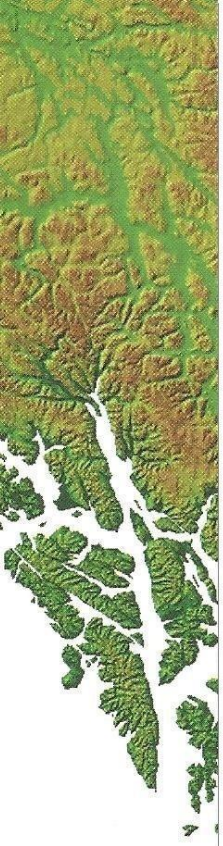

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Geotechnical Evaluation
Lot 2 Block 3
Dawson City, Yukon – 2014

Prepared For: **Yukon Government – Energy, Mines & Resources**

Date : **August 19, 2014**

Project No: **200-002-14**

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Geotechnical Evaluation
Lot 2 Block 3
Dawson City, Yukon – 2014

APPENDICES

1.0 INTRODUCTION

Chilkoot Geological Engineers Ltd. was retained by *Yukon Government (YG) - Energy Mines and Resources* to conduct a Geotechnical Evaluation at Lot 2 Block 3 located in the North End Subdivision in Dawson, Yukon.

The purpose of the evaluation was to determine the subsurface conditions at the proposed subject property and provide geotechnical recommendations regarding residential foundation construction for an envisioned cribbing and ventilated crawlspace foundation system.

Authorization to proceed was granted on June 24th, 2014 by *YG - Energy, Mines and Resources - Lands Management Branch - Lands Availability Manager*, Mr.R.Gorczyca.

The field work was conducted on July 22nd, 2014 in accordance with our July 12th, 2014 proposal following completion of the sub-surface utility locations.

While detailed descriptions of our methodology have been provided below, in brief, the subsurface conditions encountered will be suitable to allow for residential construction as described herein.

2.0 METHODOLOGY

Our work methodology was comprised of a literature review as well as a field and laboratory work programs.

2.1 Literature Review

A literature review was conducted prior to the field work program to better evaluate the regional conditions. The following sources of information were reviewed;

Surficial Geology Map

A 1:250,000 surficial geology map (*YT, File 3288*) compiled by *A.Duk-Rodkin, 1996*, was reviewed to assess the regional soil conditions.

In brief, the map described the area as being comprised of fluvial deposits.

Bedrock Geology Map

The following bedrock geology maps were reviewed through the *Yukon Geological Survey* website;

Geology, Ogilvie, Map 711A, by H.Bostock, 1942	*Scale 1:253,440*
Bedrock Geology, YT, G.S.C. Open File 3754, 2001	*Scale 1:1,000,000*

The maps suggest that Dawson is underlain mainly by green schist to lower amphibolite facis metamorphic rocks of the Yukon-Tanana Terrane.

2.2 Field Work Program

The field work program was comprised of a site reconnaissance, utility locates and drilling program.

Site Reconnaissance

A site reconnaissance was conducted to note the field conditions at the subject property on July 18th, 2014. Our observations have been presented in Section 3.3 – Site Description, below.

Utility Locates

Northwestel, *Yukon Energy Corporation* and the *City of Dawson* were contacted prior to conducting the drilling program in order to verify that the region was clear of potential underground hazards. In brief, while there were local subsurface lines (and stubs) located along the adjacent roadways, the proposed borehole location was free of underground utilities.

Drilling Program

The drilling program was conducted on July 22nd, 2014 by *Donjek Services* utilizing a CME-750 drill mounted on an FN-60 Nodwell.

The program was comprised of advancing a single borehole in order to obtain soil samples and characterize the subsurface conditions. The borehole was advanced utilizing 150 mm Ø solid-stem continuous flight augers.

The borehole was advanced to a depth of 6.1 meters.

Borehole Locations & Survey

Following completion of the drilling, the elevation of the borehole and adjacent roadway was surveyed relative to the fire hydrant (No.L7-5) located on 2nd Avenue (immediately south of the Edwards Street intersection), utilizing a (*Leica LR Rugby*) laser level. The top of the fire hydrant was given an arbitrary elevation of 100.00 meters. The elevation of the borehole has been noted on the Soil Log enclosed in Appendix A. The spot elevations taken on the adjacent roadways were noted to be in the order of 0.3 meters higher in elevation than those of the prevailing grades.

The location of the borehole was measured relative to prominent reference points and has been plotted on the Figure 2.

Soil Log

During drilling, a field soil log was maintained by the undersigned. This information was utilized to compile the Borehole Soil Log which has been enclosed in Appendix A. The appendix also includes '*Notes on Soil Classification'* the *'Unified Soil Classification System'* and the *'Classification for Frozen Soils (adapted by Linnell and Kaplar, 1966)'*, for reference purposes.

In brief, the Borehole Soil Log was compiled utilizing a combination of field log, visual observations and results of the laboratory analysis.

Sampling Program

A total of eight (8) soil samples were retained during drilling operations.

The soil samples were retained at regular intervals during the solid-stem drilling by obtaining grab samples directly from the auger flighting.

Once the soil samples were retained, they were described on the field soil logs. The soil samples were then sealed in air-tight plastic bags and numbered consecutively in order to allow for laboratory analysis.

The samples were subsequently transported to *Chilkoot Geological Engineers Ltd.'s* Whitehorse laboratory facilities to undergo more detailed examination and analysis described in *Section 2.3*, below.

Borehole Termination

The borehole was terminated within coarse grained fluvial deposits at a depth of 6.1 meters below the ground surface.

Following drilling the borehole was left undisturbed for approximately 15 minutes to assess the sidewall stability and better assess groundwater conditions. In brief, the excavation sidewalls were noted to collapse to a depth of 0.6 meters below the ground surface.

While groundwater was encountered during drilling at a depth of 2.44 meters, following drilling operations the groundwater was noted at the ground surface.

Refusal was not encountered during the drilling.

