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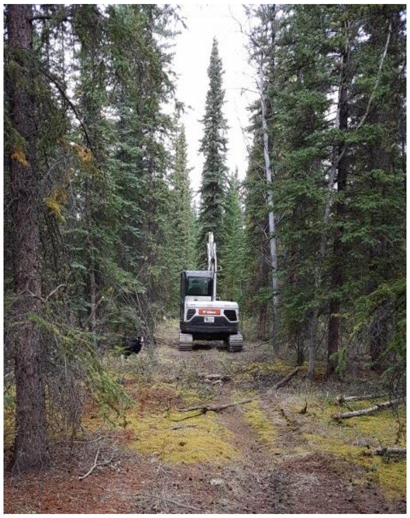
Geotechnical Evaluation
Proposed Industrial Subdivision
km 575 LHS Robert Campbell Highway #4
Carmacks, Yukon – 2019



Prepared For: **Yukon Government**

Date : **October 7th, 2019**

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FIGURES & APPENDICES

1.0 INTRODUCTION

Our firm was retained by *Yukon Government - Department of Community Services, Rural Land Development - Land Development Branch* (*YG*) under a Standing Offer Agreement (No.2017/2018-2753) to conduct a geotechnical evaluation of a proposed industrial subdivision which is to be located in Carmacks, Yukon.

The purpose of our evaluation was to assess the development potential of the study area through subsurface investigation and laboratory analysis in order to formulate geotechnical recommendations to assist in site development and preliminary foundation design where development was deemed feasible.

Our evaluation was meant to supplement our December 27th, 2018 Geotechnical Feasibility Assessment which identified the overall development potential of the proposed subdivision location based upon a literature review and site reconnaissance.

The *Village of Carmacks*, located ~ 180 km north of Whitehorse along the North Klondike Highway, is one of number of Yukon communities where there is an increasing demand for overall lot development. The study area, which measures ~10 ha in size, is located at km 575 (left-hand-side – LHS) Robert Campbell Highway #4 as noted in Figure 1.

As our recent evaluation was more comprehensive in nature than our Geotechnical Feasibility Assessment, our findings and recommendations contained herein supersede those of our previous report where conflicts may exist.

Authorization to proceed with the evaluation was granted by *YG – Community Services* - Senior Program Manager, Mr.K.Fisher on August 2nd, 2019. Our field work was subsequently conducted between August 10th and 12th in accordance with our July 29th, 2019 proposal.

Our findings have been presented herein along with a description of our methodology.

2.0 METHODOLOGY

Our work methodology was comprised of the following components.

2.1 Literature Review

Our firm reviewed our December 27th, 2018 Geotechnical Feasibility Assessment report to re-familiarize ourselves with the regional conditions and detail the field work programs. During this time, we collated the information relative to newly compiled topographical maps (which were forwarded to us by *Inukshuk Planning & Development Ltd*.) in order to detail the field work program by identifying potential test pit locations.

The new topographical survey which was based upon third party data retained in 2014 has been attached as Figure 2. While the (1.0-meter) contours intervals denoted local fluctuations in the ground surface, considering the age of the survey, it may not necessarily reflect the existing site conditions.

2.2 Field Work Program

The field work program was comprised of the following components;

Utility Locates
Northwestel, *ATCO Electric Yukon* and the *Village of Carmacks* were contacted prior to conducting the test pit program to ensure the subsurface investigation would not impact local infrastructure.

In brief, the service providers indicated they did not have any utilities located within the limits of the study area.

Site Reconnaissance
A site reconnaissance was conducted by the undersigned on August 10th, 2019 to mark anticipated test pit locations and delineate equipment access routes such that the potential for disturbance to vegetation and delays during the subsurface investigation was minimized. In addition, during this time we assessed the site conditions further to observations which were made during our geotechnical feasibility assessment.

Test Pit Program
A test pit program was conducted on August 12th, 2019 to assess the sub-surface conditions at select locations within the study area utilizing a *Bobcat E60* tracked

excavator which was equipped with a digging bucket. The excavator was supplied and operated by *Yellow Truck Excavating Inc.* of Whitehorse, Yukon and was employed under the direction of our firm.

The work consisted of excavating seven (7) test pits (TP 1-19 through TP 7-19) which were excavated at the approximate locations noted in Figure 3.

Test Pit Termination

The test pits were excavated to an average depth of 3.27 meters below the ground surface but varied between 3.1 meters (TP 1-19) and 3.4 meters (TP 2-19). With the exception of test pits TP 2-19 & TP 3-19, each of the test pits was terminated within interbedded glaciofluvial plain deposits. Test pits TP 3-19 and TP 4-19 were terminated within glaciofluvial terrace deposits.

Refusal was not encountered.

The test pits were backfilled with the excavation spoils approximately fifteen (15) minutes following completion of excavation to allow for a period of time to assess sidewall stability and potential groundwater seepage/recharge rates. The surficial organic cover, which was stockpiled separately from the excavation spoils, was subsequently utilized to cap the backfill to reduce the potential for soil erosion and promote re-vegetation.

Backfilling test pit TP 6-19

Survey Program

The locations of the test pits were recorded in the field utilizing a hand-held GPS unit.

Each location was subsequently marked utilizing wooden survey lathe such that if required, they could be more accurately surveyed by a *YG* retained surveyor. Given the regional perspective of our evaluation, the test pits were each given arbitrary elevations of 100.00 meters.

Soil Logs

During the test pit excavation, field soil logs were maintained by the undersigned to record the stratigraphy of the soils that were encountered. This information was utilized along with visual observations and the results of the laboratory analysis in order to compile the Test Pit Soil Logs which have been enclosed in Appendix A. This appendix also includes '*Notes on Soil Classification'* and a description of the *'Unified Soil Classification System'* and '*National Research Council'* permafrost classification systems which were utilized to describe the soils.

Sampling Program

Soil samples were retained at regular intervals during the subsurface investigation to allow for additional observations to be made under field and laboratory settings.

In all, a total of thirty-four (34) samples were obtained during the test pit program. While the near surface samples were retained by hand directly from the excavation sidewalls, the deeper samples were retained from the leading edge of the excavator bucket during the course of test pit excavation.

An additional sample was retained from the *Yukon Government* gravel quarry located at km 354.3 RHS of the North Klondike Highway #2 (Disposition No.900101) to characterize potential fill materials which may be utilized during site development.

Once the soil samples were retained, they were described on the field soil logs and subsequently sealed in air-tight plastic bags. The samples were numbered sequentially in order to allow for laboratory analysis as described in Section 2.3, below.

2.3 Laboratory Work Program

The laboratory work program was comprised of both physical and analytical analysis.

Physical Laboratory Analysis

The physical laboratory work program was conducted at our Whitehorse laboratory facilities and those of our sub-consultant, *Golder Associates Ltd.* (located in Burnaby, British Columbia), in order to characterize the index properties and conditions of the retained soil samples.

The analysis was conducted between August 14th and September 6th, 2019 and was comprised of the following;

Description of Analysis	***ASTM Analysis***	***Quantity***	***Laboratory***
Moisture Content	D 2216-92	34	*Chilkoot*
Grain Size Distribution	D 422-633	17	*Chilkoot*
Hydrometer	D 422-633	3	*Golder Associates*

In brief, each sample underwent moisture content analysis to determine the weight of the water within the sample relative to its dry weight. The results of the analysis have been denoted as 'MC' (⦿ - Symbol) on the Soil Logs enclosed in Appendix A.

The grain size distribution analysis was conducted on a selection of samples in order to assist in soil classification utilizing the *Unified Soil Classification System*. The results of the analysis have been noted on the Soil Logs with the percent composition of fines (silt & clay), sand and gravel denoted with the symbols - ▲, ● & ■ , respectively.

The hydrometer analysis was conducted in order to determine the percentage of sand, silt and clay which was contained within each of the test samples. These percentages were subsequently plotted on the *Soil Textural Triangle* to provide a relative assessment of the soils suitability for use as accepting soils relative to septic system design as described in Section 4.4, below. The results of the hydrometer analysis have been attached in Appendix B.

Analytical Laboratory Analysis

The total sulphate ion content of two (2) soil samples was determined by our laboratory sub-consultant *Golder Associates Ltd.* in accordance with *CSA Standard A23.1 – 3C.*

The purpose of the analysis was to assess the aggressiveness of the native and potentially imported soils relative cast-in-place concrete.

The native soil sample (No.23), retained from test pit TP 5-19, was comprised of a silt (some sand) which was similar to other silts which were encountered in the study area.

The sample of material which would potentially be imported was retained from the *YG* gravel quarry (Disposition No.900101) located at km 354.3 RHS of North Klondike Highway #2.

The results of the sulphate ion content analysis have been attached in Appendix B.

3.0 SITE CONDITIONS

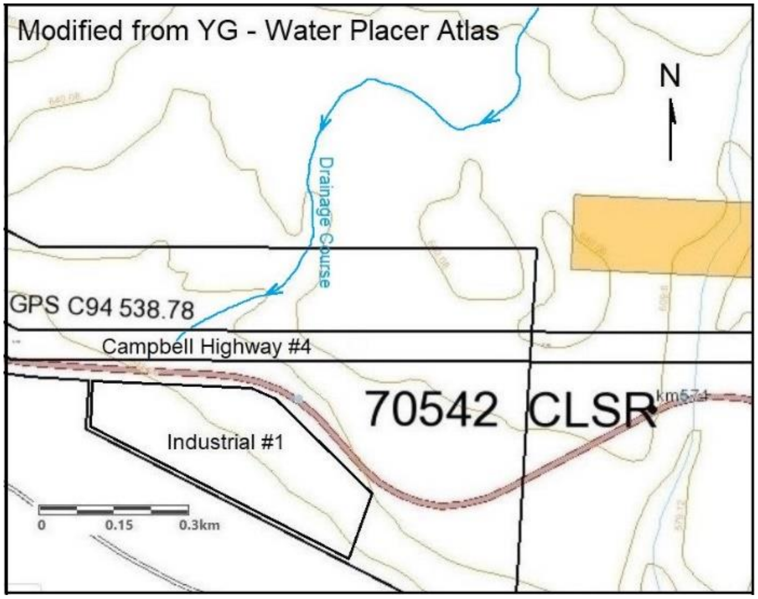
Details regarding the physiographic and geomorphic settings can be found in our December 27th, 2018 Geotechnical Feasibility Assessment report along with a description of the site.

The sub-surface conditions which were encountered during our evaluation have been summarized as follows;

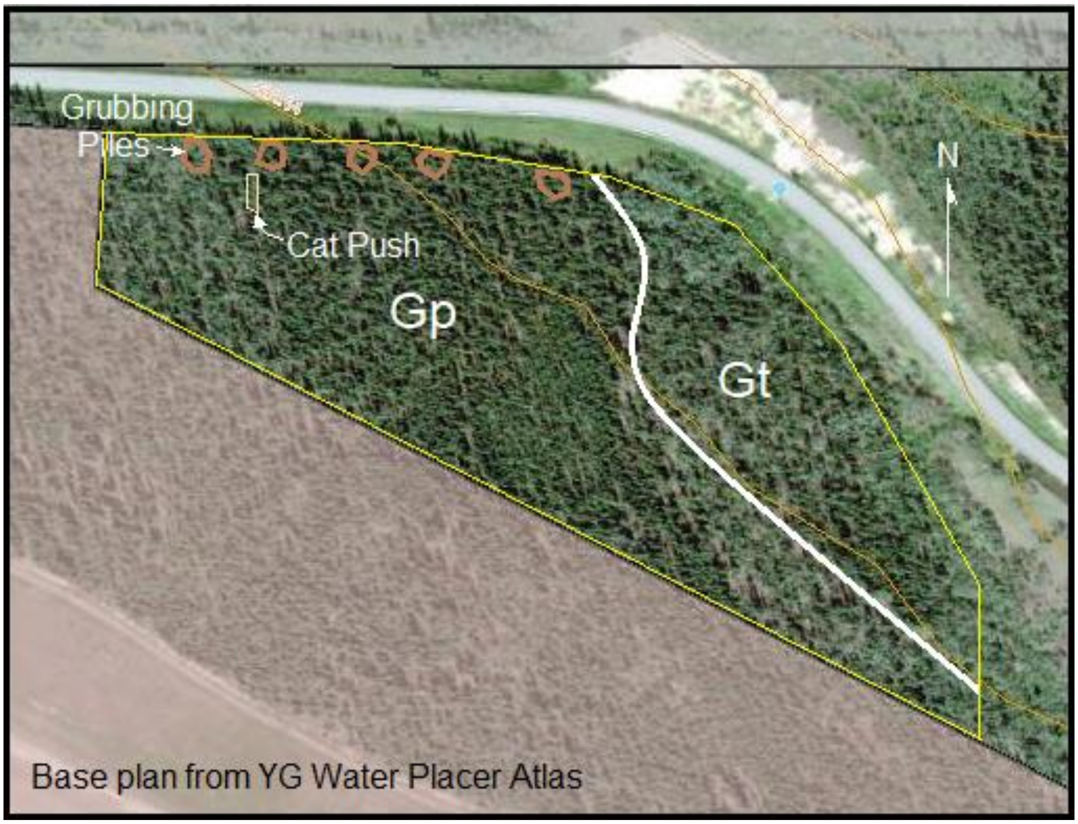
3.1 Soil Stratigraphy

The soils located within the study area were predominately comprised of glaciofluvial plain deposits. These deposits generally consisted of interbedded silts and silty sands. The southwestern realms of these deposits were covered by an eolian veneer of silty sands. The deposits located near the steeper northeastern realms of the study area were comprised of glaciofluvial terrace deposits. With the exception of test pits TP 3-19 & TP 4-19, each of the test pits was terminated within the glaciofluvial plain deposits. Test pits TP 3-19 and TP 4-19 were terminated within glaciofluvial terrace deposits.

