March 13, 2017

ISSUED FOR USE
FILE: W14103567-24
Via Email: rick.kent@gov.yk.ca

Government of Yukon
Department of Community Services
Infrastructure Development Branch
Box 2703
Whitehorse, YT Y1A 2C6

Attention: Mr. Rick Kent – Senior Program Manager

Subject: Geotechnical Evaluation – Underground Utilities Upgrade
First Ave. and Duncan Ave. at Quebec St. and Montreal St.
Mayo, YT

1.0 INTRODUCTION

1.1 General

Government of Yukon, Department of Community Services (YG-CS) retained Tetra Tech Canada Inc. (Tetra Tech) to complete a geotechnical evaluation for the proposed upgrades to underground utilities at First Avenue and Duncan Avenue, in the vicinity of Montreal and Quebec Streets in Mayo, YT. Ms. Karen Furlong authorized the work by way of signed Government Contract C00036495 dated December 19, 2016.

1.2 Scope of Services

As presented in the proposal submitted to YG-CS on November 17, 2016, Tetra Tech's scope of services for this project includes the following:

- Review of available historical geotechnical information from the project site and surrounding areas;
- Geotechnical drilling program to fill any gaps in the historical review and characterize the subsurface at the site of the proposed underground utilities upgrade; and
- Preparation of a geotechnical report providing the following:
  - Summary of the geotechnical conditions at the site, including borehole logs and laboratory test results;
  - Recommendations for safe trench excavation;
  - Recommendations for material selection and compaction requirements for pipe bedding, trench backfill, and road surface fill;
  - Insulation requirements for the trench and buried pipes; and
  - Permafrost considerations.

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1.3 Project Location

The location of the project site is presented in Figure 1. The study area includes First Avenue and Duncan Avenue, in the vicinity of Montreal and Quebec Streets.

2.0 REVIEW OF HISTORICAL INFORMATION

Tetra Tech reviewed available historical geotechnical information from the project site, and the surrounding Mayo area. Based on the historical information review, a geotechnical site investigation plan was developed to supplement the existing geotechnical data, and in some areas to confirm the subsurface conditions where historical information was available. Historical borehole locations are presented in Figure 1.

3.0 GEOTECHNICAL SITE INVESTIGATION

The geotechnical site investigation was completed on January 20 and 21, 2017. Donjeck Drilling of Whitehorse, YT was retained by Tetra Tech to drill five boreholes (BH17-01, -02, -03, -04, and -05) at the project site, as shown on Figure 1. Boreholes BH17-01, -02, -03, and -05 were drilled to a depth of 6.1 m, and BH17-04 to a depth of 9.1 m. Prior to commencing the site investigation, underground utility locates were completed and the borehole locations were cleared.

During drilling, the soil profile was logged by Tetra Tech's field representative, Mr. Taidhg Mulroy, EIT, and disturbed grab samples were collected and returned to Tetra Tech's Whitehorse laboratory for routine geotechnical index testing.

Upon completion of each borehole, the UTM coordinates were recorded with a handheld GPS and the boreholes were backfilled to grade with drill cuttings, and compacted with the drill.

4.0 SITE CONDITIONS

4.1 Surface Features

All five boreholes were drilled on the shoulders of existing roadways in Mayo. The borehole locations were snow-covered.

4.2 Subsurface Conditions

The borehole logs and geotechnical laboratory testing results are attached to this report in Appendix B. Please note that the borehole logs and laboratory results contain detailed information describing the geotechnical conditions at the project site, and should be read in preference to the general descriptions provided below.

The soil profile at the site is summarized in Table 1.

Table 1: Summary of Subsurface Soil Conditions

Soil Type	Strata Depth Range (m)				
	BH17-01	BH17-02	BH17-03	BH17-04	BH17-05
SAND and GRAVEL (FILL)	Surface to 0.5 m	-	-	Surface to 0.9 m	Surface to 1.4 m
SILT	0.5 – 3.4	-	-	0.9 – 2.9	1.4 – 2.9
SAND	-	Surface to 6.1 m	Surface to 2.9 m	2.9 – 6.2	2.9 – 6.1
SILT	-	-	2.9 – 6.1	6.2 – 9.1	-
GRAVEL	3.4 – 6.1	-	-	-	-
END of BOREHOLE	6.1	6.1	6.1	9.1	6.1

4.3 Groundwater Conditions

Groundwater may have been encountered at the bottom of BH17-02, but the borehole sidewalls sloughed before groundwater could be confirmed. Groundwater was not encountered in any of the other boreholes.

