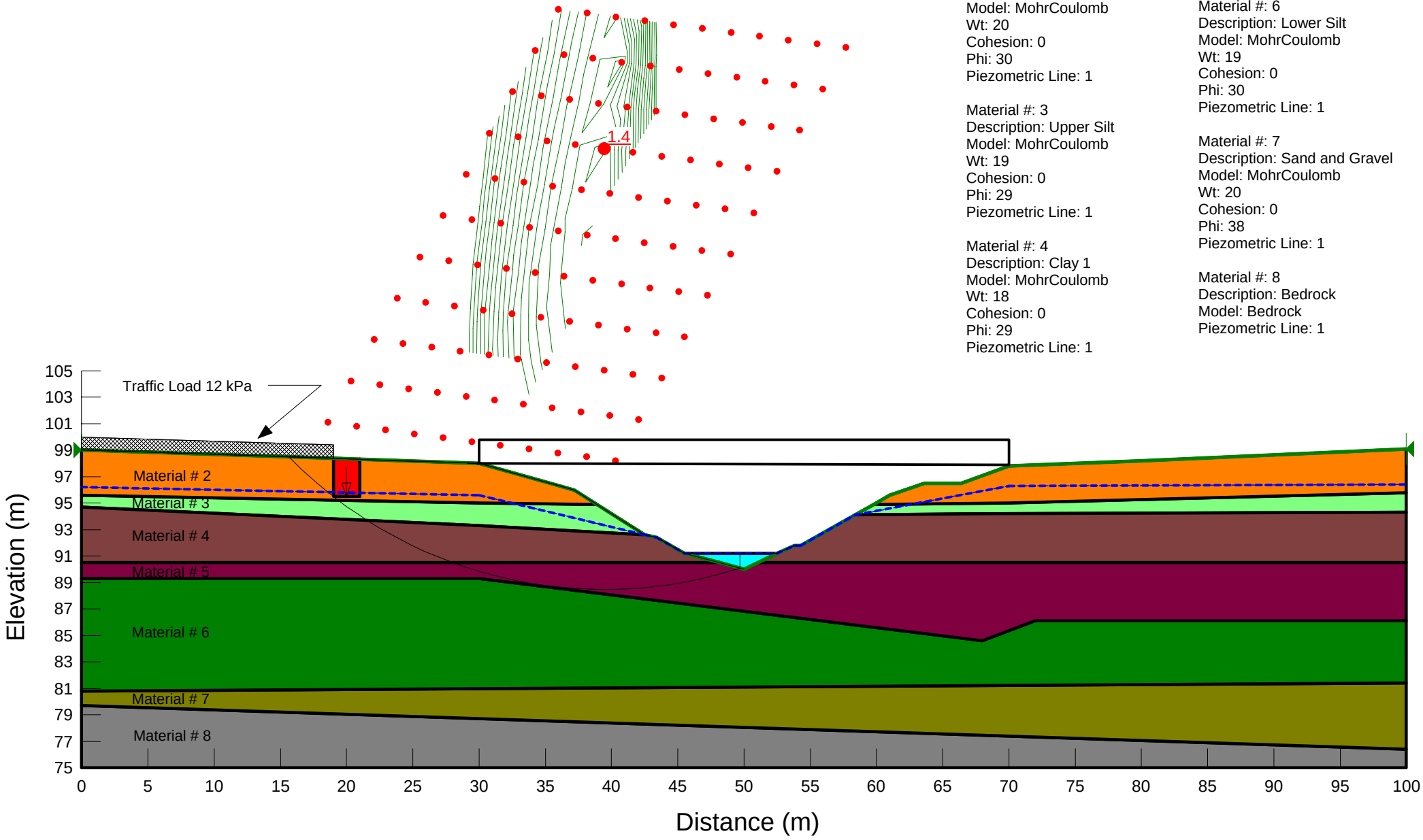
Material #: 4
Description: Clay 1
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 29
Piezometric Line: 1

Material #: 5
Description: Clay 2
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 29
Piezometric Line: 1

Material #: 6
Description: Lower Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 7
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 38
Piezometric Line: 1

Material #: 8
Description: Bedrock
Model: Bedrock
Piezometric Line: 1



Title: Bass Creek Centerline
Comments: Crib Location at 10+274.4 Bench Included
Name: UN NS CL Bass LT 10+274.4 Bench.gsz
Method: Morgenstern-Price
Horz Seismic Load: Horz Seismic Load: 0
PWP Option: PiezometricLine
Factor of Safety: 1.4

Material #: 1
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 1

Material #: 2
Description: Existing Fill
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Upper Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 29
Piezometric Line: 1

Material #: 4
Description: Clay 1
Model: SFnDatum
Wt: 18
C-Datum: 20
C-Rate of Increase: 1.5
Limiting C: 26
Elevation: 95
Piezometric Line: 1

Material #: 5
Description: Clay 2
Model: SFnDatum
Wt: 18
C-Datum: 26
C-Rate of Increase: 3.7
Limiting C: 50
Elevation: 90.5
Piezometric Line: 1

Material #: 6
Description: Lower Silt
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 7
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 38
Piezometric Line: 1

Material #: 8
Description: Bedrock
Model: Bedrock
Piezometric Line: 1