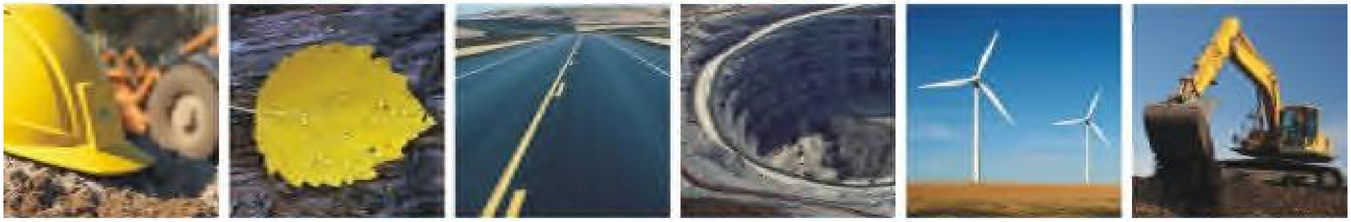
GOVERNMENT OF YUKON – COMMUNITY SERVICES INFRASTRUCTURE DEVELOPMENT BRANCH

GEOTECHNICAL EVALUATION OF ROAD SETTLEMENT HAMILTON BOULEVARD SECTION 4+640 TO 4+860, WHITEHORSE, YT



INTERIM REPORT

DECEMBER 24, 2013
ISSUED FOR USE
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1.0 INTRODUCTION

Government of Yukon Community Services Infrastructure Development Branch (CS-IDB) is exploring alternatives for stabilizing STA 4+640 to 4+860 of Hamilton Boulevard in Whitehorse, Yukon that has experienced significant settlement since construction in 2009. EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) was retained by CS-IDB to complete the geotechnical investigation of Hamilton Blvd and provide a summary of potential stabilization options.

This interim report summarizes the results of the geotechnical investigation and provides a preliminary evaluation of several design alternatives.

1.1 Background

The northern portion of Hamilton Boulevard was constructed to provide transportation, evacuation and utility corridors for residential, commercial, and recreational areas west of the city center. Continuing development has created a necessity for alternate access routes requiring the extension of Hamilton Boulevard south to the intersection of Robert Service Way and the Alaska Highway.

Construction on the south section of Hamilton Boulevard began in 2008 and was completed in 2009. STA 4+100 to STA 5+100 of Hamilton Boulevard crosses a low lying muskeg area. The embankment consists of about 3 m of quarry rock, from nearby rock cuts, placed over existing organics, fine grained and granular materials. This area has since experienced significant settlements that have affected trafficability.

A review of some of the 2008-09 construction photos indicate that geotextile may have not been placed over the original ground surface prior to placement of the quarry rock through the low lying area from STA 4+640 to 4+860.

CS-IDB has been managing the settlement by stripping and resurfacing on a yearly basis. The costs associated with yearly maintenance since 2010 has amounted to about $110,000 per year. Stabilizing Hamilton Boulevard has become a priority for CS-IDB in order to address concerns for public safety and reduce future maintenance costs.

1.2 Scope of Services

As outlined in the proposal sent to Mr. Kirn Dhillon on June 7, 2013, the scope of services for the geotechnical investigation of Section STA 4+640 to STA 4+860 of Hamilton Boulevard includes the following:

- One site visit to assess the conditions of Hamilton Boulevard and determine borehole locations;
- Drill a maximum of four boreholes through the shoulder of the roadway and into natural ground and collect split spoon samples every 1.5 m for visual characterization and laboratory testing;
- Install ground temperature cables at locations where significant permafrost has been encountered;
- Return select samples to the EBA Whitehorse laboratory for soil index testing;
- Prepare a report summarizing the results of the geotechnical investigation and a preliminary evaluation of mitigation alternatives;

- Provide monitoring of an installed ground temperature cable (GTC) for up to one year; and
- Provide Class “D” cost estimated for each option recommended.

The scope of services did not include an alternatives matrix evaluation or to determine permafrost conditions outside of the roadway footprint.

The services provided by EBA were completed under the General Conditions attached in Appendix A.

2.0 GEOTECHNICAL INVESTIGATION

2.1 Initial Site Visit

EBA personnel Kisa Elmer, EIT, and Myles Plaunt, CET, completed a site visit to Hamilton Boulevard STA 4+640 to STA 4+860 on June 11, 2013, to assess the embankment conditions and select borehole locations. During the site visit, EBA noted the following observations:

- Uneven settlement, specifically along the south bound lane (Photo 1);
- Standing water collecting in the ditches (Photo 2); and
- Tension (longitudinal) cracking at the toe of the southwest facing slopes (Photo 3) of the embankment fill. Such cracking is indicative of the underlying foundation soils settling more rapidly than the surrounding soils.

During the site visit EBA personal also noted that the area west of the Hamilton Boulevard is a localized dip in topography. Terrain inclines to the northeast and declines gently to the south and east. The site is poorly drained by natural means to the east. The road embankment appears to be damming surface water runoff from the northeast slope. No drainage paths have been constructed to successfully manage surface water.

Vegetative cover in the area is mainly coniferous trees. Vegetation along the northeast side of the northbound lane embankment has been flooded with standing water and has consequently perished. New growth, such as lily pads and sage grasses, plus the presence of tadpoles, suggests that these ponded areas exist year round. Vegetation along the west side of the south bound lane varies from dense coniferous forests, to open canopy forests with some deciduous brush. There is also an area of muskeg that has no standing water that seems to drain to the subsurface.

2.2 Drilling Investigation

The geotechnical drilling program was completed from June 17 to 20, 2013 under the supervision of EBA’s representative, Kisa Elmer, EIT. The program was completed using a Sandvik M5 ODEX Air Rotary drill owned and operated by Midnight Sun Drilling Company Inc. Standard and large penetration testing (SPT and LPT) was completed using 50 mm and 75 mm split spoons to collect soil samples for visual classification. Grab samples were also collected from the air rotary discharge at select locations.

Four boreholes were advanced in depressions along the shoulder of Hamilton Boulevard: two along the northbound lane and two along the southbound lane. EBA selected borehole locations in areas that would provide geotechnical data on areas experiencing the most settlements and distributed evenly along the section under investigation. The location of each borehole is presented on Figure 1.

Figure 2 presents the profile of soil stratigraphy, subsurface conditions encountered, and instrumentation installed. The elevations are manually interpreted from profiles provided by CS-IDB. Some variation in elevation can be expected. The stratigraphy shown has been interpreted from borehole logs and superimposed to the profile of the inside right lane of the roadway, with some engineering judgement applied.

2.3 Foundation Material

General stratigraphy included an average one metre of SAND and GRAVEL (Fill) overlying three metres of quarry rock underlain by varying thicknesses of PEAT and organic material, SILT, SAND, and SILT (Till). Weathered bedrock was encountered in Borehole BH02 at a depth of 14.4 m below grade. Table 1 summarizes the stratigraphy encountered in Boreholes BH01 to BH04.

Table 1: Generalized Soil Stratigraphy of Hamilton Boulevard Section STA 4+640 to STA 4+860

Soil Stratum (m)	BH01	BH02	BH03	BH04
SAND and GRAVEL (Fill)	0 – 1.3	0 – 3.1	0 – 0.5	0 – 3.4
Quarry Rock (Fill)	1.3 – 5.1	3.1 – 5.2	0.5 – 4.0	3.4 – 5.8
PEAT	5.1 – 6.9	5.2 – 5.9	4.0 – 5.5	5.8 – 7.6
SILT	6.9 – 7.5	5.9 – 8.7	5.5 – 6.7	7.6 – 9.5
SAND	-	-	6.7 – 8.5	-
ORGANICS	7.5 – 9.1	-	-	`-
SAND and GRAVEL		8.7 – 12.6		
SILT	9.1 – 10.7	-	-	-
TILL	10.7 – 15.7	12.6 – 14.4	8.5 – 11.6	9.5 – 10.1
Weathered Bedrock	-	14.4 – 14.6	-	-
End of Hole	15.7	14.6	11.6	10.1

Standard penetration tests indicate that the roadway is very dense to hard. The underlying PEAT, SILT and SAND are estimated to be loose or soft where unfrozen. Density increased with depth from compacted to dense SAND, GRAVEL, and SILT (Till).

Detailed borehole logs and laboratory test results are presented in Appendix B.

2.4 Permafrost and Ground Water

Permafrost was encountered in three of the four boreholes advanced, within the underlying PEAT and SILT. The thickness of permafrost varied from 0.8 m of frozen PEAT in Borehole BH01, 2.0 m of frozen SILT in Borehole BH02, and 1.4 m of ICE and frozen SILT in Borehole BH03. The PEAT in Borehole BH01 had an moisture content of 178% (by weight), the frozen SILT in Borehole BH02 contained 27% moisture content (by weight), and the ICE and frozen SILT in Borehole BH03 contained 60% moisture content (by weight). No permafrost was encountered in Borehole BH04.

One GTC was installed at Borehole BH03, the borehole with the most ICE content, to a depth of 11.3 m. Monthly readings for July, August, September, October, and December 2013, are included in Figure 3. Monthly readings will continue for a full year, at which time EBA will prepare a final report with the updated monitoring results and any changes to the settlement data.

Ground water was observed in Borehole BH04 at 4.3 m below the road surface, within the quarry rock embankment. The ground water level encountered during the drilling of Borehole BH04 roughly corresponded to the elevation of standing water observed along the east side of the northbound lane embankment. The completion depth of BH04 was into the underlying SILT Till and permafrost was not encountered. The underlying PEAT had a moisture content of 298% (by weight), while the SILT was saturated with a moisture content of 218% (by weight) at 8 m, decreasing to 23% at 8.7 m.

3.0 DISCUSSION

The main cause of the settlement that Hamilton Boulevard experiences at section STA 4+640 to 4+860 is the thawing of ice-rich silt and peat beneath the quarry rock fill. It appears that the original geotechnical investigation[1] may not have included subsurface testing in this specific area.

4.0 RECOMMENDATIONS AND OPTION EVALUATION

The following recommendations and option evaluation is based on the results of the investigation program completed by EBA. Since CS-IDB has expressed an interest for innovation designs for the restoration of the Hamilton Boulevard subsidence issues, EBA has completed a preliminary evaluation and provided the following potential stabilization alternatives (Table 2), which are based on performance, cost implications, schedule/traffic interruptions, and potential for innovation.

Table 2: Preliminary Evaluation of Options for Stabilizing South Hamilton Boulevard

Option	Alternative	Method
Preserve Existing Infrastructure	Monitor and Maintain	Leave as gravel road and grade throughout the year or re-grade and resurface with chip seal as required.
Reconstruct Embankment	Excavate Ice, Silt and Organics	Excavate existing road structure and between 3 to 4 m of organics and silt, and replace with compacted engineering fill.
Placement of Multi-plates	Excavate Embankment Material and install multiple structures	Excavate existing road structure, install structural foundations and structures, and backfill with engineered fill
Concrete Bridge	Install Piles, Piers, Girders and Concrete Deck	Installation of rock socketed piles, concrete pile caps, concrete/steel girders and concrete deck

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[1] Hamilton Boulevard Extension, Falcon Drive South to Alaska Highway, 2007 Revised Alignment for the Government of Yukon. Quest Engineering Group, and Hoggan Engineering and Testing (1980) Ltd. Final Report. May 2007.

A brief explanation of each option along with a preliminary evaluation is provided in the subsections below.

4.1 Monitor Settlement and Continued Maintenance

The preservation of the existing structure requires estimating a timeframe for settlement along this section of Hamilton Boulevard. The settlement is influenced by two main factors: permafrost thaw and consolidation of organics and fine grained material.

The Stefan equation (shown below) was used to provide a rough estimated thaw period for the 2.0 m and 1.5 m of permafrost encountered in Boreholes BH02 and BH03, respectively.

$$X = \frac{\sqrt{(2k_f T_s)}}{L} \cdot \sqrt{t}$$

Where:

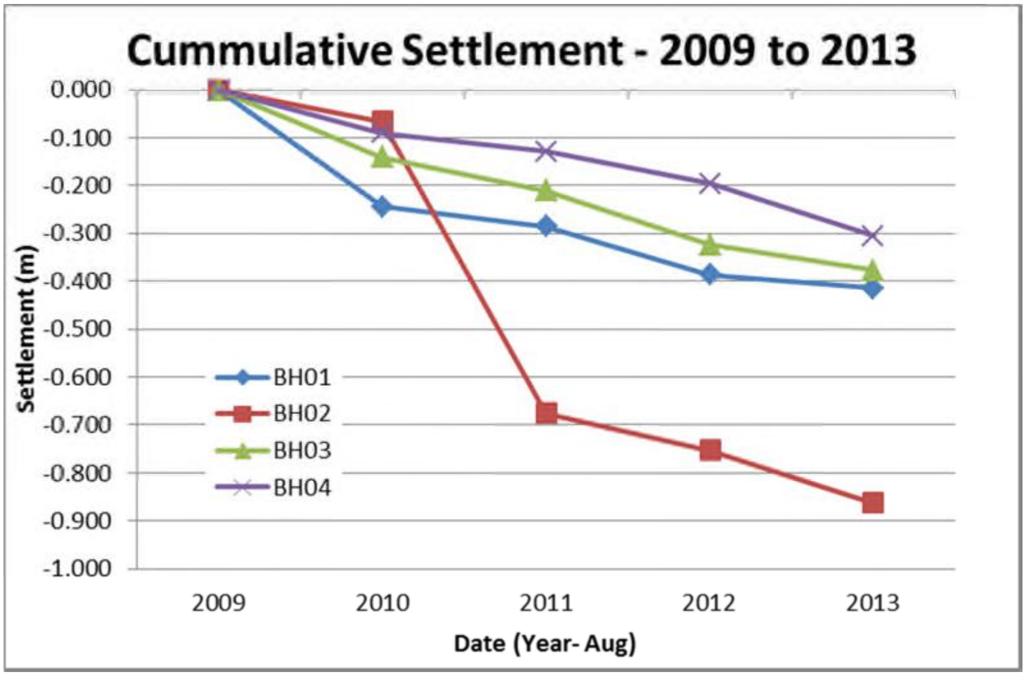
X equals the thickness of material thawed,
k_s is the thermal conductivity of frozen soil,
L is the latent heat,
T_s is the mean annual temperature applied to the frozen soil, and
t is the time required to thaw the frozen soil to X depth.

