

March 29, 2018

Government of Yukon  
Department of Community Services  
Infrastructure Development Branch (C-13)  
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ISSUED FOR USE  
FILE: ENG.WARC03242-12  
Via Email: catherine.macDonald@gov.yk.ca

**Attention:** Ms. Catherine MacDonald, Project Manager

**Subject:** Geotechnical Evaluation – New Outfall Line – Church Street  
Dawson City, 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 proposed upgrades to the sanitary and water underground utilities in Dawson City, YT. Ms. Catherine MacDonald authorized the work by way of signed Government Contract C00040319, dated September 18, 2017.

This report addresses the proposed new outfall line on Church Street. The geotechnical evaluations for proposed upgrades to underground utilities on 3<sup>rd</sup> and 4<sup>th</sup> Avenues, and the report assessing the feasibility of bedrock excavation for the Craig Street sewer line are presented under separate covers.

### 1.2 Scope of Services

Based on the proposal submitted to YG-CS on September 15, 2017, Tetra Tech's scope of services includes the following items:

- Project management, including establishing project documentation, project coordination and communication between Tetra Tech, YG-CS, and other consultants as required, and other miscellaneous administrative tasks;
- A review of available historical geotechnical information from the project site and surrounding areas;
- A geotechnical drilling program to characterize the subsurface conditions along the proposed outfall line route west of Front Street; and
- The preparation of a geotechnical report including:
  - A summary of the geotechnical conditions at the site, including borehole logs and laboratory test results;
  - A summary of the groundwater conditions in the area;
  - Recommendations for safe trench excavation;
  - Recommendations for material selection and compaction requirements for pipe bedding and trench backfill;

- Recommendations for reconstruction of the grass-covered area between Front Street and the dike following installation of the new outfall line;
- Recommendations for reconstruction of the disturbed portion of the dike following installation of the new outfall line; and
- Recommendations for riprap at the outlet of the new outfall line into the Yukon River.

### 1.3 Project Location

The location of the proposed outfall line alignment is presented in Figure 1. The study area consists of the portion of the outfall line alignment from Front Street to the Yukon River.

## 2.0 GEOTECHNICAL SITE INVESTIGATION

The geotechnical site investigation was completed on October 6, 2017. Donjeck Drilling of Whitehorse, YT was retained by Tetra Tech to drill two boreholes (BH17-09 to -10), as shown on Figure 1. Both boreholes were drilled to the target depth of 9.1 m below ground surface. Prior to drilling, underground utility locates were completed and the borehole locations were cleared for the presence of underground lines.

A third borehole was planned west of the dike, on the shore of the Yukon River, but the access route to this area was too steep and narrow for the drill rig to safely navigate.

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. Geotechnical index testing included moisture content and grain size analyses to verify soil classifications made during drilling, and to further characterize subsurface conditions including frost susceptibility and level of saturation. In addition, environmental samples for hydrocarbons, metals, and asbestos testing were collected based on location and depth recommendations from Associated Engineering (AE). Samples collected for hydrocarbons and metals testing are labelled ESA on the borehole logs. Samples collected for asbestos testing are labelled ASA on the borehole logs. Testing and reporting of test results for these samples was not completed by Tetra Tech, nor are the results included in this report.

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 by the drill.

BH17-09 was drilled on the grass-covered area between Front Street and the dike. The sod under the borehole footprint was cut out of the ground before drilling, and replaced following drilling to minimize disturbance to the grass.

## 3.0 SITE CONDITIONS

### 3.1 Surface Features

BH17-09 was drilled on the flat, grass-covered area between Front Street and the dike. BH17-10 was drilled on the top of the dike, through the compacted gravel surface. BH17-10 was drilled approximately 30 m north of the proposed alignment of the outfall line due to the presence of existing buried underground utilities running below the dike. Vegetation (grass on the front street side, small trees and brush on the river side) is growing on both sides of the dike.

## 3.2 Subsurface Conditions

The borehole logs and laboratory testing results are included in Appendix B. Please note that the borehole logs contain detailed information describing the geotechnical conditions, and should be read in preference to the generalized descriptions provided below.