The lack of groundwater may be related to seasonal water level fluctuations in the nearby Mayo and Stewart Rivers. Based on Tetra Tech's previous experience in the community of Mayo, it is anticipated groundwater will be encountered between 2.0 and 6.0 m at the project site during the summer season.

4.4 Permafrost and Seasonal Frost Penetration

Permafrost was encountered in BH17-03 and BH17-04, at depths of 4.4 and 7.2 m, respectively. In both boreholes the permafrost was encountered in silts and excess ice was present, constituting up to 50% of the soil material. Given the presence of excess ice, settlement should be anticipated in the event of permafrost thaw in these areas.

Seasonal frost was encountered near surface in all five boreholes. Based on the soil profile and regional climate data, the maximum depth of seasonal frost penetration can be assumed to be about 3.0 m below ground surface.

4.5 Bedrock

Bedrock was not encountered in any of the boreholes.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Trench Excavation

Tetra Tech understands that the underground utilities upgrade will be completed using conventional cut and cover trenching techniques, with depth of installation up to 4.0 m below ground surface. At these depths, the exposed subgrade is generally anticipated to consist of sand and/or silt, with some areas of gravel at the base of the excavation, all overlain by sand and gravel fill.

According to Yukon *Workers' Compensation Health and Safety Board Regulations,* trenches deeper than 1.2 m must be sloped or shored, and trenches must not be sloped steeper than 3H:4V. If the excavation intersects material in which excess sloughing is observed, shallower sidewall slopes may be required. A trench box, or other shoring methods, should be used if steeper side wall slopes are desired. Spoil piles must be kept away from the edge of the trench, the recommended setback should be at least the depth of the trench.

Despite the lack of groundwater encountered during drilling, groundwater can be expected during trench excavation, due to changes in the local groundwater levels related to the nearby Mayo and Stewart Rivers, seasonal ground thaw, and spring freshet. Therefore, a dewatering plan should be established prior to commencing excavation and pumps should be available throughout the duration of excavation and utilities installation.

5.2 Pipe Bedding

Tetra Tech understands that the upgraded overlying water lines will be bedded in bedding sand, and that the upgraded underlying sewer lines in bedding stone. A Class “B” pipe bedding configuration (commonly used on YG and City of Whitehorse projects with 150 mm of bedding under and beside the pipe, and 300 mm above the pipe) is recommended for this project. In this configuration, the bedding material will provide proper support and protection of the utility lines during backfill.

The bedding stone will require nominal compactive effort (rodding, small plate tamper, or similar) applied during placement to seat the stone particles against one another and minimize voids adjacent to or below the pipe. All bedding stone should be fully encapsulated in non-woven geotextile filter fabric to prevent internal erosion and migration of fine particles into the bedding stone from the surrounding native soils.

Bedding sand should be placed in lifts not exceeding 300 mm in thickness, moisture conditioned, and compacted to at least 95% Standard Proctor Maximum Dry Density (SPMDD). During construction, if groundwater is encountered around the depths of installation bedding stone may be required around the water lines instead of bedding sand to maintain workability. Bedding materials should conform to the gradation specifications presented in Table 2.

Table 2: Recommended Gradation for Pipe Bedding Materials

Bedding Sand		Bedding Stone	
Particle Size (mm)	**% Passing (by weight)**	**Particle Size (mm)**	**% Passing (by weight)**
10	100	25.0	100
5.0	80 – 100	20.0	70 – 100
2.0	55 – 100	12.5	55 – 100
0.63	25 – 65	10.0	30 – 80
0.25	10 – 40	5.00	0 – 40
0.080	2 – 15	2.00	0 – 10

5.3 Trench Backfilling

Tetra Tech understands that the trench above the bedded utilities will be backfilled with native and/or fill materials removed during the excavation. This is considered acceptable provided the backfill is placed in relatively thin lifts (approximately 200 mm maximum thickness), moisture conditioned, and compacted to at least 95% SPMDD below a depth of 1.0 m from final grade. Between 1.0 and 0.5 m from final grade, trench backfill is to be placed in approximately 200 mm thick lifts, moisture conditioned, and compacted to at least 98% SPMDD. The final 0.5 m to surface should be road structure, as detailed in Section 4.4. Tetra Tech recommends that saturated soils not be used for trench backfill, as these soils will likely be difficult to place and compact.