Solving Stefan's equation for t allows EBA to estimate that the permafrost encountered in Boreholes BH02 and BH03 during the geotechnical investigation is likely to be completely thawed within 5 to 10 years and most of the settlement should be complete.

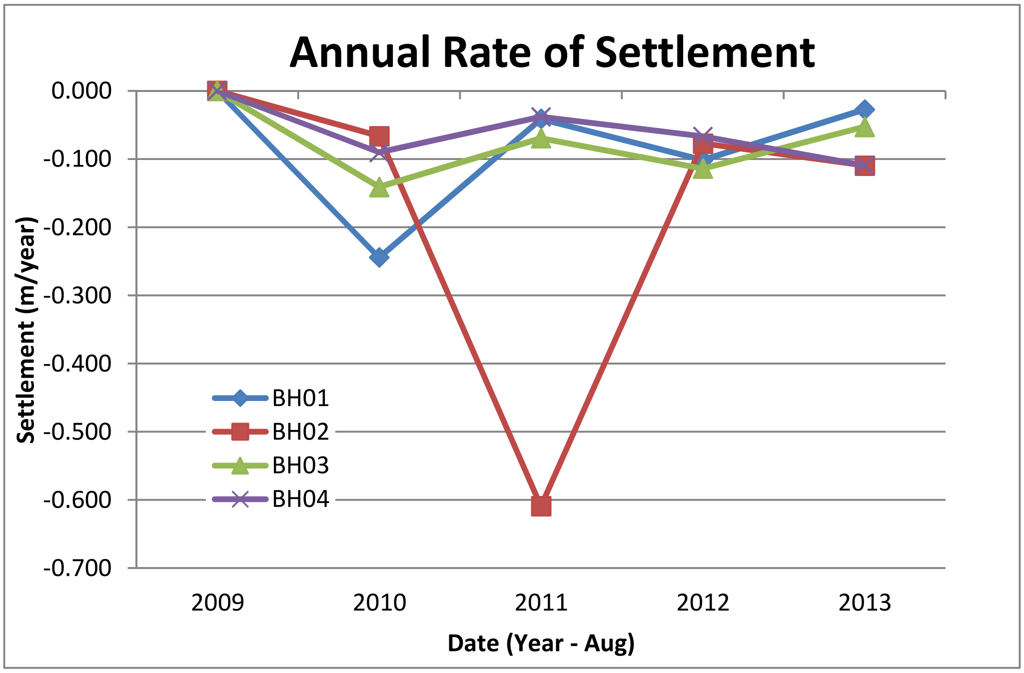
One should also consider that there are variations in permafrost conditions throughout section STA 4+640 to STA 4+860 that will result in differential settlements along this section of roadway. For example, the locations of Boreholes BH02 and BH03 are likely to experience up to one metre of settlement from thawing ice and that consolidation will also occur simultaneously as the thaw-front advances in depth. Consolidation of the underlying PEAT and SILT may also continue after the permafrost has thawed. The rate and overall amount of consolidation settlement is assumed to be lower than the rate and overall amount of thaw-settlement.

As for monitoring of the settlement that has already occurred, CS-IDB was able to provide roadway surface survey data that has been collected randomly throughout the spring, summer and fall months since October 2009. The surface elevations were collected from set stations along the alignment and EBA has determined that some of the actually locations showing signs of greatest settlement (EBA borehole locations) were not surveyed. The following Graphs 1 and 2 show overall and rate settlement, at the borehole locations. Some of the elevations were determined from break lines between two known points and only in close proximity to the actual borehole locations. The actual elevations of the borehole locations may have settlement values greater than what has been shown on the following Graphs 1 and 2.

Graph 1: Cumulative Settlement



Graph 2: Annual Rate of Settlement



The results indicate that there may be a slight decrease in the rate of settlement but EBA has determined that data is not very accurate and the collection of more survey data over the next 5 to 10 years will be required to better determine when settlement will stop.

As settlement from thawing ice and consolidation of underlying PEAT and SILT continues to occur the perimeter guard rails along each lane will have to be repaired or possibly replaced with concrete Jersey curbs that can be relocated during annual repairs.

EBA is assuming that the annual cost of maintaining the roadway will decrease as the foundation soils thaw and consolidate.

4.1.1 Acceleration of Thaw Process

Methods of accelerating the thaw process will, in theory, reduce the thaw period with the aim of reducing the cost of maintenance over the lifecycle of the road. One method available is water injection. The process requires drilling into the embankment in a grid pattern to provide a corridor for water injection. Increased maintenance will be required during the accelerated thaw period. Therefore, it would be cost effective to leave the section as a gravel road and re-grade as required throughout the year.

The intention of accelerating the thaw process is to decrease the overall maintenance costs. As previously stated the natural thaw period could take up to 5 to 10 years; therefore, the costs associated with water injection may be greater than the cost of annual repairs associated with natural thaw.

4.2 Reconstruction with Excavation Unsuitable Foundation Material

The reconstruction and excavation alternative requires excavating the existing embankment to remove unsuitable foundation material and replacing it with engineered fill to provide a stable foundation for Hamilton Boulevard. To excavate down to dense soils would require a sub-excavation ranging from 8 m to 10 m, including 5 m of quarry rock embankment.

The advantages of reconstructing the embankment and removing the PEAT and soft SILT are:

- High confidence of success;
- Construction process uses conventional equipment and methods familiar to local contractors;
- Would allow for installation of a culvert;
- Reduced annual repair costs; and,
- Reduced safety concerns for the public.

Disadvantages include:

- High cost;
- Management of groundwater during construction;
- Labour intensive; and
- Long duration of project and increased traffic delays during reconstruction.

4.3 Arch Multi-plate

The arch multi-plate option requires excavation of the embankment materials down to an elevation that would allow for the installation of the foundation piles into bedrock. Concrete pile cap footings would be installed to allow for the connection of each multi-plate/culvert structure. Arch multi-plate structures could span up to 25 m and section STA 4+640 to STA 4+860 would require approximately 10 such structures. Constructing such structures would require about 14 m of engineered fill, which would result in an elevated road alignment. The advantages of constructing arch multi-plate structures:

- No excavation of the underlying PEAT and SILT;
- No management of groundwater during construction;
- High confidence of success;
- Construction process uses conventional equipment and methods familiar to local contractors;
- Reduced annual repair costs; and
- Reduced safety concerns for the public.

Disadvantages include:

- High cost;
- Requirement for more site investigation work and extensive design engineering;
- Requirement of the installation of rock socketed piles and concrete pile caps (footings):
- Requirement of additional engineered fill materials that are suitable for placement next to the arch multi-plate structures;
- Labour intensive; and
- Long duration of project and increased traffic delays during reconstruction.

4.4 Concrete Bridge

The concrete bridge option requires no excavation of the embankment materials but would require the installation of rock socketed foundation piles into bedrock to support the concrete/steel girders that would then see the placement of the concrete bridge deck panels. It is assumed that the bridge would have to span the section STA 4+640 to STA 4+860 and would have to accommodate the existing width of both traffic lanes.

The advantages of constructing concrete bridge:

- No excavation of the embankment materials and underlying PEAT and SILT;
- No management of groundwater during construction;
- High confidence of success;
- Construction process uses conventional equipment and methods familiar to local contractors;

- Reduced annual repair costs; and
- Reduced safety concerns for the public.

Disadvantages include:

- High cost;
- Requirement for more site investigation work and a lot of design engineering;
- Labour intensive; and
- Moderate duration of project and increased traffic delays during reconstruction.

5.0 CLASS "D" COST ESTIMATE

EBA has put together the following Class "D" cost estimate for comparison of the four options listed above.

Table 3: Class "D" Cost Estimate

Option	Cost	Details
Monitor and Maintain - 10 years (including additional investigation work)	$1,200,000	It has been estimated at $120,000 per year and additional investigation work should be completed to determine the extent of the permafrost and to allow for installation of more monitoring instrumentation.
Reconstruction and Excavation	$2,500,000	This would require the excavation of the unsuitable material and possibly groundwater control through the use of sheet piles. Engineering costs are included.
Multi-plates	$20,000,000	Previous experience working with large multi-plates has put the cost at around $2,000,000 for a 25 metre span. It would take about 10 multi-plates to span the impacted area. Engineering costs are included.
Concrete Bridge	$8,700,000	The cost are based on a 3 m by 3 m grid of rock socketed piles and a concrete surfacing of 300 m in length by 12 m wide by 0.5 m in thickness. Engineering costs are included.

6.0 SOME OTHER ALTERNATIVES

EBA researched the potential for innovative mitigation options; however, these options have yet to be tried in permafrost environments and at this time are not considered to be as effective or economical in mitigating thaw-settlement.

6.1 Refreezing of Permafrost

The City of Whitehorse is located within the discontinuous permafrost zone and the conditions of permafrost encountered during the geotechnical investigation varied greatly. The use of passive thermosyphons is not feasible in this location due to the patchy nature and 0.0˚C temperatures of the permafrost encountered. The option to mechanically freeze the embankment would establish stability.

However, the long term use of mechanical freezing systems is considered to be impractical for this project for the following reasons:

- The mechanical system will require a power source; and,
- The soil is considered frost susceptible. Mechanical freezing will likely result in the development of ice lenses causing frost heave and further damage to the road embankment and surface.

6.2 Floating Road Construction

The floating road construction option involves bringing to equilibrium the weight of the road and the in situ strength of the PEAT and SILT, after the permafrost has thawed. Different techniques could be used to achieve equilibrium, including the use of geosynthetics, geogrid, wood, light weight embankment material such as recycled tires[2] or lightweight cement, and embankment thickness optimization. This method is typically used only in circumstances where the 'cut and fill' of unsuitable foundation materials is not feasible or economically.

Advantages:

- Avoid excavating of soft, saturated PEAT and SILT.

Disadvantages:

- Requires specialized expertise for design and construction;
- May still experience some settlement as the permafrost thaws and the peat consolidates; and
- Slow building process with multiple stages leading to lengthy delays for traffic.

Circumstances that do not favour the design of a floating road:

- Lack of experience of local contractors;
- Vertical and horizontal alignment restrictions along Hamilton Boulevard that may govern the thickness of the roadway; and
- Melting permafrost will continue to cause surface settlement.

7.0 FUTURE MONITORING AND INVESTIGATION WORK

With respect to immediate requirements EBA suggests the following monitoring and investigation work be completed:

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[2] Referenced Material: Recycled Tires as Lightweight Fill, Bernie Mills, M.Sc.Eng., P.Eng. and Jared McGinn, P.Eng., P.Geo

7.1 Monitoring

- Continue to regularly monitor future settlement as compared to original design grades of Hamilton Boulevard. A benchmark and survey monuments should be established at select areas (present borehole locations) that will monitor the greatest settlement, and surveys completed prior to and after annual repair work to monitor settlement rates. The survey monuments should be positioned in locations (outside the protective guard rail) where they will not be disturbed during ongoing annual repairs. In the interim the post tops of the perimeter guard rails could be surveyed until the guard has to be replaced or other survey monuments have been installed.
- Continue with monthly monitoring of the GTC in Borehole BH03 to assist in monitoring the rate of permafrost thaw.

7.2 Investigation Work

- Additional investigation work to the north and south of the presently investigated section of Hamilton Boulevard should be completed to assist in determining the extent of the permafrost. This would also assist in determining material volumes should any of the re-construction alternatives be selected.
- Additional GTCs could also be installed along the road to assist in alignment during any additional site investigation work to assist in determining the rate of permafrost thaw.

8.0 LIMITATIONS OF REPORT

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9.0 CLOSURE

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

Respectfully submitted,
EBA Engineering Consultants Ltd.