The generalized soil profile along the proposed outfall line alignment is summarized in Table 1.

**Table 1: Summary of Subsurface Soil Conditions**

Soil Type	Strata Depth Range (m)	
	BH17-09	BH17-10
TOPSOIL/ROOT MAT	Surface to 0.3 m	-
SILT	0.3 – 2.8	-
SAND	2.8 – 4.6	-
SILT	4.6 – 6.4	-
SAND and GRAVEL (FILL)	-	Surface to 7.7 m
GRAVEL	6.4 – 9.1	7.7 – 9.1
END of BOREHOLE	9.1	9.1

## 3.3 Groundwater Conditions

Groundwater was encountered in BH17-09 at 5.3 m below ground surface. Groundwater was encountered in BH17-10 at approximately 7.4 m below ground surface, but the stabilized level was not confirmed due to sidewall sloughing at the bottom of the borehole. Both boreholes are located in the area hydraulically connected to the Yukon River, and as a result groundwater levels are expected to fluctuate seasonally with the river.

## 3.4 Permafrost and Seasonal Frost

Neither permafrost nor seasonal frost was encountered in either borehole. Based on the soil profile and regional climate data, the maximum depth of seasonal frost can be assumed to be approximately 3 m below ground surface.

This location is directly on the assumed delineation between the permafrost and non-permafrost zones in Dawson City. As such, while permafrost was not encountered during drilling, it is considered likely permafrost is present nearby. A map of Dawson City showing the current assumed permafrost extents is shown on Figure 2.

## 3.5 Bedrock

Bedrock was not encountered in any of the boreholes, nor was it expected.

# 4.0 DISCUSSION AND RECOMMENDATIONS

## 4.1 Trench Excavation

Tetra Tech understands that the underground utility upgrades will be completed using conventional cut and cover trenching techniques with depths of installation between 3 and 7 m below ground surface. At these depths between Front Street and the dike the exposed subgrade is generally expected to consist of silt, sand, granular fill from the construction of the dike, or the underlying gravel. If possible, Tetra Tech recommends that the trench be excavated within the footprint of the trench for the existing underground utilities in order to reduce disturbance to native ground.

As noted in Section 3.4, frozen soil was not encountered during drilling, but due to the site’s location on the delineation between the permafrost and non-permafrost zones, frozen soils may be encountered during excavation. If frozen soils are encountered, it will likely begin rapidly thawing if exposed to ambient summer temperatures. Depending on the time of year when excavation takes place, seasonal frost may be present as well in the trench excavation.

Trenching should be carried out in accordance with applicable *Occupational Health and Safety Regulations*. Trenches deeper than 1.2 m must be sloped or shored according to *Yukon Workers’ Compensation Health and Safety Board Regulations* prior to workers entering the trench. Unfrozen silt and organics may be soft and saturated, requiring a shallower slope than the Regulations stipulate.

Where the exposed subgrade is silt, the base of the excavation will be very sensitive to disturbance. Upon excavation, the base of the trench in these areas should be immediately covered with non-woven geotextile filter fabric and a 150 mm thick layer of 25 mm bedding stone (pipe bedding material) placed to protect the subgrade soil and provide a stable working surface during underground utility installation. The gradation for the 25 mm bedding stone is specified on Table 2 below.

**Table 2: Bedding Stone Gradation Specifications**

Particle Size (mm)	% Passing by Mass
25.0	100
20.0	70 – 100
12.5	55 – 100
10.0	30 – 80
5.00	0 – 40
2.00	0 – 10

Where underground utility upgrades will require excavation through the grass-covered area between Front Street and the dike, the sod and top soil should be carefully excavated so as not to mix it with the underlying soils. This material should be stockpiled for reuse on the surface of the backfilled excavation.

## 4.2 Trench Backfilling

As discussed above, 25 mm bedding stone is proposed for use as pipe bedding. This type of material can be considered to be practically self-compacting; however, nominal compaction effort (rodding, small plate tamper, or similar) should be applied during placement to ensure the particles are well seated against one another and that no voids remain adjacent to or below the pipe. All pipe bedding 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 soils.