5.4 Roadway Reconstruction

In order to avoid existing utility lines during drilling, boreholes were located at the edge of, or slightly off of the surface of the existing roadways. As a result, the thickness of granular structure present above existing utility lines may differ from what was encountered during drilling.

The road surface should be re-established above the upgraded utility lines with a minimum of 500 mm of granular structure (400 mm of 80 mm pit run gravel and 100 mm of 20 mm crushed basecourse). The pit run gravel should be placed in 200 mm lifts, moisture conditioned, and compacted to at least 98% SPMDD. The crushed basecourse should be placed in a single 100 mm thick lift, moisture conditioned, and compacted to at least 98% SPMDD. The recommended gradations for pit run gravel and crushed basecourse are provided on Table 3.

Table 3: Recommended Gradation for Road Structure Materials

80 mm Pit Run Gravel		20 mm Crushed Basecourse	
Particle Size (mm)	**% Passing (by weight)**	**Particle Size (mm)**	**% Passing (by weight)**
80	100	-	-
25	55 – 100	20	100
12.5	42 – 84	12.5	64 – 100
5.00	26 – 65	5.00	36 – 72
1.25	11 – 47	1.25	12 – 42
0.315	3 – 30	0.315	4 – 22
0.080	0 – 8	0.080	3 – 6

5.5 Insulation Requirements

Tetra Tech recommends the use of insulated pipes, with factory insulation thickness to be determined by thermal protection requirements. Additional insulation is not considered necessary, or recommended, to protect permafrost areas below the upgraded utilities. Board insulation in the trenches may do more harm than good, as it restricts seasonal frost penetration required to maintain permafrost.

5.6 Permafrost Considerations

Some disturbance and localized thawing of permafrost should be anticipated during underground utility installation when frozen soil is exposed to ambient above freezing temperatures. The impact of thawing permafrost can be reduced by staging construction activities to install the underground utilities in relatively short, 20 to 30 m segments; thereby minimizing the amount of time that the frozen soils are exposed to thawing conditions between excavation and backfilling. Furthermore, installing the upgraded underground utilities within the footprint of the trenches for the existing underground utilities will minimize the amount of disturbance to native ground and will locate the upgraded utilities in areas that may have already experienced some permafrost thaw.

Notwithstanding any measures taken to minimize thawing of permafrost, some permafrost thaw and associated settlement should be anticipated beneath the underground utilities due to disturbance caused during installation as well as from the effects of long-term climate change. When the type and schedule of pipes to be used is being specified, the risk of lateral support loss, as a result of permafrost thaw, should be considered. A loss of lateral support can result in the pipe being subjected to full overburden pressure.

6.0 CONSTRUCTION TESTING AND MONITORING

All recommendations presented are site-specific and based on the assumption that an adequate level of monitoring during construction will be provided, and that all construction will be carried out by a suitably qualified, experienced contractor. An adequate level of construction monitoring also provides opportunity to verify that the recommendations based on geotechnical data obtained from the boreholes are applicable to the entirety of the project site. Appropriate quality assurance and quality control testing should be undertaken during construction to confirm that construction is completed in accordance with the recommendations provided in this report.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon, Department of Community Services and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) 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 Government of Yukon, Department of Community Services, 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. Tetra Tech's General Conditions are provided in Appendix A of this report.

8.0 CLOSURE

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

Respectfully submitted,
Tetra Tech Canada Inc.