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FIGURES

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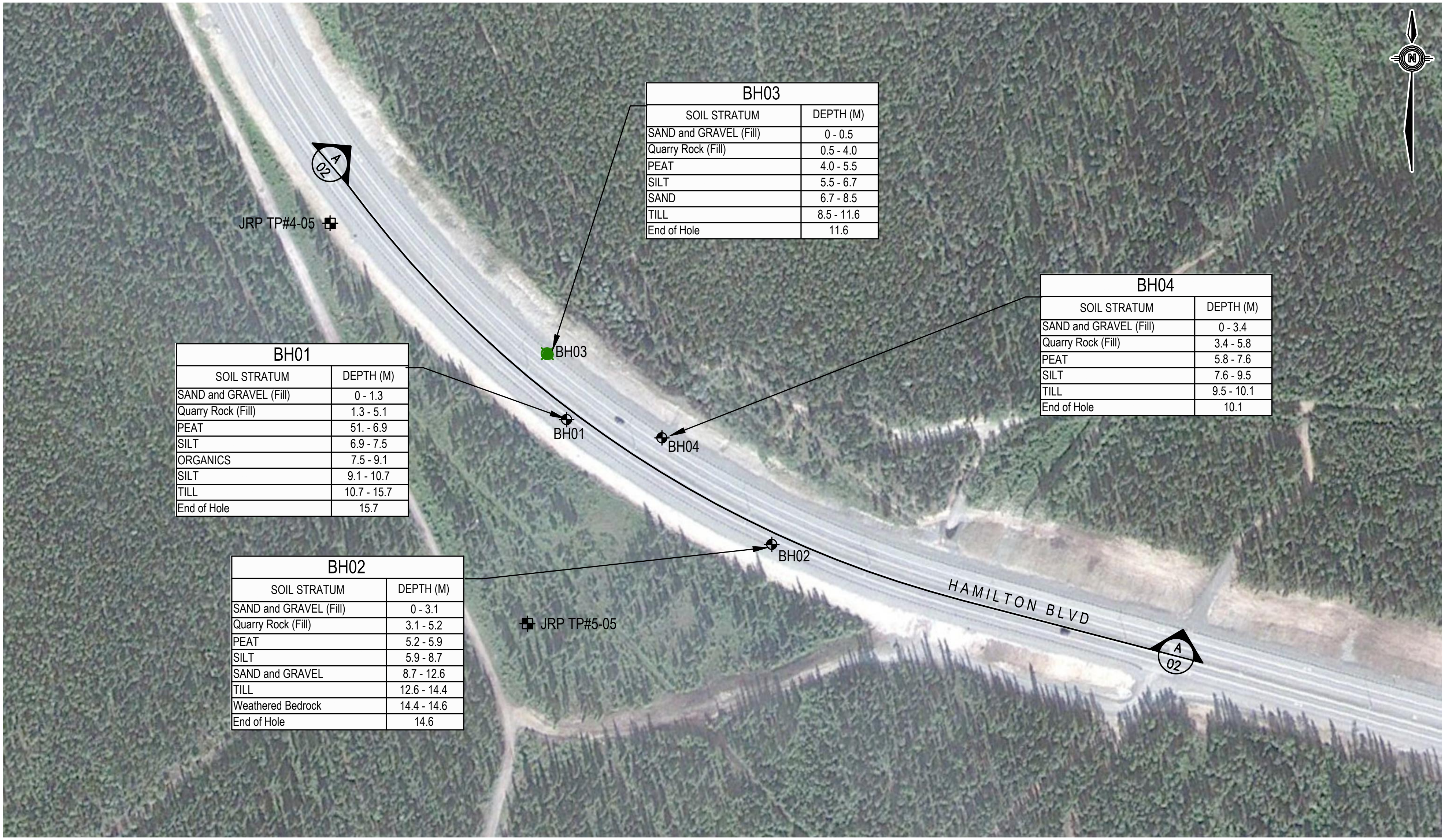


BH03

SOIL STRATUM	DEPTH (M)
SAND and GRAVEL (Fill)	0 - 0.5
Quarry Rock (Fill)	0.5 - 4.0
PEAT	4.0 - 5.5
SILT	5.5 - 6.7
SAND	6.7 - 8.5
TILL	8.5 - 11.6
End of Hole	11.6

BH04

SOIL STRATUM	DEPTH (M)
SAND and GRAVEL (Fill)	0 - 3.4
Quarry Rock (Fill)	3.4 - 5.8
PEAT	5.8 - 7.6
SILT	7.6 - 9.5
TILL	9.5 - 10.1
End of Hole	10.1

BH01

SOIL STRATUM	DEPTH (M)
SAND and GRAVEL (Fill)	0 - 1.3
Quarry Rock (Fill)	1.3 - 5.1
PEAT	51. - 6.9
SILT	6.9 - 7.5
ORGANICS	7.5 - 9.1
SILT	9.1 - 10.7
TILL	10.7 - 15.7
End of Hole	15.7

BH02

SOIL STRATUM	DEPTH (M)
SAND and GRAVEL (Fill)	0 - 3.1
Quarry Rock (Fill)	3.1 - 5.2
PEAT	5.2 - 5.9
SILT	5.9 - 8.7
SAND and GRAVEL	8.7 - 12.6
TILL	12.6 - 14.4
Weathered Bedrock	14.4 - 14.6
End of Hole	14.6

LEGEND:

⊕ - BOREHOLE LOCATION

● - GROUND TEMPERATURE CABLE LOCATION

⊞ - TEST PIT LOCATION

0 100

Scale: 1: 2 500 (metres)

STATUS

ISSUED FOR REVIEW

CLIENT

Yukon
Government
Community Services

eba
A TETRA TECH COMPANY

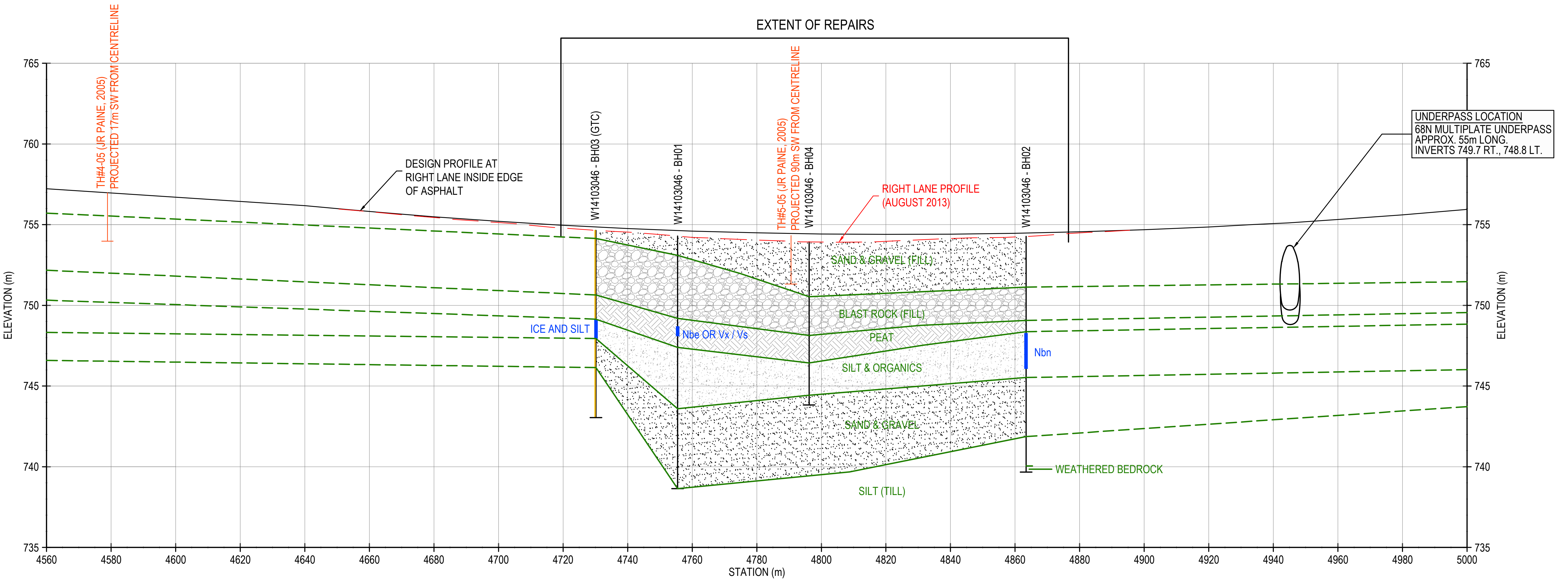
GEOTECHNICAL INVESTIGATION
HAMILTON BOULEVARD - WHITEHORSE, YUKON

SITE PLAN SHOWING BOREHOLE LOCATIONS

PROJECT NO.	DWN	CKD	REV
W14103046-02	CB	KAE	0

OFFICE	DATE
EBA-WHSE	October 18, 2013

Figure 1



0 — 50
Scale: 1: 1 250 (metres)
HORIZONTAL SCALE

0 — 10
Scale: 1: 250 (metres)
VERTICAL SCALE
5x VERTICAL EXAGGERATION

LEGEND:

▮	- INDICATES THICKNESS OF FROZEN GROUND
GTC	- GROUND TEMPERATURE CABLE
Nbn	- FROZEN SOILS WITH NON-VISIBLE ICE, WELL BONDED, NO EXCESS ICE
Nbe	- FROZEN SOILS WITH NON-VISIBLE ICE, WELL BONDED, EXCESS ICE
Vx	- FROZEN SOILS WHICH CONTAIN INDIVIDUAL ICE CRYSTALS OR INCLUSIONS
Vs	- FROZEN SOILS WITH STRATIFIED OR DISTINCTLY ORIENTED ICE FORMATIONS
- - -	- INFERRED STRATIGRAPHY THICKNESSES AND DEPTHS

NOTE
THIS FIGURE WAS PRODUCED IN COLOUR;
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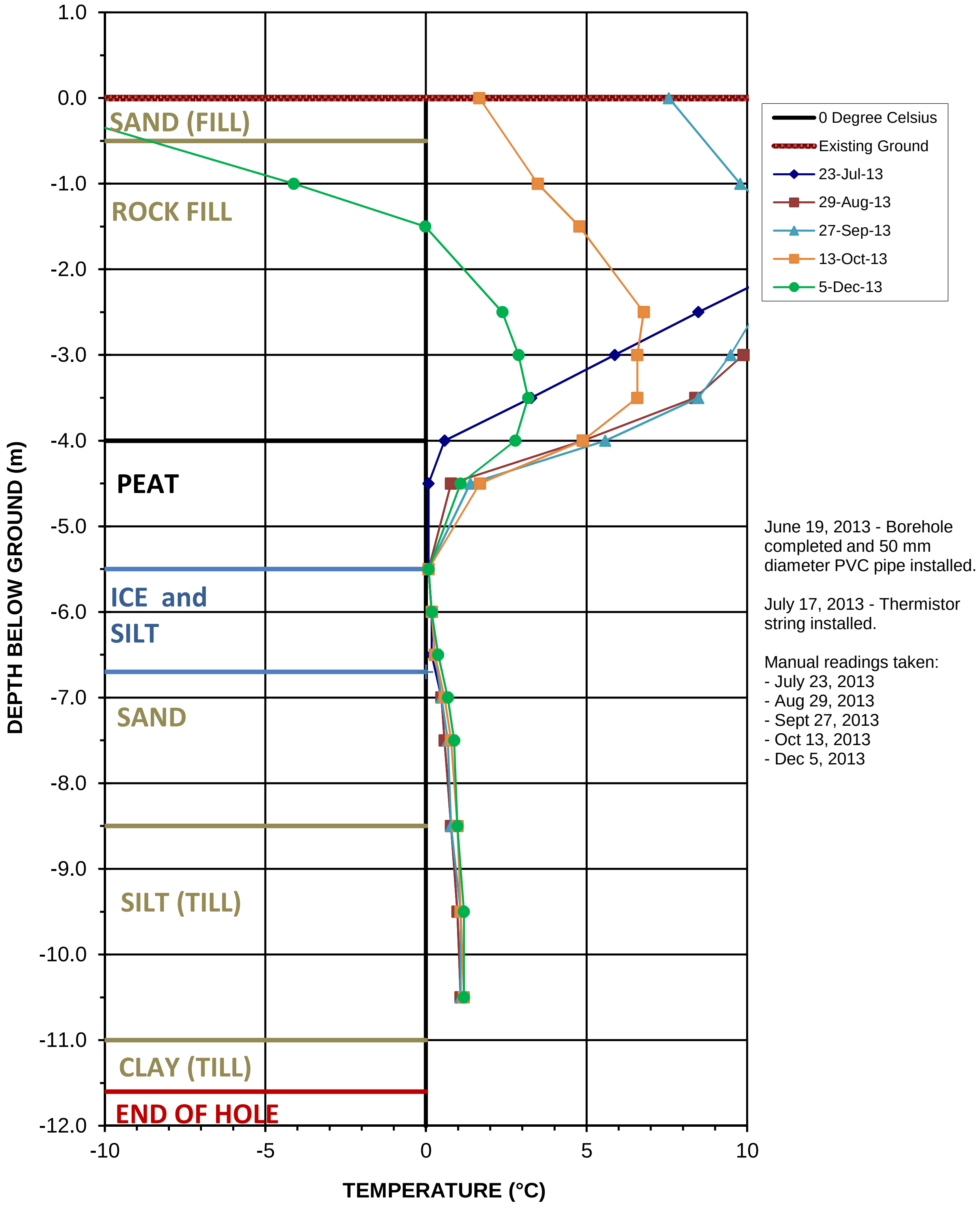
GEOTECHNICAL INVESTIGATION
HAMILTON BOULEVARD - WHITEHORSE, YUKON

CROSS-SECTION A - A'

PROJECT NO.	DWN	CKD	REV
W14103046-02	CB	CPC	0
OFFICE	DATE		
EBA-WHSE	October 18, 2013		

Figure 2

Q:\Whitehorse\Data\0201drawings\Whitehorse\W141\W14103046-02 Hamilton Blvd Geotechnical Investigation\W14103046-02 Fig.2_R0.dwg [FIGURE 2] December 24, 2013 - 11:52:28 am (BY: BUCHAN, CAMERON)



June 19, 2013 - Borehole completed and 50 mm diameter PVC pipe installed.