The upper realms of test pit TP 7-19 exhibited a sequence of interbedded organics and silts at depths between 1.00 and 1.65 meters. This interbedded sequence may be an indication of ancient flood events that may be associated with the drainage course which was identify flowing through the glaciofluvial ice stagnation complex deposits located upslope of the study area. This drainage course was identified in the *YG Water Placer Atlas* as illustrated in the figure, below.



The approximate distribution of the surficial deposits and disturbed areas was delineated as illustrated below;



Base plan from YG Water Placer Atlas

These deposits were characterized as follows;

<u>Glaciofluvial Plain Deposits (Gp) - (TP 1-19, TP2-19 & TP 5-19 through TP 7-19)</u>

The surficial geology map (*GSC Map 1879A*) describes these deposits as being comprised of pebble to cobble gravels, massive to thickly bedded and capped by sand and silt. They are planar in nature and measure between 1 meter to greater than 10 meters thick.

Each of the test pits excavated in the glaciofluvial plain deposits encountered the sand/silt cap which was predominately comprised of interbedded non-plastic silts (which contained varying amounts of sand) and silty sands. The underlying gravels described in the surficial geology map were not encountered.

The average moisture content of the silts was noted to be 8.1 % by weight (but varied between 5.9 and 12.5 %). The average moisture content of the silty sands was noted to be 4.1% (but varied between 2.0 and 6.8%). These values generally indicated damp soil

conditions. The underlying gravels encountered in test pit TP 6-19 were noted to have a moisture content of 1.6%, indicating dry-damp conditions.
Based upon our observations of the test pit sidewalls, the relative density of this deposit was noted to be firm/compact.

Glacifluvial Terrace Deposits (Gt) - (TP 3-19 & TP4-19)
These deposits were generally comprised of a similar sequence of interbedded silts and silty sands which overlay sandy gravel deposits which contained up to a trace of silt and cobbles in size to 100 mm. While the sandy gravels only measured 100 mm thick in TP 3-19, these deposits likely prevail at greater depths.

The average moisture content of the sandy gravel was noted to be 1.9 % by weight (but varied between 1.4 and 2.5 %), indicating generally dry-damp moisture conditions.

Based upon our observations of the test pit sidewalls, the relative density of these soils was noted to be compact.

Surficial Soil Deposits
The above noted soil deposits were generally overlain with a thin (50-75 mm thick) veneer of surficial organics, (150 mm of) volcanic ash and up to 0.45 meters of firm to stiff, oxidized silt deposits.

Surficial Eolian Deposits
A discontinuous veneer of eolian deposits which were comprised of silty sands were encountered in the southern realms of the study area. These deposits overlay the surficial soils deposits described above and measured approximately 200 mm thick in test pit TP 6-19. Regionally, it’s understood that these eolian deposits are < 2 meters thick. Considering the windborne nature of deposition, these deposits are loose and unconsolidated.

Fills
A series of grubbing piles which are remnants from construction of Campbell Highway #4 are located along the northwestern periphery of the site as illustrated in Figure 3.

A historical exploration trench, which was likely excavated with a bulldozer, was noted in the approximate (‘cat push’) location illustrated in the figure inset above.

3.2 Groundwater

While a trace of oxidation (which suggests that the subsurface may have intermittently harbored groundwater in the past) was occasionally noted within the interbedded soil deposits, groundwater was not encountered in any of the test pits which were excavated.

3.3 Bedrock

There was no indication of bedrock in any of the test pits which were excavated.)

3.4 Permafrost

Although Carmacks is located in a zone where extensive discontinuous permafrost may be encountered (as identified in the Permafrost Map of Canada - Heginbottom et al, 1995), there was no evidence permanently frozen soils would be present within the study area.

4.0 DISCUSSIONS

4.1 Development Potential

The site and subsurface conditions which were encountered will allow for development of the industrial subdivision as noted in Figure 3. In general, it's understood that following clearing and grubbing operations, subdivision development will involve road construction, building construction and septic field installations utilizing conventional construction methodologies

The subsurface soils were comprised of glaciofluvial plain and terrace deposits which consisted of interbedded silts and silty sand deposits which are thought to overlie gravel deposits. In general, these soils and the subsurface conditions will allow for development in regions which were identified as having a suitable development potential. However, additional consideration will be required to mitigate the potential hazards related to the presence of a local slope and regional drainage course as described below.

View of study area facing southwest.

4.2 Building Foundations

Buildings can be founded upon conventional footings or monolithic-slab concrete foundation systems which are designed and constructed as described herein. However, geotechnical evaluations should be conducted to verify the site-specific design parameters.

4.3 Sulphate Ion Analysis

The total sulphate ion content of two (2) soil samples was determined by our laboratory sub-consultant *Golder Associates Ltd.* in accordance with *CSA Standard A23.1 – 3C*. The purpose of the analysis was to assess the aggressiveness of the native and potentially imported soils relative to cast-in-place concrete.

The native soil sample (TP 5-19 - No.23) was comprised of a silt (some sand), which was commonly encountered within the glaciofluvial plain deposits. The sulphate ion analysis of this sample revealed the total sulfate ion content was 0.01 %.

The potentially imported material sample was comprised of sandy gravel which was retained from the *YG* gravel quarry (Disposition No.900101) located at km 354.3 RHS of North Klondike Highway #2. The sulphate ion content analysis of this sample revealed the total sulfate ion content was 0.06 %.

As these values are lower than 0.10 % threshold set forth by the *American Concrete Institute – Building Code Requirements for Structural Concrete* (ACI 318-05 – Table 4.3.1), the potential for sulphate exposure is expected to be negligible. As such, its anticipated that standard concrete which is designed as described herein can be utilized during the foundation work.

The sulphate ion content of any imported fill which will be utilized during foundation construction/backfill should be assessed to verify their suitability once a source has been determined.

The results of the sulphate ion content analysis have been attached in Appendix B.

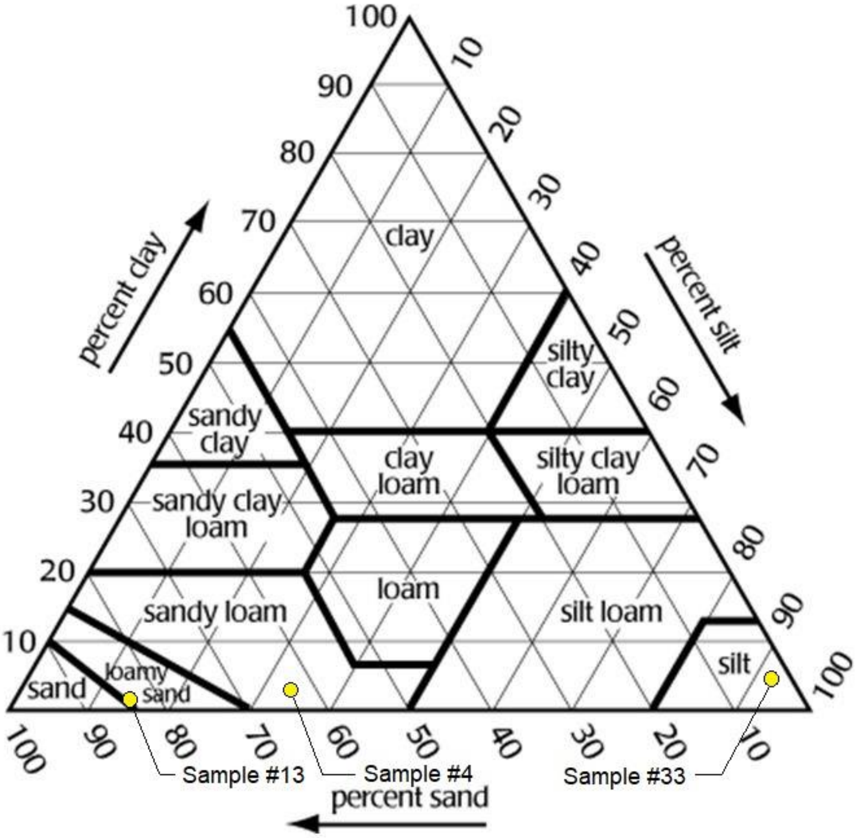
4.4 Septic Field Suitability

The results of the hydrometer analysis were utilized to determine the amount of clay sized particles (<0.002 mm) contained within each of the samples. This allowed for the respective percentages of sand, silt and clay to be plotted on the *Soil Texture Classification Triangle* such that the materials overall suitability for use as accepting (septic field) soils could be determined as is typical in provincial jurisdictions where regional assessments are conducted.

The percentages of sand, silt and clay for the samples analyzed were determined as follows;

Test Pit	***Sample No.***	***Gravel %***	***Sand %***	***Silt %***	***Clay %***	***Textural Soil Classification***
TP 1-19	4	12.3	50.3	34.5	2.9	sandy loam
TP 3-19	13	8.3	74.0	16.4	1.3	loamy sand
BH 7-19	33	0.0	2.1	92.1	5.8	silt

These values subsequently plotted on the *Soil Texture Classification Triangle* as follows;



Relative to the *Province of Manitoba – Onsite Wastewater Management Systems Program*, each of the soil samples was classified as being suitable for traditional subsurface systems.

Given the variability in the soils which were encountered and as required by *Yukon Health and Social Services*, site-specific assessments should be conducted at the time of individual lot development through percolation testing to verify the suitability of the anticipated accepting soils relative to *YG – Design Specifications for Sewage Disposal Systems*. In addition, during this time, the absence of a confining layer (such as groundwater or bedrock) located within 1.2 meters of the base of the envisioned septic field should be verified, as their presence would potentially preclude septic construction.

If a confining layer prevents septic field construction, then the use of an insulated holding tank or else raised field may be required during lot development.

4.5 Surface Drainage

The surficial soils which were encountered within the study area are generally free draining and so site drainage can be managed through the use of standard ditches/swales and site grading.

While we did not observe any signs of recent erosion which would be attributed to surface waters, the (300 mm Ø) discharge flume located along the highway embankment immediately northeast of the study area was not functional. As such, some sedimentation was noted along the periphery of the study area in this region and in a region located immediately down-slope of erosion rills which were identified as noted in Figure 3.

Discharge flume conditions

4.6 Potential Hazards

The steep slope located along the northeastern realm of the study area may pose a hazard relative to increased surface water runoff and potential for slope movements. While indications of slope movements were not observed during the course of our evaluation some isolated locations of slope erosion were noted. These regions were associated with the failure of a highway drainage flume and nearby erosion rills (as noted in Figure 3).

The presence of silts which were interbedded with rootlets and organics were noted in test pit TP 7-19 to a depth of 1.6 meters. The interbedded nature (at depths of 1.0, 1.3 and 1.6 meters) suggests this region has been subjected to repeated flood events. While the origin of these events could not be verified, it’s possible the deposits are associated with a drainage course which was identified in the *YG – Water Placer Atlas* (as described in Section 3.1, above).

Our observations of the lower realms of this drainage course did not reveal any signs that it harbored any recent surface waters. Furthermore, our observations of the highway in the region of the potential discharge area did not reveal the presence of any culverts.

4.7 Geotechnical Setbacks

A geotechnical setback (30 meters in width as illustrated in Figure 3) should be observed relative to the steep slope which is located along the northeastern periphery of the site. While building construction should not be allowed in these regions, the construction of roads and ditches within these setback areas could be considered. While septic field construction should be avoided in these areas, if required, they could be considered by qualified personnel on a case-by-case basis.

4.8 Seismic Site Response

The study area was classified for seismic site response in accordance with the *National Building Code of Canada*, based upon the information obtained during the field work program. In general, the classification is based upon the type of soils that are located below the intended structure(s) as follows:

CLASS	SOIL TYPE
A	hard rock
B	rock
C	dense soil or soft rock
D	stiff soil
E	>3 m of ‘soft soil’
F	Others (liquefiable, peat, etc.)

Based upon the presence of the glaciofluvial plain and terrace deposits, the soils within the study area would be classified as a Class D site.

4.9 Geotechnical Evaluations

Geotechnical evaluations should be conducted at any location where buildings and subsurface infrastructure is proposed to verify site-specific geotechnical parameters.

4.10 Hydrogeological Assessment

A hydrogeological study would be required to assess the suitability of the study area relative to water well installations.

5.0 RECOMMENDATIONS

The following recommendations have been provided as a guideline for subdivision development. Considering the variable nature of the soil types and conditions which were encountered, any references to allowable bearing capacities herein are for discussion purposes only. The allowable soil bearing values at any proposed building location would need to be determined by qualified personnel through site-specific geotechnical evaluations which are conducted prior to design and construction.

5.1 Deleterious Materials

Clearing and grubbing operations will be required to remove the existing trees/vegetation from regions where subdivision development is to occur. During this time, timber should be salvaged as outlined by the land use permit(s).

The surficial organics, volcanic ash, eolian soils and near surface (firm to stiff) silts located within ~1 meter of the ground surface are deleterious as they contain organics and rootlets. In addition, as the majority of the underlying glaciofluvial plain and terrace deposits were frost susceptible, they too would be considered deleterious unless measures for frost protection are undertaken during building foundation design and construction as described herein. As such, all deleterious materials should be removed from within the building load envelope(s) such that the structural fills and/or foundation components can be founding upon approved underlying glaciofluvial plain or terrace deposits. In addition, the deleterious surficial organics and volcanic ash materials will need to be removed from below roads and parking areas to allow for sub-base and base construction as described herein.