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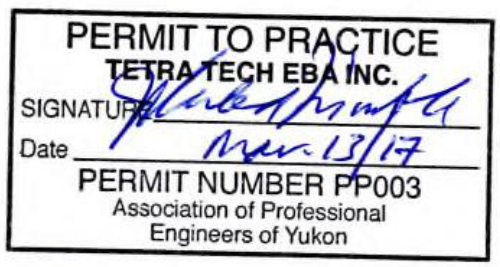

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/chr

Attachments: Figures (1)
Appendix A: Tetra Tech's General Conditions
Appendix B: Borehole Logs and Laboratory Test Results

FIGURES

NOTE : THE IMAGERY SHOWN ON THIS PLAN WAS EXTRACTED FROM GOOGLE EARTH PRO EDITION (DATED 2004)

0 100m

Scale: 1:2,500 @ 8.5"x11"

LEGEND

- BOREHOLE LOCATION
- HISTORICAL BOREHOLE LOCATION
- HISTORICAL TESTPIT LOCATION
- AREA OF PROPOSED UNDERGROUND UTILITIES UPGRADE

CLIENT

Yukon Government

TETRA TECH

2017 UNDERGROUND UTILITY UPGRADES MAYO, YUKON

SITE PLAN SHOWING BOREHOLE LOCATIONS

PROJECT NO.	DWN	CKD	REV
W14103567-24	CB	TM	0

OFFICE	DATE
EBA-WHSE	January 27, 2017

Figure 1

Q:\Whitehorse\Data\0201drawings\Mayo\W14103567-24 2017 Underground Utility Upgrades\W14103567-24 Fig.1-R0.dwg [FIGURE 1] March 07, 2017 - 11:46:09 am (BY: BUCHAN, CAMERON)

APPENDIX A

TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT – YUKON GOVERNMENT

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

1.1 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 TETRA TECH’s Client, the Yukon Government. TETRA TECH 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 TETRA TECH’s Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH’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 TETRA TECH shall be deemed to be the original for the Project.

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

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

1.3 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH 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.

1.4 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. TETRA TECH 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.

1.5 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.

1.6 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. TETRA TECH 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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.

1.12 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.

1.13 SAMPLES

TETRA TECH 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.

1.14 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

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

APPENDIX B

BOREHOLE LOGS AND LABORATORY TEST RESULTS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 TO 20%	0 to 4
Loose	20 TO 40%	4 to 10
Compact	40 TO 75%	10 to 30
Dense	75 TO 90%	30 to 50
Very Dense	90 TO 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (KPA)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

MODIFIED UNIFIED SOIL CLASSIFICATION

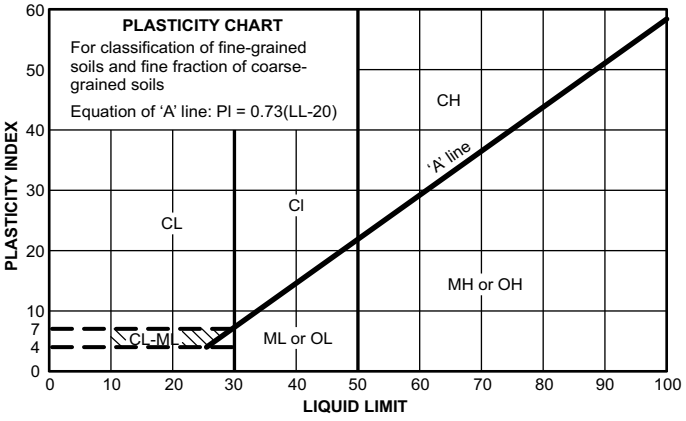
MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels and gravel-sand 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 ■

Borehole No: **BH17-01**

Yukon Government

Project: Mayo Underground Utility Upgrades	Project No: W14103567-24
Location: First Ave. and Duncan Ave.	
Mayo, YT	UTM: 455654 E; 7051771 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Depth (ft)
0								0
	Solid stem auger	SAND and GRAVEL (FILL) - trace silt, well graded, frozen, greyish brown	Seasonally Frozen					
		SILT - some clay, some sand, trace gravel, frozen, dark greyish brown						
1		- no visible gravel			SA01	31.2		
		- firm (est.), damp, brown	Unfrozen					
2					SA02	21.9		
		- moist, soft (est.), medium plastic, dark grey						
3					SA03	32.9		
		GRAVEL - sandy, well graded, sub rounded, moist, loose (est.), reddish brown						
4					SA04	2.5		
		- 10 cm silt layer						
5								
		- some silt						
					SA05	9.4		
6		END of BOREHOLE at 6.1 m (Target Depth).						
7								
8								
9								
10								