July 17, 2013 - Thermistor string installed.

Manual readings taken:
- July 23, 2013
- Aug 29, 2013
- Sept 27, 2013
- Oct 13, 2013
- Dec 5, 2013

Figure 3 - Ground Temperature Profile
BH03
Hamilton Boulevard Station 4+730

PHOTOGRAPHS

Photo 1: Hamilton Boulevard, aspect NW, June 11, 2013

Photo 2: Ponded water along north bound lane, aspect NW, June 11, 2013

Photo 3: Longitudinal cracking in embankment atBH01, June 18, 2013

Photo 4: Longitudinal cracking along south bound embankment, aspect NW, June 18, 2013

Photo 5: Ice rich SILT in BH03 (5.45 m – 5.9 m)

Photo 6: ICE and SILT in BH03 (5.9 m – 6.35 m)

Photo 7: ICE and SILT in BH03 (6.3 m – 6.75 m)

Photo 8: BH03 Setup, aspect NW

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

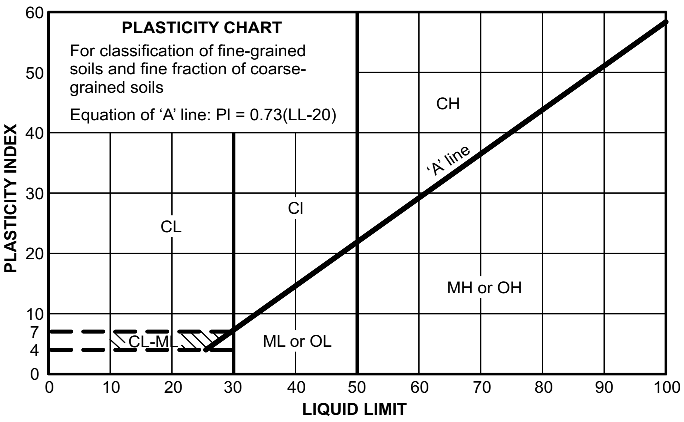
During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability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

APPENDIX B

BOREHOLE LOGS AND TEST RESULTS

MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
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	Classification on basis of percentage of fines Less than 5% pass 75 µm sieve GW, GP, SW, SP More than 12% pass 75 µm sieve GM, GC, SM, SC 5% to 12% pass 75 µm sieve 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	
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		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
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = D_{60} / D_{10}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly-graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		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
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
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			



* 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	▨

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.

VISIBLE ICE GREATER THAN 50% BY VOLUME

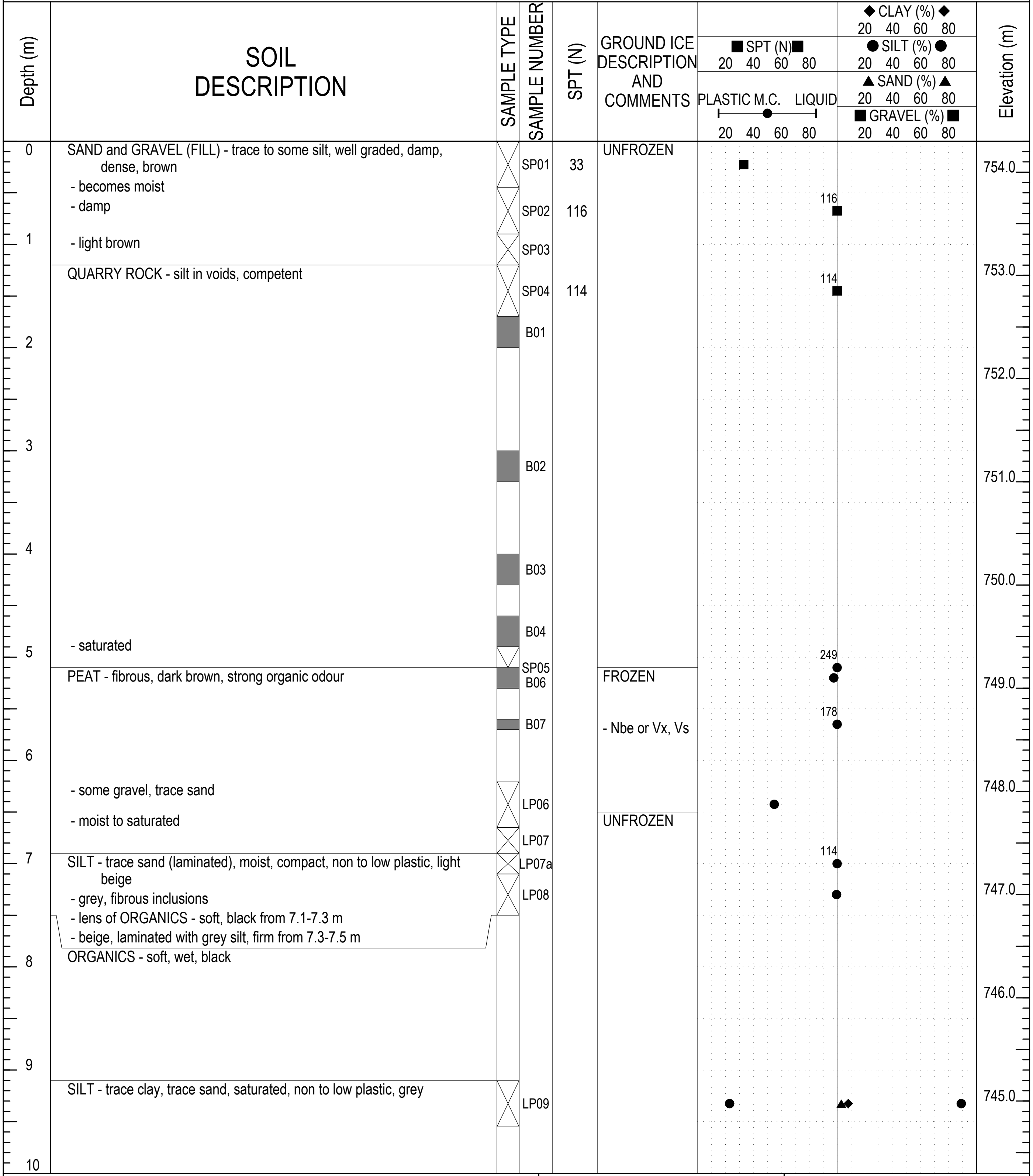
ICE	ICE + Soil Type	Ice with soil inclusions	■
	ICE	Ice without soil inclusions (greater than 25 mm thick	■

LEGEND: Soil □ Ice ■

Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+755	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH01
Whitehorse, YT	6728929N; 494751E; Zone 8	ELEVATION: 754.3 m

SAMPLE TYPE ▨ DISTURBED ◩ NO RECOVERY ☒ SPT ☰ A-CASING ‖ SHELBY TUBE ▮ CORE

BACKFILL TYPE ▨ BENTONITE ⁘ PEA GRAVEL ||| SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ⁘ SAND



SAND and GRAVEL (FILL) - trace to some silt, well graded, damp, dense, brown
- becomes moist
- damp
- light brown

QUARRY ROCK - silt in voids, competent
- saturated

PEAT - fibrous, dark brown, strong organic odour
- some gravel, trace sand
- moist to saturated

SILT - trace sand (laminated), moist, compact, non to low plastic, light beige
- grey, fibrous inclusions
- lens of ORGANICS - soft, black from 7.1-7.3 m
- beige, laminated with grey silt, firm from 7.3-7.5 m

ORGANICS - soft, wet, black

SILT - trace clay, trace sand, saturated, non to low plastic, grey

SAMPLE NUMBER	SPT (N)
SP01	33
SP02	116
SP03	
SP04	114
B01	
B02	
B03	
B04	
SP05	
B06	
B07	
LP06	
LP07	
LP07a	
LP08	
LP09	

UNFROZEN

FROZEN

- Nbe or Vx, Vs

UNFROZEN

LOGGED BY: KAE	COMPLETION DEPTH: 15.65m
REVIEWED BY: CPC	COMPLETE: 6/17/2013
DRAWING NO:	Page 1 of 2

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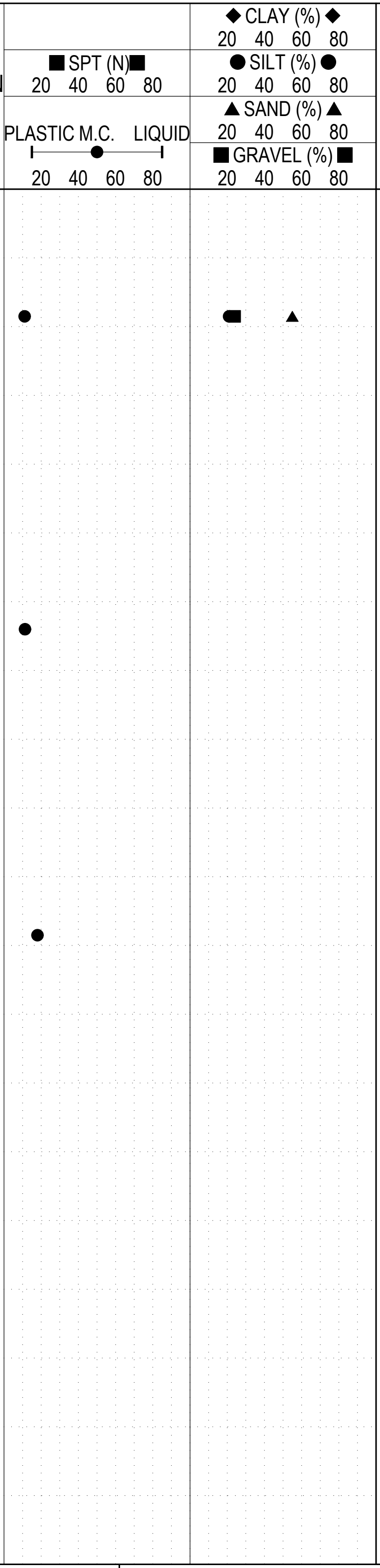
Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+755	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH01
Whitehorse, YT	6728929N; 494751E; Zone 8	ELEVATION: 754.3 m

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)
10					UNFROZEN	744.0
	SAND (TILL) - gravelly, silty, medium grained, gravel <50 mm, rounded, saturated, very dense, grey					
11		☒	LP10			743.0
12		▇	B08			
	- no recovery in spoon	☒	LP11			742.0
13	- silty, trace gravel	▇	B09			741.0
14	- SPT blocked by 3" gravel - light brown, sample washed	☒	LP12			740.0
15		☒	LP13			739.0
	END OF BOREHOLE @ 15.7 m (target depth) NOTE: backfilled with grout to bottom of quarry rock, drill cuttings and grout to surface					
16						738.0
17						737.0
18						736.0
19						735.0
20						