Backfill

Following our observations, the boreholes were backfilled utilizing the auger cuttings. Bentonite pellets were placed at the interface between the fills and organic strata in accordance with good drilling practices in order to separate potential hydrological zones.

Photographs

Photos were taken during the work to document the field work program, laboratory soils samples and site conditions. A selection of these photos has been provided in Appendix C.

2.3 Laboratory Work Program

A physical laboratory work program was conducted in order to characterize the index properties and conditions of the retained soil samples.

The analysis was conducted between July 24th and June 31st, 2014 at our Whitehorse laboratory facilities. In brief, the analysis was comprised of natural moisture content determination and visual laboratory classification of all eight (8) retained soil samples. The moisture content analysis was conducted in accordance with ASTM D 2216-92. The results of the analysis have been denoted as ‘MC’ (◉ - Symbol) on the Soil Logs enclosed in Appendix A.

Grain size distribution analysis was also conducted on three (3) of the samples (in accordance with ASTM D 422-633) in order to classify the soil utilizing the *Unified Soils Classification System*. The results of the analysis have been summarized on the Soil Logs enclosed in Appendix A with the percent composition of fines (silt & clay), sand and gravel denoted with the symbols - ▲, ● & ■ respectively.

3.0 SITE CONDITIONS

3.1 General

The subject property is comprised of historically disturbed land which is currently vacant.

3.2 Legal Description and Site Location

The legal description of the subject property is;

Lot 2 Block 3 (CLSR 79122, LTO 96-110 YT)

The subject property is located in the North End Subdivision in Dawson, Yukon, as noted in Figure 1.

The subject property (a.k.a. ‘site’) is approximately 0.046 ± ha in size and is rectangular in shape (50’ by 100’).

Access to the site is via Judge Street which lies to the north.

3.3 Site Description

Regionally, the subject property is located on the banks of the Yukon River and so very little relief in elevation is noted within the townsite.

Local site development and residential construction is occurring on a number of nearby properties. The work appears to be comprised of placement of clean granular backfill upon which cribbing and residential houses are being constructed.

While the topography of the subject property is generally level, there are subtle variations which measure in the order of 1.5 meters across the property. In general, the western portions of the site are low lying and are dominated by ponded water. This area of ponded water adjoins Lot 1 to the south. The remainder of the surface drainage is undefined. The eastern portions of the lot are approximately 1 meter higher in elevation. The elevations of Judge Street and Albert Street are in general 0.5 to 1.0 meters higher in elevation than the prevailing lot grades.

The majority of the site is void of trees with the exception of a strand of trees predominately comprised of willows. Sedge grass was prevalent throughout the western portions of the site.

An old shack was noted on the sites western lot boundary.

3.4 Geomorphology

Glaciation

Although the full extent of the earliest glaciation is unknown, evidence shows that the Dawson area and Klondike Plateau have probably never been glaciated.

Natural Hazards

The following natural hazards are regionally present;

> *Mass Wasting/Creep*
>
> The site is located approximately 300 meters from the prominent slide area which is undergoing mass wasting/creep. Creep is caused by the repeated expansion and contraction of the upper part of the regolith (weathered bedrock surface) through freeze/thaw and wetting/drying cycles. Combined with gravitational forces, this process results in slope movement in generally steep terrain, although even shallow slopes may exhibit this behavior. As it is

understood that the nearby slide is undergoing such movement at a rate of approximately 5 cm/year, it would not pose a direct hazard.

Floods

As with the majority of Dawson, the site would be prone to flood events if it were not for the protective dike which was established in the 1980’s. The site would have been previously flooded prior to the establishment of the dike.

3.5 Surficial Geology

The deposits noted in the Dawson area are comprised of Klondike River Valley Deposits. These deposits are characterized by organics/peat which overlie fine grained fluvial materials ranging from sands to silts with minor amounts of gravel. These materials overlie predominately coarse grained materials (where the tailings are derived). Based upon the undersigned’s past experience in the Dawson area, it is anticipated that these soils are clean and contain high percentages of cobble to boulder sized materials.

Due to the poor founding nature of the soils located in the Dawson area, considerable amounts of fill have been imported to facilitate both historical and recent development. The historical fills overlie the above noted native deposits and are typically coarse grained but contain an appreciable amount of fines and deleterious materials.

Historically, this region of Dawson was known to be a swampy area.

3.6 Bedrock Geology

In brief, the geology maps suggest that Dawson is underlain mainly by green schist to lower amphibolite facis metamorphic rocks of the Yukon-Tanana Terrane. While the depth to bedrock in the low lying valley regions will vary, it is understood that it is typically encountered at depths of 20 to 30 meters in the region of the townsite.

3.7 Subsurface Conditions

Soil Stratigraphy

Detailed descriptions of the soil stratigraphy that was encountered have been provided on the Borehole Soil Log attached in Appendix A.

In general, the subsurface soil units which were encountered can be classified as;

> **Unit # 1 – Fill;**
> which are coarse grained and contain an appreciable amount of fines, overlying;
>
> **Unit # 2 – Peat/Organic Stratum;**
> which are wet and rich in organics, overlying;
>
> **Unit # 3 – Alluvial Channel Deposits;**
> which are predominately silty in nature, but may contain finer clay sized materials and/or coarser granular materials, overlying;
>
> **Unit # 4 – Alluvial Valley Deposits;**
> which are predominately clean, coarse grained and contain cobble and possibly boulder sized materials.

A detailed description of the soil units encountered during our firm's field work program has been provided below.

Unit # 1 – Fill;

The fill is comprised of predominately coarse grained materials which contained varying amounts of fines and organics. The fill extended to a depth of 0.45, 0.61, 1.2 meters below the existing ground surface. As with all undocumented fills, the fill may contain rubble, scrap steel, high levels of fines/organics and/or other deleterious materials.

Given the sites location in the historical Sawmill District in Dawson City, the fills may also contain varying amounts of sawdust, scrap lumber and wood chips.

Native Deposits

The native deposits are comprised of an organic stratum overlying alluvial channel and valley deposits.