As the soil deposits are susceptible to a loss of strength if they become disturbed, wet or desiccated, caution will need to be exercised during construction. Temporary roads and laydown areas may need to be prepared in order to facilitate subdivision/lot development and building construction.

Surficial organics which are removed during site preparation should be stockpiled separately and either utilized for landscaping or else removed from the site. The glaciofluvial plain and terrace deposits can be utilized as general purpose (non-structural) fill so long as the materials are compacted to approximately 95% of the materials corresponding maximum proctor density at (or near) the materials optimum moisture content (unless otherwise over-ridden by the recommendations provided herein). If these soils are wet to saturated, they will need to be removed from the site and wasted.

5.2 Footings

Light industrial buildings may be supported by continuous and spread footings with slab-on-grade concrete foundation systems constructed in accordance with the recommendations contained herein.

Founding Strata

Deleterious materials should be sub-excavated to expose a uniform level subgrade surface comprised of approved glaciofluvial plain or terrace deposits. Ideally, these soils should be comprised of the underlying sandy gravels where glaciofluvial terrace deposits are encountered.

Allowable Bearing Pressure

The net allowable bearing pressure should not be greater than 110 kilopascals for conventional strip footings or 130 kilopascals for spread footing types of foundation systems. These figures include the total of all live and dead loads.

Structural Fill

The footing components should be underlain with a 150 mm thick layer of approved 20 mm minus crushed granular aggregate compacted to a minimum of 100 % of the materials corresponding maximum Proctor dry density at (or within ± 2% of) the materials optimum moisture content.

All deleterious materials below the slab-on-grade components should be sub-excavated to the depth of the approved founding strata and replaced with structural fill as recommended herein.

Interior backfill (below the slab components) should be comprised of the following;

THICKNESS ^{A}	COMPACTION ^{B}	COMPOSITION
100 mm	100 %	20 mm minus crushed granular aggregate, Overlying
200 mm	100 %	80 mm minus sub-base course aggregate, Overlying
As required	100 %	200 mm minus pit run, Overlying

NA	95 % (or as directed)	approved subgrade

Notes;

[A] – The thickness of the granular pad should be uniform throughout its entirety. All materials should be placed in uniform, level lifts that do not exceed 150 mm in thickness, as measured following compaction. The exception to this would be the 200 mm thick layer of 80 mm minus granular aggregate which can be placed in a single lift so long as adequate compaction is attained.

[B] – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content.

Exterior backfill around footing column and wall components should be comprised of non-frost susceptible well graded granular aggregates with particle that measure less than 80 mm in size. This material should be compacted to a minimum of 95 % of the materials corresponding maximum Proctor dry density at (within ± 2% of) the materials optimum moisture content, unless otherwise over-ridden by recommendations provided herein.

Slab Components

The slab components should be structurally separated from other components of the structure.

Differential Movements

Foundations constructed in accordance with the recommendations contained herein may experience differential movements in the order of (+/-) 25 mm.

Lateral Earth Pressures

The foundation walls (and potentially other retaining walls) should be designed to resist lateral earth pressures.

Walls will be subjected to lateral earth pressures in an ‘at-rest’ condition and thus should be designed to withstand these pressures. The lateral earth pressure is linear and can be calculated at a given depth ‘H’ below the ground surface as;

$P_0 = k_0(\gamma_s H+Q)$

where: P_0 = Lateral Earth Pressure ‘at-rest’ condition
with no movement at given depth H (in kPa)
k_0 = coefficient of earth pressure ‘at-rest’ condition
(utilize 0.45 for granular backfill)
γ_s = unit weight of soil
(utilize 22.5 kN/m^3 for granular backfill)
H = depth below finished grade (m)
Q = other surcharge pressures at finished grade (in kPa)

The above noted calculation assumes static conditions and that the backfill remains in a drained (unsaturated) condition.

The height of the backfill between the interior and exterior sides of wall components should not measure greater than 300 mm during construction such that undesirable lateral forces are not induced.

Weeping Tile System

In general, a weeping tile system will not be required where free draining soils are encountered at the footing elevations. However, if fine-grained or silty soils are encountered at the footing elevation or if basements are to be considered, a weeping tile system should be incorporated into the foundation design as these types of soils are not generally free draining, or, in the case of basements, as a precautionary measure.

5.3 Monolithic Footing/Slab-On-Grade (Monolithic Slab)

Light industrial buildings may be supported by monolithic slab foundation systems which are founded on an approved subgrade which is prepared in accordance with the recommendations provided herein. If heavy loads are anticipated, the foundation should be designed as a heavily reinforced structural slab.

Founding Strata

Deleterious materials should be sub-excavated to expose a uniform level subgrade surface comprised of approved glaciofluvial plain or terrace deposits. Ideally, these soils should be comprised of the underlying sandy gravels where glaciofluvial terrace deposits are encountered.

Allowable Bearing Pressure

The net allowable bearing pressure should not be greater than 140 kilopascals for a monolithic slab type of foundation system. This figure includes the total of all live and dead loads.

Structural Fill

Monolithic slabs should be founded upon a structural granular pad comprised of the following;

THICKNESS [A]	**COMPACTION [B]**	**COMPOSITION**
200 mm [C]	100 %	20 mm minus crushed granular aggregate, Overlying
400 mm	100 %	80 mm minus sub-base course aggregate, Overlying
As required [D]	100 %	200 mm minus pit run, Overlying
NA	95 % (or as directed)	approved subgrade

Notes;

[A] – The thickness of the granular pad should be uniform. All materials should be placed in uniform, level lifts that do not exceed 150 mm in thickness, as measured following compaction. The exception to this would be the 200 mm thick layer of 20 mm minus granular aggregate which can be placed in a single lift so long as adequate compaction is attained.

[B] – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content.

[C] – This thickness should be maintained below both the central slab and peripheral thickened slab components.

[D] – Should extend to the depth of approved subgrade material such that the thickness of the granular pad and insulation is equivalent to 3 meters.

The above noted structure assumes the presence of a 200 mm thick reinforced concrete slab which incorporates a thickened edge of slab component.

Differential Movements

Foundations constructed in accordance with the recommendations contained herein may experience differential movements in the order of (+/-) 25 mm.

5.4 Excavations

Excavations should be conducted utilizing a heavy tracked excavator equipped with a smooth lipped (clean-up) bucket in order to minimize disturbance of the subgrade materials.

The subgrade materials are subject to a loss of strength if they are disturbed (or become wet/saturated or desiccated). As such, equipment should not be allowed to operate directly on the subgrade surfaces. The exception to this would be the vibratory drum compactor where proof-rolling may be required as authorized by the onsite geotechnical consultant.

Loose, disturbed, remolded or slough materials should not be allowed to remain in prepared excavation(s). If the subgrade becomes saturated or loses its strength, these disturbed materials should be sub-excavated to expose a suitable founding surface approved by the retained geotechnical consultant. If a suitable founding surface cannot be prepared through mechanical means, then hand cleaning may be necessary.

Excavation difficulties are not generally anticipated so long as seasonal frost is not encountered. However, the contractor should be prepared to adjust their construction methodology and excavation profiles as soil and site conditions dictate.

The excavation limits will be governed by the proposed building elevation and that of the founding strata. The excavation limits should be defined by the theoretical loading footprint which can be described as a 1:1 slope which extends outwards from the building perimeter until the founding strata has been attained (plus 1 meter horizontally). This angle of repose should be reduced to 2:1 (horizontal to 1 vertical), or less, in regions where weak, fine-grained (or saturated) soil deposits are encountered.

The base of the excavation(s) should be prepared in such a manner that the subgrade elevation does not vary. Specifically, the entire excavation should be excavated to the lowest elevation at which approved subgrade deposits are encountered. This will allow for the establishment of structural backfill which is of uniform thickness.

The locations of sub-surface utilities should be confirmed by the retained contractor prior to excavation.

5.5 Temporary Excavations & Worker Safety

Worker safety is paramount.

Temporary excavations to conventional depths at this site should comply with current regulations under the *Yukon Workers Compensation Board* - *Occupational Health & Safety Act*.

The excavation sidewall (slope) stability will be dependent upon the material characteristics, configuration of the excavation and length of exposure. In general, side slopes cut at 1:1 should allow for adequate stability provided the depth of excavation does not exceed one (1) meter. Otherwise side slopes should be cut at 2:1 (horizontal/vertical). If these parameters are to be exceeded, then they should be verified and monitored by qualified geotechnical personnel throughout construction.

Slope stability will be poor if wet/saturated materials, fills or clean granular materials are encountered. As such, more gradual cut slopes may be required in these areas to minimize the potential for slope failure(s).

The contractor should be prepared to adjust their construction methodology and excavation profiles as soil and site conditions dictate.

5.6 Backfill Requirements

The structural and imported fills should consist of an approved, clean, inorganic, well graded sand and gravel mixture which conform to the recommended grain size distribution noted in Appendix C.

All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

Exterior backfill should be evenly placed around the sides of the building such that the difference in backfill height between any of the sides is no more than 300 mm such that undesirable lateral forces are not induced. If interior backfill is required, the difference in backfill height on either side of the foundation wall(s) should not measure greater than 300 mm during construction unless authorized by the structural consultant.

Considering backfill will be placed adjacent to foundation walls, the compaction effort should be applied with equipment that will not compromise the foundations integrity.

This may require utilizing light hand-operated compaction equipment and reducing the lift thicknesses. Exterior backfill work in these regions should not be conducted until approval is obtained from the structural consultant.

Typically backfill adjacent to wall components should not be conducted until seven (7) days have elapsed from the time of concrete placement such that adequate concrete strengths are attained.

5.7 Insulation

Care will be required to minimize the degree of potential foundation movement due to frost penetration, which is in the order of 3 meters in the Carmacks region.

Footings

Typically, frost protection is achieved through a combined use of rigid (SM Styrofoam) insulation and depth of soil cover to attain an equivalent of three (3) meters of soil cover. As such, the thickness of rigid insulation will be dependent upon the depth of the footing.

For design purposes, two (2) inches of rigid (SM Styrofoam) insulation should be provided for every one (1) foot of soil cover which is not provided.

The rigid insulation should extend laterally no less than 1.2 m from the exterior edge of the concrete foundation walls. The thickness of insulation should be increased in regions where additional heat loss is expected, such as the corners of the building(s).

Monolithic Slab

Typically frost protection for monolithic slabs is afforded through the use of the underlying non-frost susceptible structural fills upon which the concrete slab is placed. However, as per good construction practice, some amount of rigid insulation should be placed directly below the concrete and extend laterally no less than 1.2 m from the slab edge.

As the rigid insulation is impervious, it should be placed in such a manner that a positive (2%) gradient (away from the building) is maintained to allow for proper sub-drainage. Seams of successive layers of insulation should be staggered or otherwise taped where weak zones are created.

In addition to frost protective measures, provisions should be included to protect the subsoils from excessive desiccation in regions where there is an intense degree of concentrated heat (such as potential boiler/furnace areas) to limit soil volume changes to tolerable amounts.

Subsurface utilities should be placed at depths >3 meters or else have equivalent insulation in order to protect them from frost. Additional thermal protection (in the form of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures) should be considered in regions where critical infrastructure is installed.

All building structures should be closed to the weather and heated prior to the onset of freezing temperatures. These buildings should subsequently be heated during the winter months (and when freezing temperatures prevail) for the remainder of the building’s lifespan.

5.8 Concrete

All concrete work should conform to *Canadian Standards Association* (*CSA*) standard CAN/CSA – A23.1 and A23.2. According to the standard, the concrete should be designed to satisfy the minimum environmental durability requirements as defined by its exposure class. The exposure class is dependent upon the presence of chlorides and sulphates, freezing/thawing conditions and degree of soil saturation.

Based upon the results of sulphate ion content analysis, the potential for sulphate exposure is expected to be negligible. As such, it’s anticipated that standard concrete which is designed as described herein can be utilized during foundation work.

> While the sulphate ion content results of the sample retained from the *YG* granular quarry (Disposition No.900101) also indicated that the potential for sulphate exposure is expected to be negligible, the sulphate ion content of any imported fill which will be utilized during foundation construction/backfill should be assessed to verify their suitability once a source has been determined.

Normal Portland cement (C.S.A. Type 10), should be used in all concrete which is in direct contact with the soil.

Concrete subject to freeze-thaw cycles and potential deicing chemicals should be designed in accordance with C.S.A. A23.1-94, Section 15.

The concrete should have a minimum 28-day compressive strength of 25 megapascals and be air entrained (~ 4 to 6 percent). This assumes a maximum aggregate size of 20 mm.

Higher strength (32 Mpa) concrete should be utilized where concrete may be subject to freeze/thaw cycles or where heavy loads are anticipated.

5.9 Structural Breaks & Reinforcing

Structural breaks and reinforcing (rebar) should be integrated into the foundation to control cracking and allow for differential movements caused by soil volume changes of the underlying soil.

Additional measures should be incorporated into the design if dynamic and/or point loads are expected. This should include thickening and reinforcing the areas of the slab that may be subjected to these additional forces. Monolithic slabs should incorporate a thickened edge of slab component.

The slab component(s) of footing types of foundations should be structurally separated from other foundation components.

5.10 Vapor Barrier

A non-deteriorating vapor barrier should be placed beneath all concrete surfaces to prevent desiccation of the sub-base materials and promote concrete hydration.

