A TETRA TECH COMPANY

June 6, 2012

ISSUED FOR USE
EBA FILE: W14101624

Yukon Government
Highways and Public Works – Transportation Engineering Branch
461 Range Road
Whitehorse, Yukon Y1A 3A4

Via Email: muhammad.idrees@gov.yk.ca

Attention: Mr. Muhammad Idrees, Geotechnical Program Manager

Subject: Final Geotechnical Evaluation and Pile Design
Tatchun Creek Bridge – km 382 North Klondike Highway, Yukon

1.0 INTRODUCTION

1.1 General

Yukon Government, Department of Highways and Public Works – Transportation Engineering Branch (YG) retained EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA), to complete a geotechnical evaluation and pile design for the proposed new Tatchun Creek bridge located at km 382 on the North Klondike Highway in Yukon.

This report presents the subsurface soil conditions encountered during the geotechnical investigation conducted on site, and includes recommendations for pile design and installation. For additional conditions regarding use of this report, please refer to EBA's General Conditions included in Appendix A.

1.2 Project Details

EBA understands YG intends to construct a new bridge to replace the existing single span structure built in 1959. The new single span bridge is going to be longer than the existing bridge, but in the same location, and will be founded on driven steel pipe piles.

The site is located at Tatchun Creek, km 382 on the North Klondike Highway, approximately 25 km north of Carmacks, Yukon. The approximate UTM coordinates (NAD 83 datum) of the site are 6,906,370 N and 431,970 E in Zone 8 on mapsheet 115 I/8.

1.3 Scope of Services

EBA's scope of services for this project was presented to YG in the Proposal for Geotechnical Services submitted on August 18, 2011 and is summarized below:

Phase 1: Conceptual Design and Geotechnical Site Investigation

- Review existing available geotechnical information for the subject site
- Determine additional geotechnical information requirements based on existing information

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- Prepare a geotechnical investigation plan to obtain the required additional geotechnical information
- Provide qualified staff to direct drilling program, collect samples, and prepare borehole logs
- Present and discuss conceptual design based on geotechnical investigation findings

Phase 2: Final Design and Tender Documents

- Prepare geotechnical report containing pile design
- Provide geotechnical support throughout the design process
- Respond to any enquiries related to the design during tendering

Authorization to complete the above scope of services was provided by way of a YG contract dated August 26, 2011, issued by Muhammad Idrees.

2.0 SITE INVESTIGATION

The geotechnical investigation consisted of advancing a total of four boreholes to varying depths at the subject site. The borehole locations are shown on Figure 1. The investigation began on November 14, 2011 and was completed November 18, 2011. The boreholes were drilled with a track mounted M4 drill rig capable of advancing both solid and hollow stem augers, owned and operated by Midnight Sun Drilling Ltd. of Whitehorse, Yukon. EBA's site representative was Mr. Justin Pigage, EIT.

BH01 was advanced with solid stem augers to a depth of 20.0 m. BH02, BH03, and BH04 were advanced with hollow stem augers to depths of 18.5 m, 17.0 m, and 17.0 m, respectively. BH01 was advanced adjacent to the roadway in the ditch, BH02 through BH04 were advanced on the shoulder of the roadway through the road embankment.

Standard penetration tests (SPTs) were conducted in 1.5 m intervals in boreholes advanced using hollow stem augers. Disturbed grab samples from the auger flights and split spoon samples from the SPT's were returned to EBA's Whitehorse laboratory for index property testing. The results are presented on the borehole logs in Appendix B. Particle size distribution plots, and Atterberg limit determinations follow the borehole logs.

3.0 SITE CONDITIONS

3.1 Surface Conditions

Tatchun Creek flows through the site from south to north. Local topography is relatively flat with both sides of the site sloping gently towards the creek. Regionally, Tatchun Creek lies at the bottom of a valley approximately 0.5 km wide. Vegetation on site consists of coniferous and deciduous trees of varying size and density.

3.2 Subsurface Conditions

The subsurface conditions on site were determined through interpretation of the four boreholes advanced on site during the geotechnical investigation. Relevant subsurface conditions are summarized in Table 1.

Table 1: Relevant Subsurface Soil Conditions – Tatchun Creek Bridge

Soil Type	Strata Depth Range (m)			
	BH01	BH02	BH03	BH04
Sand and Gravel (Fill)	–	0.0 – 3.0	0.0 – 3.5	0.0 – 3.0
Sand and Gravel	0.0 – 4.0	3.0 – 4.5	3.5 – 6.0	3.0 – 7.0
Silt	4.0 – 13.0	4.5 – 10.5	6.0 – 10.5	7.0 – 12.0
Clay	13.0 – 20.0	10.5 – 18.5	10.5 – 17.0	12.0 – 17.0
End of Borehole	20.0	18.5	17.0	17.0

General subsurface conditions consist of about 3.0 m of SAND and GRAVEL road fill, underlain by 1.5 to 4.0 m of native SAND and GRAVEL, underlain by 5.0 to 9.0 m of SILT, underlain by CLAY of unknown thickness.

Standard Penetration Tests were conducted in BH02 through BH04 during the investigation. The N values obtained in the field were corrected as suggested in the Canadian Foundation Engineering Manual (CFEM 2006). The averaged field N values and corrected N values are shown in Table 2. SPT data was not collected from the embankment fill or underlying SAND and GRAVEL layers because of the cobbly nature of the soils.

Table 2: Average Field and Corrected N Values - Tatchun Creek Bridge

Depth Below Grade(m)	Average Field SPT Result	Corrected SPT Result*
4.5	9	10
6.0	12	12
7.5	12	11
9.0	13	12
10.5	21	19
12.0	17	15
13.5	16	14
15.0	23	19

*N values corrected as suggested by Meyerhof (1976).

3.3 Groundwater

Groundwater was encountered in all four boreholes at about the elevation of Tatchun Creek, 2.0 m below ground surface in BH01 and between 5.0 and 6.0 m below the road surface in BH02 through BH04.

3.4 Permafrost

Permafrost was not encountered during the geotechnical investigation.