Unit # 2 –Peat/Organic Stratum;

A peat/organic stratum underlay the fill at a depth of 0.45 meters. The peat is organic rich, wet to saturated and compressible in nature. The soil unit is comprised of a veneer of organics and rootlets which overlie organic rich silt. The soil unit measured 1.07 meters thick.

Unit # 3 – Alluvial Channel Deposits;

Alluvial channel deposits were encountered a depth of 1.52 meters.

The deposits were comprised of moist to wet, non to low plastic silt which contained varying amounts of clay, sand and gravel. Due to the nature of channel deposition, this deposit was noted to grade coarser with depth although it may also contain regions of predominately organic deposits which are a result of channel infilling. Cobbles and possibly boulder sized materials may be encountered near the base of this deposit.

Unit # 4 – Alluvial Valley Deposits;

Granular alluvial deposits were encountered below the channel deposits at a depth of 4.1 meters.

While a representative sample could not be obtained due to the presence of groundwater, based upon the undersigned's past experience, these soils are clean and comprised of coarse grained granular soils. While the soil unit is extremely dense and contains cobbles and possibly boulder sized materials, given its dynamic geomorphology it may also include organics, ice lenses and other deleterious materials.

Based upon the undersigned's experience, the soil unit is likely frozen and thaw stable. The borehole was terminated within this soil unit at a depth of 6.1 meters.

Groundwater

A region of ponded water was evident on the western portions of the subject (and adjoining) property (which lay to the south). During drilling, groundwater was encountered at a depth of 2.44 meters. Following drilling operations, the groundwater was noted to have risen to the ground surface.

Groundwater flow would be north-west, towards the Yukon River, which is located approximately 270 meters from the subject property.

Permafrost

The study area lies within the zone of widespread discontinuous permafrost. The permafrost can vary from poorly bonded soils with non-visible ice to massive ice lenses ranging in size to tens of meters. Regionally the permafrost is probably more than 100 m thick with taliks (thawed subsurface) present beneath large rivers and lakes and beneath south-facing slopes. These thawed regions may also be encountered where the site has been previously cleared.

While there was no evidence of permanently frozen soils, the alluvial valley deposits (Soil Unit #4) is likely frozen near the interface with the above noted fine grained soil unit.

Seasonal Frost

The soils encountered would generally be exposed to seasonal frost to depths of approximately 1.8 meters. This depth of penetration would vary depending upon the thickness of the organic strata (Soil Unit # 2) which acts as insulation for the underlying soils.

Cobbles and Boulders

Cobbles and potential boulders would be present within the base of the alluvial channel deposits (Soil Unit # 3) and throughout the underlying alluvial valley deposits (Soil Unit # 4).

Bedrock

There was no indication of bedrock within the borehole which was advanced.

4.0 DISCUSSIONS

The subsurface conditions which will be encountered within the limits of the subject property pose additional challenges upon standard construction practices given the presence of the fill, compressible organics, groundwater potential and underlying permafrost. The use of standard concrete footing and/or slab-on-grade systems will not be feasible (without costly development) at the site due to the presence of underlying permafrost and compressible soils.

As such, based upon our findings, light residential building(s) should be supported by a (PWF) cribbing and ventilated crawlspace foundation system founded on an approved granular pad which extends a minimum of 1.8 meters below the underside of the PWF pad footing. Long-term maintenance will be required throughout the life of the structure to periodically level the residence on the cribbing to accommodate fluctuations in the underlying soil volumes and overall site conditions.

Considering the local site elevations, the granular pad should be constructed such that its surface is in the order of 1 meter higher in elevation than the prevailing road grade. If the underlying organic soil unit is disturbed, then consideration should be given to replacing the soil unit with an equivalent level of thermal protection through the use of SM Styrofoam.

As a minimum, the south side of the ventilated crawlspace should be well insulated to minimize the undesirable effects of the sun. The ventilated crawlspace should be opened during the course of the winter to allow for accumulated heat to escape from beneath the structure. Alternately, the zone should be closed in the summer time to prevent exterior heated air from impacting the constructed granular base and underlying permafrost. Ultimately, degradation of any local or regional permafrost is not desirable and as such, efforts should be undertaken to protect the natural thermal regime.

5.0 RECOMMENDATIONS

5.1 Foundation Type

The proposed building may be supported by a cribbing and ventilated crawlspace foundation system founded upon an approved granular base constructed in accordance with recommendations provided herein.

5.2 Allowable Bearing Pressure

The allowable bearing pressure should not be greater than 105 kilopascals for a cribbing and ventilated crawlspace foundation system constructed on the structural granular pad described herein.

This figure includes the total of all live and dead loads.

5.3 Differential Movements

Differential movements in the order of (+/-) 25 mm may occur with the proposed foundation system. Periodic adjustment to the cribbing system should be anticipated throughout the life of the structure in order to accommodate the movements when these limits are exceeded or if gross settlement/heave occurs.

5.4 Deleterious Materials

Exposed sub-grade surfaces should be inspected by qualified geotechnical personnel to assess the suitability of the prepared sub-grade surface on a case-by-case basis. The organic soils are highly compressible and so additional consideration may be required if they are exposed at the sub-grade elevation.

Excavation of the near surface onsite fills will be required allow for subsequent backfill utilizing non-frost-susceptible materials in accordance with Section 5.7 – Structural Fill.

Depending upon the composition, select fill materials 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. Excavated fills which are frozen, have high moisture content or are saturated, will not be suitable for this use and so should be hauled to waste.

5.5 Excavations

Excavations should be conducted utilizing a tracked excavator equipped with a clean-up bucket in order to minimize disturbance to the sub-grade materials.

While excavation difficulties are not expected, hard digging will be encountered if/where frozen soils are encountered. If permafrost is exposed during excavation, it should be protected from degradation by implementing an accelerated work program, utilizing insulated tarps and/or scheduling the project to such a time that thermal loss would be minimized.

Loose, disturbed, remolded or slough materials should not be allowed to remain in prepared excavation(s). If a suitable founding surface cannot be prepared through mechanical means, then hand cleaning may be necessary.