TETRA TECH

Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: 20 January 2017
Logged By: TM	Completion Date: 20 January 2017
Reviewed By: JTP	Page 1 of 1

Borehole No: **BH17-02**

Yukon Government

Project: Mayo Underground Utility Upgrades	Project No: W14103567-24
Location: First Ave. and Montreal St.	
Mayo, YT	UTM: 455845 E; 7051742 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Depth (ft)
0								0
	Solid stem auger	SAND - silty, trace gravel, poorly graded, frozen, light greyish brown	Seasonally Frozen					
1					SA06	19.8		3
		- dry, loose (est.)	Unfrozen					
2		- gravelly, some silt, well graded			SA07	3.3		7
3								10
4					SA08	2.6		13
		- moist						
5								16
6								20
		END of BOREHOLE at 6.1 m (Target Depth).						
7								23
8								26
9								29
10								32

TETRA TECH

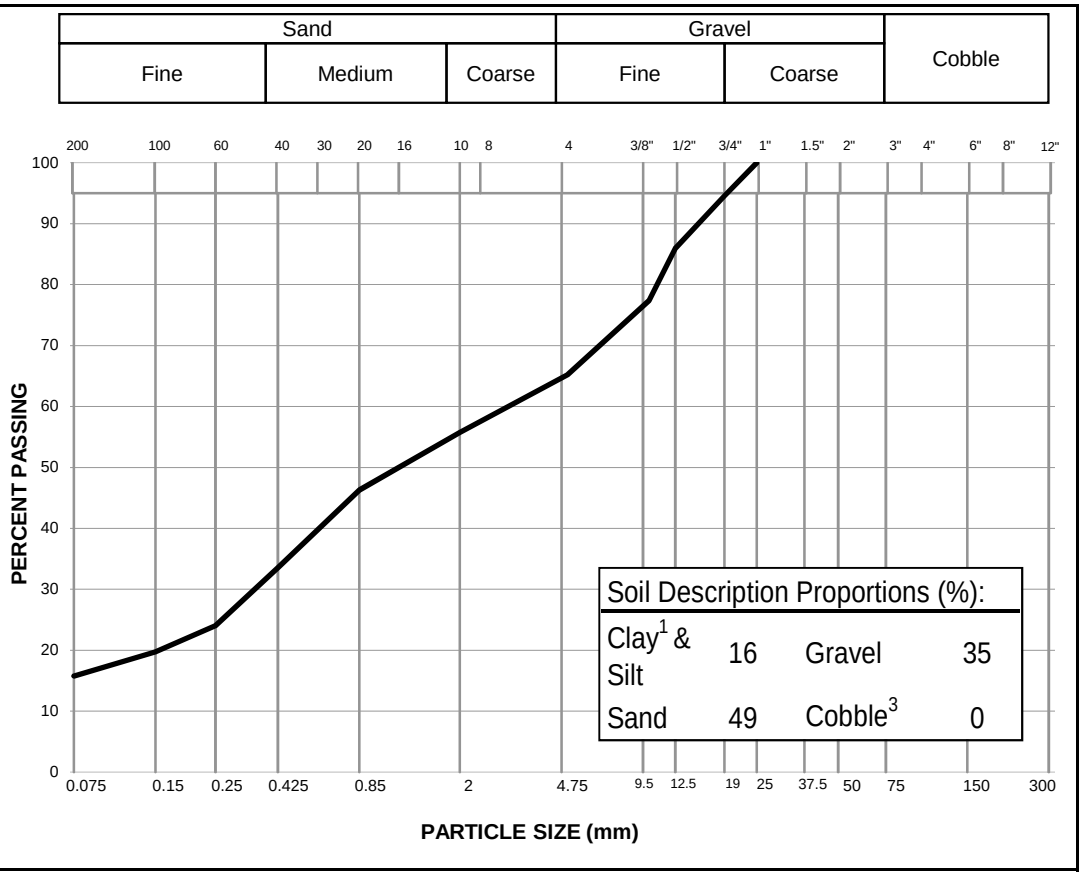
Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: 20 January 2017
Logged By: TM	Completion Date: 20 January 2017
Reviewed By: JTP	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	2017 UG Utility Upgrades - Geotech.	Sample No.:	SA07
Project No.:	W14103567-24	Material Type:	
Site:	Mayo, YT	Sample Loc.:	BH17-02
Client:	YG CS - Community Infrastructure	Sample Depth:	2.1 m
Client Rep.:	Rick Kent	Sampling Method:	Grab
Date Tested:	February 9, 2017 By: AT	Date sampled:	January 20, 2017
Soil Description[2]:	SAND - gravelly, some silt	Sampled By:	TM
		USC Classification:	Cu: #N/A
Moisture Content:	3.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	95
12.5	86
10	77
5	65
2	56
0.85	46
0.425	34
0.25	24
0.15	20
0.075	15.8