3.5 Bedrock

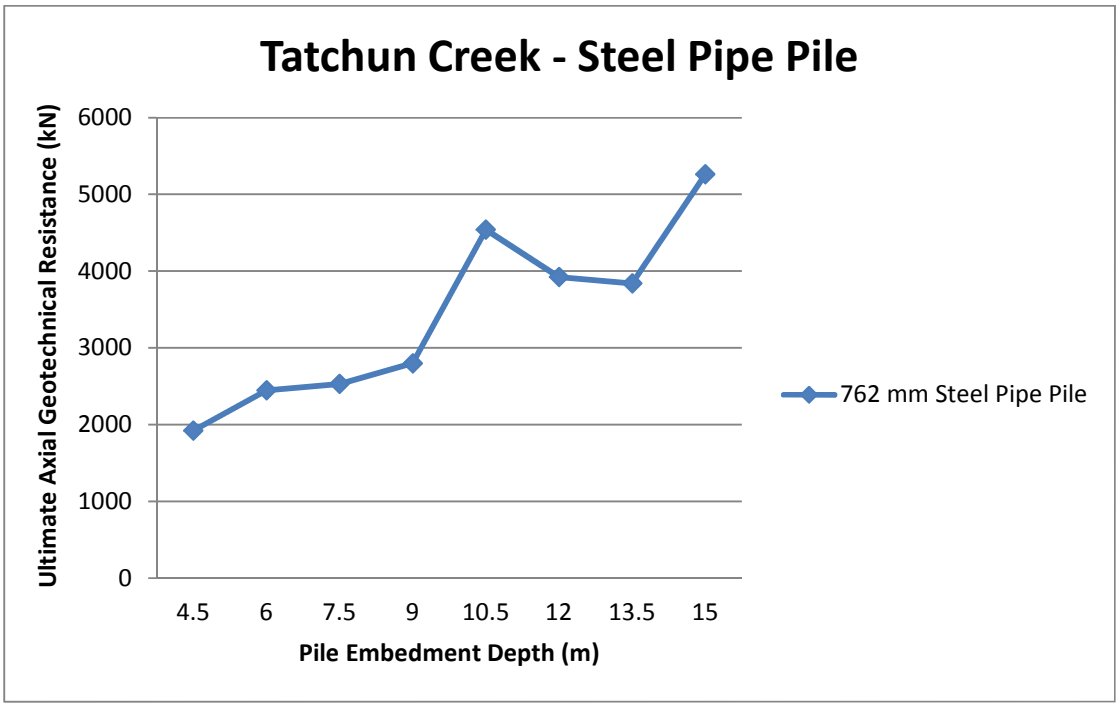
Bedrock was not encountered during the geotechnical investigation.

4.0 RECOMMENDATIONS

EBA considers the site acceptable for driven steel pipe pile bridge abutment foundations. EBA understands each bridge abutment will be founded on a single row of five 762 mm x 15.9 mm diameter steel pipe piles. The values presented in this report are specific to the above pile dimensions, if other pile dimensions are desired EBA can be contacted for updated design charts. EBA should be given the opportunity to review the final pile design prior to construction to verify adequacy.

4.1 Steel Pipe Pile

Steel pipe piles for the bridge abutments can be designed using the ultimate axial geotechnical resistances shown in the following design chart:



Steel pipe piles with an outside diameter of 762 mm and a wall thickness of 15.9 mm driven with an open end and internal driving shoe were assumed in determining the above ultimate axial geotechnical resistances. The driving shoe must be internal (same size or smaller than the pile diameter) to maintain skin friction over the length of the pile. The anomaly at 10.5 m depth is related to the transition from silt to clay and increased end bearing.

4.2 Geotechnical Resistance Factor

The geotechnical resistance factors required to calculate the factored axial resistances for piles are provided in Table 3. The geotechnical resistance factors should be incorporated into the bridge abutment foundation design.

Table 3: Geotechnical Resistance Factors – Pile Design

Item	Resistance Factor*
Static Analysis – Compression	0.4
Static Analysis – Uplift	0.3

*Resistance factors obtained from CHBDC (2006) for piles designed with static analysis only. If on-site pile driving analyzer (PDA) testing is conducted a resistance factor of 0.5 can be used.

4.3 Group Effects

For design purposes the pile group capacity can be considered equal to the sum of the individual pile capacities provided the piles are spaced at least three diameters on centre. If closer pile spacing is required, EBA should be contacted for updated pile capacities due to group effects.

4.4 Frost Heave Considerations

The underlying silt encountered during the investigation as shallow as 1.5 m below the ground surface is considered frost susceptible. The concrete pile caps will likely be exposed below the bridge (no snow cover) allowing for deeper frost penetration. Minimum pile embedment depths of 8.0 m should be used to resist the potential frost jacking forces generated by the underlying silts. If shorter piles are desired, EBA can provide insulation recommendations to reduce the risk of frost related movements.

4.5 Seismic Conditions

Based on the Canadian Highways Bridge Design Code (CHBDC, CAN/CSA-S6-06) Clause 4.4.6 Site Effects, and the data obtained during the site investigation, the Soil Profile Type III is recommended for design.

A peak ground acceleration (PGA) value of 0.11g has been established for this site by Associated Engineering in the Preliminary Design Report (Associated Engineering, March 2011). This value has a 10% probability of exceedance in 50 years (475 year return period).

4.6 Seismic Liquefaction and Displacements

Based on the soil stratigraphy established for the site, there is a potential for seismically induced liquefaction and/or cyclic mobility which could result in lateral and/or vertical displacements.

The saturated portion of SAND and GRAVEL layer between 3 to 7 m depths (approximately) is considered to have low risk of liquefaction. The anticipated liquefaction induced vertical settlement at the top of the road embankment is less than 100 mm. The anticipated liquefaction induced lateral spreading is summarized in the following table.

Table 4: Anticipated Liquefaction Induced Lateral Spreading

Depth from Top of Road Embankment (m)	Anticipated Lateral Spread (mm)
0	70 – 100
2.5	70 – 100
3.0 or greater	0

The SILT layer between 4 to 12 m depths (approximately) and the CLAY layer below 12 m depth (approximately) are not of concern for cyclic mobility or seismically induced lateral displacements.

Lateral pile analysis results (p-y curves) were provided to the structural engineer as part of the geotechnical design. These data are available from EBA upon request.

4.7 Abutment Design and Backfill

Backfill placed for approach and abutment construction is to be non-frost susceptible (NFS) pit run gravel conforming to the specifications in Table 5, placed in lifts no thicker than 150 mm, moisture conditioned and compacted to at least 98% of the maximum dry density using standard effort (as per ASTM D698) at ± 2% of optimum moisture content.

Table 5: Recommended Granular Material Specifications

Engineered Fill (Pit Run Gravel)	
Particle Size (mm)	**% Passing by Mass**
80.0	100
25.0	55 – 100
12.5	42 – 84
5.00	26 – 65
1.25	11 – 47
0.315	3 – 30
0.080	0 – 8

Abutment wall design for the site should consider lateral loads under both static and seismic loading conditions. Abutment walls are typically supported at both the top and bottom and are therefore considered non-yielding walls for the purpose of design. Non-yielding walls without sloped backfill in un-saturated homogenous soils, like those on the subject site, and an overall height less than 4.5 m can be designed using the following expression:

$$P_{OE} = P_O + \Delta P_{OE}$$

where P_{OE} is the total lateral load per unit length of the non-yielding wall (kN/m) and is composed of a static load (P_O) and a seismic load (ΔP_{OE}).