The surrounding surfaces should be graded so as to direct water away from the excavation.

The sub-grade is sensitive to disturbance and so caution should be exercised during excavation and backfill operations. Wheeled equipment should not be allowed on the sub-grade surface. The sub-grade should be covered once exposed to minimize degradation as the sub-grade is moisture sensitive.

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

5.6 Excavation Parameters

The excavation parameters will be governed by the underside of PWF cribbing pad elevation.

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 (exterior edge of PWF pad) perimeter until the founding strata has been attained (plus 1 meter horizontally).

The base of the excavation should be prepared in such a manner that positive drainage (at 2%) is maintained from a centrally located high spot.

The excavation backslopes should be cut at 1:1 to assist in side slope stability.

The actual configuration of the excavation should be verified by the retained geotechnical consultant at the time of construction.

5.7 Structural Fill

Any residential buildings should be founded upon structural fill, comprised of an approved, clean, inorganic, well graded sand and gravel mixture which conform to the recommended grain size distribution for imported fill attached as Appendix B.

The granular pad should measure ~ 1.8 meters thick and should be comprised of the following;

Structural Granular Pad

UNIT	**THICKNESS**	**COMPACTION** [C]	**COMPOSITION** [D]
Base	150 mm[A]	100 %	20 mm minus crushed granular aggregate, overlying
Sub-base	450 mm	98 %	80 mm minus sub-base course aggregate, overlying
Sub-base	1200 mm[B]	95 %	150 mm minus and/or Class I Rip-Rap sub-base course aggregate, overlying
Geotextile Fabric	NA	NA	Non-woven filter fabric
Sub-grade	NA	95 %	approved native sub-grade materials

Notes;

[A] – The prepared surface of the granular backfill should be level in the region where PWF pads are to be placed. The granular pad should extend a minimum of 1.0 meters beyond the edge of the pad at these locations.

[B] – The thickness of this unit should be uniform through-out the building load envelope. The intent is to construct a 1.8 meter thick granular pad while maintaining at minimum 300 mm thick zone of existing fill above the organic soil stratum (Soil Unit # 2).

If long-term movements are to be reduced and/or if an increased allowable bearing capacity is required, then the sub-base should extend to the underlying coarse grained fluvial deposits provided the site conditions on the adjacent lots allow for it. Additional assessment will be required if this option is to be considered as construction dewatering and thermal protection aspects will need to be carefully assessed, on a case-by-case basis.

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

Caution should be exercised during compaction as the underlying sub-grade materials are moisture sensitive and subject to a loss of strength if disturbed.

All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction. The exception to this would be if Class I Rip-Rap (or equivalent coarse) materials are utilized. Typically these materials are placed in 0.5 meter thick lifts prior to leveling and static rolling.

[D] - If groundwater infiltration is encountered at the sub-grade elevation, then the backfill should be comprised of Class I Rip-Rap or else some other approved coarse fill. The course Class I Rip Rap (or equivalent) should be fully encased in geotextile fabric.

A recommended grain size distribution for the specified imported fills has been provided in Appendix B.

5.8 Filter Fabric

Due to the potential degradation of the excavation base and other exposed materials over time, the use of a filter fabric will be required to facilitate backfill operations. The fabric should extend across the excavation base and excavation sidewalls. If successive pieces are required, they should be either sewn or overlapped by a minimum of 1.5 meters. The overlap should be in the same direction as that of advancing backfill operations.

5.9 Crawlspace

A ventilated crawlspace should be incorporated into the foundation design. Specifically, this would involve skirting the building perimeter with a sub-wall which incorporates a wire mesh or lattice work such that air flow below the structure is unrestricted during the winter months. These openings should be configured in such a manner that they can be closed in the summer months. The south side of the crawlspace should be insulated as a minimum requirement.

The crawlspace must be protected from rain, snow and the ingress of surface and groundwater at all times.

5.10 Structural Breaks & Reinforcing

Structural breaks and reinforcement should be integrated into the building design to allow for differential movements caused by soil volume changes of the underlying soils.

5.11 Site Drainage

The granular pad construction and surrounding areas should be graded to direct surface water away from the building structure. Typically, a 2 percent slope will be suitable for this purpose.

Eaves troughs should be incorporated into the roof structure. The discharge/outflows should extend a minimum of 3 meters away from the building structure.

5.12 Inclement Weather

The sub-grade and construction materials should be protected from drying, freezing, snow and surface/groundwater at all times.

5.13 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*.

In general, side slopes cut at 1:1 (horizontal/vertical) should allow for adequate stability provided that the depth of the excavation does not exceed 2 meters. If these parameters are to be exceeded, then they should be verified and monitored by qualified geotechnical personnel during the time of construction. The excavation sidewall (slope) stability will be dependent upon the material characteristics, configuration of the excavation, length of exposure, presence of groundwater and other similar factors which should be re-evaluated at the time of construction.

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

5.14 Surface and Groundwater

As groundwater will likely be encountered during construction, the Contractor should be prepared to conduct construction dewatering operations throughout the course of foundation preparation. Surface and groundwater should be removed from excavations at all times during granular pad construction to ensure a dry working area.

Caution should however be exercised as lowering of the local groundwater regime may affect nearby structures due to settlement of the underlying soils. More detailed analysis would be required to assess the effects of construction dewatering on neighboring structures (i.e., buildings, utility poles, etc.) if the depth of excavation exceeds 1 meter.

5.15 Temporary Stockpiles

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

5.16 Sub-surface Utilities

Sub-utilities should be embedded in a bedding sand conforming to the grain size specifications provided in Appendix B. The utility pipe should be established on a base of bedding sand which measures 300 mm thick. In addition, the bedding sand should extend a minimum of 300 mm on all sides of the pipe. The material should be compacted to a minimum of 95% of the materials corresponding Proctor density at (or near) the materials optimum moisture content. If utility trenches are located within the building load envelope, then the materials should be compacted to 98% of the materials corresponding Proctor density at (or near) the materials optimum moisture content.