Tetra Tech understands that standard practice in Dawson City is to backfill the remainder of the trench using the native and/or fill materials removed during excavation. This is considered acceptable provided the backfill is placed in relatively thin lifts (approximately 150 mm maximum thickness), moisture conditioned, and compacted to at least 95% Standard Proctor Maximum Dry Density (SPMDD) to within 1.0 depth from final grade. The final 1.0 m of trench backfill should be placed in maximum 150 mm thick lifts, moisture conditioned, and compacted to 98% SPMDD. Tetra Tech recommends that any saturated and/or highly organic soils encountered not be used as backfill, and should be removed from the site.

To re-establish the grass-covered area between Front Street and the dike, the salvaged topsoil and sod should be spread over the backfilled excavation to re-establish a level field surface, and seeded with grass. The seeded topsoil surface should be watered as required to promote growth, and access should be restricted until the new grass has taken root and is growing.

### 4.3 Insulation Requirements

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Based on the standard 75 mm thickness of factory insulation installed on the outside of pipes, additional insulation is not considered necessary to protect the pipe from freezing provided there is at least 2.4 m of soil cover above the line.

If permafrost is encountered, some disturbance and localized thawing 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.

Notwithstanding any measures taken to minimize impacts, if permafrost is encountered, some thaw and associated settlement should be anticipated beneath the outfall line due to disturbance caused during installation as well as long-term climate change effects. Permafrost thaw below underground lines conveying their contents under pressure is not anticipated to have a significant detrimental effect to the operation of the line over its design life because these lines are not dependent on pipe gradient to operate effectively. Underground lines that are dependent on gradient to operate effectively should be installed at steeper than standard gradients, in accordance with standard practice in Dawson City, so that minimal settlement caused by permafrost thaw will not render the line inoperable. As previously noted, installing the new outfall line within the existing trench will minimize the amount of disturbance to virgin ground and will locate the new utilities in areas that have already undergone some settlement from any thawing permafrost.

### 4.4 Dike Reconstruction

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The granular fill excavated from the dike should be stockpiled separately from other native material to be used for dike reconstruction. Following installation of the outfall line, the dike should be reconstructed based on the recommendations of a qualified geotechnical engineer, licensed to practice in the Yukon following an inspection of the excavation. The reconstruction recommendations will assist with protecting the dike from the creation of a potential failure plane or drainage pathways that could compromise the future performance of the structure, and with bridging the reconstructed dike section to the undisturbed sections to either side. The original design specifications for the construction of the dike are on file with the City of Dawson.

### 4.5 Riprap Requirements

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A simplified hydraulic analysis of the Yukon River adjacent to Dawson was completed to estimate the velocities during the extreme flood events. The flood characteristics was then used to size the riprap required to protect the outfall structure.

Historical hydrometric data collected from Water Survey of Canada were used to complete a flood frequency analysis for the peak instantaneous flows. A total of 33 year of data was available for the Yukon River at Dawson Station. The flood frequency statistical analysis software, HyfranPlus, was used to fit selected best fit statistical distributions to the flow data. Several probability distributions were tested, and visual inspection was relied upon to select the best distribution for each station. Table 3 summarizes the peak flood magnitude for various return periods.

**Table 3: Flood Magnitude for Various Return Period –Yukon River at Dawson City**

Return Period (Year)	Peak Flow (m3/s)
200	16,700
100	15,100
50	13,500
20	11,600
10	10,200
5	8,940
3	8,000
2	7,160

A simplified hydraulic analysis was completed using FlowMaster V8i for the section of the Yukon River adjacent to Dawson using the estimated peak flows. The cross sectional data was collected from “Environmental and Hydrologic Overview of the Yukon River Basin, Alaska and Canada” by USGS (2000). Using the velocities estimated from the hydraulic analysis, the required rock size and dimensions to avoid scour and erosion were estimated.