The static lateral earth load P_O (kN/m) which acts at 0.33H above the base of the wall can be determined using the following expression:

$$P_O = k_O\left(\frac{\gamma_B H^2}{2} + QH\right)$$

where:

k_O = At-rest earth pressure coefficient (unitless) = 0.33

γ_B = Bulk unit weight of the back-fill soil (kN/m^3) = 21.5

H = Height of the wall (m)

Q = Surcharge pressure at ground surface from construction equipment – use 15 kPa

The seismic lateral earth load ΔP_{OE} (kN/m) which acts at 0.6H above the base of the wall can be determined using the following expression:

$$\Delta P_{OE} = k_h \gamma_B H^2$$

where:

k_h = Site specific peak ground acceleration (unitless) = 0.11

γ_B = Bulk unit weight of the soil (kN/m^3) = 21.5

H = Height of the wall (m)

4.8 Concrete

EBA recommends that all concrete for the bridge abutments be designed, mixed, placed and tested in accordance with the recent edition of the Canadian Standards Associations (CSA) standard CAN/CSA-A23.1 and A23.2. According to these standards, concrete should be designed to at least satisfy minimum durability requirements as defined by exposure class.

The exposure class of the concrete is dependent upon the presence or lack of chlorides, sulphates, freezing and thawing conditions and soil saturation. Based on the aforementioned recommendations the foundation system will have concrete exposed to cycles of freezing and thawing. The governing exposure class is "F-2". There are no reactivity issues associated with aggregates supplied by Whitehorse concrete producers. Therefore, fly ash or blended cement and fly ash will not be required on this project.

In addition to the above, CAN/CSA-A23.1 also provides recommendations for cold weather concrete placement. These include protecting freshly placed concrete from freezing temperatures.

4.9 Pile Driving Equipment Review, Design, Observation and Testing Services

All pile design recommendations presented are site specific and based on the assumption that an adequate level of construction monitoring during pile installation will be provided, and that all construction will be carried out by a suitable qualified, experienced contractor. An adequate level of construction monitoring also ensures the recommendations based on data obtained during the geotechnical investigation are relevant to other areas of the site.

It is recommended EBA be given the opportunity to review the contractor's pile driving equipment (hammer size and type) prior to construction. This review will ensure that the hammer energy will not overstress the pile and that the proposed set (blows per inch) at the end of pile driving will achieve the desired capacity. This review would require two weeks to complete.

EBA should also be given the opportunity to review the details of the final design related to the geotechnical aspects of the bridge abutment foundations, prior to construction. Past experience has shown that this action many prevent inconsistencies, poor performance, and/or increased costs that may lead to disputes.

The placement and compaction of backfill for abutment construction should be overseen to ensure the recommendations contained herein are adhered to. Pile driving should be overseen by a geotechnical engineer licensed to practice in the Yukon to verify the design pile capacities are being achieved during construction. EBA would be pleased to provide these services, upon request.

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Yukon Government and their agents. EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company, does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Yukon Government, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. EBA's General Conditions are provided in Appendix A of this report.

6.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Sincerely,
EBA Engineering Consultants Ltd.

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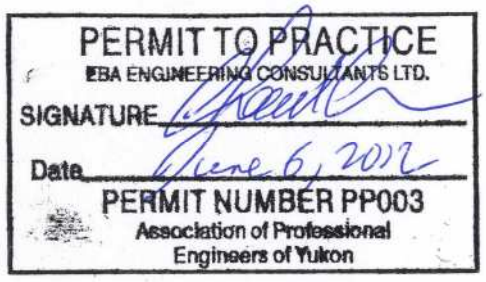
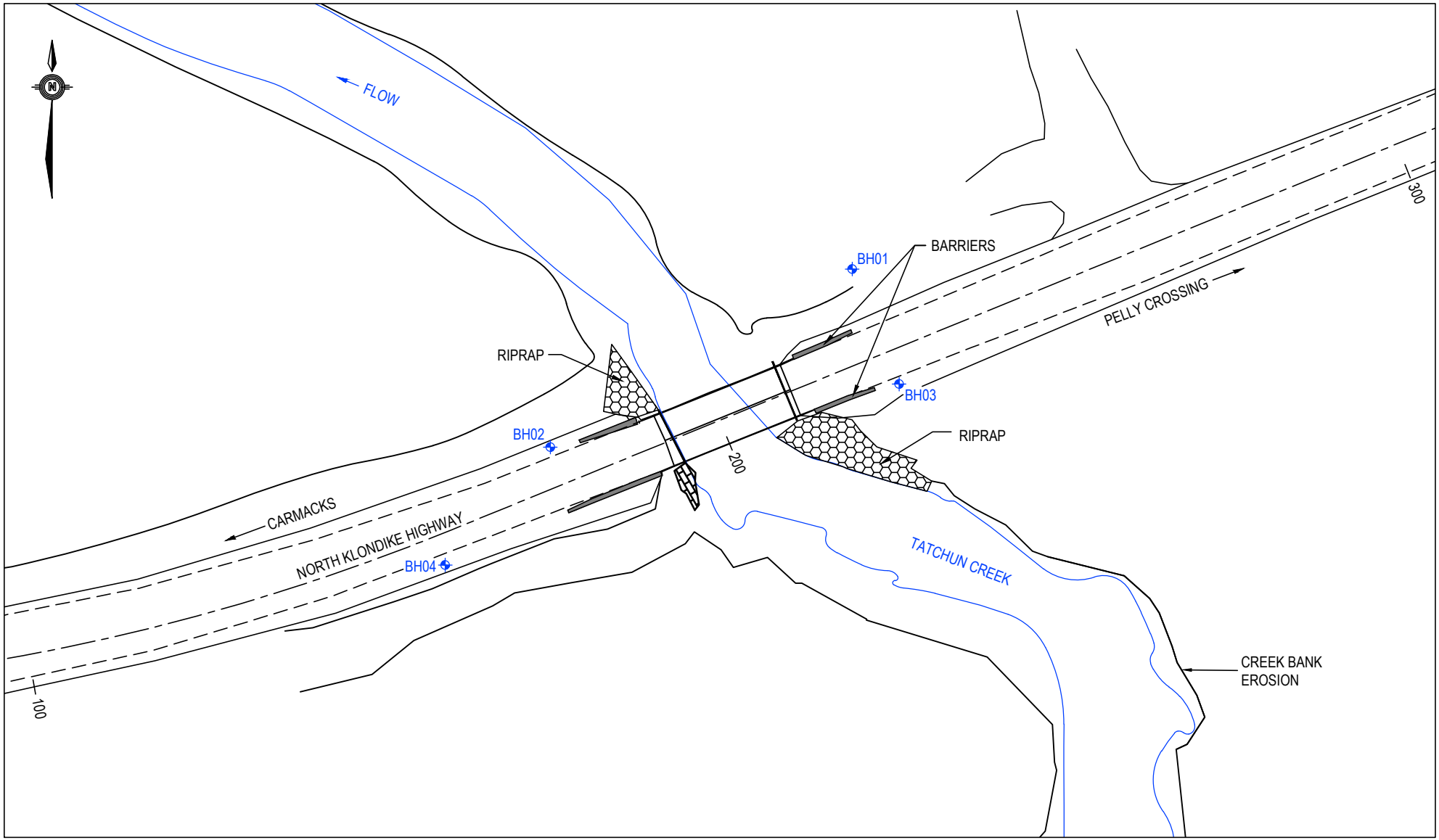