5.11 Inclement Weather

The subgrade, excavations and construction materials should be protected from drying, freezing, rain, snow, surface waters and groundwater at all times.

The subgrade materials are subject to a loss of strength if they become wet/saturated and so caution will need to be exercised during construction. Once exposed, the subgrade surface should immediately be covered with a structural granular course to protect it from precipitation, desiccation and/or disturbances.

5.12 Surface and Groundwater

Groundwater is not anticipated during construction. However, as seasonal fluctuations may affect the flow regime, the Contractor should be prepared to undertake construction dewatering measures to ensure a dry working area.

Surface and groundwater should be removed from excavations at all times during foundation construction, subsurface utility installation and access road preparation.

The surrounding surfaces should be graded so as to direct surface waters away from excavations, temporary stockpiles and excavation spoils.

Ditches and Swales

Ditches and swales should be incorporated into the design and construction phases to control perimeter, site and subdivision drainage.

Site Grading

The drainage in the region of building sites, septic fields and roadways should be carefully controlled.

The surrounding areas should be graded to direct surface water away from the building structures and foundation/excavations. Typically, a 2 percent slope which extends a minimum of 5 meters away from the building perimeter will be sufficient for this purpose.

Surficial Cover

Exterior foundation backfill should be capped with a (200 mm thick layer of) low permeability soil or surface cover which is placed around the perimeter of building foundations following concrete placement in non-structural regions. The low permeability soil/surface cover will assist in directing surface waters away from the foundation and limits of the former excavation. The backfill should be placed to protect the sides of concrete slabs and prevent undermining of the slab during periods of heavy precipitation/run-off.

Eaves troughs

Eaves troughs should be incorporated into the building roof structures. The outlets from the roof drains should extend a minimum of 3.0 meters away from the building structures such that the discharged water is directed away from the structures.

5.13 Culvert Installations

Corrugated steel pipe (CSP) culverts should be incorporated where lot accesses and drainage is required in order to maintain positive drainage.

Culverts should be placed upon a 300 mm thick layer of clean bedding sand. This bedding sand should encompass the culvert such that a protective annulus which is no less than 300 mm thick is established around the culvert.
Culvert bedding and backfill should be placed in 150 mm thick lifts compacted to 95% of the materials maximum proctor dry density at (or near ± 2%) of the material's optimum moisture content.

Culverts should have a minimum soil cover of 500 mm.

The culvert inlet and outlet areas should be covered with protective rip-rap in accordance with good design and construction practices.

Consideration should be given to oversizing the culverts in central regions of the site as a precautionary measure relative to the historical drainage course which was identified during our evaluation.

5.14 Roads & Parking Areas

Following clearing, grubbing and stripping operations, the structure for roads and parking areas should be comprised of;

UNIT	THICKNESS	COMPACTION [C]	COMPOSITION
Base	200 mm[A]	100 %	20 mm minus crushed granular aggregate, overlying
Sub-base	300 mm	98 %	80 mm minus sub-base course aggregate, overlying
Sub-base	300 mm[B]	95%	150 mm minus pit run, overlying
Subgrade	NA	95 %	approved native subgrade materials [D]

Notes;

[A] – Thickness can be reduced to 150 mm in parking areas.

[B] – The thickness of this sub-base layer should be increased if heavy traffic loads are anticipated or if additional material is required to meet the anticipated design elevations.

[C] – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content. All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

[D] – The subgrade should be proof-rolled. If deflections are noted, these weak zones should be sub-excavated and replacement with an approved pit run which is compacted to no less than 95% of the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content. The use of geotextile fabric should be considered if poor subgrade materials are encountered or if additional structural support is required.

Roadways and parking areas should be designed to incorporate a minimum of 2% crowns such that positive drainage is provided.

If bituminous surface treatment (BST) of the roadway(s) is to be considered, we recommend that it is applied no earlier than one year following road construction to allow time for consolidation/settlement.

5.15 Temporary Stockpiles

Stockpiled materials that may be utilized during construction should be protected from segregation and the ingress of snow, frost, rain and surface waters.

5.16 Subsurface Utility Installations

New subsurface utility lines should be installed at a depth equivalent to 3 meters of soil cover and protected from frost. Where critical infrastructure is required, these lines should be well protected from frost through the use of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures as determined by a qualified municipal engineer.

The utility pipes should be placed upon a base of bedding sand which measures 300 mm thick. The bedding sand should extend a minimum of 300 mm around the pipe (to form a protective annulus). If subgrade conditions are poor, then the use of (clear stone) drain rock encased in geotextile filter fabric should be utilized in lieu of the bedding sand. The bedding sand and drain rock should conform to the grain size specifications provided in Appendix C.

The soil deposits which were encountered will generally be suitable for use as trench backfill in non-structural areas so long as these materials are free of organics and are not frozen or wet/saturated.

The trench backfill should be comprised of an approved pit run in regions where trenches intersect building (or road) load envelope(s). Cobbles larger than 150 mm in size should not be placed within 1 meter of the utility pipes.

Trench backfill materials should be placed in lifts which do not exceed 200 mm as measured following compaction. These materials should be compacted to a minimum of 95% of the materials corresponding maximum Proctor dry density at (or near) the materials optimum moisture content. The compaction effort should be increased to a minimum of 98 % of the materials corresponding maximum Proctor dry density in regions where the sub-surface utilities cross roadways/parking areas or other regions where loading envelopes may be affected.

5.17 Other Considerations

The discharge flume and erosion rills located on the highway embankment (as noted in Figure 3) should be rehabilitated/armored to reduce the potential for continued slope erosion. In addition, the density of the vegetation on the slope should increased to reduce the potential for erosion and slope movement.

5.18 Construction Schedule

Subdivision development (ie road construction, building construction, septic field installations, etc.) should be conducted during the summer months such that the potential of encountering seasonal frost is minimized. These projects should be completed prior to the onset of winter conditions. Building projects which are undertaken should be closed to the weather and heated prior to the onset of freezing temperatures (and whenever freezing temperatures) prevail throughout the remainder of the building’s lifespan.

5.19 Geotechnical Evaluations

Geotechnical evaluations should be conducted at any location where buildings and subsurface infrastructure is proposed to verify site-specific geotechnical parameters. A portion of the evaluation should assess whether or not gravel deposits underlie the building location(s) such that the design bearing capacities can be modified to reflect the higher allowable bearing capacities that these types of deposits will generally allow. In addition, the suitability of soils located at the proposed septic field locations should be verified at this time.

5.20 Construction Monitoring, Testing and Inspection Services

Qualified geotechnical personnel should provide construction monitoring, testing and inspection services during access road construction and other earthworks which may be required during the course of subdivision development. In addition, the future lot owners should retain geotechnical personnel to monitor, test and inspect building foundations and subsurface infrastructure during individual lot development to identify potential site-specific liabilities and verify good construction practices are undertaken.

5.21 Site Survey

Although topographical survey data of the site is available from 2014, a more recent survey should be undertaken by qualified personnel to assist the design team in establishing site grading profiles relative to the current site conditions.

6.0 CONCLUSIONS

6.1 Site Suitability

The site and subsurface conditions which were encountered will allow for industrial subdivision development in regions which were identified as having a suitable development potential as noted in Figure 3. These regions are generally comprised of glaciofluvial plain and terrace deposits where interbedded silts and silty sands are present. However, caution will need to be exercised during subdivision and lot development as deleterious soils were identified.

6.2 Deleterious Materials

The presence of deleterious surficial organics, volcanic ash, eolian soils and frost susceptible glaciofluvial plain and terrace deposits were identified throughout the study area. As such, caution will need to be exercised during building foundation and access road preparation by removing these materials from beneath the respective load envelopes and through adequate precautionary measures during design and construction.

As the soil deposits are susceptible to a loss of strength if they become disturbed, wet or desiccated, temporary roads and laydown areas may need to be prepared in order to facilitate subdivision/lot development and building construction.

6.3 Surface Utilities

The construction of roads and ditches utilizing conventional cut/fill construction methodologies will be feasible in the study area following adequate site preparation. In general, this will require the removal of the surficial organics, eolian deposits and volcanic ash following clearing and grubbing operations. While the granular components of the road structure would measure in the order of 0.8 meters thick, the constructed thickness would need to be based upon the subgrade conditions which are encountered at the time of construction, the anticipated traffic loads and the design elevations.

The drainage in the region of building sites, septic fields and roadways should be carefully controlled to direct surface water away from the infrastructure.

6.4 Building Foundations/Construction

Buildings can be founded upon conventional footing or monolithic-slab types of concrete foundation systems which are founded upon approved glaciofluvial plain or terrace deposits. However, as these deposits are predominately frost susceptible, the foundations will need to be designed and constructed as described herein.

6.5 Sulphate Attack Potential

The sulphate ion content analysis revealed the potential for sulphate exposure is expected to be negligible. As such, standard concrete which is designed as described herein can be utilized during the foundation work.

The sulphate ion content of proposed imported fill(s) which will be utilized during foundation construction/backfill should be assessed to verify their suitability once a source has been determined.

6.6 Septic Field Suitability

The glaciofluvial plain and terrace deposits which were encountered should be suitable to allow for the installation of traditional septic fields and subsurface utilities. However, some soils may have too high a percolation rate to allow for adequate processing of the sewage effluent and so an imported filter sand would need to be placed below the septic field in these areas to slow down the rate of percolation.

Percolation tests will need to be conducted as required by *Yukon Health and Social Services* at the time of individual lot development to verify the suitability of the anticipated accepting soils at the proposed septic field locations relative to *YG – Design Specifications for Sewage Disposal Systems*.

6.7 Subsurface Utilities

The glaciofluvial plain and terrace deposits which were encountered should be suitable to allow for the installation of shallow utilities.

New subsurface utility lines should be installed at a depth equivalent to 3 meters of soil cover for frost protection. Critical infrastructure should be well protected from frost through the use of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures.

6.8 Seismic Site Classification

Based upon the information obtained during the field work program the study area was classified as a Class D site for seismic site response in accordance with the *National Building Code of Canada*.

6.9 Potential Hazards & Geotechnical Setbacks

A geotechnical setback (30 meters in width) should be observed relative to the steep slope which is located within and adjacent to the site as an increased hazard potential related to surface water run-off and potential slope movements may exist in these areas. As such, building construction and septic field placement in these setback regions and potential discharge areas should be restricted.

Additional consideration may be required in regions located down-gradient of the potential discharge region associated with the drainage course which was identified in the *YG – Water Placer Atlas*. This may include incorporating a potential drainage easement through the study area as a precautionary measure in the event the drainage regime changes.

The discharge flume and erosion rills located on the highway embankment (as noted in Figure 3) should be rehabilitated/armored to reduce the potential for continued slope erosion. The density of the vegetation on the slope should be increased to further reduce the potential for erosion and slope movement.

6.10 Geotechnical Evaluations

Geotechnical evaluations should be conducted at any location where buildings and subsurface infrastructure are proposed to verify site-specific geotechnical parameters.

6.11 Hydrogeological Assessment

A hydrogeological study would be required to assess the suitability of the study area relative to water well installations.

7.0 LIMITATIONS

This report is intended for the sole use of the *Yukon Government.*

No portion of this report may be used as a separate entity; it is intended to be read in its entirety.

Any use of this report by a third party is the responsibility of such third party.

The recommendations provided herein are based upon the subsurface conditions encountered at the time of our investigation, current construction techniques and generally accepted engineering practices. The content within this report reflects our best judgment in light of the information available to our firm at the time of report preparation.

The anticipated construction conditions have been discussed, but only to the extent that they may influence design decisions. Any references to construction methods contained herein, express our opinion and are not intended to direct contractors on how to carry out construction. Prospective contractors should be aware that the information presented herein and our corresponding discussions may not be sufficient to assess all factors that may have an effect upon construction. The elevations noted herein are for discussion purposes only.

It is important to emphasize that the geotechnical investigation component of any evaluation is, in fact, a random sampling of the site and that subsequent discussions and assessments of the retained information are based upon the results obtained at the sample locations. Due to the geomorphological nature of the deposits which were encountered, interpolations of the subsurface conditions between the test locations have not been made or been implied.

Should unexpected conditions be encountered during construction, our firm should be notified immediately in order to confirm the suitability of our recommendations. If required, our firm may alter or modify our recommendations and conclusions at such time.

8.0 CLOSURE

Thank you for providing our firm with the opportunity to conduct the above noted geotechnical evaluation.

We trust that the information we have provided will be suitable for your purposes, however, if you should have any questions or concerns, please feel free to contact the undersigned at your convenience.

Respectfully Submitted,

CHILKOOT GEOLOGICAL ENGINEERS LTD.