In general, the excavation spoils should be suitable for use as backfill so long are not located within the building load envelope or else parking areas. Otherwise the remaining trench backfill should conform to the recommended grain size distributions provided in Appendix B.

The pipes should be well insulated to prevent freezing by means of soil cover, physical coating, heat trace or combination thereof.

Where utility trenches penetrate Unit # 2 – Organics and Unit # 3 – Alluvial Channel Deposits, sloping of the base of the trench away from the building should be considered (such that positive subsurface drainage is maintained and the potential for subsurface groundwater inflow from within the existing utility trenches is minimized). The use of a trench plug to minimize the potential of groundwater inflow through the trench should be considered.

Where possible, underground utilities be situated outside of the building perimeter to facilitate future maintenance.

5.17 Future Assessment

Given the dynamic geomorphology of the native soils, the potential exists that the soils contain deleterious materials which may not allow for long-term use of the site. This would include the presence of massive ice lenses, thick organic deposits, liquefied soils and other similar geotechnical liabilities. As such, we recommend a geotechnical evaluation be conducted to verify the soil conditions within the perimeter of the anticipated building load envelope once a preliminary design has been determined.

5.18 Construction Monitoring and Testing

During construction, qualified geotechnical personnel should monitor the excavation and side slopes and inspect all sub-grade surfaces prior to backfill to verify that the prepared sub-grade surface is suitable for use.

Materials testing services should be conducted during granular pad construction to assess the suitability of the imported structural fills through laboratory testing and to verify that adequate compaction has been attained through in-situ field density (compaction) testing.

6.0 CONCLUSIONS

The subsurface conditions encountered at the site will be suitable to allow for construction of a structural granular pad upon which a residential structure can be constructed upon PWF cribbing and ventilated crawlspace foundation system.

If long-term movements are to be reduced and/or if an increased soil bearing capacity is required, then the sub-base should extend to the underlying coarse grained fluvial deposits provided the site conditions on the adjacent lots allow for it. Additional assessment will be required if this option is to be considered as construction dewatering and thermal protection aspects will need to be carefully assessed, on a case-by-case basis once the building site has been identified.

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 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 data presented may not be sufficient to assess all factors that may have an effect upon construction. While references to underground utilities have been made, the locations of sub-surface utilities should be verified by the retained Contractor prior to construction.

It is important to emphasize our evaluation is based, in fact, on a random sampling of the subject property site. Our comments are based upon the results obtained at the borehole and sample locations. Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions between the borehole and other locations on the site have not been made or been implied. The soil and ground conditions at this site are dynamic and thus the subsurface composition and conditions will vary.

Our evaluation is limited in that it was a preliminary feasibility assessment. A detailed geotechnical evaluation and thermal assessment of any proposed building structure would need to be conducted if suitable founding conditions are to be assured.

The recommendations have been provided without consideration to the affects of deep and long-term thaw of local and/or regional permafrost which may stem from global warming, the proposed or nearby construction/structures or other causes.

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 at such time.

8.0 CLOSURE

Thank you for allowing our firm to provide you with the above noted assessment. While we trust the information will suit your purposes, please feel free to contact the undersigned if you have any questions or concerns.

Respectfully Submitted,

CHILKOOT GEOLOGICAL ENGINEERS LTD.

#1277
TARES DHARA

PERMIT TO PRACTICE
Signature
Date August 19th, 2014
PERMIT NUMBER: PP025
Association of Professional Engineers of Yukon

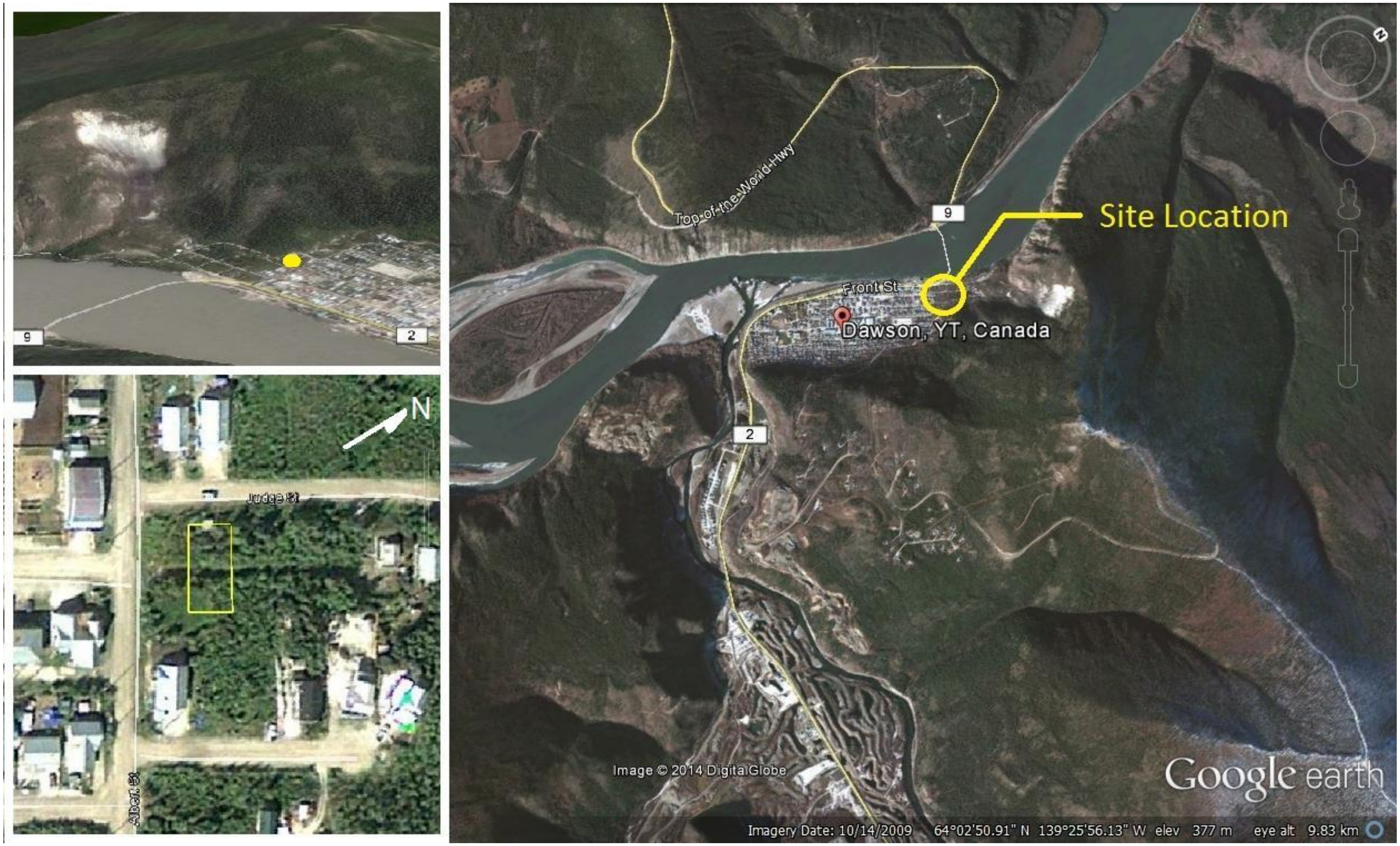
Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