FIGURES

Q:\Whitehorse\Data\0201drawings\Whitehorse\W141\W14101624 New Tatchun Creek Bridge\W14101624 Fig.1_R0.dwg [FIGURE 1] December 13, 2011 - 5:17:35 pm (BY: BUCHAN, CAMERON)



LEGEND:

- BOREHOLE LOCATION

0 25

Scale: 1: 750 (metres)

CLIENT

Yukon
Highways and Public Works
Transportation Engineering Branch

eba
A TETRA TECH COMPANY

GEOTECHNICAL EVALUATION - TATCHUN CREEK, YT

SITE PLAN SHOWING BOREHOLE LOCATIONS

PROJECT NO.	DWN	CKD	REV
W14101624	CB	JRT	0

OFFICE	DATE
EBA-WHSE	December 13, 2011

Figure 1

APPENDIX A

APPENDIX A EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA’s Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA’s Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA’s instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

APPENDIX B BOREHOLE LOGS AND LAB TEST RESULTS

MODIFIED UNIFIED SOIL CLASSIFICATION

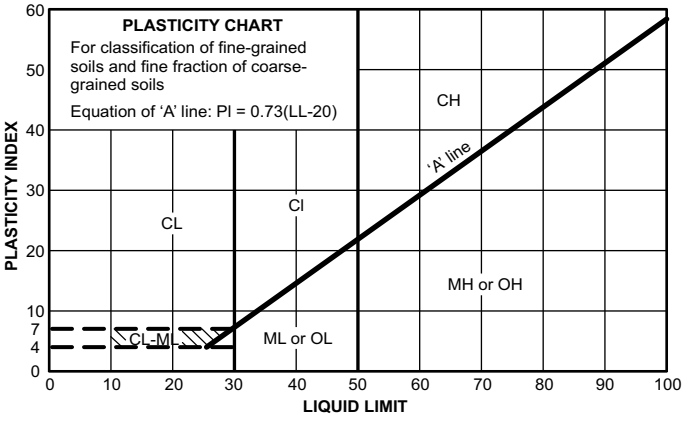
MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly-graded sands and gravelly sands, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS	Liquid limit <50	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity
		Liquid limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
	CLAYS Above "A" line on plasticity chart negligible organic content	Liquid limit <30	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Liquid limit 30-50	CI	Inorganic clay of medium plasticity, silty clays
		Liquid limit >50	CH	Inorganic clay of high plasticity, fat clays
	ORGANIC SILTS AND CLAYS	Liquid limit <50	OL	Organic silts and organic silty clays of low plasticity
		Liquid limit >50	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils

LABORATORY CLASSIFICATION CRITERIA

Classification on basis of percentage of fines
GW, GP, SW, SP
GM, GC, SM, SC
Borderline classification requiring use of dual symbols

$C_U = D_{60} / D_{10}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3		
Not meeting both criteria for GW		
Atterberg limits plot below 'A' line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols	
Atterberg limits plot above 'A' line and plasticity index greater than 7		
$C_U = D_{60} / D_{10}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3		
Not meeting both criteria for SW		
Atterberg limits plot above 'A' line and plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols	
Atterberg limits plot above 'A' line and plasticity index greater than 7		

Less than 5% pass 75 µm sieve
More than 12% pass 75 µm sieve
5% to 12% pass 75 µm sieve



* Based on the material passing the 75 mm sieve

† ASTM Designation D 2487, for identification procedure see D 2488 USC as modified by PFRA

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	
	Nbn	No excess ice, well-bonded	
	Nbe	Excess ice, well-bonded	

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	
	Vc	Ice coatings on particles	
	Vr	Random or irregularly oriented ice formations	
	Vs	Stratified or distinctly oriented ice formations	

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	
	ICE	Ice without soil inclusions (greater than 25 mm thick	

NOTES:

1. Dual symbols are used to indicate borderline or mixed ice classifications.
2. Visual estimates of ice contents indicated on borehole logs ± 5%
3. This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil ☐ Ice ■

Geotechnical Evaluation	CLIENT: YG - Highways & Public Works	BOREHOLE NO: W14101624-BH01
New Tatchun Creek Bridge	DRILL: M4T w/Solid Stem Augers	PROJECT NO: W14101624
km 382.4 Klondike Hwy, YT	6906384N; 431983E; Zone 8	ELEVATION: 506.1m

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Elevation (m)
0	SAND and GRAVEL - some silt, well graded, medium grained, damp, loose (est.), dark brown, occasional cobble			UNFROZEN			506.0
1			SA01		●		505.0
2							504.0
3	- becomes trace silt, wet, easy drilling		SA02		●	● ■ ▲	503.0
4	SILT - some clay, trace sand, moist, soft, low plastic, grey		SA03		●		502.0
5	- trace of gravel for 2.0 m						501.0
6			SA04		●		500.0
7	- no sand, damp, firm		SA05		●		499.0
8							498.0
9			SA06		●		497.0
10			SA07		●		496.0
11			SA08		●		495.0
12							494.0
13			SA09		●		493.0
14	CLAY - silty, trace sand, damp, very stiff, plastic, grey						492.0
15			SA10		●		491.0
16			SA11		●		490.0
17							489.0
18			SA12		●		488.0
19			SA13		●		487.0
20			SA14		●		486.0
21	END OF BOREHOLE @ 20.0 m (no more augers)						

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LOGGED BY: JTP	COMPLETION DEPTH: 20m
REVIEWED BY: JRT	COMPLETE: 11/14/2011
DRAWING NO:	Page 1 of 1