#1277
TARES DHARA

PERMIT TO PRACTICE
Signature
Date October 7, 2019
PERMIT NUMBER: PP025
Association of Professional Engineers of Yukon

Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

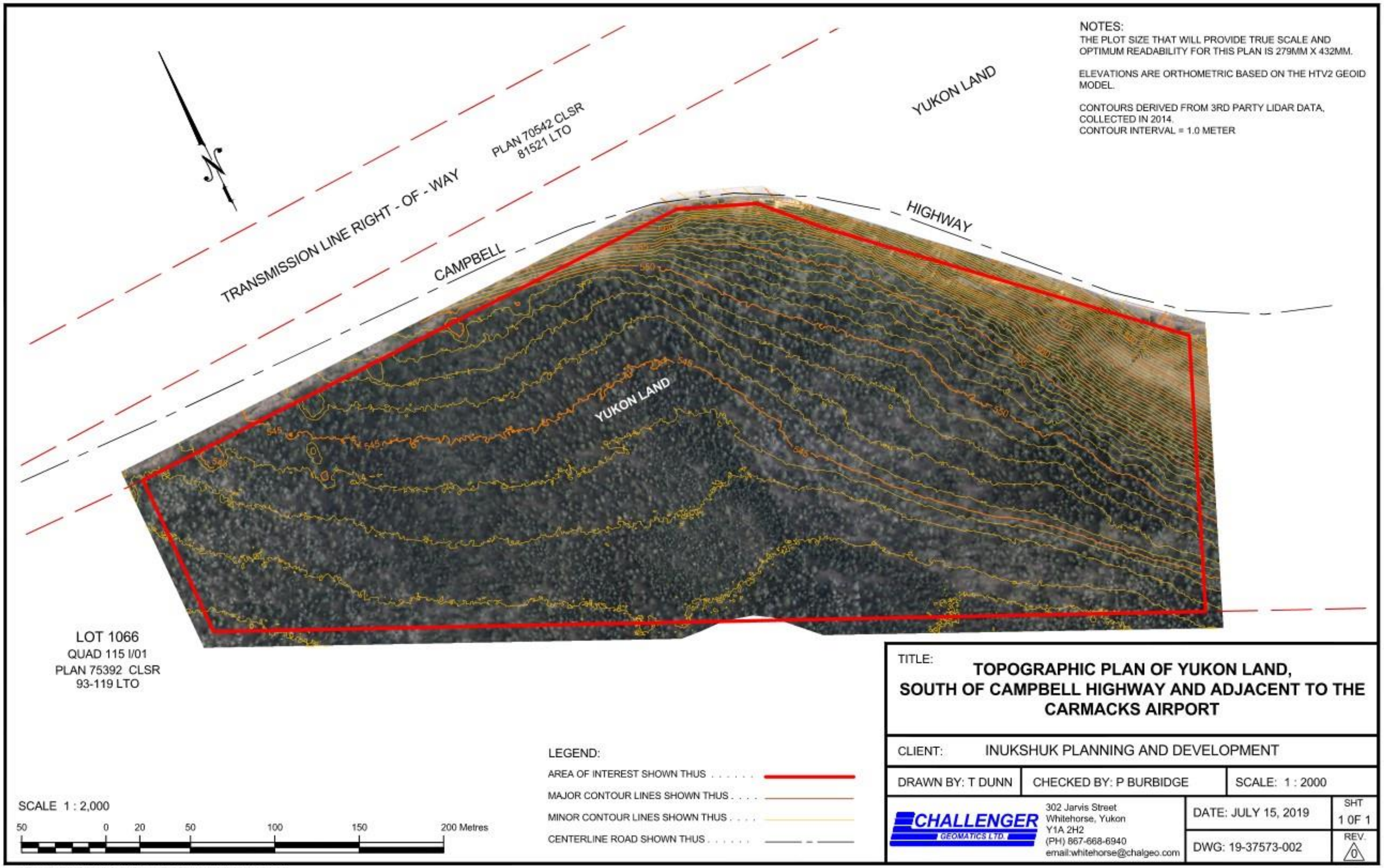
Geotechnical Evaluation
Proposed Industrial Subdivision
km 575 LHS Robert Campbell Highway #4 - Carmacks, Yukon – 2019

Figure 1 – Location of Study Area

Based map modified from Google Earth – Not to Scale – Locations are approximate

Compiled Sept.10th, 2019 by T.Dhara, P.Eng.

Geotechnical Evaluation
Proposed Industrial Subdivision
km 575 LHS Robert Campbell Highway #4 - Carmacks, Yukon – 2019
Figure 2 – Site Topography



NOTES:
THE PLOT SIZE THAT WILL PROVIDE TRUE SCALE AND OPTIMUM READABILITY FOR THIS PLAN IS 279MM X 432MM.

ELEVATIONS ARE ORTHOMETRIC BASED ON THE HTV2 GEOID MODEL.

CONTOURS DERIVED FROM 3RD PARTY LIDAR DATA, COLLECTED IN 2014.
CONTOUR INTERVAL = 1.0 METER

LEGEND:
AREA OF INTEREST SHOWN THUS . . . . . . 🟥
MAJOR CONTOUR LINES SHOWN THUS . . . . ―
MINOR CONTOUR LINES SHOWN THUS . . . . ―
CENTERLINE ROAD SHOWN THUS . . . . . . ― – ―

TITLE: TOPOGRAPHIC PLAN OF YUKON LAND, SOUTH OF CAMPBELL HIGHWAY AND ADJACENT TO THE CARMACKS AIRPORT

CLIENT: INUKSHUK PLANNING AND DEVELOPMENT

DRAWN BY: T DUNN | CHECKED BY: P BURBIDGE | SCALE: 1 : 2000

CHALLENGER
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email:whitehorse@chalgeo.com

DATE: JULY 15, 2019
SHT 1 0F 1
DWG: 19-37573-002
REV. 0

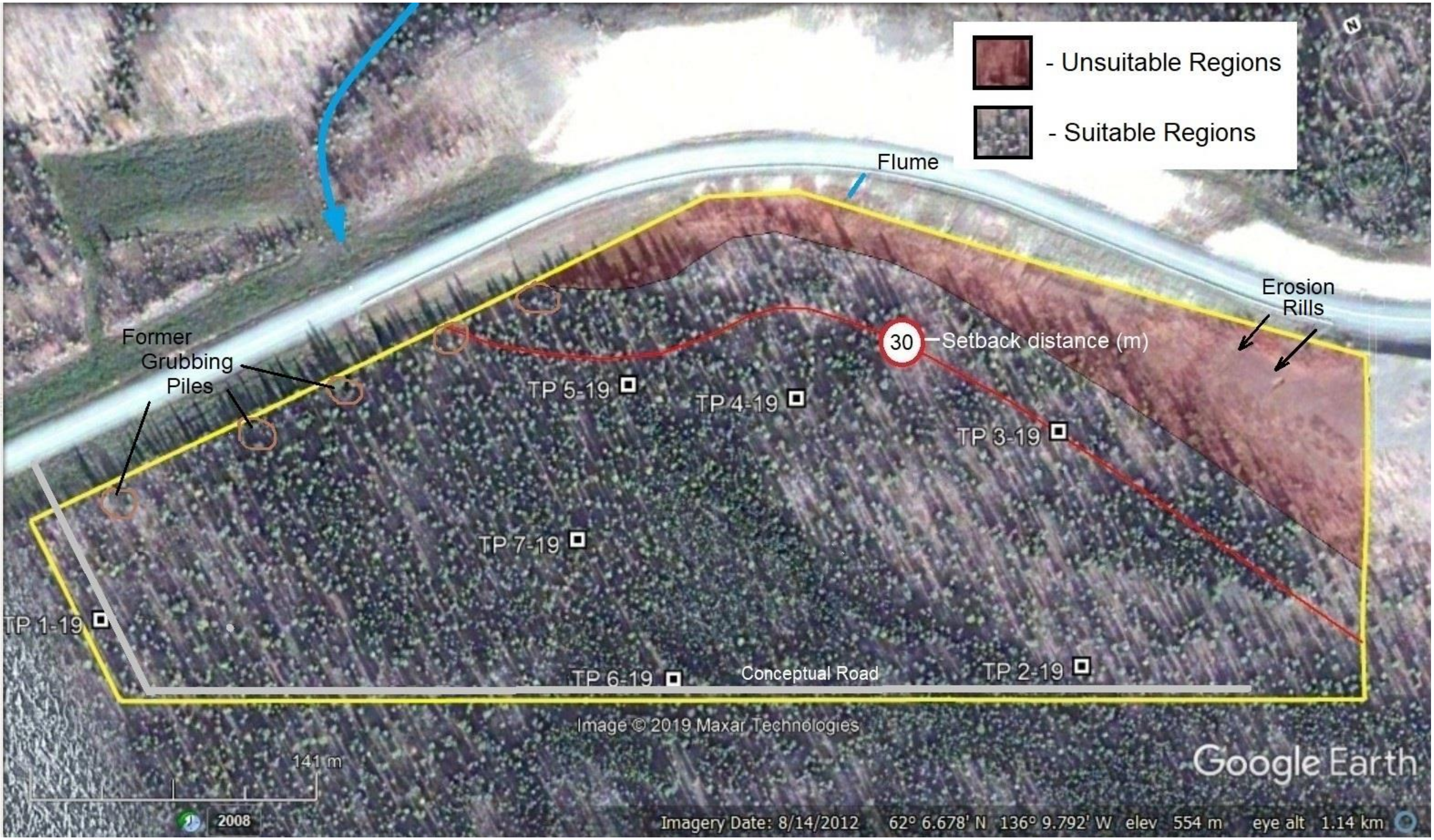
Job:37573

Based map supplied by *Inukshuk Planning & Development Ltd.*

Compiled Sept.10th, 2019 by T.Dhara, P.Eng.

CHILKOOT GEOLOGICAL ENGINEERS LTD.

Geotechnical Evaluation
Proposed Industrial Subdivision
km 575 LHS Robert Campbell Highway #4 - Carmacks, Yukon - 2019
Figure 3 – Development Potential & Test Pit Locations



Based map modified from Google Earth – Not to Scale – Locations are approximate.

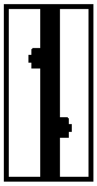
Compiled Sept.10th, 2019 by T.Dhara, P.Eng.

APPENDIX A

Soil Logs

NOTES ON SOIL LOGS

Soil Log - Sample Type

Symbol	Test Pitting	Drilling
	**Grab Samples** Retained from excavation sidewall or base	**Auger Sample** Retained from auger flighting
	**Bucket Sample** Retained from leading edge of excavator bucket	**Split-Spoon Sample** Retained from Split-Spoon sampler tube

Soil Description

The soil is named after its principal component and modified by other components as follows;

Percent of Component	Modifier
> 15 %	XXX - ey
11% to 15%	some XXX
5% to 10%	trace XXX

Examples;

SILT	SAND	GRAVEL	Description
6	32	62	Sandy Gravel trace Silt
55	6	39	Gravelly Silt trace Sand
43	36	21	Silty Gravelly Sand

Note: In the cases where the coarse fraction (sand & gravel) comprise > 50% of the sample, then the larger component of the coarse fraction becomes the principal component.

Relative Density / Consistency (Qualitative Classification)

Granular Soils	(Relative Density)
Very Loose	- Considerable sidewall slough noted
Loose	- Some sidewall slough noted – Easy digging
Compact/ Medium-Dense	- Unimpeded excavation – little to no sidewall slough
Dense	- Considerable effort required during excavation – Stable vertical sidewalls
Very Dense	- Extreme difficulty in excavation

Cohesive (fine-grained) Soils	(Consistency)
Very Soft	- Exudes between fingers when squeezed by hand
Soft	- Molded by light finger pressure
Firm	- Molded by strong finger pressure
Stiff	- Cannot be molded by fingers – Can be indented by thumb
Very Stiff	- Can only be indented by thumbnail
Hard	- Cannot be indented by thumbnail

At times, the consistency of non-plastic fine-grained soils are described utilizing the relative density terms.

Relative Moisture

Described as - *dry, damp, moist* or *wet* - relative to the principal soil matrix.

For example, a moisture content of 10 percent may be classified as ‘*moist to wet*’ for a coarse grained soil (sand or gravel) but ‘*damp*’ for a fine-grained cohesive soil.

The moisture content is recorded as a percentage (%) of the weight of water within the soil sample relative to the dry weight of the sample.

Recovery

Refers to the (linear) amount of sample retained after driving the Split Spoon (SPT) sampler tube 18 inches.

Recorded as a percentage (i.e. 12 inch sample/18 drive = 66 %)

N-Value

Refers to the total number of blows required to drive the Split Spoon sampler tube the final 12 inches of the 18 inch drive.