Geotechnical Evaluation

Lot 2 Block 3 - Dawson, Yukon – 2014

FIGURE 1 – Site Location



Based map modified from Google Earth

Compiled August 5, 2014 by T.Dhara

Geotechnical Evaluation
Lot 2 Block 3 - Dawson, Yukon – 2014
FIGURE 2 – Borehole Location

Not to Scale – Locations are approximate
Base plan from Google Earth

Compiled August 7, 2014 by T.Dhara

APPENDIX A

Borehole Soil Log

NOTES ON SOIL LOGS

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.

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

Relative Density (Qualitative Classification)

Cohesive Soils

Very Soft - Exudes between fingers when squeezed by hand

Soft - Moulded by light finger pressure

Firm - Moulded by strong finger pressure

Stiff - Cannot be moulded by fingers – Can be indented by thumb

Very Stiff - Can only be indented by thumbnail

Hard - Cannot be indented by thumbnail

Granular Soils

Very Loose - Considerable sidewall sloughage noted

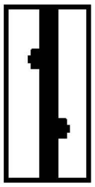
Loose - Some sidewall sloughage noted – Easy digging

Compact/ Medium-Dense - Unimpeded excavation – little to no sidewall sloughage

Dense - Considerable effort required during excavation – Stable vertical sidewalls

Very Dense - Extreme difficulty in excavation

Soil Log - Sample Type

Symbol	Test Pitting	Drilling
	**Grab Sample** 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

Relative Moisture

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

> For example, a moisture content of 10 percent may be classified as '*moist*' for a coarse grained soil (sand or gravel) but '*damp*' for a fine grained (silt) 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.

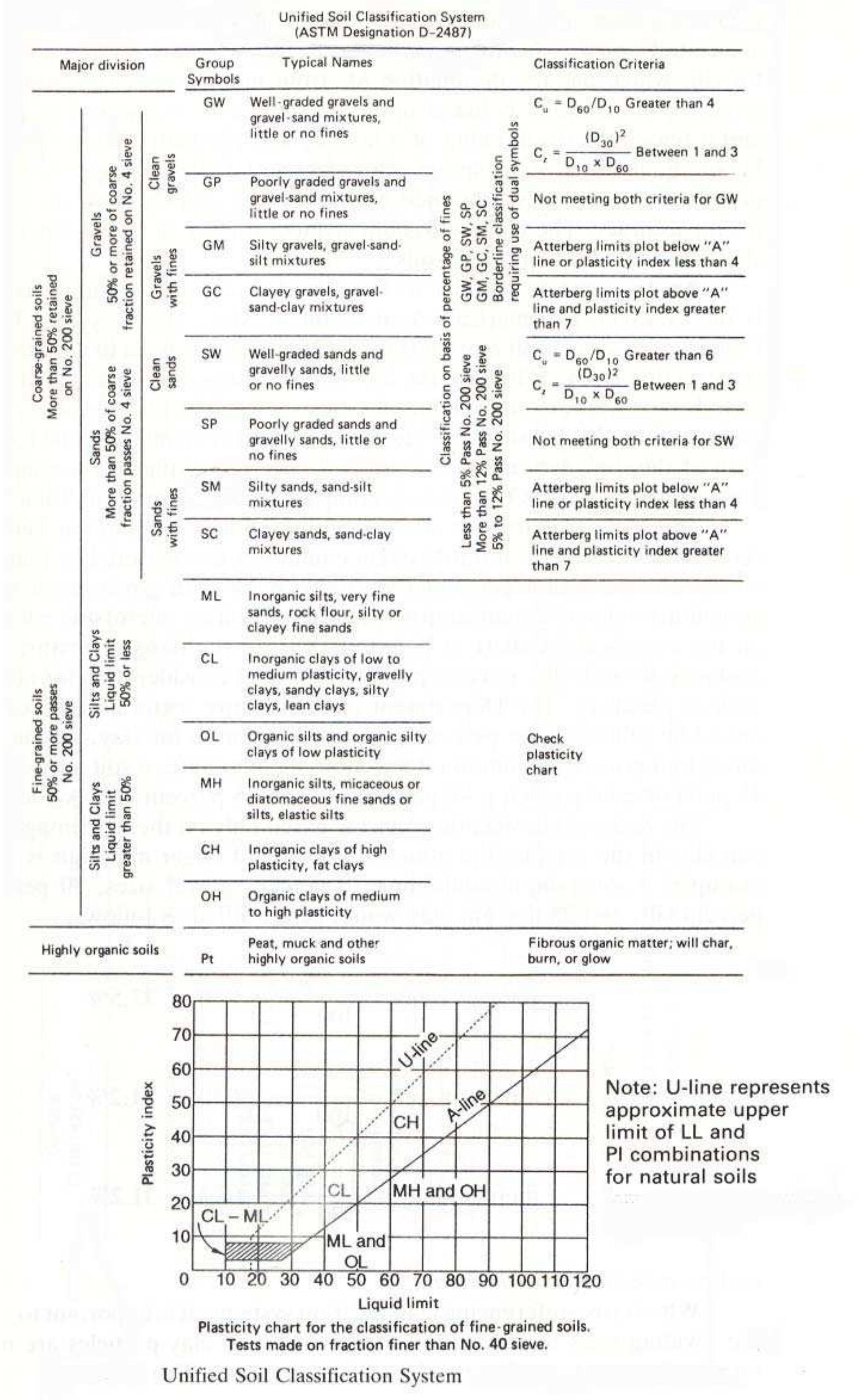
Recorded as a percentage (i.e. 12 inch sample/18 drive = 66 %)