In order to protect the outfall pipe and the reconstructed section of the dike, a riprap class of 50 kg, with approximate average dimension of 350 mm should be used. The riprap layer should have a nominal thickness of 600 mm. To avoid scouring, the existing soil at the toe of the reconstructed dike section and at the outfall pipe outlet should be excavated to a minimum depth of 600 mm and be replaced with the prescribed rocks. Around the outfall pipe outlet, the total width of the riprap should be 1500 mm, extending up to 1200 mm from the end of pipe into the Yukon River.

Note that this is the minimum size based on a purely hydraulic analysis. The effects of ice scour and plucking have not been included. The final riprap design should match the original design, incorporating local experience obtained over the past 30 plus years of operation.

## 4.6 Future Drilling

As noted above in Section 2.0, a third borehole was planned located to the west of the dike, on the shore of the Yukon River, but the access route to this area was too steep and narrow for the drill rig to safely navigate. If YG-CS wants to drill this location prior to construction of the outfall line, Tetra Tech recommends that a small tracked drill rig, such as Midnight Sun Drilling’s Marl M4CT drill rig, be retained to access this location.

## 5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon, Department of Community Services and its 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. Use of this report is subject to the terms and conditions stated in Tetra Tech’s Limitations, which are provided in Appendix A of this report.

## 6.0 CLOSURE

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

Respectfully submitted,  
Tetra Tech Canada Inc.



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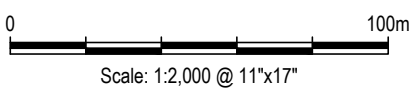
## FIGURES

- Figure 1 Site Plan Showing Borehole Locations
- Figure 2 Assumed Permafrost Delineation – Dawson City