Relative Density based upon SPT 'N' Value

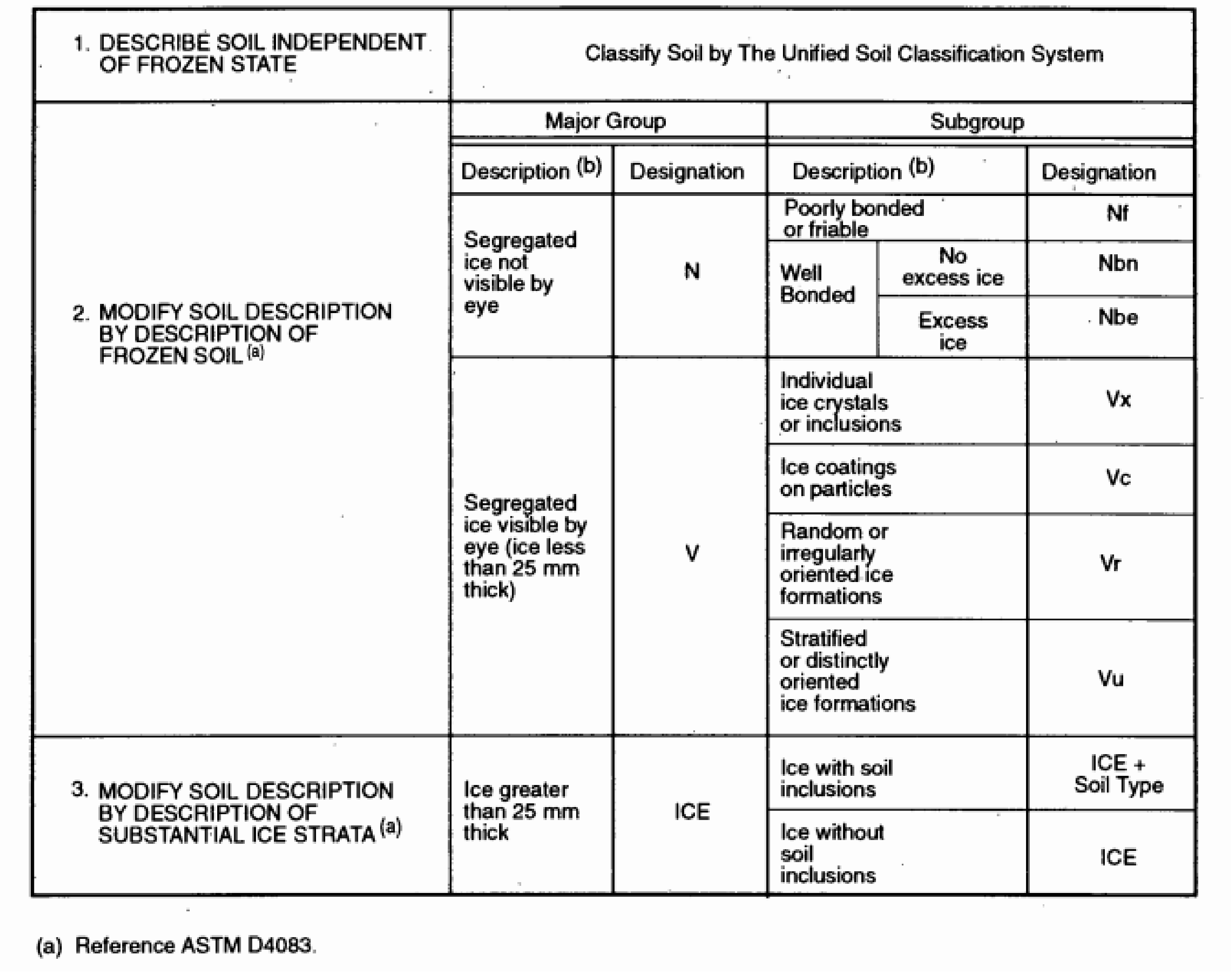
Non-cohesive (Granular) Soil		Cohesive (Clayey) Soils	
Relative Density	**Blows per Foot (N-value)**	**Consistency**	**Blows per Foot (N-value)**
Very Loose	< 5	*Very Soft*	0 to 2
Loose	5 to 9	*Soft*	3 to 4
Compact	10 to 29	*Firm*	5 to 8
Dense	30 to 50	*Stiff*	9 to 15
Very Dense	> 50	*Very Stiff*	16 to 30
		Hard	> 30

Undrained Shear Strength of Cohesive Soils

Consistency	Undrained Shear Strength	
	p.s.f	kN/m^2
Very Soft	< 375	<20
Soft	375-750	20-40
Firm	750-1500	40-75
Stiff	1500-3000	75-150
Very Stiff	3000-6000	150-300
Hard	>6000	<300

Description & Classification of Frozen Soils – National Research Council (NRC)

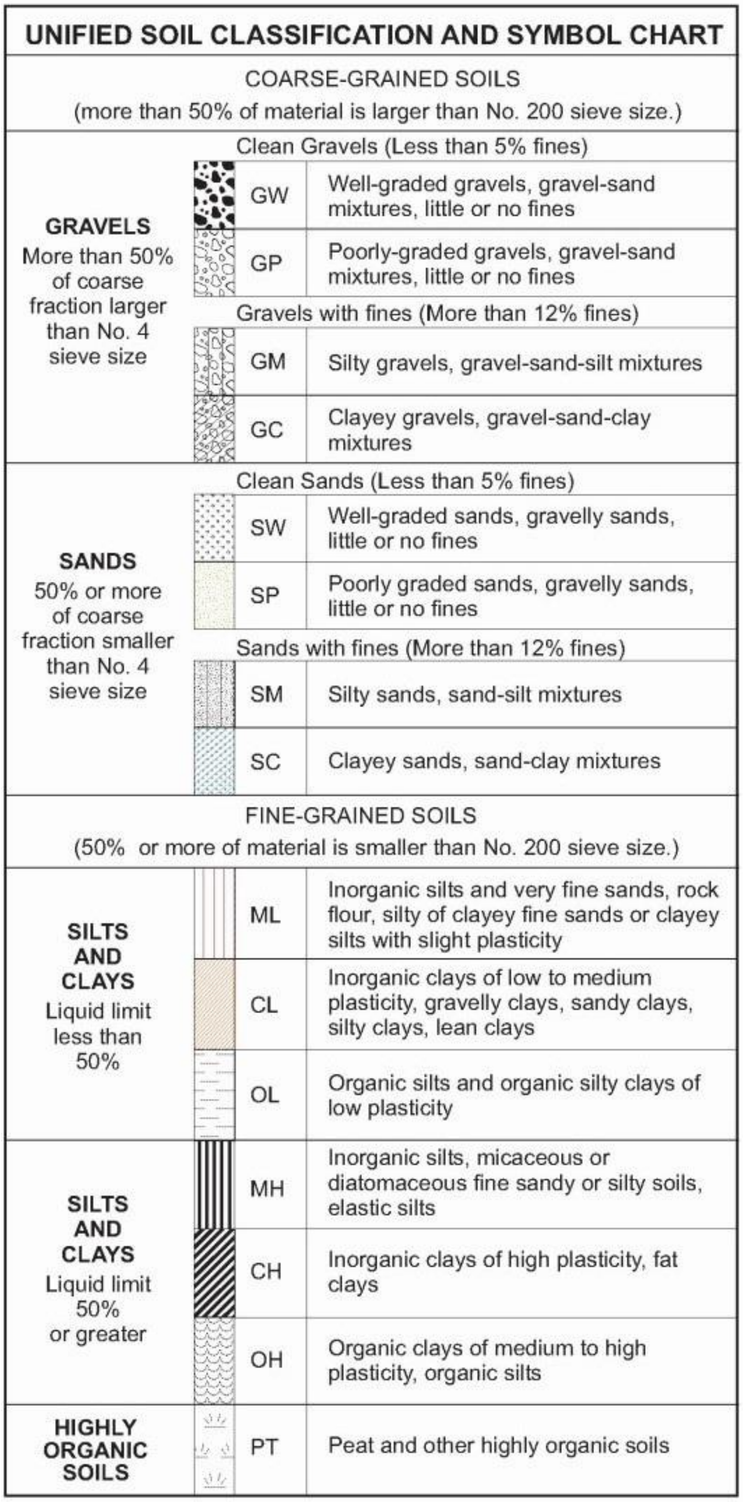
(Adapted from Linnell & Kaplar, 1966)



1. DESCRIBE SOIL INDEPENDENT OF FROZEN STATE	Classify Soil by The Unified Soil Classification System				
	Major Group		Subgroup		
	Description (b)	Designation	Description (b)		Designation
2. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF FROZEN SOIL (a)	Segregated ice not visible by eye	N	Poorly bonded or friable		Nf
			Well Bonded	No excess ice	Nbn
				Excess ice	Nbe
	Segregated ice visible by eye (ice less than 25 mm thick)	V	Individual ice crystals or inclusions		Vx
			Ice coatings on particles		Vc
			Random or irregularly oriented ice formations		Vr
			Stratified or distinctly oriented ice formations		Vu
3. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF SUBSTANTIAL ICE STRATA (a)	Ice greater than 25 mm thick	ICE	Ice with soil inclusions		ICE + Soil Type
			Ice without soil inclusions		ICE

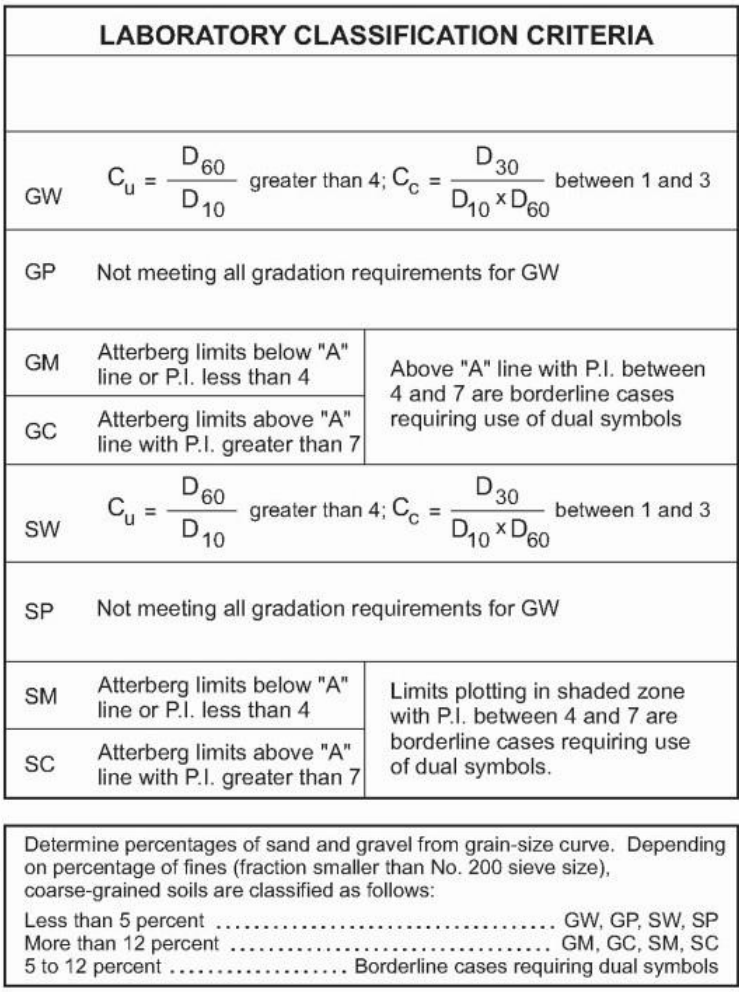
(a) Reference ASTM D4083.

Unified Soil Classification System



UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)			
	Clean Gravels (Less than 5% fines)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	▨	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	▨	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)		
	▨	GM	Silty gravels, gravel-sand-silt mixtures
	▨	GC	Clayey gravels, gravel-sand-clay mixtures
	Clean Sands (Less than 5% fines)		
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	▨	SW	Well-graded sands, gravelly sands, little or no fines
	▨	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)		
	▨	SM	Silty sands, sand-silt mixtures
	▨	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)			
SILTS AND CLAYS Liquid limit less than 50%	▨	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	▨	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	▨	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	▨	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	▨	CH	Inorganic clays of high plasticity, fat clays
	▨	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	▨	PT	Peat and other highly organic soils



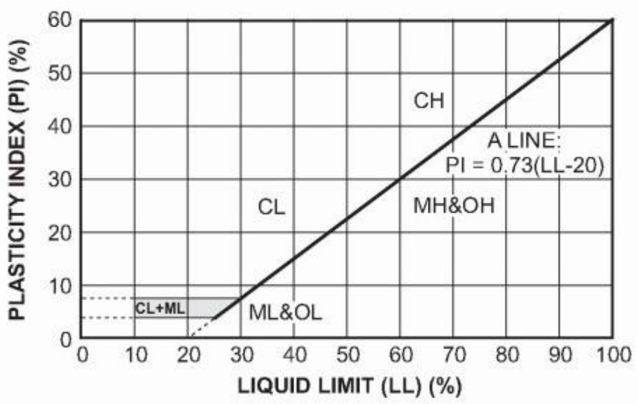
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent .... GW, GP, SW, SP
More than 12 percent .... GM, GC, SM, SC
5 to 12 percent .... Borderline cases requiring dual symbols

PLASTICITY CHART



CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.10 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT

1-19

Sheet 1 of 1

Relative Density	Stratigraphic Description	Relative Moisture	USCS/NRC
soft loose	SURFICIAL ORGANICS (50 mm)	moist damp	ORG
firm	VOLCANIC ASH (150 mm)	damp	ASH
firm	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp	ML
	SANDY SILT -non-plastic, fine grained, beige-brown		
compact	GRAVELLY SAND trace SILT - fine to medium grained, poorly graded, beige-brown	damp	SP-SM
compact	SILTY SAND some GRAVEL - fine grained, poorly graded, beige-brown	moist	SM
compact	SANDY SILT - non-plastic, fine grained, beige-brown	moist	ML

Test Pit terminated at 3.10 m below the ground surface. Groundwater not encountered.

Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	▲ - FINES	● - SAND	■ - GRAVEL	MC
1	NA	NA	NA	NA				6.1
2	NA	NA	NA	NA				4.9
3	NA	NA	NA	NA	8.2	56.3	35.5	3.5
4	NA	NA	NA	NA	37.4	50.3	12.3	6.8
5	NA	NA	NA	NA	77.8	22.2	0.0	12.5

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.40 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT
2-19
Sheet 1 of 1

Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC
soft loose	SURFICIAL ORGANICS (50 mm)	moist damp								ORG
firm	VOLCANIC ASH (150 mm)	damp	☒	6	NA	NA	NA	NA	GRAVEL 0.0 SAND 8.7 MC 6.4 FINES 91.3	ASH
firm	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp	☒	7	NA	NA	NA	NA	MC 5.9	ML
	SANDY SILT -non-plastic, fine grained, beige-brown									ML
compact	- as above	damp		8	NA	NA	NA	NA	GRAVEL 0.0 SAND 20.8 MC 6.8 FINES 79.4	
compact	SILTY SAND trace GRAVEL - brown	damp		9	NA	NA	NA	NA	MC 3.1	SM
compact	SANDY SILT - non-plastic - beige-brown	damp								ML
compact	SILTY SAND - brown	damp								SM
compact	SANDY SILT - non-plastic - beige-brown	damp								ML
compact	SILTY SAND - brown	damp								SM
compact	SANDY SILT - non-plastic - beige-brown	damp		10	NA	NA	NA	NA	MC 6.0	ML

Laboratory Results legend: ▲ - FINES ● - SAND ■ - GRAVEL; PL ⊢ MC ⊙ ⊣ LL; scale 20 40 60 80

Test Pit terminated at 3.40 m below the ground surface.
Groundwater not encountered.