LOGGED BY: KAE	COMPLETION DEPTH: 15.65m
REVIEWED BY: CPC	COMPLETE: 6/17/2013
DRAWING NO:	Page 2 of 2

PARTICLE SIZE ANALYSIS REPORT

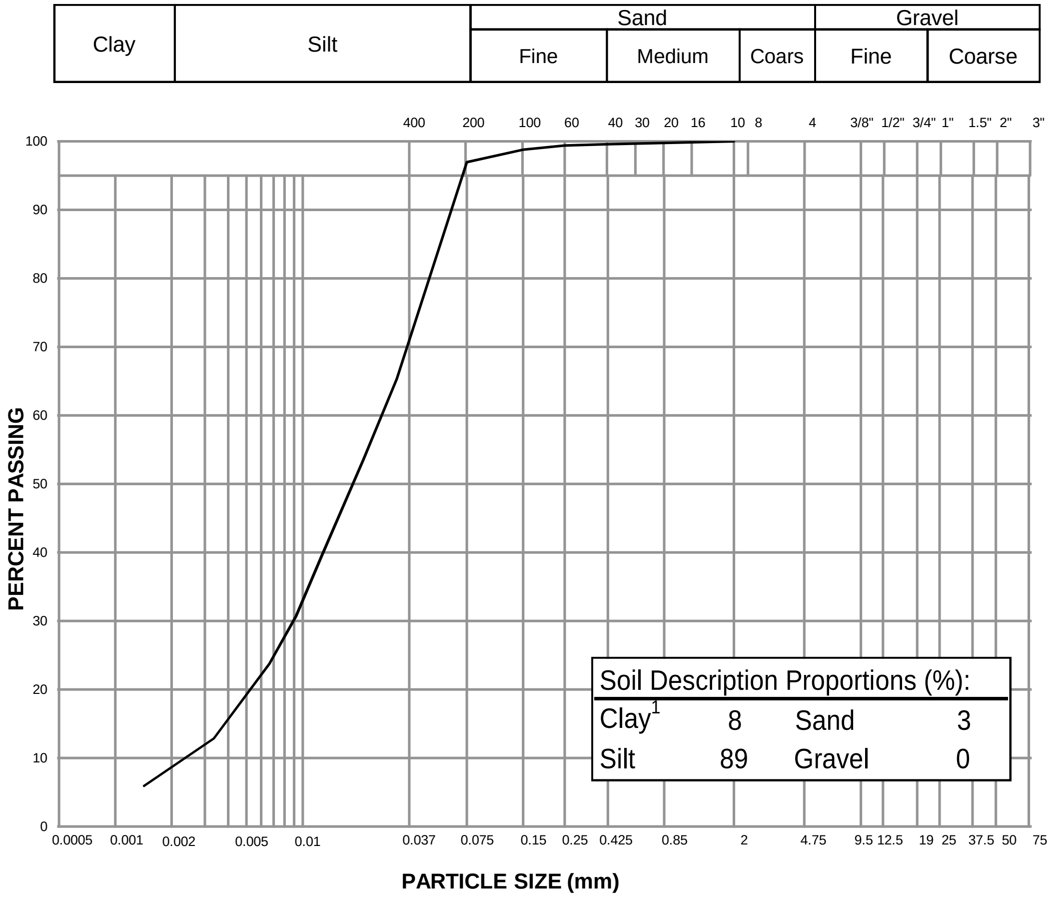
ASTM D422, C136 & C117

Project: Geotechnical Evaluation
Project No.: W14103046-02
Site: South Hamilton Blvd, Whitehorse, YT
Client: YG - Community Services
Client Rep.: Kirn Dhillon
Date Tested: June 26, 2013 By: SG
Soil Description[2]: SILT - trace clay, trace sand

Sample No.: LP09
Material Type:
Sample Loc.: BH01
Sample Depth: 9.1 - 9.55 m
Sampling Method: Split Spoon
Date sampled: June 17, 2013
Sampled By: KAE
USC Classification: Cu: 10.5

Moisture Content: 22.9% Cc: 1.2

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	100
0.425	100
0.25	99
0.15	99
0.075	97
0.0318	65.3
0.0210	53.5
0.0127	39.6
0.0092	30.7
0.0066	23.8
0.0034	12.9
0.0014	5.9



Soil Description Proportions (%):

Clay[1]	8	Sand	3
Silt	89	Gravel	0

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:

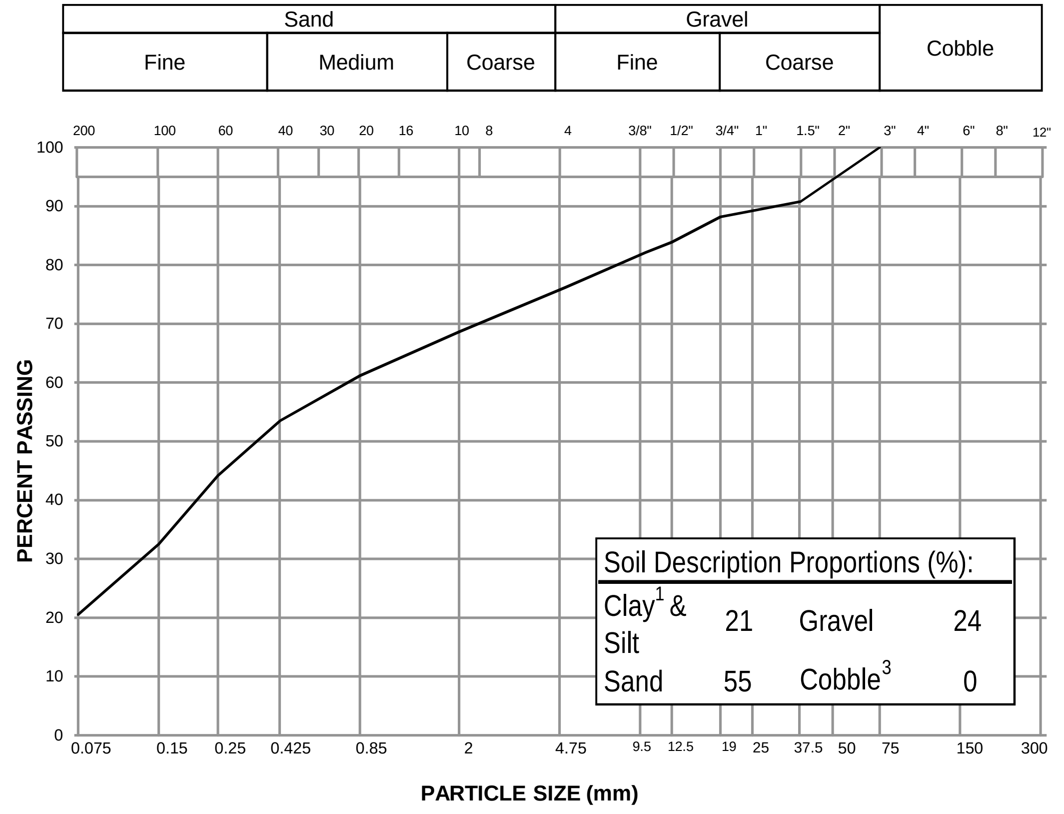
Reviewed By: ____________ P. Eng

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Geotechnical Evaluation	Sample No.:	LP10
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH01
Client:	YG - Community Services	Sample Depth:	10.7 - 11.15 m
Client Rep.:	Kirn Dhillon	Sampling Method:	Split Spoon
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 17, 2013
Soil Description[2]:	SAND - gravelly, silty	Sampled By:	KAE
		USC Classification:	Cu: n/a
Moisture Content:	11.1%		Cc: n/a

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	100
50	
38	91
25	89
19	88
12.5	84
10	82
5	76
2	69
0.85	61
0.425	53
0.25	44
0.15	33
0.075	21



Soil Description Proportions (%):

Clay[1] & Silt	21	Gravel	24
Sand	55	Cobble[3]	0

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

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: ____________________

Remarks: ____________________

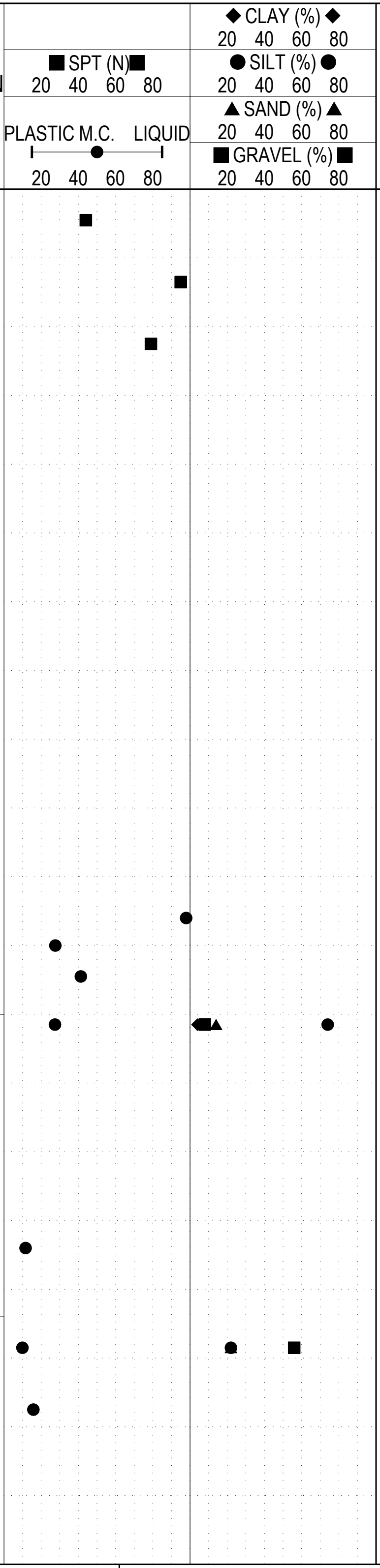
Reviewed By: ____________________ P. Eng

Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+865	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH02
Whitehorse, YT	6728872N; 494844E; Zone 8	ELEVATION: 753.4 m

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	SAND and GRAVEL (FILL) - trace silt, well graded, gravel <30 mm, damp, dense, light brown	☒	SP01	44	UNFROZEN	753.0
		☒	SP02	95		
1	GRAVEL (FILL) - some sand, gravel <30 mm captured in SPT, angular, damp, very dense, light brown	☒	SP03	79		752.0
	- gravel <50 mm	▨	B01			
2						751.0
3	QUARRY ROCK (FILL) - damp, competent	▨	B02			750.0
4						749.0
		▨	B03			
5	- organic inclusions					
	PEAT - black, root and fibre inclusions, organic odour	▨	B04			748.0
		☒	LP04a			
	- some silt to silty, no root inclusions	☒	LP04			
6	SILT - some sand, trace gravel, trace clay, saturated, non to low plastic, grey	☒	LP05		FROZEN, Nbn	747.0
7						746.0
	- becomes some gravel, <30 mm, sub-angular, flat, ellongated	▨	B05			
8	- gravelly, sandy, gravel <75 mm, angular	☒	LP06		UNFROZEN	745.0
	SAND - some silt, trace gravel, fine and medium grained, saturated, dense (est.), grey	☒	LP07			
9						744.0
10	GRAVEL - sandy, trace silt, gravel <20 mm, sub-rounded, wet, dense	▨	B06			



LOGGED BY: KAE	COMPLETION DEPTH: 14.6m
REVIEWED BY: CPC	COMPLETE: 6/18/2013
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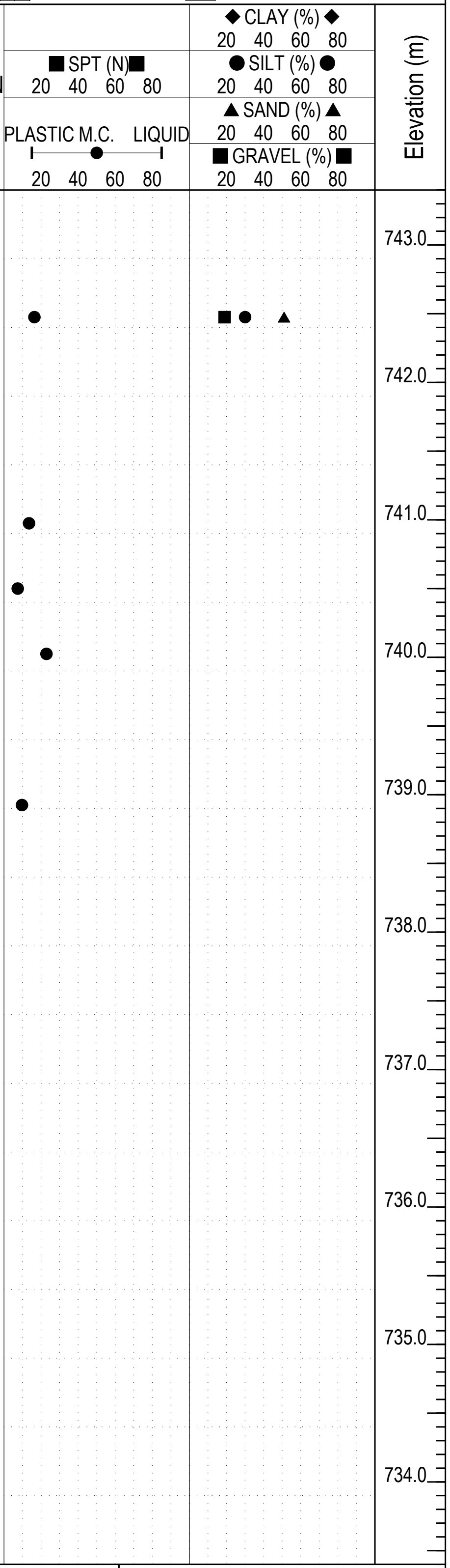
Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+865	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH02
Whitehorse, YT	6728872N; 494844E; Zone 8	ELEVATION: 753.4 m