**LEGEND**

-  - BOREHOLE LOCATION
-  - UNDERGROUND UTILITY UPGRADE AREA



CLIENT

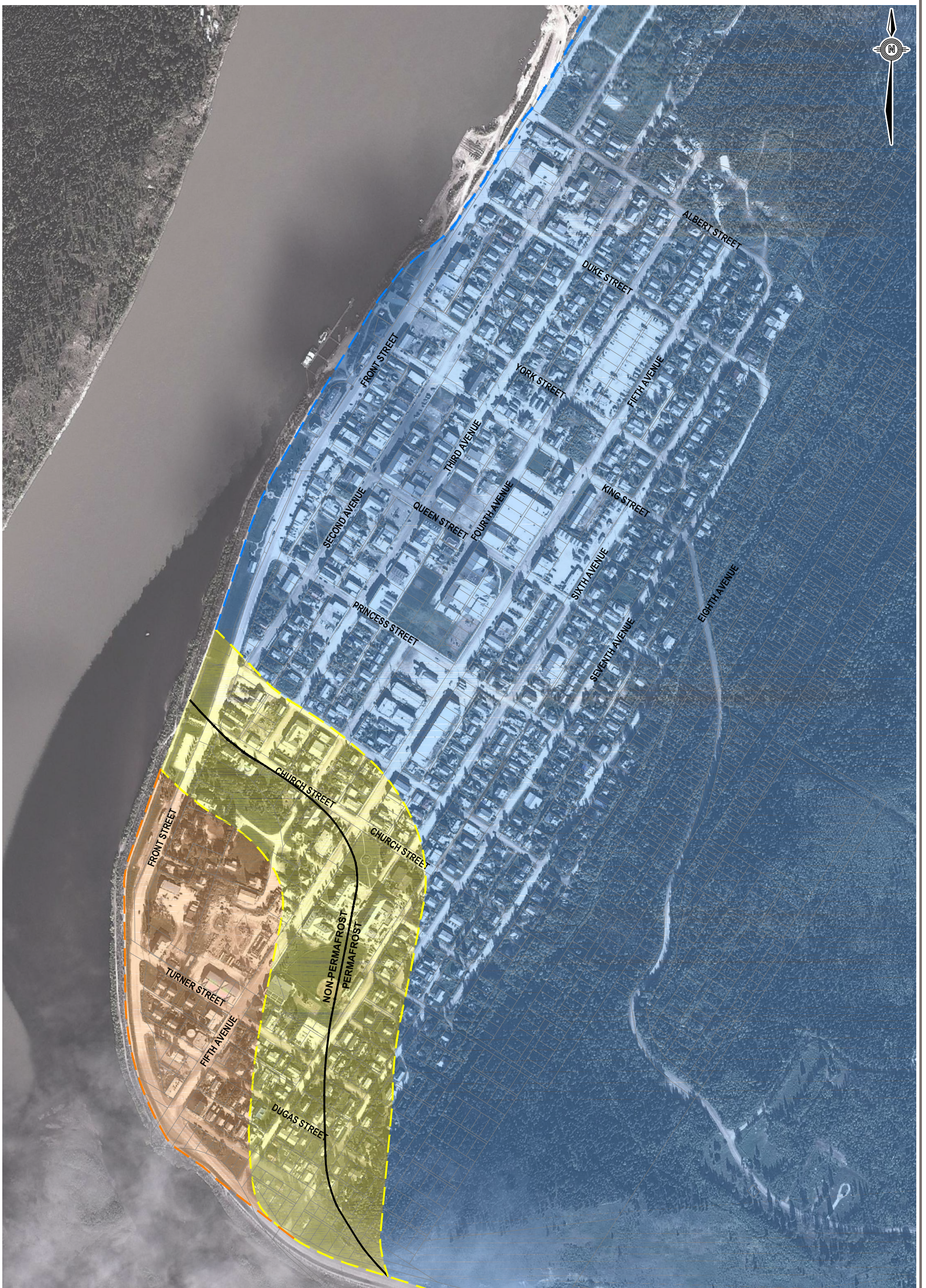


GEOTECHNICAL EVALUATION  
CHURCH STREET OUTFALL LINE  
DAWSON CITY, YUKON

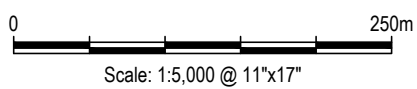
**SITE PLAN SHOWING BOREHOLE LOCATIONS**

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OFFICE EBA-WHSE	DATE October 27, 2017		

**Figure 1**



- LEGEND**
- PERMAFROST TRANSITION ZONE
  - PERMAFROST ZONE
  - NON-PERMAFROST ZONE



CLIENT



GEOTECHNICAL EVALUATION  
CHURCH STREET OUTFALL LINE  
DAWSON CITY, YUKON

**ASSUMED PERMAFROST DELINEATION - DAWSON CITY**

PROJECT NO. ENG.WARC03242-12	DWN CB	CKD TM	REV 0
OFFICE EBA-WHSE	DATE October 27, 2017		

**Figure 2**

## APPENDIX A

### TETRA TECH / YUKON GOVERNMENT LIMITATIONS ON THE USE OF THIS DOCUMENT

# LIMITATIONS ON USE OF THIS DOCUMENT

## GEOTECHNICAL

### 1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

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Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, 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 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

### 1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

### 1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

### 1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

## 1.7 ENVIRONMENTAL AND REGULATORY ISSUES

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

## 1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards 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.

## 1.9 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.

## 1.10 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 historical 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 exploration and review may be necessary.

## 1.11 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.

## 1.12 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.

## 1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact 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, and construction sequence are known.

## 1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and 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.

## 1.15 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 satisfactory 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.

## 1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters 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 used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