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

Specification: _____

Remarks: _____

Reviewed By: _____ P.Eng.

TETRA TECH

Borehole No: **BH17-03**

Yukon Government

Project: Mayo Underground Utility Upgrades	Project No: W14103567-24
Location: First Ave., East of Quebec St.	
Mayo, YT	UTM: 456026 E; 7051739 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Depth (ft)
0		SAND - gravelly, some silt, well graded, frozen, light greyish brown	Seasonally Frozen					0
1	Solid stem auger				SA09	6.9		3
2		- trace silt, dry, loose (est.)	Unfrozen		SA10	2.6		8
3		SILT - some clay, some sand, stratified, moist, firm (est.), non-plastic, dark grey						10
4		- no visible sand - frozen	Permafrost - Vs, Vr - 50% Ice		SA11	24.6		12
5					SA12	66.2		15
6					SA13	95		18
6		END of BOREHOLE at 6.1 m (Target Depth).						20
7								23
8								26
9								29
10								32

TETRA TECH

Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: 20 January 2017
Logged By: TM	Completion Date: 20 January 2017
Reviewed By: JTP	Page 1 of 1

Borehole No: **BH17-04**

Yukon Government

Project: Mayo Underground Utility Upgrades	Project No: W14103567-24
Location: Duncan Ave. and Quebec St.	
Mayo, YT	UTM: 455978 E; 7051655 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Depth (ft)
0		SAND and GRAVEL (FILL) - silty, well graded, frozen, light brown	Seasonally Frozen					0
					SA14	16		2
1		SILT - trace clay, trace sand, stratified, frozen, dark brown						3
					SA15	38.1		4
		- clayey, moist, stiff (est.), non-plastic	Unfrozen					5
2								6
					SA16	27		7
								9
3		SAND - gravelly, trace silt, well graded, dry, loose (est.), light greyish brown						10
								11
					SA17	2.6		12
4								13
		- some silt						14
								15
5	Solid stem auger							16
					SA18	5.6		17
		- fibrous organic inclusion						18
		- moist, dark grey, no visible gravel or silt			SA19	17		19
6								20
		SILT - clayey, wet, soft (est.), plastic, dark grey						21
								22
7					SA20	33		23
		- frozen	Permafrost - Vs, Vr - 40-50% Ice					24
								25
8								26
								27
					SA21	64.1		28
9								29
		END of BOREHOLE at 9.1 m (Target Depth).						30
								31
10								32