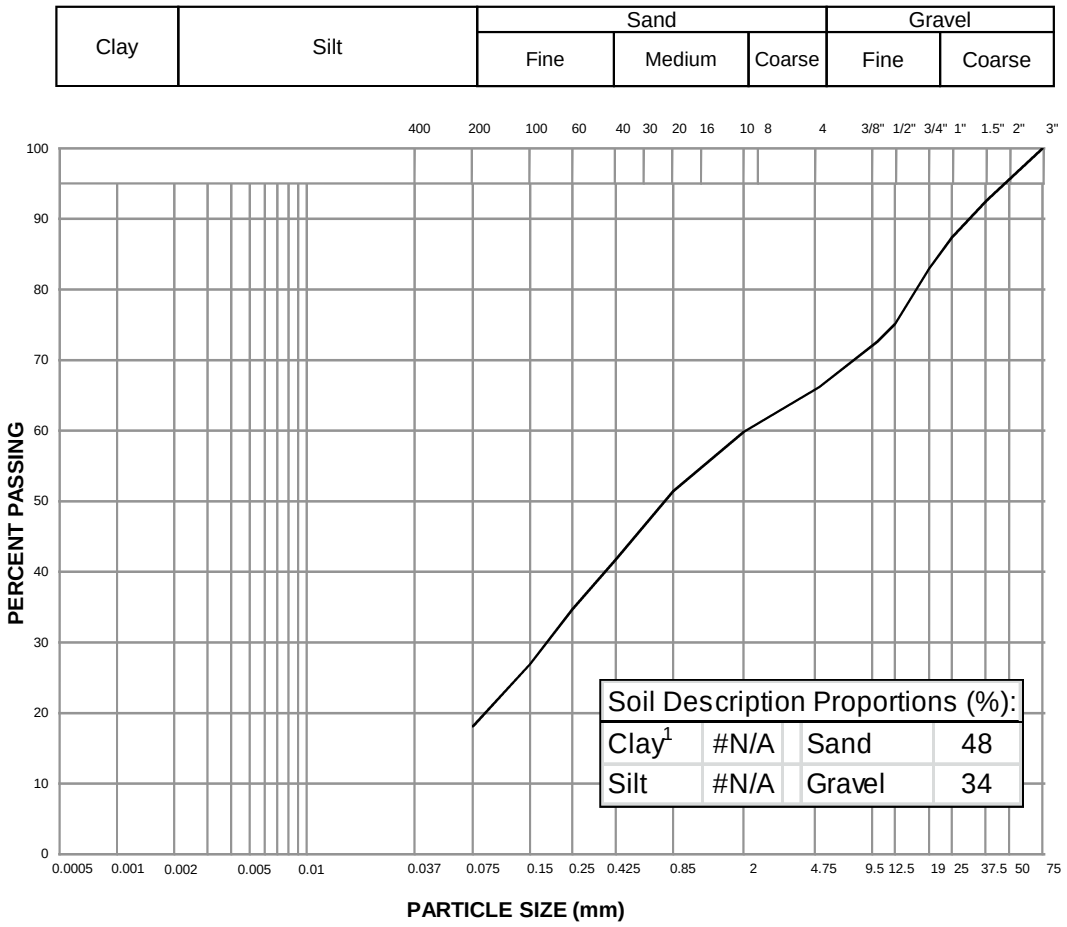
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422, C136 & C117

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Sample No.:	SA02
Project No.:	W14101624	Material Type:	
Site:	km 382.4 Klondike Hwy, YT	Sample Loc.:	BH01
Client:	YG - Highways & Public Works	Sample Depth:	2.5 3.0 m
Client Rep.:	Muhammad Idrees	Sampling Method:	Grab
Date Tested:	November 23, 2011 By: MR	Date sampled:	November 14, 2011
Soil Description[2]:	SAND - gravelly, some silt	Sampled By:	JTP

Moisture Content: 9.0%

Particle Size (mm)	Percent Passing
75	100
50	
38	93
25	87
19	83
12.5	75
10	73
5	66
2	60
0.85	51
0.425	42
0.25	35
0.15	27
0.075	18
#N/A	-0.3
#N/A	-0.3
#N/A	-0.3
#N/A	-0.3
#N/A	-0.3
#N/A	-0.3
#N/A	-0.3



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____

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Geotechnical Evaluation	CLIENT: YG - Highways & Public Works	BOREHOLE NO: W14101624-BH02
New Tatchun Creek Bridge	DRILL: M4T w/Hollow Stem Augers	PROJECT NO: W14101624
km 382.4 Klondike Hwy, YT	6906364N; 431941E; Zone 8	ELEVATION: 508.7m

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SPT (N)	GROUND ICE DESCRIPTION AND COMMENTS	Elevation (m)
0	GRAVEL and SAND (FILL) - trace silt, well graded, medium grained, sub-rounded gravel, brown, cobbles throughout				FROZEN TO 0.5 m	508.0
1	- becomes dry, compact - grinding, hard drilling, possible cobbles		SA15		UNFROZEN	507.0
2						
3	SAND and GRAVEL - some silt, well graded, medium grained, damp, compact, brown, occasional cobble					506.0
4			SA16			505.0
5	SILT - some clay, trace sand, damp, firm, plastic, grey		SA17	11		504.0
6	- becomes some sand, low plastic		SA18	12		503.0
7						502.0
8	- becomes trace sand, trace gravel		SA19	12		501.0
9	- difficult drilling for 3.0 m, stiff soil		SA20	12		500.0
10						499.0
11	CLAY - silty, trace sand, damp, stiff, plastic, grey		SA21	22		498.0
12			SA22	15		497.0
13						496.0
14			SA23	18		495.0
15	- becomes trace gravel, very stiff		SA24	33		494.0
16						493.0
17	- no gravel, dry - slow, difficult drilling, hard soil		SA25	34		492.0
18	- no sand, hard		SA26	47		491.0
19	END OF BOREHOLE @ 18.5 m (refusal in hard silt) NOTE: Road fill pilot drilled with solid stem augers, switched to hollow below fill. Refusal in silt due to size of rig and overall depth of hole.					490.0
20						489.0
21						488.0

SPT (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | CLAY (%) 20 40 60 80 | SILT (%) 20 40 60 80 | SAND (%) 20 40 60 80 | GRAVEL (%) 20 40 60 80

eba A TETRA TECH COMPANY	LOGGED BY: JTP	COMPLETION DEPTH: 18.5m
	REVIEWED BY: JRT	COMPLETE: 11/15/2011
	DRAWING NO:	Page 1 of 1