## 1.17 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.

## 1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

## APPENDIX B

### BOREHOLE LOGS AND LABORATORY 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	LABORATORY CLASSIFICATION CRITERIA		
<b>COARSE - GRAINED SOILS</b> More than 50% retained on No. 75 µm sieve*	<b>GRAVELS</b> 50% or more of coarse fraction retained on No. 4 sieve	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	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	
		GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		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	
		<b>SANDS</b> More than 50% of coarse fraction passes No. 4 sieve	<b>CLEAN SANDS</b>		SW	Well-graded sands and gravelly sands, little or no fines
	SP			Poorly-graded sands and gravelly sands, little or no fines	Not meeting both criteria for SW	
	<b>SANDS WITH FINES</b>		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	
	<b>FINE-GRAINED SOILS (by behavior)</b> 50% or more passes 75 µm sieve*	<b>SILTS</b> Liquid limit	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity		
MH			Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
<b>CLAYS</b> Above 'A' line on plasticity chart negligible organic content Liquid limit		CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays			
		CI	Inorganic clay of medium plasticity, silty clays			
		CH	Inorganic clay of high plasticity, fat clays			
<b>ORGANIC SILTS AND CLAYS</b> Liquid limit		OL	Organic silts and organic silty clays of low plasticity			
		OH	Organic clays of medium to high plasticity			
<b>HIGHLY ORGANIC SOILS</b>		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				VISIBLE ICE LESS THAN 50% BY VOLUME			
GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION		GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable		V	Vx	Individual ice crystals or inclusions	
	Nbn	No excess ice, well-bonded			Vc	Ice coatings on particles	
	Nbe	Excess ice, well-bonded			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)	
ICE		ICE	Ice without soil inclusions (greater than 25 mm thick)	ICE		Ice without soil inclusions (greater than 25 mm thick)	

- NOTES:**
- Dual symbols are used to indicate borderline or mixed ice classifications.
  - Visual estimates of ice contents indicated on borehole logs ± 5%
  - 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

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit	Moisture Content	Liquid Limit	Elevation (m)
0		TOPSOIL and GRASS ROOT MAT	Unfrozen				20	40	80	320
1	Solid stem auger	SILT (POSSIBLE FILL) - some sand, some gravel, sub-rounded gravel, damp, firm, non-plastic, dark greyish brown, some organic inclusions above 1.5 m, trace debris inclusions		ASA9						
1.1				SA41	11	●				319
2				SA42	17.2	●				318
2.1				ESA5						
3		SAND - silty, poorly graded, damp, compact (est.), greyish brown		SA43	17.6	●				317
4		- some gravel below 3.5 m		SA44	13.9	●				316
5		SILT - trace sand, moist, firm (est.), non-plastic, dark grey		SA45	32.1	●				315
6		- large pieces of wood debris at 5.7 m - some sand below 5.9 m								314
7	GRAVEL and SAND - some cobbles, poorly graded, sub-rounded to rounded, moist, dense (est.), brownish grey		SA46	7.2	●				313	
8			SA47	9.7	●				312	
9		END of BOREHOLE at 9.1 m (Target Depth)							311	
10									310	



Contractor: Donjeck Drilling

Completion Depth: 9.1 m

Drilling Rig Type: Truck mounted CME75

Start Date: 6 October 2017

Logged By: TM

Completion Date: 6 October 2017

Reviewed By: JRT

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Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Moisture Content (%)			Elevation (m)
							Plastic Limit	Moisture Content	Liquid Limit	
0		SAND and GRAVEL (FILL) - some cobbles, some silt, well graded, sub-angular to sub-rounded gravel, dry, compact (est.), greyish brown	Unfrozen				20	40	80	321
1	Solid stem auger	- light grey below 1.3 m			SA48	2				320
2				SA49	2.5				319	
3					SA50	2.2				318
4					ASA10 SA51	3				317
5					ESA6					316
6					SA52	2.6				315
7										314
8			GRAVEL and SAND - some cobbles, poorly graded, sub-rounded to rounded, wet, dense (est.), brownish grey			SA53	6.8			
9		END of BOREHOLE at 9.1 m (Target Depth)								312
10										