TETRA TECH

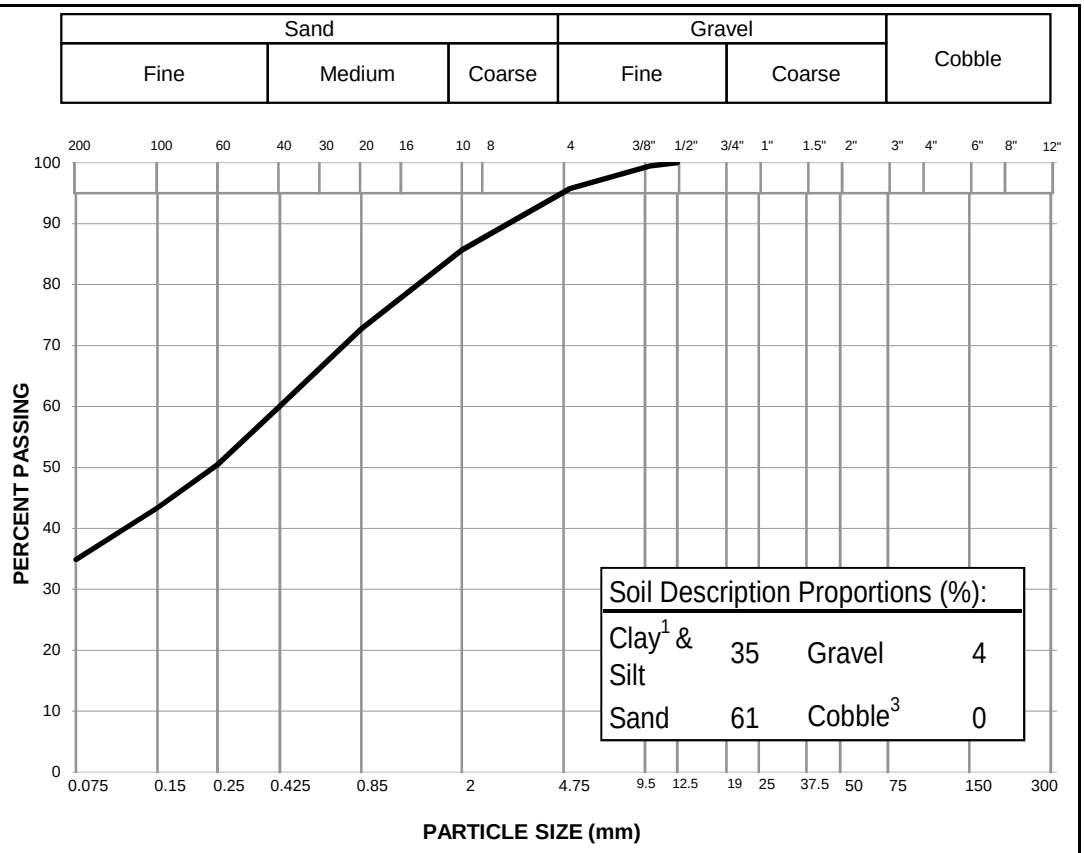
Contractor: Donjeck Drilling	Completion Depth: 9.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: 20 January 2017
Logged By: TM	Completion Date: 20 January 2017
Reviewed By: JTP	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	2017 UG Utility Upgrades - Geotech.	Sample No.:	SA14
Project No.:	W14103567-24	Material Type:	
Site:	Mayo, YT	Sample Loc.:	BH17-04
Client:	YG CS - Community Infrastructure	Sample Depth:	0.6 m
Client Rep.:	Rick Kent	Sampling Method:	Grab
Date Tested:	February 9, 2017 By: AT	Date sampled:	January 20, 2017
Soil Description[2]:	SAND - silty, trace gravel	Sampled By:	TM
		USC Classification:	Cu: #N/A
Moisture Content:	16.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	100
10	100
5	96
2	86
0.85	73
0.425	60
0.25	50
0.15	43
0.075	34.9



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.