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



Unified Soil Classification System
(ASTM Designation D-2487)

Major division			Group Symbols	Typical Names		Classification Criteria
Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% Pass No. 200 sieve GW, GP, SW, SP More than 12% Pass No. 200 sieve GM, GC, SM, SC 5% to 12% Pass No. 200 sieve Borderline classification requiring use of dual symbols	$C_u = D_{60}/D_{10}$ Greater than 4 $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_u = D_{60}/D_{10}$ Greater than 6 $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7
Fine-grained soils 50% or more passes No. 200 sieve	Silts and Clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands		Check plasticity chart
			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 greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity		
Highly organic soils			Pt	Peat, muck and other highly organic soils		Fibrous organic matter; will char, burn, or glow

Note: U-line represents approximate upper limit of LL and PI combinations for natural soils

Plasticity chart for the classification of fine-grained soils. Tests made on fraction finer than No. 40 sieve.

Unified Soil Classification System

Figure 18. UNIFIED SOIL CLASSIFICATION SYSTEM

Table 1.2 Description and classification of frozen soils (adapted from Linnell and Kaplar, 1966)

<table>
<tr><td>I: Description of soil phase (independent of frozen state)</td><td colspan="6">Classify soil phase by the unified soil classification system</td><td colspan="3">Classify soil phase by the unified soil classification system</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Major group</td><td colspan="4">Subgroup</td><td rowspan="2">Field identification</td><td rowspan="2">Pertinent properties of frozen materials which can be measured by physical tests to supplement field identification</td><td rowspan="2">Thaw characteristics</td></tr>
<tr><td>Description</td><td>Designation</td><td colspan="2">Description</td><td colspan="2">Designation</td></tr>
<tr><td rowspan="7">II: Description of frozen soil</td><td rowspan="3">Segregated ice not visible by eye</td><td rowspan="3">N</td><td colspan="2">Poorly bonded or friable</td><td colspan="2">Nf</td><td rowspan="3">Identify by visual examination; to determine presence of excess ice, use procedure under note (3) and hand magnifying lens as necessary; for soils not fully saturated estimate degree of ice saturation (medium, low); note presence of crystals or of ice coatings around larger particles</td><td rowspan="7">In-place temperature
Density and void ratio
a. In frozen state
b. After thawing in place
Water content (total H_2O, including ice)
a. Average
b. Distribution
Strength
a. Compressive
b. Tensile
c. Shear
d. Adfreeze
Elastic properties
Plastic properties
Thermal properties
Ice crystal structure (using optical instruments)
a. Orientation of axes
b. Crystal size
c. Crystal shape
d. Pattern of arrangement</td><td rowspan="3">Usually thaw-stable</td></tr>
<tr><td rowspan="2">Well bonded</td><td>No excess ice</td><td rowspan="2">Nb</td><td>n</td></tr>
<tr><td>Excess ice</td><td>e</td></tr>
<tr><td rowspan="4">Segregated ice visible by eye (ice 25 mm or less thick)</td><td rowspan="4">V</td><td colspan="2">Individual ice crystals or inclusions</td><td colspan="2">Vx</td><td rowspan="4">For ice phase, record the following as applicable
Location — Size
Orientation — Shape
Thickness — Pattern of arrangement
Length
Spacing
Hardness }
Structure } per part III below
Color }
Estimate volume of visible segregated ice present as percent of total sample volume</td><td rowspan="6">Usually thaw-unstable</td></tr>
<tr><td colspan="2">Ice coatings on particles</td><td colspan="2">Vc</td></tr>
<tr><td colspan="2">Random or irregularly oriented ice formations</td><td colspan="2">Vr</td></tr>
<tr><td colspan="2">Stratified or distinctly oriented ice formations</td><td colspan="2">Vs</td></tr>
<tr><td rowspan="2">III: Description of substantial ice strata</td><td rowspan="2">Ice greater than 25 mm thick</td><td rowspan="2">ICE</td><td colspan="2">Ice with soil inclusions</td><td colspan="2">ICE + soil type</td><td rowspan="2">Designate material as ice and use descriptive terms as follows, usually one item from each group, as applicable:
Hardness: hard, soft (of mass, not of individual crystals)
Structure: clear, cloudy, porous, candled, granular, stratified
Color: colorless, gray, blue
Admixtures: contains few thin silt inclusions</td><td rowspan="2">Same as part II above, as applicable, with special emphasis on ice crystal structure</td></tr>
<tr><td colspan="2">Ice without soil inclusions</td><td colspan="2">ICE</td></tr>
</table>

(see notes on p. 32)

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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(867) 335-2085 chilkoot@northwestel.net