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
10	(est.), grey				UNFROZEN
11	SAND - silty, some gravel, fine grained, saturated, compact (est.), grey	☒	LP08		
		☒	LP09		
12		☒	LP10		
	SILT (TILL) - some clay, trace gravel, trace sand, moist, stiff (est.), non to low plastic, brown	▨	B07		
13	CLAY (TILL) - silty, moist, very stiff (est.), low to medium plastic, grey, oxidization staining	☒	LP11		
	SILT - moist, compact (est.), non to low plastic, saturated, light brown	☒	LP11a		
14		☒	LP12		
	WEATHERED BEDROCK - weak	☒	LP12a		
	END OF BOREHOLE @ 14.6 m (target depth) NOTE: backfilled with grout to quarry rock, drill cutting and grout to surface				
15					
16					
17					
18					
19					
20					



eba A TETRA TECH COMPANY	LOGGED BY: KAE	COMPLETION DEPTH: 14.6m
	REVIEWED BY: CPC	COMPLETE: 6/18/2013
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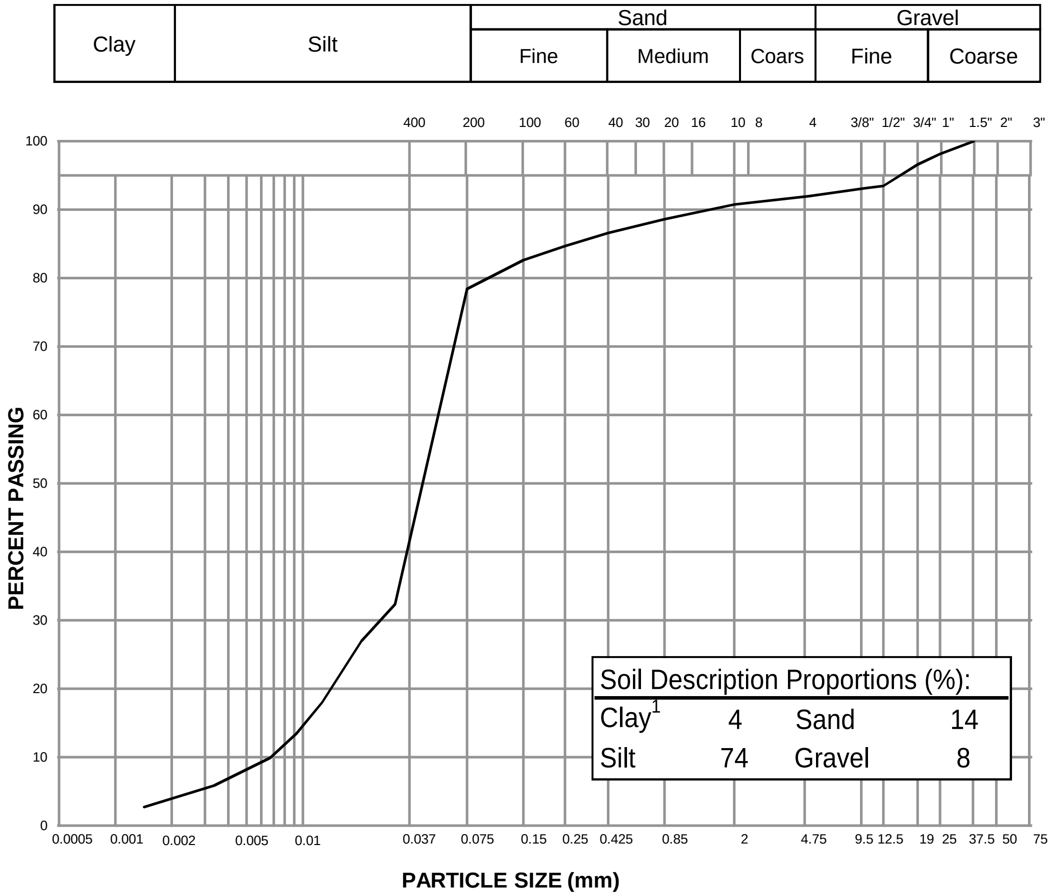
PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Geotechnical Evaluation	Sample No.:	LP05
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH02
Client:	YG - Community Services	Sample Depth:	5.85 - 6.3 m
Client Rep.:	Kirn Dhillon	Sampling Method:	Split Spoon
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 17, 2013
Soil Description[2]:	SILT - some sand, trace gravel, trace clay	Sampled By:	KAE
		USC Classification:	Cu: 8.5
Moisture Content:	27.4%		Cc: 1.8

Particle Size (mm)	Percent Passing
75	
50	
38	100
25	98
19	97
12.5	93
10	93
5	92
2	91
0.85	89
0.425	87
0.25	85
0.15	83
0.075	78
0.0310	32.4
0.0206	27.0
0.0127	18.0
0.0092	13.5
0.0067	9.9
0.0034	5.8
0.0014	2.7



Soil Description Proportions (%):

Clay[1]	4	Sand	14
Silt	74	Gravel	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: P. Eng

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PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Geotechnical Evaluation	Sample No.:	LP06
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH02
Client:	YG - Community Services	Sample Depth:	8.2 - 8.65 m
Client Rep.:	Kirn Dhillon	Sampling Method:	Split Spoon
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 17, 2013
Soil Description[2]:	GRAVEL - sandy, silty	Sampled By:	KAE

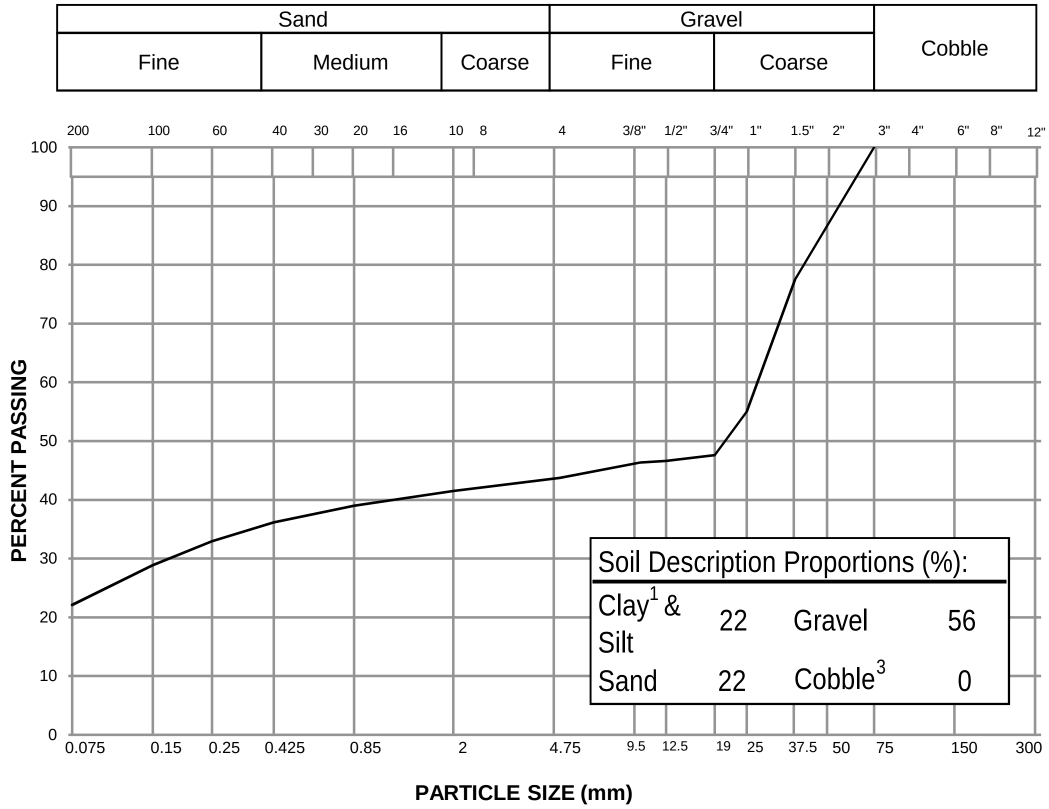
USC Classification:

Cu: n/a

Moisture Content: 9.9%

Cc: n/a

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	100
50	
38	48
25	48
19	48
12.5	47
10	46
5	44
2	42
0.85	39
0.425	36
0.25	33
0.15	29
0.075	22



Soil Description Proportions (%):

Clay[1] & Silt	22	Gravel	56
Sand	22	Cobble[3]	0

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

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification:

Remarks:

Reviewed By: P. Eng

eba
A TETRA TECH COMPANY

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

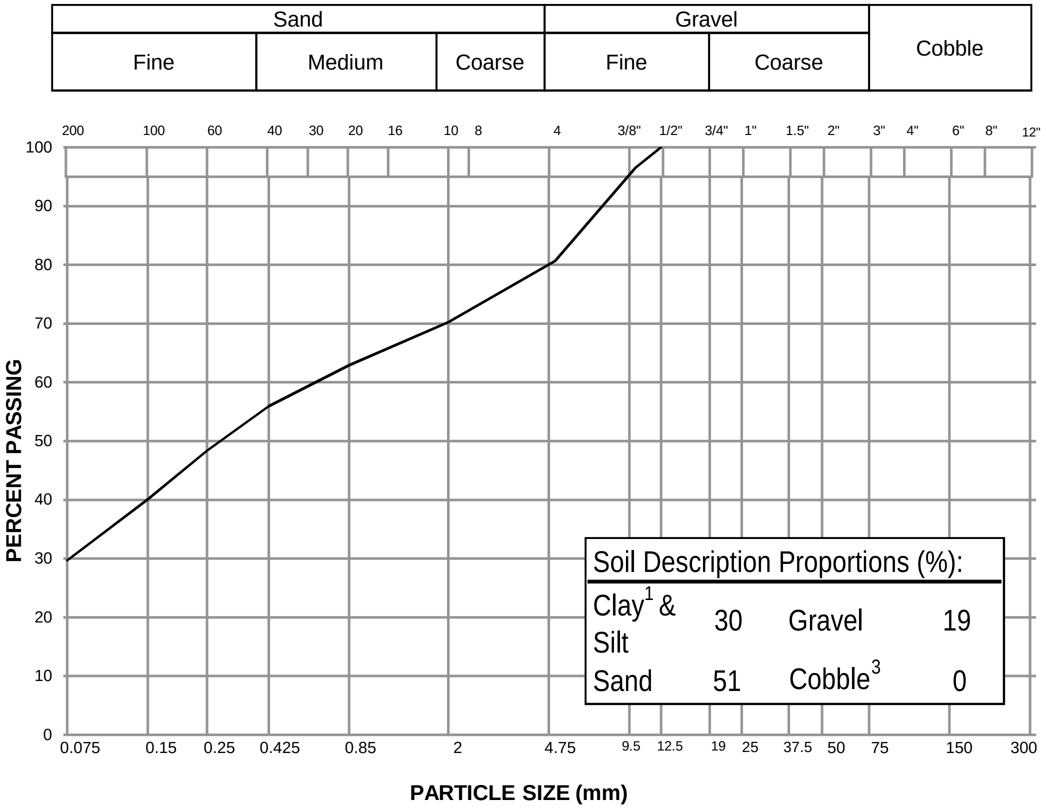
Project:	Geotechnical Evaluation	Sample No.:	LP08
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH02
Client:	YG - Community Services	Sample Depth:	10.7 - 11.15 m
Client Rep.:	Kirn Dhillon	Sampling Method:	Split Spoon
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 17, 2013
Soil Description[2]:	SAND - silty, some gravel	Sampled By:	KAE
		USC Classification:	

Cu: n/a

Moisture Content: 16.4%

Cc: n/a

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	100
10	96
5	81
2	70
0.85	63
0.425	56
0.25	48
0.15	40
0.075	30



Soil Description Proportions (%):

Clay[1] & Silt	30	Gravel	19
Sand	51	Cobble[3]	0

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

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification:

Remarks:

Reviewed By: ____________ P. Eng

A TETRA TECH COMPANY

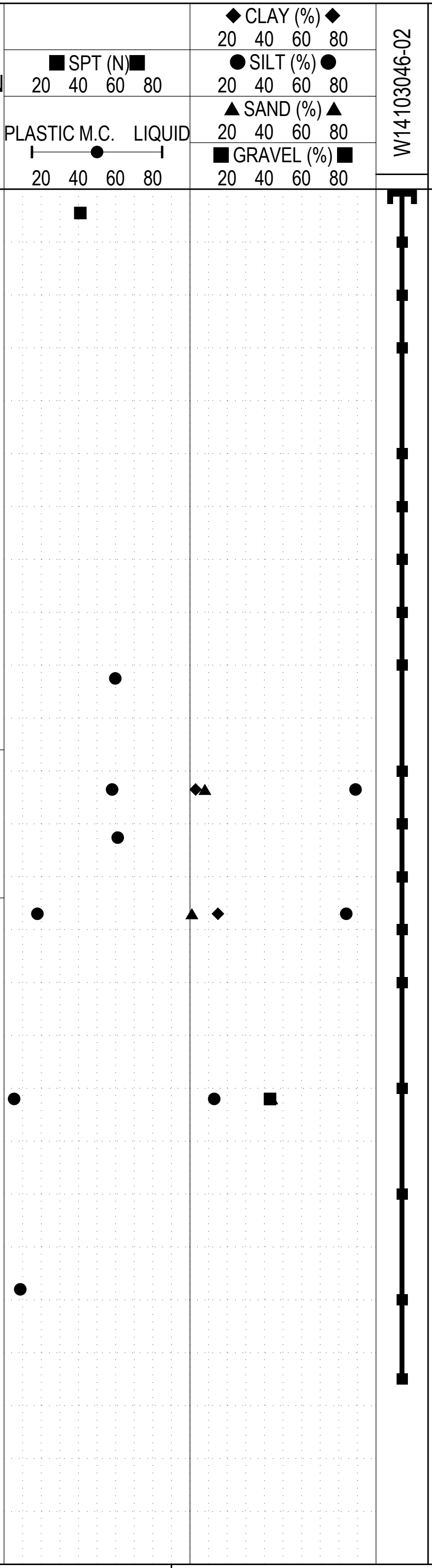
Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+730	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH03
Whitehorse, YT	6728951N; 494737E; Zone 8	ELEVATION: 755 m