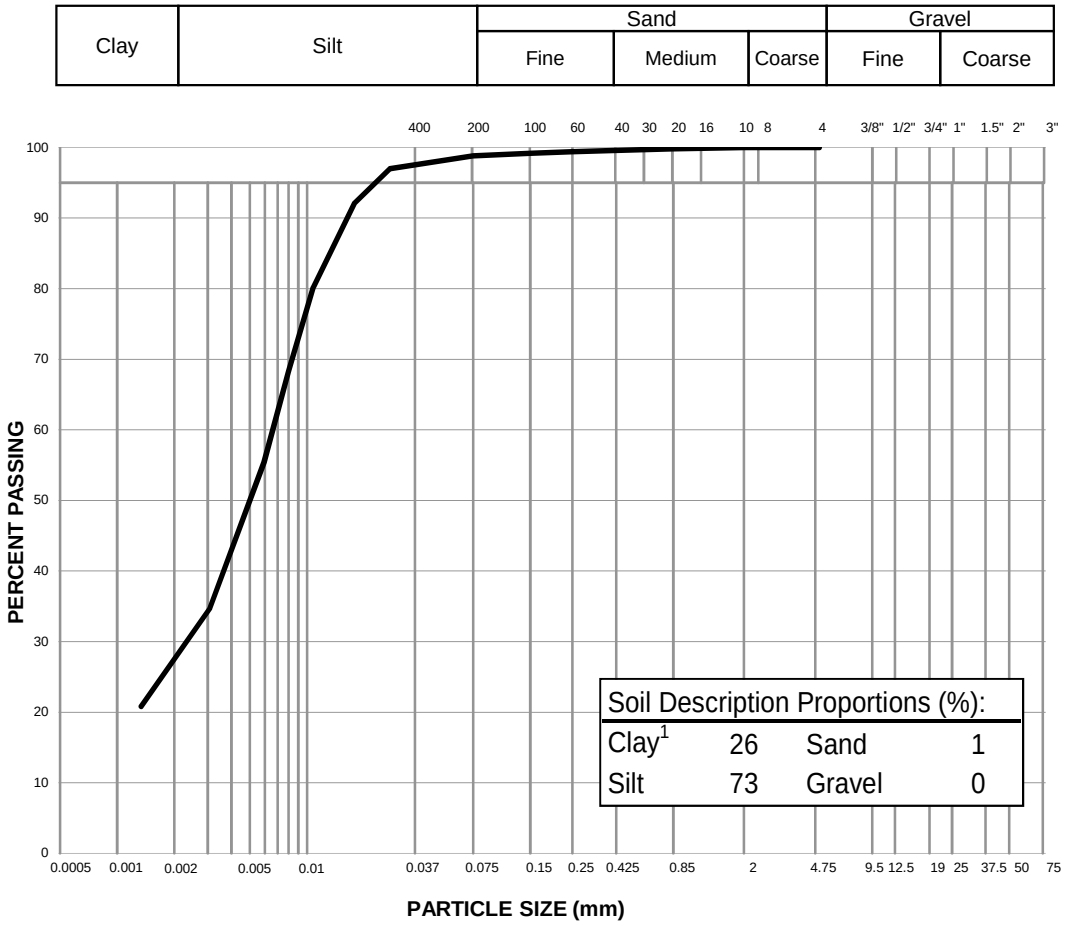
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	2017 UG Utility Upgrades - Geotech.	Sample No.:	SA16
Project No.:	W14103567-24	Material Type:	
Site:	Mayo, YT	Sample Loc.:	BH17-04
Client:	YG CS - Community Infrastructure	Sample Depth:	2.1 m
Client Rep.:	Rick Kent	Sampling Method:	Grab
Date Tested:	February 2, 2017 By: AT	Date sampled:	January 20, 2017
Soil Description[2]:	SILT - clayey, trace sand	Sampled By:	TM
		USC Classification:	Cu: #N/A
Moisture Content:	27.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	100
2	100
0.85	100
0.425	100
0.25	99
0.15	99
0.075	98.8
0.0274	97.0
0.0177	92.1
0.0108	80.2
0.0080	68.3
0.0059	55.4
0.0031	34.6
0.0013	20.8



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.

TETRA TECH

Borehole No: **BH17-05**

Yukon Government

Project: Mayo Underground Utility Upgrades	Project No: W14103567-24
Location: Duncan Ave. and Montreal St.	
Mayo, YT	UTM: 455833 E; 7051662 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Depth (ft)
0								0
1	Solid stem auger	SAND and GRAVEL (FILL) - some silt, well graded, frozen, greyish brown	Seasonally Frozen		SA22	23.5		2
2		SILT - sandy, frozen, greyish brown - dry, soft (est.) - firm (est.)	Unfrozen		SA23	10.3		8
3		SAND - trace silt, well graded, dry, compact (est.), greyish brown - 10 cm silt layer - some gravel			SA24	2		13
4								
5		- gravelly - silty			SA25	6.7		17
6		END of BOREHOLE at 6.1 m (Target Depth).						20
7								23
8								26
9								29
10								32

TETRA TECH

Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: 21 January 2017
Logged By: TM	Completion Date: 21 January 2017
Reviewed By: JTP	Page 1 of 1