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng. Aug.12, 2019
Data Entry By: T.Dhara, P.Eng. Aug.27-Sept.20
Reviewed By: Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.30 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT

3-19

Sheet 1 of 1

Relative Density	Stratigraphic Description	Relative Moisture	USCS/NRC
soft		moist	
loose	SURFICIAL ORGANICS (50 mm)	damp	ORG
firm	VOLCANIC ASH (150 mm)	damp	ASH
stiff	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp	ML
	SANDY SILT -non-plastic, fine grained, beige-brown		ML
compact	- as above odd rootlet to 1.0 m beige-brown	damp	
compact	SILTY SAND trace GRAVEL - fine to medium grained, poorly graded, brown	damp	SM
compact	SANDY GRAVEL trace SILT - m-c grained, poorly graded, odd fractured cobble in size to100 mm, grey-brown	dry-damp	GP-GM
compact	SILTY SAND - fine grained, poorly graded, beige-brown	damp	SM

Test Pit terminated at 3.30 m below the ground surface.
Groundwater not encountered.

Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	▲ - FINES	● - SAND	■ - GRAVEL	MC
11	NA	NA	2.5	NA	90.4	9.6	0.0	4.9
12	NA	NA	NA	NA				6.0
13	NA	NA	NA	NA	17.7	74.0	8.3	2.0
14	NA	NA	NA	NA	8.5	30.9	60.6	1.8
15	NA	NA	NA	NA				3.9

PL ⊢—⊙—⊣ LL


#11


#14

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.30 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT

4-19

Sheet 1 of 1

Laboratory Results (%): ▲ - FINES ● - SAND ■ - GRAVEL PL ⊢⊙⊣ LL (MC) — scale 20 40 60 80

Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC
soft loose	SURFICIAL ORGANICS (50 mm)	moist damp								ORG
firm stiff	VOLCANIC ASH (150 mm)	damp damp	☒	16	NA	NA	NA	NA	⊙ 5.6	ASH
	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown		☒	17	NA	NA	NA	NA	■ 0.0 ● 1.3 ⊙ 5.9 ▲ 98.7	ML
	SANDY SILT -non-plastic, fine grained, odd rootlet to 0.5 m, beige-brown									ML
compact	SILT - non-plastic, beige-brown	damp								
compact	SILTY SAND - fine grained, poorly graded, beige-brown	damp		18	NA	NA	NA	NA	■ 0.0 ⊙ 3.2 ▲ 49.7 ● 50.3	SM
compact	SANDY GRAVEL trace SILT - medium to coarse grained, poorly graded, odd cobble in size to 100 mm, brown	damp		19	NA	NA	NA	NA	⊙ 2.5	GP-GM
				20	NA	NA	NA	NA	⊙ 1.7 ▲ 6.2 ● 21.9 ■ 71.8	

Test Pit terminated at 3.30 m below the ground surface.
Groundwater not encountered.

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.30 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT
5-19
Sheet 1 of 1

Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC
soft loose	SURFICIAL ORGANICS (50 mm)	moist damp								ORG
firm	VOLCANIC ASH (150 mm)	damp	☒	21	NA	NA	NA	NA	3.3	ASH
firm	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp	☒	22	NA	NA	NA	NA	8.4	ML
	SANDY SILT -non-plastic, fine grained, odd rootlet to 0.6 m, beige-brown									ML
compact	SILT some SAND - non-plastic, fine grained, interbedded, beige-brown	damp		23	NA	NA	NA	NA	11.0	ML
compact	SILTY SAND - fine grained, poorly graded, beige-brown	damp								SM
	- as above			24	NA	NA	NA	NA	4.6	SM

Test Pit terminated at 3.30 m below the ground surface.
Groundwater not encountered.

Laboratory Results legend: ▲ - FINES ● - SAND ■ - GRAVEL; PL ⊢ MC ⊙ ⊣ LL; 20 40 60 80

Elev. (m) / Depth ft: 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0

Depth m: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.20 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT
6-19
Sheet 1 of 1

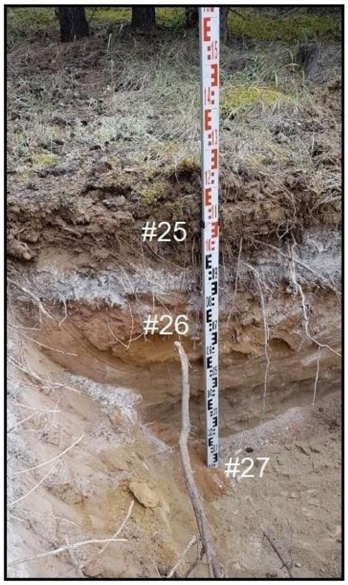
Relative Density	Stratigraphic Description	Relative Moisture
soft loose	SURFICIAL ORGANICS (75 mm)	moist damp
loose firm	SILTY SAND - fine to medium grained, poorly graded, rootlets, brown	damp damp
firm	VOLCANIC ASH (150 mm)	damp
compact	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp
	SANDY SILT -non-plastic, fine grained, odd rootlet to 0.8 m, beige-brown	
compact	SILT trace SAND -non-plastic, fine grained, beige-brown	damp
	SILTY SAND - fine grained, poorly graded, beige-brown - as above but increasing moisture	
compact	SAND trace GRAVEL trace SILT - medium to coarse grained, poorly graded, odd cobble in size to 100 mm, brown	dry-damp

Test Pit terminated at 3.20 m below the ground surface. Groundwater not encountered.

USCS/NRC
ORG
SM
ASH
ML
ML
SM
SP-SM

Field Sample / Laboratory Results (%) — ▲ - FINES ● - SAND ■ - GRAVEL; PL ⊙ MC LL

Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	MC	Fines	Sand	Gravel
☒	25	NA	NA	NA	NA	2.9	21.	78.	0.4
☒	26	NA	NA	NA	NA	2.9			
☒	27	NA	NA	NA	NA	7.5	85.6	14.4	0.0
▮	28	NA	NA	NA	NA	3.7			
▮	29	NA	NA	NA	NA	6.0	45.6	54.4	0.0
▮	30	NA	NA	NA	NA	1.4	6.6	83.7	9.6



Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

TEST PIT LOG

Client: Yukon Government - Community Services
Location: Carmacks, Yukon - Industrial Subdivision #1
Project: Geotechnical Evaluation - Proposed Lot Development
Date Excavated: August 12, 2019

Elevation: 100.00 meters
TP Termination Depth: 3.30 meters
Instrumentation: NA
Weather: Scattered Cloud 22°

TEST PIT
7-19
Sheet 1 of 1

Relative Density	Stratigraphic Description	Relative Moisture	USCS/NRC
soft loose	SURFICIAL ORGANICS (50 mm)	moist damp	ORG
firm	VOLCANIC ASH (150 mm)	damp	ASH
firm	SANDY SILT -non-plastic, fine grained, rootlets reddish-brown	damp	ML
compact	SANDY SILT -non-plastic, fine grained, odd rootlet to 0.5 m, beige-brown	dry-damp	ML
firm	SAND trace SILT - fine grained, poorly graded, beige-brown	damp	ML ORG ML ORG ML ORG
	SILT trace CLAY -non to slight plasticity - grey-brown - w/ interbedded rootlets & organic inclusions @ 1.0, 1.3 & 1.6 m		ML
compact	SILTY SAND - fine grained, poorly graded, beige-brown - as above	damp	SM

Test Pit terminated at 3.30 m below the ground surface. Groundwater not encountered.

Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)
31	NA	NA	NA	NA	3.0
32	NA	NA	NA	NA	2.7 6.1 1.9 91.1
33	NA	NA	NA	NA	0.0 2.1 9.2 97.9
34	NA	NA	NA	NA	4.4

▲ - FINES ● - SAND ■ - GRAVEL
PL ⊢⊙⊣ LL MC

Excavated By: Yellow Truck Exc.
Excavator Type: Bobcat E63
Bucket Type: Digging

Groundwater Levels
▽ Inferred ▼ Observed

Logged By: T.Dhara, P.Eng.	Aug.12, 2019
Data Entry By: T.Dhara, P.Eng.	Aug.27-Sept.20
Reviewed By:	Sept.23, 2019

APPENDIX B

Golder Associates Laboratory Results

Hydrometer Analysis

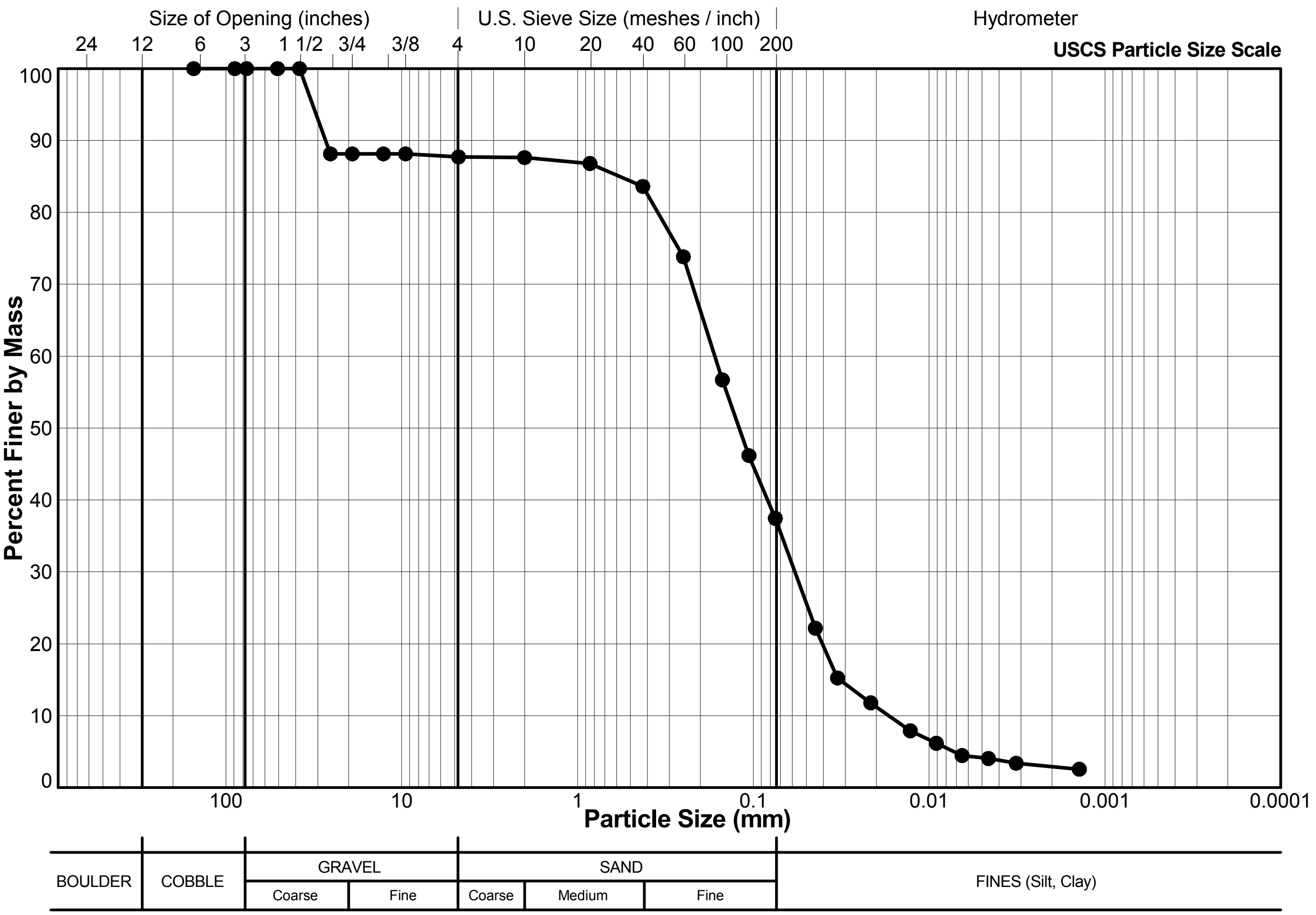
Sulphate Ion Content Analysis

SUMMARY OF PARTICLE SIZE DISTRIBUTION

ASTM D 422

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

Sample Location: Industrial Site #1
Sample No.: TP1-19 - SA4
Depth (m): 2.0
Lab Schedule No.: B19-275



Legend

Sieve Size (USS)	(mm)	Particle Size (mm)	Percent Passing
6"	152.4		100.0
3.5"	88.9		100.0
3"	76.2		100.0
2"	50.8		100.0
1 1/2"	38.1		100.0
1"	25.4		88.1
3/4"	19.1		88.1
1/2"	12.7		88.1
3/8"	9.5		88.1
#4 US MESH	4.75		87.7
#10 US MESH	2		87.6
#20 US MESH	0.85		86.8
#40 US MESH	0.425		83.6
#60 US MESH	0.25		73.8
#100 US MESH	0.15		56.7
#140 US MESH	0.106		46.2
#200 US MESH	0.075		37.4
		0.0444	22.2
		0.0332	15.2
		0.0215	11.8
		0.0128	7.9
		0.0091	6.2
		0.0065	4.5
		0.0046	4.0
		0.0032	3.4
		0.0014	2.6