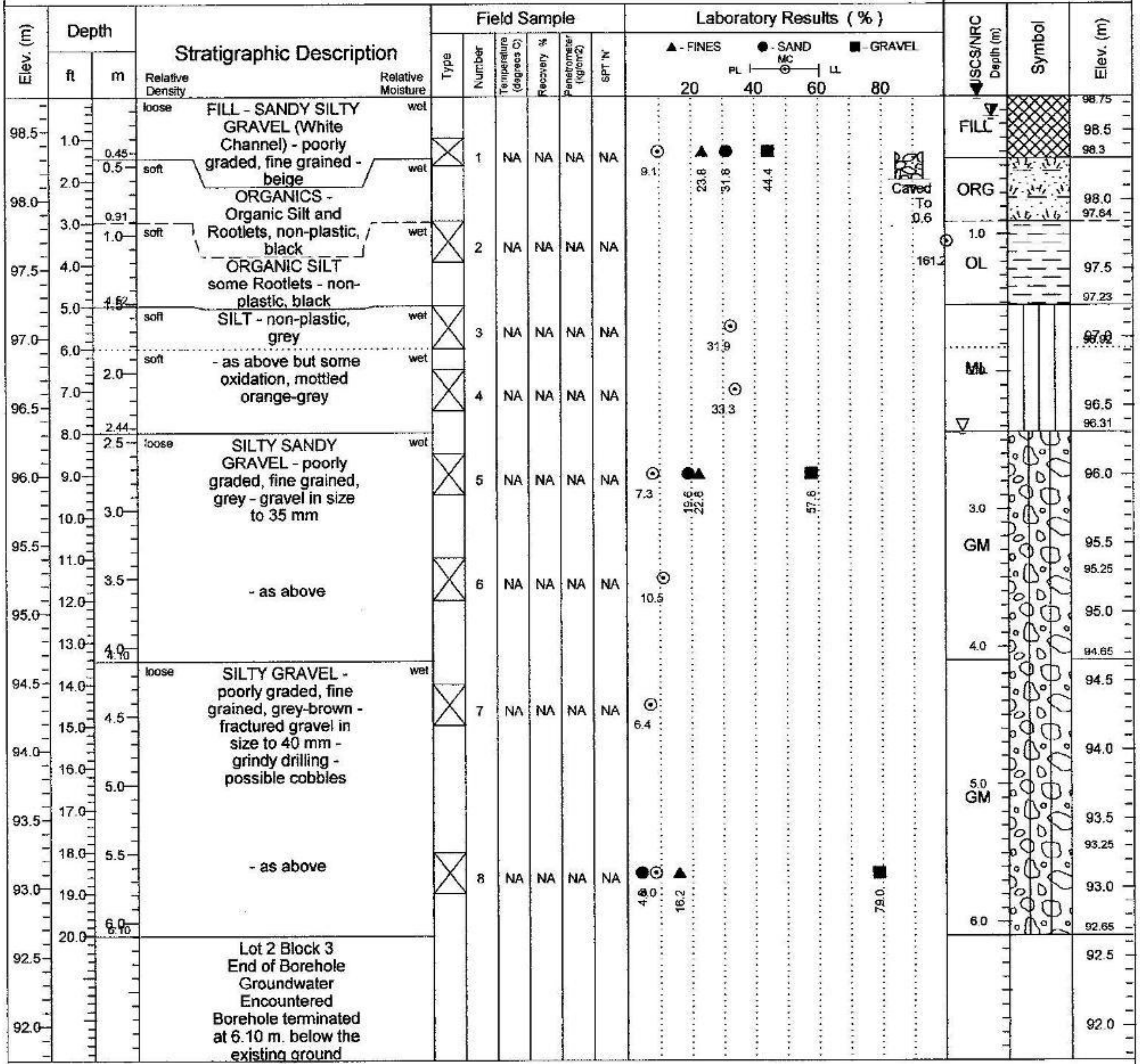
BOREHOLE LOG

Client : Yukon Government - Energy, Mines & Resources
Location : Dawson, Yukon
Project : Geotechnical Evaluation
Chilkoot Project No. : 200-002-14

Date Drilled: July 22, 2014
Elevation : 98.75 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE
1-14
Sheet 1 of 1

Depth m	Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC
0.45	loose	FILL - SANDY SILTY GRAVEL (White Channel) - poorly graded, fine grained - beige	wet	☒	1	NA	NA	NA	NA	⊙ 9.1 ▲ 23.8 ● 31.8 ■ 44.4	FILL
0.91	soft	ORGANICS - Organic Silt and Rootlets, non-plastic, black	wet								ORG
1.52	soft	ORGANIC SILT some Rootlets - non-plastic, black	wet	☒	2	NA	NA	NA	NA	⊙ 161.2	OL
	soft	SILT - non-plastic, grey	wet	☒	3	NA	NA	NA	NA	⊙ 31.9	ML
2.44	soft	- as above but some oxidation, mottled orange-grey	wet	☒	4	NA	NA	NA	NA	⊙ 33.3	ML
	loose	SILTY SANDY GRAVEL - poorly graded, fine grained, grey - gravel in size to 35 mm	wet	☒	5	NA	NA	NA	NA	⊙ 7.3 ● 19.6 ▲ 22.8 ■ 57.6	GM
4.10		- as above		☒	6	NA	NA	NA	NA	⊙ 10.5	GM
	loose	SILTY GRAVEL - poorly graded, fine grained, grey-brown - fractured gravel in size to 40 mm - grindy drilling - possible cobbles	wet	☒	7	NA	NA	NA	NA	⊙ 6.4	GM
6.10		- as above		☒	8	NA	NA	NA	NA	● 4.8 ⊙ 8.0 ▲ 16.2 ■ 79.0	GM
		Lot 2 Block 3 End of Borehole Groundwater Encountered Borehole terminated at 6.10 m. below the existing ground surface.									



Drilled By : Donjek Services
Drill Type : CME 750 (FN60)
Auger Type : 150 mm Solid Stem
Bit Type : Fish Tail

Water Level(s)
▽ During Drilling
▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : July 22, 2014

Data Entry By : T.Dhara, P.Eng.
Date : August 10, 2014

Reviewed By: T.Dhara
Date : August 14, 2014

CHILKOOT GEOLOGICAL ENGINEERS LTD.

APPENDIX B

Recommended Grain Size Distribution for Import Fills

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	2-15
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

Photo # 1 – Site conditions during drilling operations facing north-east from Albert Street.

Photo # 2 – BH 1-14

Sample No.6 – 3.35 meters

Photo # 3 – BH 1-14 – Site conditions upon completion of drilling operations.