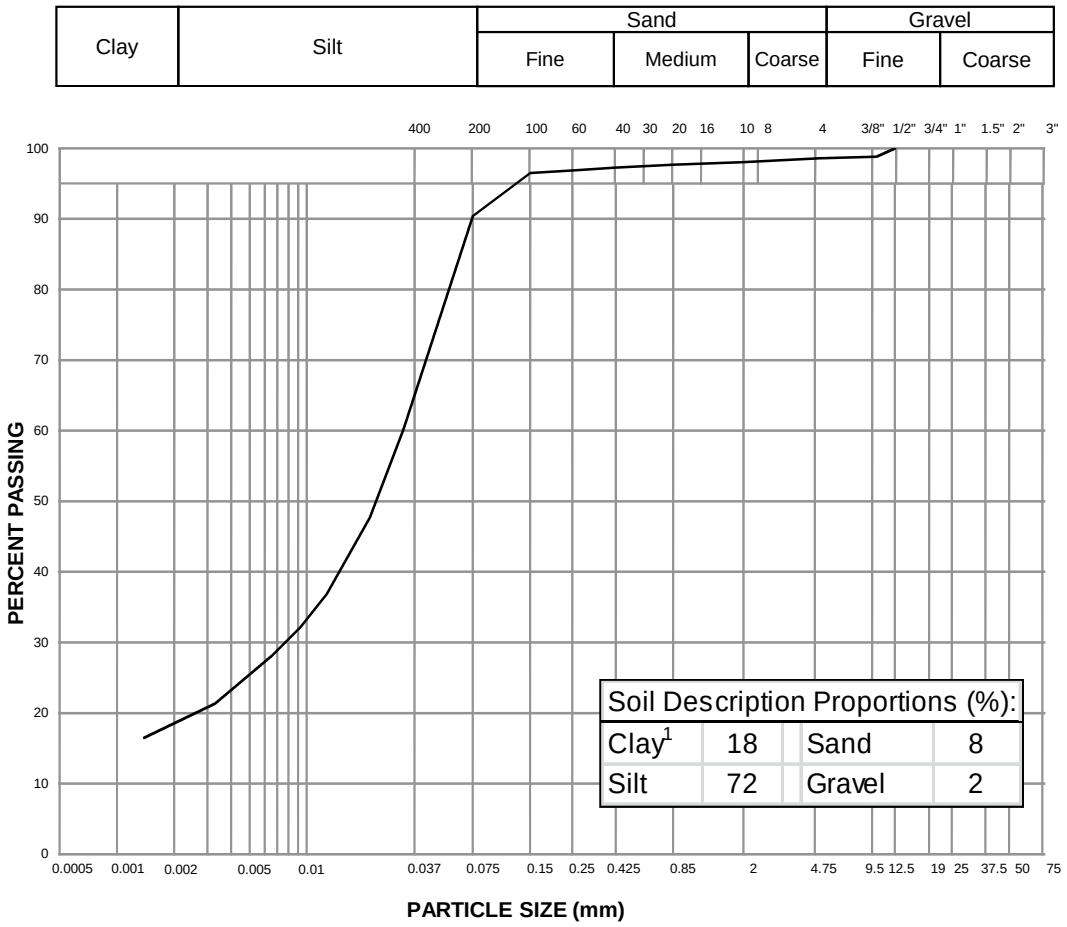
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422, C136 & C117

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Sample No.:	SA18
Project No.:	W14101624	Material Type:	
Site:	km 382.4 Klondike Hwy, YT	Sample Loc.:	BH02
Client:	YG - Highways & Public Works	Sample Depth:	6.0 - 6.45 m
Client Rep.:	Muhammad Idrees	Sampling Method:	SPT
Date Tested:	November 23, 2011 By: MR	Date sampled:	November 15, 2011
Soil Description[2]:	SILT - some clay, trace sand, trace gravel	Sampled By:	JTP

Moisture Content: 22.0%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	100
10	99
5	99
2	98
0.85	98
0.425	97
0.25	97
0.15	96
0.075	90
0.0322	60.2
0.0213	47.6
0.0128	36.9
0.0092	32.0
0.0066	28.2
0.0033	21.4
0.0014	16.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____

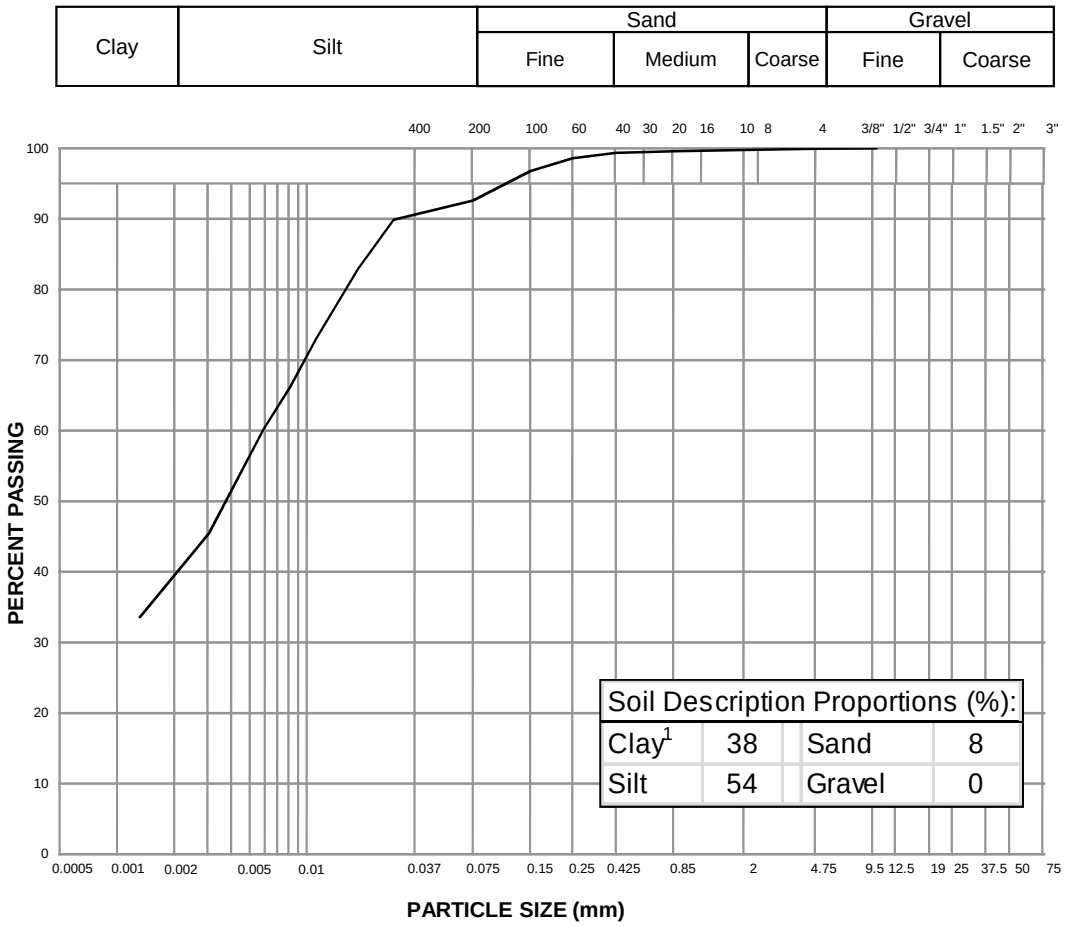
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422, C136 & C117

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Sample No.:	SA25
Project No.:	W14101624	Material Type:	
Site:	km 382.4 Klondike Hwy, YT	Sample Loc.:	BH02
Client:	YG - Highways & Public Works	Sample Depth:	16.5 - 16.95 m
Client Rep.:	Muhammad Idrees	Sampling Method:	SPT
Date Tested:	November 23, 2011 By: MR	Date sampled:	November 15, 2011
Soil Description[2]:	CLAY - silty, trace sand	Sampled By:	JTP

Moisture Content: 22.2%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	100
0.85	100
0.425	99
0.25	99
0.15	97
0.075	93
0.0286	89.9
0.0187	83.0
0.0112	73.1
0.0082	66.2
0.0059	60.3
0.0030	45.4
0.0013	33.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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Reviewed By: _____

Geotechnical Evaluation	CLIENT: YG - Highways & Public Works	BOREHOLE NO: W14101624-BH03
New Tatchun Creek Bridge	DRILL: M4T w/Hollow Stem Augers	PROJECT NO: W14101624
km 382.4 Klondike Hwy, YT	6906369N; 431990E; Zone 8	ELEVATION: 508.6m