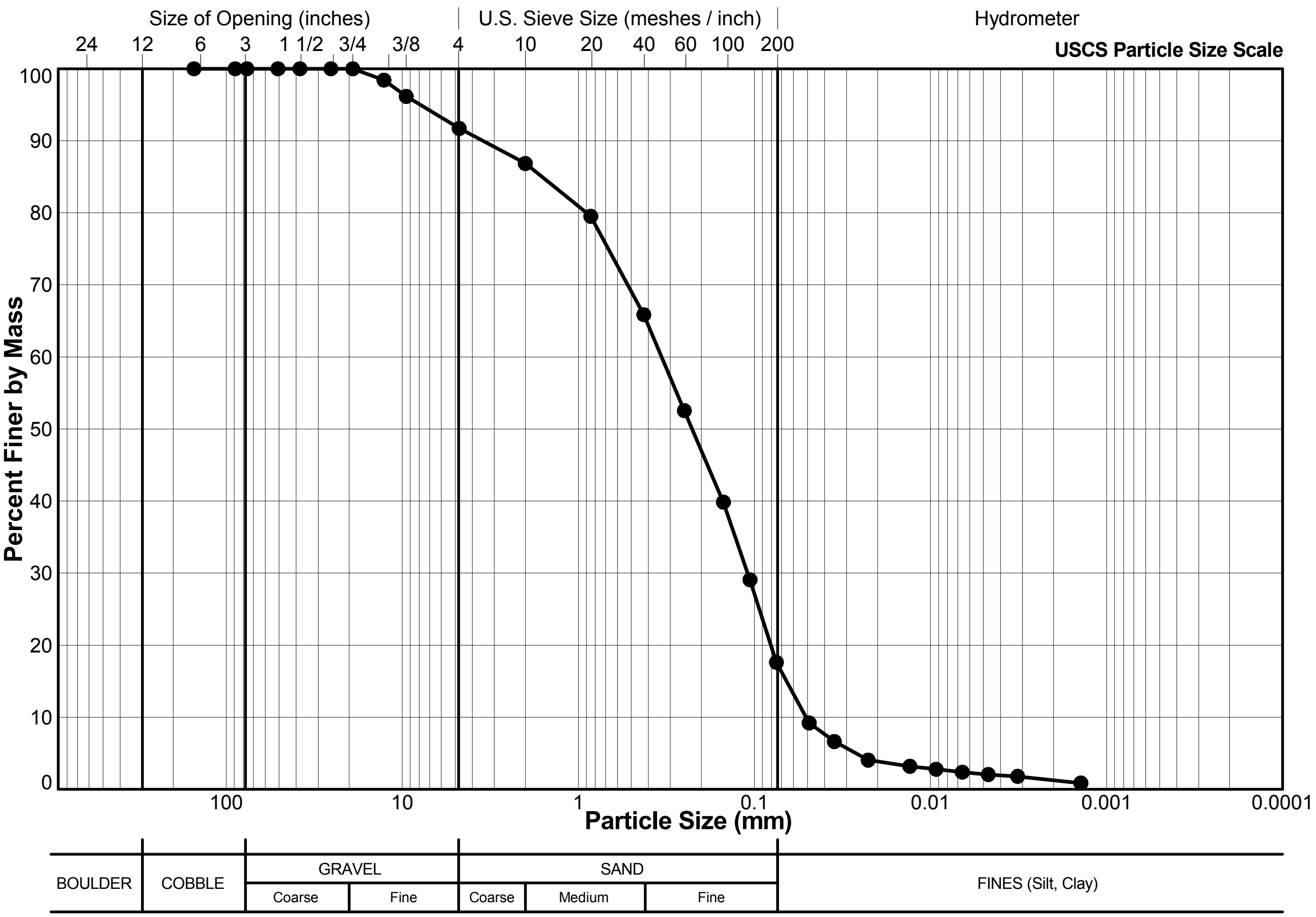
DC/VN	**8/29/2019**	**SJ**	**9/4/2019**
Tech	Date	Checked	Date

SUMMARY OF PARTICLE SIZE DISTRIBUTION

ASTM D 422

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

Sample Location: Industrial Site #1
Sample No.: TP3-19 - SA13
Depth (m): 1.9
Lab Schedule No.: B19-275



Legend

Sieve Size (USS)	(mm)	Particle Size (mm)	Percent Passing
6"	152.4		100.0
3.5"	88.9		100.0
3"	76.2		100.0
2"	50.8		100.0
1 1/2"	38.1		100.0
1"	25.4		100.0
3/4"	19.1		100.0
1/2"	12.7		98.4
3/8"	9.5		96.2
#4 US MESH	4.75		91.7
#10 US MESH	2		86.8
#20 US MESH	0.85		79.5
#40 US MESH	0.425		65.9
#60 US MESH	0.25		52.5
#100 US MESH	0.15		39.9
#140 US MESH	0.106		29.1
#200 US MESH	0.075		17.6
		0.0489	9.2
		0.0352	6.6
		0.0226	4.0
		0.0131	3.2
		0.0093	2.8
		0.0066	2.4
		0.0047	2.0
		0.0032	1.8
		0.0014	0.9

DC/VN	**8/28/2019**	**SJ**	**9/4/2019**
Tech	Date	Checked	Date

National IM Server:GINT_GAL_NATIONALIM Unique Project ID:2328 Output Form:_LAB_PARTICLE SIZE (W/ GRADATIONS) 2018 SJohn 6/9/19

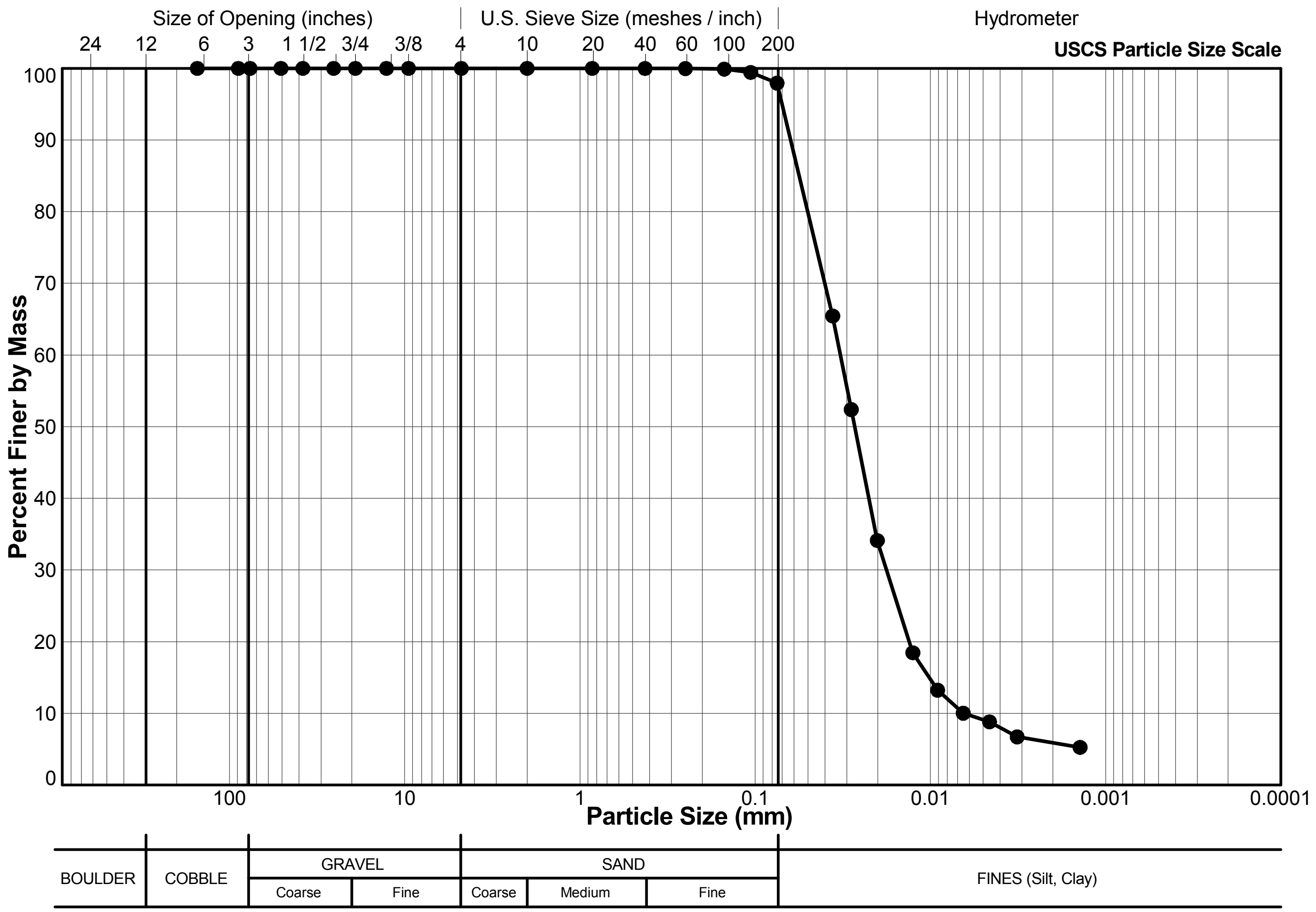
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION

ASTM D 422

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

Sample Location: Industrial Site #1
Sample No.: TP7-19 - SA33
Depth (m): 1.7
Lab Schedule No.: B19-275



Legend

Sieve Size (USS)	(mm)	Particle Size (mm)	Percent Passing
6"	152.4		100.0
3.5"	88.9		100.0
3"	76.2		100.0
2"	50.8		100.0
1 1/2"	38.1		100.0
1"	25.4		100.0
3/4"	19.1		100.0
1/2"	12.7		100.0
3/8"	9.5		100.0
#4 US MESH	4.75		100.0
#10 US MESH	2		100.0
#20 US MESH	0.85		100.0
#40 US MESH	0.425		100.0
#60 US MESH	0.25		100.0
#100 US MESH	0.15		99.9
#140 US MESH	0.106		99.4
#200 US MESH	0.075		97.9
		0.0361	65.4
		0.0283	52.4
		0.0201	34.1
		0.0126	18.5
		0.0091	13.2
		0.0065	10.0
		0.0046	8.8
		0.0032	6.7
		0.0014	5.2

DC/VN	**8/29/2019**	**SJ**	**9/4/2019**
Tech	Date	Checked	Date

National IM Server:GINT_GAL_NATIONALIM Unique Project ID:2328 Output Form:_LAB_PARTICLE SIZE (W/ GRADATIONS) 2018 SJohn 6/9/19

DETERMINATION OF TOTAL OR WATER-SOLUBLE SULPHATE ION CONTENT OF SOIL

CSA A23.2-3B

September 6, 2019
Project Number: 1780303-6000

CHILKOOT GEOLOGICAL ENGINEERS LTD.
5B Bennett Road
Whitehorse, YT
Y1A 5P7

Attention: Mr. Tares Dhara, P.Eng.

PROJECT: Carmacks, Yukon

Date sampled: August 12, 2019
Date tested: August 30, 2019

Sampled by: Client - TD
Tested by: RZ

Site Location	Sample ID	Total Sulphate Ion Content %	Water-Soluble Sulphate Ion Content %
Industrial Site #1	TP5-19, Sample #23	0.01	Not Applicable *
YG Pit - Disposition #900101	YG Pit, Sample #1	0.06	Not Applicable *

Notes:

1. * Per Clause 9.1.4, the water-soluble sulphate ion content need not be tested when the total sulphate ion content is less than 0.20%
2. Detection limit for the test is 0.005%

Reported by: R. Zhu

Reviewed by: ______________________
S. John, AScT

APPENDIX C

Recommended Grain Size Distribution for Imported Fills

Appendix C

Recommended Grain Size Distribution for Imported Fill

Gran E Pit Run	
Sieve Size (mm)	% Passing By Wt
200	100
80	75-100
25	55-100
12.5	42-84
5	26-65
1.25	11-47
0.315	3-30
0.08	2-13
LA Abrasion 35 % Max Loss	

80 mm minus Sub-base	
Sieve Size (mm)	% Passing By Wt
80	100
25	60-100
12.5	40-90
5	20-65
1.25	9-35
0.315	3-15
0.08	0-8
LA Abrasion 35 % Max Loss	

Clear Stone	
Sieve Size (mm)	% Passing By Wt
28	100
20	70-100
12.5	55-100
10	30-80
5	0-40
2	0-10
NA	NA
LA Abrasion 35 % Max Loss	

Bedding Sand	
Sieve Size (mm)	% Passing By Wt
10	100
5	80-100
2	55-100
0.63	25-65
0.25	10-40
0.08	2-10

20 mm minus Base Course	
Sieve Size (mm)	% Passing By Wt
20	100
12.5	64-100
5	36-72
1.25	12-42
0.315	4-22
0.08	3-6

Class I Rip-Rap	
Sieve Size (mm)	% Passing By Wt
450	100
350	80
300	50
200	20

Class II Rip-Rap	
Sieve Size (mm)	% Passing By Wt
800	100
600	80
500	50
300	20

Class III Rip-Rap	
Sieve Size (mm)	% Passing By Wt
1200	100
900	80
800	50
500	20