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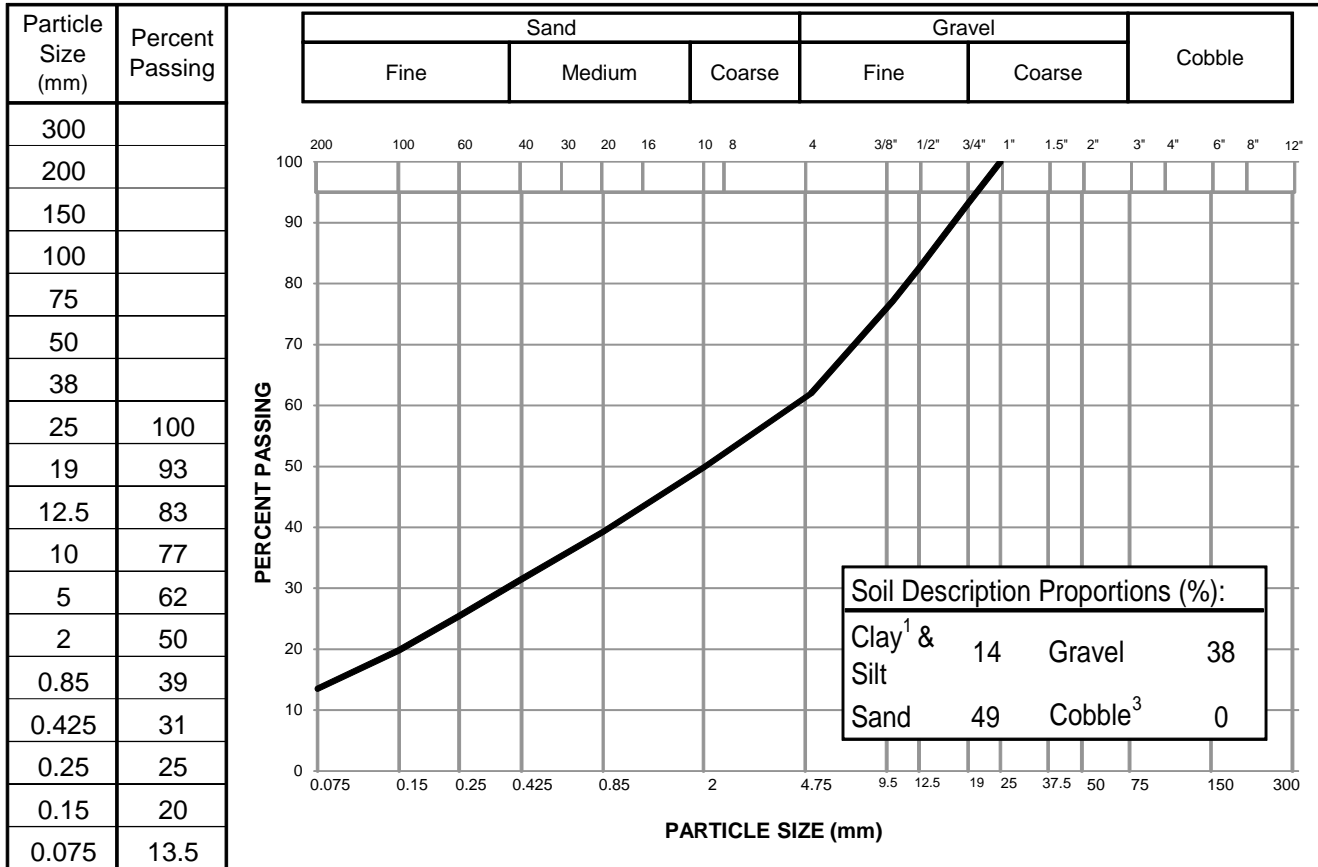
Reviewed By: JRT

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# PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Dawson City Underground Utilities	Sample No.:	SA49
Project No.:	ENG.WARC03242-12	Material Type:	-
Site:	Dawson City, Yukon	Sample Loc.:	BH17-10
Client:	YG - Community Services	Sample Depth:	2.3 m
Client Rep.:	Catherine MacDonald	Sampling Method:	Grab
Date Tested:	October 21, 2017	By:	AMT
Date Tested:	October 21, 2017	Date sampled:	October 6, 2017
Soil Description <sup>2</sup> :	SAND and GRAVEL - some silt	Sampled By:	TM
		USC Classification:	Cu: 72.2 Cc: 0.5
Moisture Content:	2.5%		



Notes: <sup>1</sup> The upper clay size of 2 um, per the Canadian Foundation Engineering Manual  
<sup>2</sup> The description is visually based & subject to Tt WM4400 description protocols  
<sup>3</sup> If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: \_\_\_\_\_

Remarks: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Reviewed By: P.Eng.

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