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SPT (N)	GROUND ICE DESCRIPTION AND COMMENTS	Elevation (m)
0	GRAVEL and SAND (FILL) - trace silt, well graded, medium grained, sub-rounded gravel, brown, cobbles throughout				FROZEN TO 0.5 m	508.0
1	- becomes dry, compact				UNFROZEN	
2	- hard drilling, grinding on cobbles for 2.0 m					507.0
3						506.0
4	SAND and GRAVEL - some silt, well graded, medium grained, damp, compact, brown, occasional cobble					505.0
5	- becomes wet, trace silt		SA27			504.0
6	SILT - trace clay, trace sand, damp, firm, low plastic, grey		SA28	8		503.0
7						502.0
8	- no sand, moist		SA29	11		501.0
9	- becomes damp, stiff		SA30	25		500.0
10						499.0
11	CLAY - silty, trace sand, damp, very stiff, plastic, grey		SA31	21		498.0
12	- becomes some sand		SA32	20		497.0
13						496.0
14	- becomes trace sand, stiff		SA33	14		495.0
15	- no sand		SA34	20		494.0
16	- slow difficult drilling, stiff soil					493.0
17	- becomes very stiff		SA35	17		492.0
18	END OF BOREHOLE @ 17.0 m (refusal in hard soil) NOTE: Road fill pilot drilled with solid stem augers, switched to hollow below fill. Refusal due to size of rig and overall depth of hole.					491.0
19						490.0
20						489.0
21						488.0

SPT (N) ■ 20 40 60 80

PLASTIC M.C. ● LIQUID 20 40 60 80

◆ CLAY (%) ◆ 20 40 60 80

● SILT (%) ● 20 40 60 80

▲ SAND (%) ▲ 20 40 60 80

■ GRAVEL (%) ■ 20 40 60 80

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LOGGED BY: JTP	COMPLETION DEPTH: 17m
REVIEWED BY: JRT	COMPLETE: 11/17/2011
DRAWING NO:	Page 1 of 1

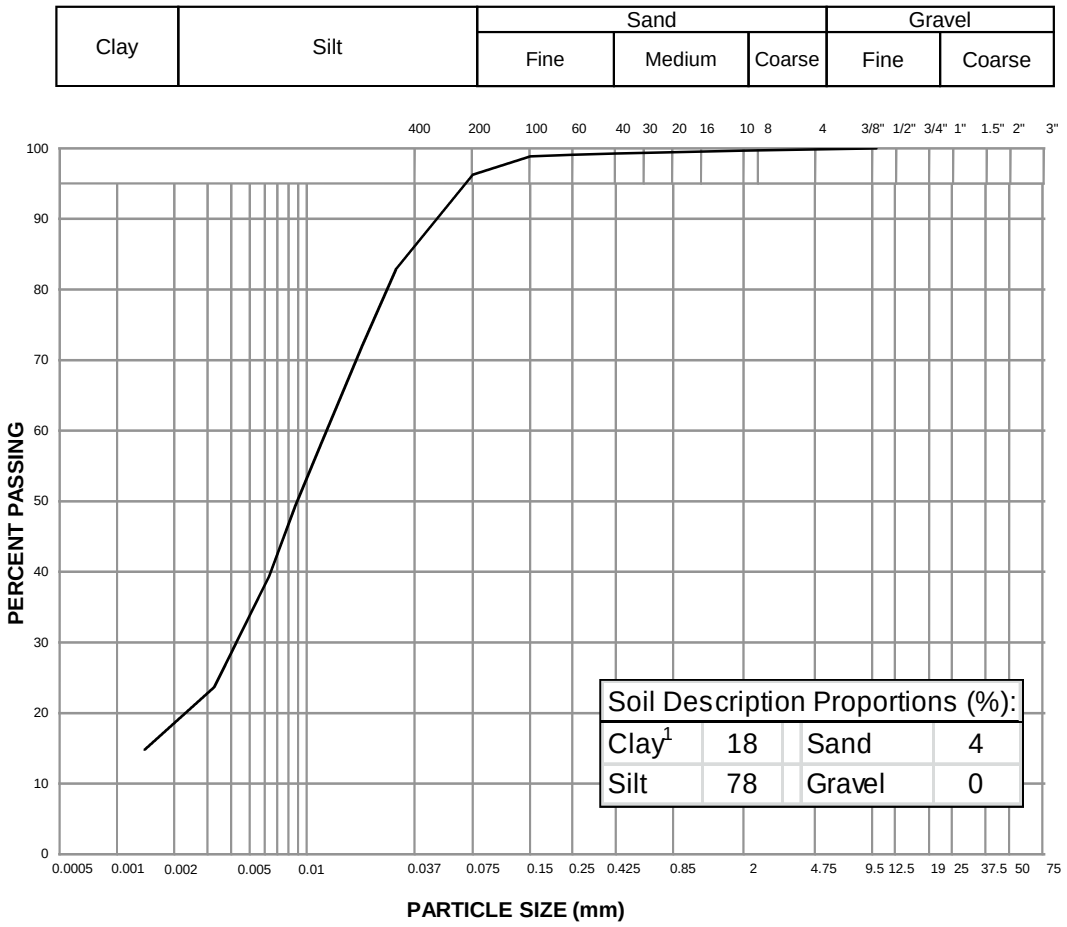
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422, C136 & C117

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Sample No.:	SA30
Project No.:	W14101624	Material Type:	
Site:	km 382.4 Klondike Hwy, YT	Sample Loc.:	BH03
Client:	YG - Highways & Public Works	Sample Depth:	9.0 - 9.45 m
Client Rep.:	Muhammad Idrees	Sampling Method:	SPT
Date Tested:	November 23, 2011 By: MR	Date sampled:	November 16, 2011
Soil Description[2]:	SILT - some clay, trace sand	Sampled By:	JTP

Moisture Content: 24.7%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	100
0.85	99
0.425	99
0.25	99
0.15	99
0.075	96
0.0295	82.9
0.0195	72.0
0.0119	58.2
0.0087	49.3
0.0063	39.5
0.0033	23.7
0.0014	14.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____

Geotechnical Evaluation	CLIENT: YG - Highways & Public Works	BOREHOLE NO: W14101624-BH04
New Tatchun Creek Bridge	DRILL: M4T w/Hollow Stem Augers	PROJECT NO: W14101624
km 382.4 Klondike Hwy, YT	6906343N; 431915E; Zone 8	ELEVATION: 509.1m