SAMPLE TYPE ▨ DISTURBED ◺ NO RECOVERY ☒ SPT ☰ A-CASING ▥ SHELBY TUBE ▮ CORE

BACKFILL TYPE ▨ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▧ DRILL CUTTINGS ⁘ SAND

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SPT (N)	GROUND ICE DESCRIPTION AND COMMENTS
GRAVEL and SAND (BST SURFACE) - some silt, gravel well graded, damp, brownish grey	☒	SP01	41	UNFROZEN
QUARRY ROCK - sand in voids, competent				
	▨	B01		
- organics in voids	▨	B02		
PEAT - fibrous, soft, moist, black, blast rock chip inclusions, strong odour	▨	B03		
	☒	LP02		
- no rock chips in sample	☒	LP03		
ICE and SILT - trace sand, trace clay, non to low plastic, grey	☒	LP04		FROZEN - Vs, ice lenses <1 cm at 50 mm spacing @ 5.45 m
	☒	LP05		
	☒	LP06		
SAND - some silt, trace gravel, fine and medium grained, wet, compact (est.), dark grey	☒	LP07		- Vs/Vr lenses 10 mm by 10 mm @ 5.9 m - clear ice @ 6.3 m
- trace gravel, trace silt, fine				UNFROZEN @ 6.7 m
	☒	LP08		
SILT (TILL) - gravelly, sandy, gravel rounded, <50 mm, moist, dense (est.), non to low plastic, grey	▨	B04		
	▨	B05		
- becomes some gravel, trace sand, trace clay, saturated, compact, non to low plastic, olive	☒	LP09		
	☒	LP09a		
CLAY (TILL) - gravelly, some silt, some sand, gravel <40 mm, rounded, dense, non to low plastic, beige	▨	B06		
END OF BOREHOLE @ 11.6 m (target depth) NOTE: 2" PVC pipe for GTC installed to 11.3 m, no screen, grout to surface				

Depth (m)	Elevation (m)
0	755.0
1	754.0
2	753.0
3	752.0
4	751.0
5	750.0
6	749.0
7	748.0
8	747.0
9	746.0
10	745.0
11	744.0
12	743.0
13	742.0



LOGGED BY: KAE	COMPLETION DEPTH: 11.6m
REVIEWED BY: CPC	COMPLETE: 6/20/2013
DRAWING NO:	Page 1 of 1

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PARTICLE SIZE ANALYSIS REPORT

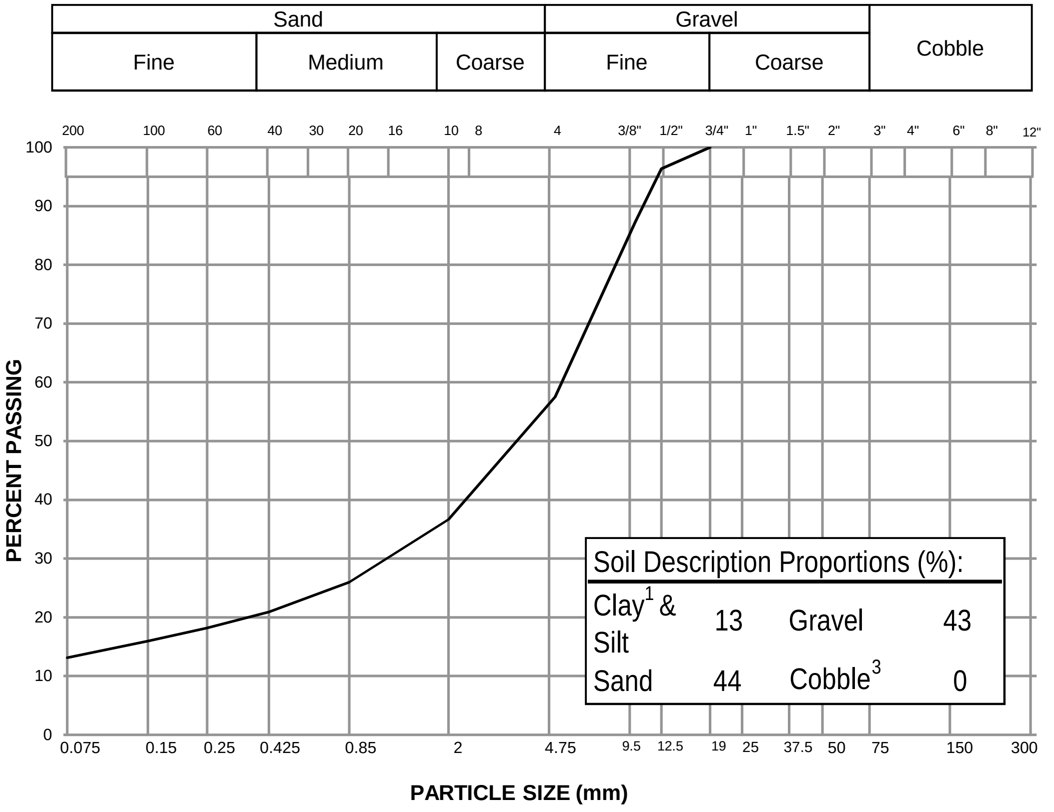
ASTM D422, C136 & C117

Project: Geotechnical Evaluation
Project No.: W14103046-02
Site: South Hamilton Blvd, Whitehorse, YT
Client: YG - Community Services
Client Rep.: Kirn Dhillon
Date Tested: June 26, 2013 By: SG
Soil Description[2]: SAND and GRAVEL - some silt

Sample No.: B04
Material Type:
Sample Loc.: BH03
Sample Depth: 8.5 - 8.7 m
Sampling Method: Split Spoon
Date sampled: June 19, 2013
Sampled By: KAE
USC Classification: Cu: n/a
Cc: n/a

Moisture Content: 5.4%

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	100
12.5	96
10	87
5	58
2	37
0.85	26
0.425	21
0.25	18
0.15	16
0.075	13



Soil Description Proportions (%):

Clay[1] & Silt	13	Gravel	43
Sand	44	Cobble[3]	0

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
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification:

Remarks:

Reviewed By: P. Eng

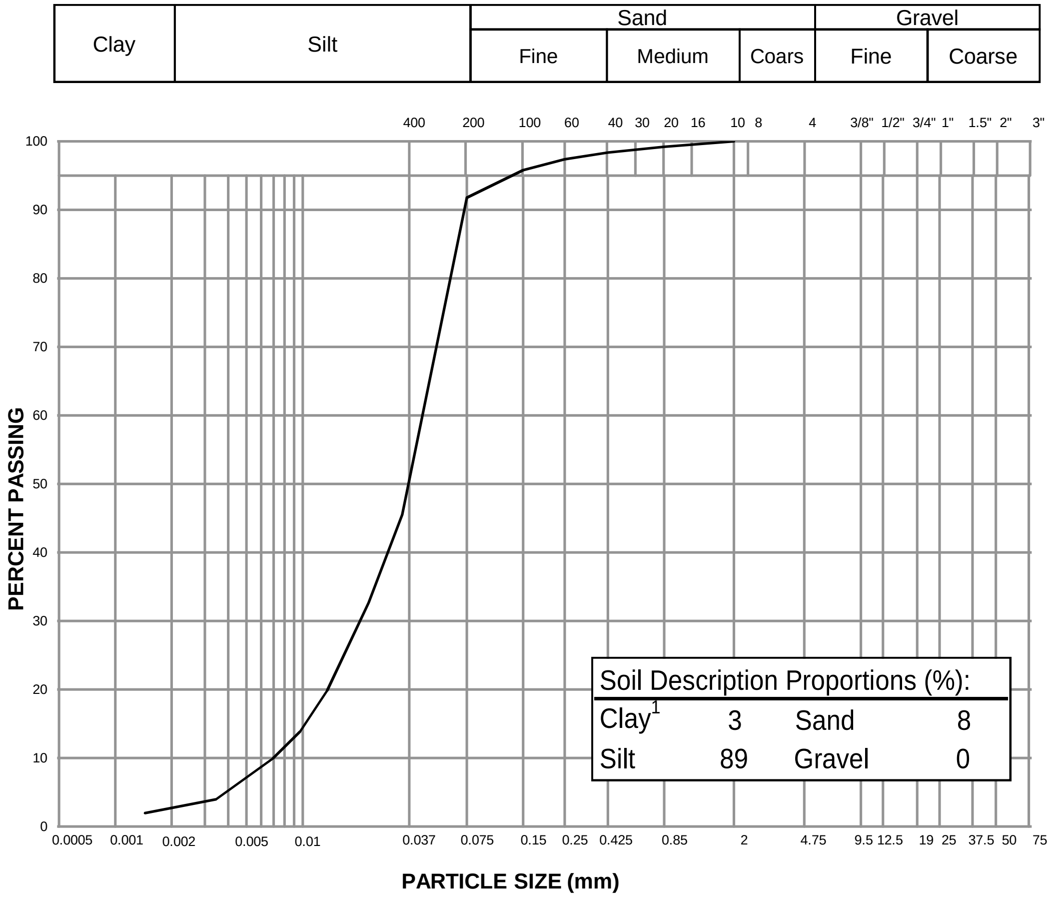
eba A TETRA TECH COMPANY

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Geotechnical Evaluation	Sample No.:	LP04
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH03
Client:	YG - Community Services	Sample Depth:	5.45 - 5.9 m
Client Rep.:	Kirn Dhillon	Sampling Method:	Split Spoon
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 19, 2013
Soil Description[2]:	SILT - trace sand, trace clay	Sampled By:	KAE
		USC Classification:	Cu: 6.7
Moisture Content:	58.1%		Cc: 1.3

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	99
0.425	98
0.25	97
0.15	96
0.075	92
0.0340	45.5
0.0224	32.7
0.0135	19.8
0.0097	13.9
0.0069	9.9
0.0034	4.0
0.0014	2.0



Soil Description Proportions (%):

Clay[1]	3	Sand	8
Silt	89	Gravel	0

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: P. Eng

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A TETRA TECH COMPANY

PARTICLE SIZE ANALYSIS REPORT

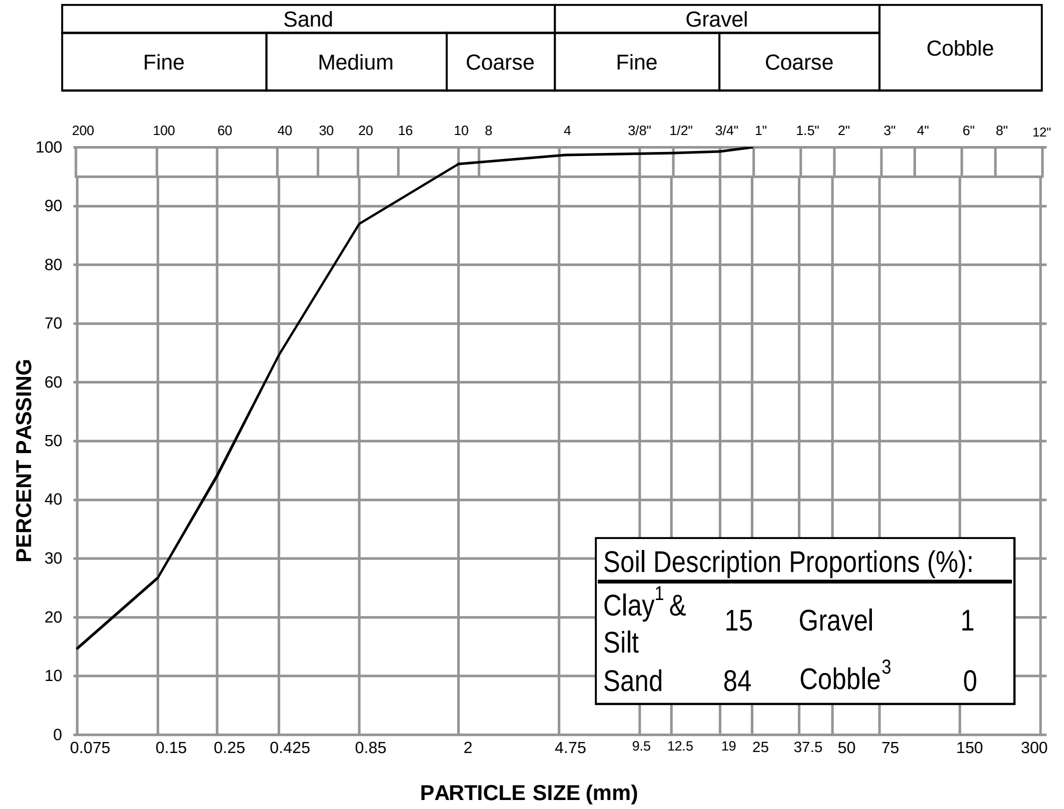
ASTM D422, C136 & C117

Project: Geotechnical Evaluation
Project No.: W14103046-02
Site: South Hamilton Blvd, Whitehorse, YT
Client: YG - Community Services
Client Rep.: Kirn Dhillon
Date Tested: June 26, 2013 By: SG
Soil Description[2]: SAND - some silt, trace gravel

Sample No.: LP07
Material Type:
Sample Loc.: BH03
Sample Depth: 6.75 - 6.95 m
Sampling Method: Split Spoon
Date sampled: June 19, 2013
Sampled By: KAE
USC Classification:
Cu: n/a
Cc: n/a

Moisture Content: 17.9%

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	99
12.5	99
10	99
5	99
2	97
0.85	87
0.425	65
0.25	44
0.15	27
0.075	15



Soil Description Proportions (%):

Clay[1] & Silt	15	Gravel	1
Sand	84	Cobble[3]	0

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
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification:

Remarks:

Reviewed By: P. Eng

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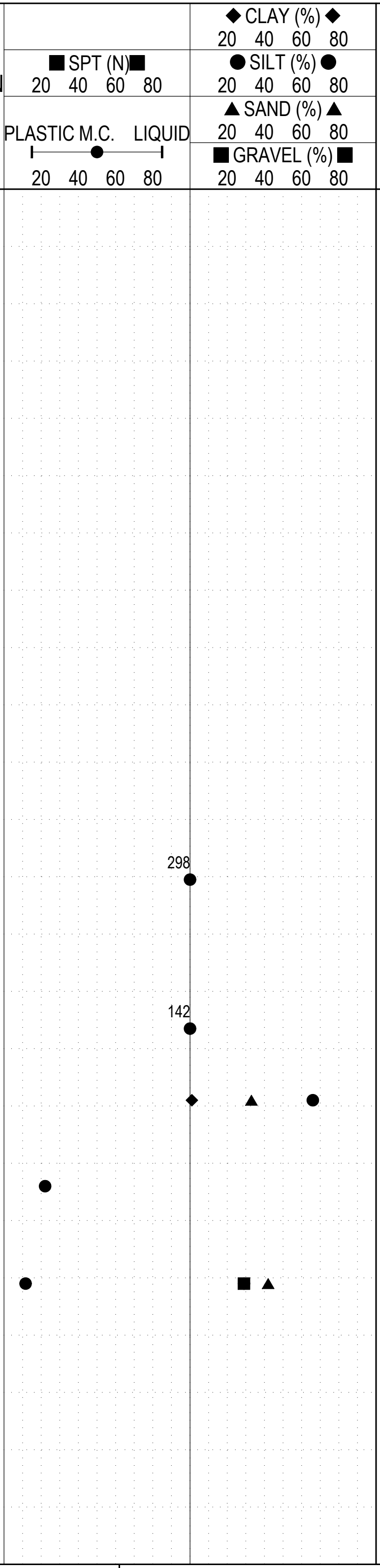
Geotechnical Evaluation	CLIENT: YG - Community Services	PROJECT NO. - BOREHOLE NO.
Hamiltion Boulevard STA 4+795	DRILL: Sandvic M5 ODEX (Air Rotary)	W14103046-BH04
Whitehorse, YT	6728919N; 494794E; Zone 8	ELEVATION: 754 m

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	Elevation (m)
0	GRAVEL and SAND (FILL) - trace to some silt, well graded, damp, dense, brown			UNFROZEN	754.0
1					753.0
		▨	B01		
2					752.0
3					751.0
	QUARRY ROCK - broken down by drill action, sand and gravel in voids, competent	▨	B02		
4					750.0
▼					▼
	- free water pumped up through drill rods, probable water table				
		▨	B03		
5					749.0
	- organics in voids, peat, wood and roots	▨	B04		
6	PEAT - wood and roots, saturated, soft, strong organic swampy odour - damp	☒	LP01		748.0
	- charcoal and ash 10 mm thick at 6.4 m				
7		☒	LP02		747.0
	- highly weathered peat, olive at 7.1 m	☒	LP03		
	- trace silt at 7.5 m				
8	SILT - sandy, trace clay, saturated, soft (easy drilling), olive grey	▨	B05		746.0
	- some sand, trace gravel, non to low plastic, grey	▨	B06		
9					745.0
	SAND - gravelly, silty, saturated/washed, dense (est.), dark grey	▨	B07		
10					744.0
	END OF BOREHOLE @ 10.1 m (target depth) NOTE: backfilled with grout to quarry rock, bentonite to surface, gravel cover				
11					743.0
12					742.0



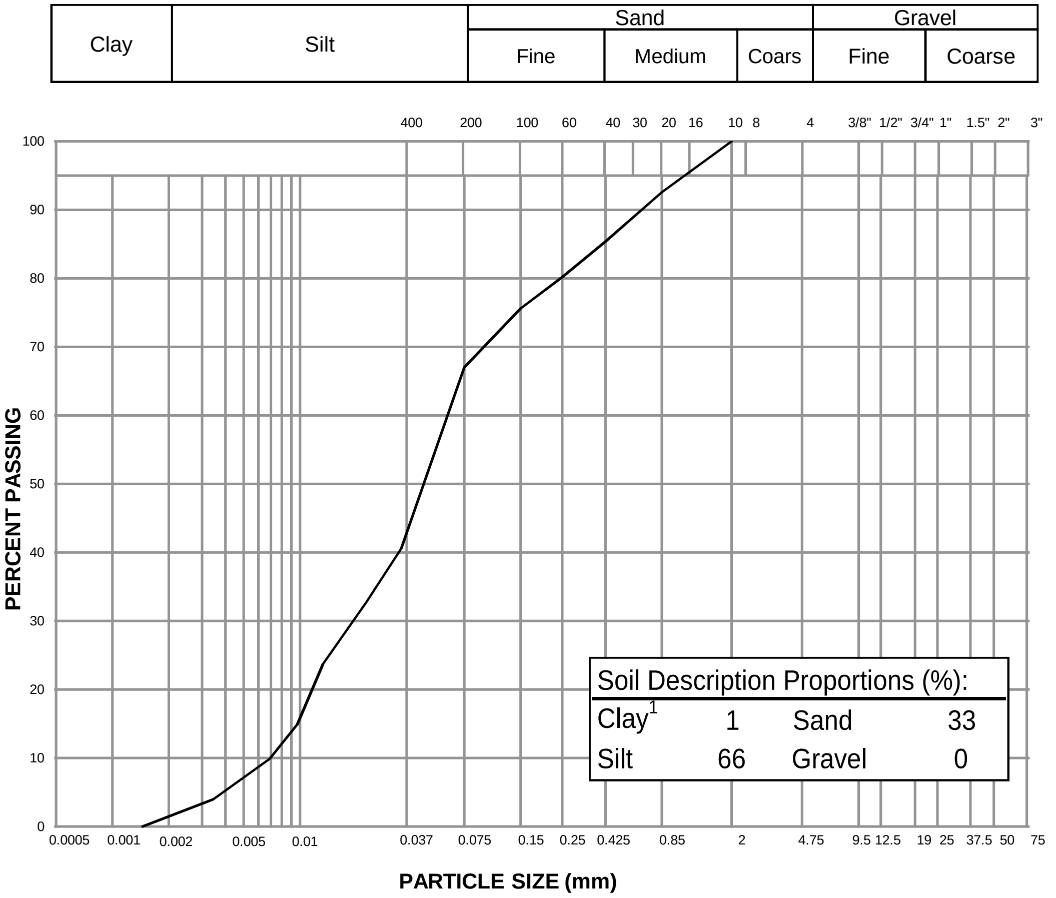
eba A TETRA TECH COMPANY	LOGGED BY: KAE	COMPLETION DEPTH: 10.1m
	REVIEWED BY: CPC	COMPLETE: 6/20/2013
	DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Geotechnical Evaluation	Sample No.:	B05
Project No.:	W14103046-02	Material Type:	
Site:	South Hamilton Blvd, Whitehorse, YT	Sample Loc.:	BH04
Client:	YG - Community Services	Sample Depth:	7.9 - 8.0
Client Rep.:	Kirn Dhillon	Sampling Method:	Grab
Date Tested:	June 26, 2013 By: SG	Date sampled:	June 20, 2013
Soil Description^2:	SILT - sandy, trace clay	Sampled By:	KAE
		USC Classification:	Cu: 9.2
Moisture Content:	217.7%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	93
0.425	85
0.25	80
0.15	76
0.075	67
0.0346	40.6
0.0224	32.7
0.0133	23.8
0.0097	14.9
0.0069	9.9
0.0034	4.0
0.0014	0.0



Soil Description Proportions (%):

Clay[1]	1	Sand	33
Silt	66	Gravel	0

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: ______________________ P. Eng

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PARTICLE SIZE ANALYSIS REPORT

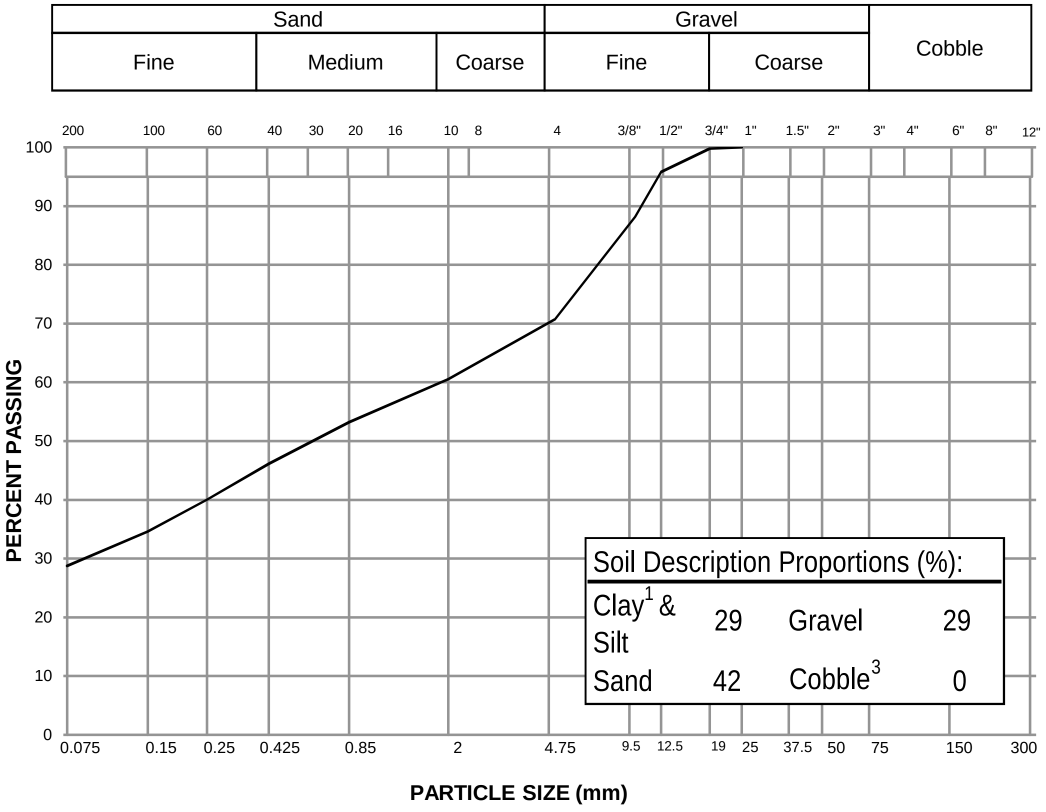
ASTM D422, C136 & C117

Project: Geotechnical Evaluation
Project No.: W14103046-02
Site: South Hamilton Blvd, Whitehorse, YT
Client: YG - Community Services
Client Rep.: Kirn Dhillon
Date Tested: June 26, 2013 By: SG
Soil Description[2]: SAND - gravelly, silty

Sample No.: B07
Material Type:
Sample Loc.: BH04
Sample Depth: 9.5 - 9.6 m
Sampling Method: Grab
Date sampled: June 20, 2013
Sampled By: KAE
USC Classification: Cu: n/a
Cc: n/a

Moisture Content: 1024.2%

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	100
12.5	96
10	88
5	71
2	60
0.85	53
0.425	46
0.25	40
0.15	35
0.075	29



Soil Description Proportions (%):

Clay[1] & Silt	29	Gravel	29
Sand	42	Cobble[3]	0

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

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification:

Remarks:

Reviewed By: P. Eng

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