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SPT (N)	GROUND ICE DESCRIPTION AND COMMENTS	Elevation (m)
0	GRAVEL and SAND (FILL) - trace silt, well graded, medium grained, sub-rounded, brown, cobbles throughout				FROZEN TO 0.5 m	509.0
1	- becomes damp, compact				UNFROZEN	508.0
2						507.0
3	SAND and GRAVEL - silty, well graded, medium grained, moist, loose, brown, occasional cobble					506.0
4	- hard drilling, grinding, possible cobbles		SA36			505.0
5	- sand seam 0.2 m thick, uniformly graded		SA37	4		504.0
6	- becomes wet		SA38	100		503.0
7	- hard drilling, grinding, possible cobbles - becomes compact					502.0
8	SILT - some clay, trace sand, damp, firm, plastic, grey		SA39	9		501.0
9	- no sand		SA40	12		500.0
10						499.0
11	- becomes trace clay, low plastic		SA41	15		498.0
12	CLAY - silty, trace sand, damp, stiff, plastic, grey		SA42	14		497.0
13						496.0
14	- slow difficult drilling, stiff soil		SA43	17		495.0
15	- becomes very stiff		SA44	17		494.0
16						493.0
17	- becomes hard		SA45	41		492.0
	END OF BOREHOLE @ 17.0 m (refusal in hard silt)					
18	NOTE: Road fill pilot drilled with solid stem augers, switched to hollow below fill. Refusal in silt due to size of rig and overall depth of hole.					491.0
19						490.0
20						489.0
21						

SPT (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | CLAY (%) 20 40 60 80 | SILT (%) 20 40 60 80 | SAND (%) 20 40 60 80 | GRAVEL (%) 20 40 60 80

eba A TETRA TECH COMPANY	LOGGED BY: JTP	COMPLETION DEPTH: 17m
	REVIEWED BY: JRT	COMPLETE: 11/18/2011
	DRAWING NO:	Page 1 of 1

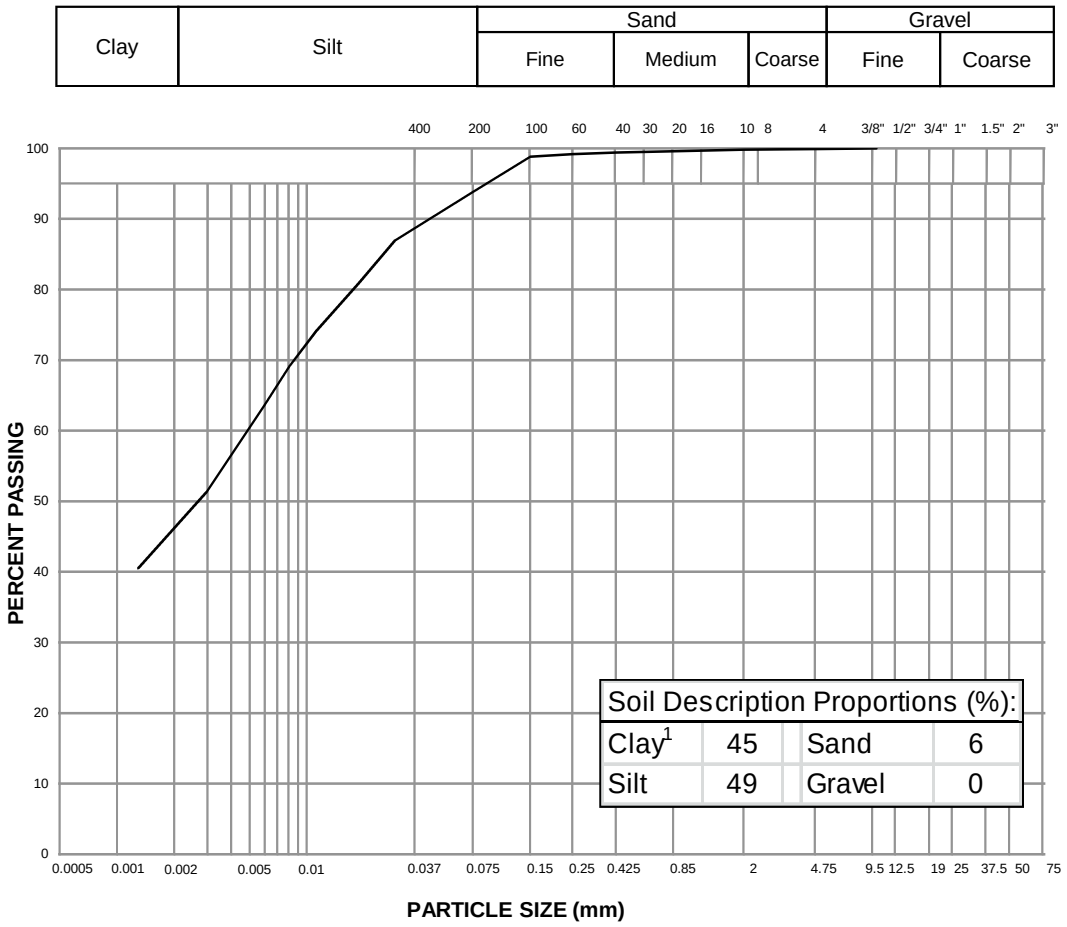
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422, C136 & C117

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Sample No.:	SA42
Project No.:	W14101624	Material Type:	
Site:	km 382.4 Klondike Hwy, YT	Sample Loc.:	BH04
Client:	YG - Highways & Public Works	Sample Depth:	12.0 - 12.45 m
Client Rep.:	Muhammad Idrees	Sampling Method:	SPT
Date Tested:	November 23, 2011 By: MR	Date sampled:	November 18, 2011
Soil Description[2]:	CLAY - silty, trace sand	Sampled By:	JTP

Moisture Content: 27.4%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	100
0.85	100
0.425	99
0.25	99
0.15	99
0.075	94
0.0290	86.9
0.0189	81.0
0.0112	74.1
0.0081	69.2
0.0059	63.2
0.0030	51.4
0.0013	40.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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Reviewed By: _____

ATTERBERG LIMITS - LABORATORY RESULTS SUMMARY

ASTM D4318

Project:	New Tatchun Creek Bridge - Geotech. Eval.	Test Hole No.:	various		
Project No.:	W14101624	Submitted By:	JTP	Sampled By:	JTP
Client:	YG - Highways & Public Works	Date Sampled:	November 14-18, 2011	Tested By:	MR
Attention:	Muhammad Idrees	Date Tested:	November 23, 2011	Laboratory:	Whitehorse

Test Hole Number	Sample ID	Depth (m)	Moisture Content (%)	Atterberg Limits			Mod. USCS	Soil Description Type, constituants/composition, structure, moisture, consistency, plasticity, colour, odour, inclusions.
				LL	PL	PI		
BH02	SA18	6.0-6.45	22.0	24	21	3	ML-NP	SILT - some clay, trace sand, trace gravel
BH02	SA25	16.5-16.95	22.2	40	21	19	CI	CLAY - silty, trace sand
BH03	SA30	9.0-9.45	24.7	29	22	7	ML-NP	SILT - some clay, trace sand
BH04	SA42	12.0-12.45	27.4	39	17	22	CI	CLAY - silty, trace sand

Remarks:

Reviewed By:

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