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Geotechnical Feasibility Assessment
Proposed Country Residential Development
Lot #1 – Group 10 (CLSR 8887)
Carmacks, Yukon – 2018

Prepared For: **Yukon Government**

Date : **December 27th, 2018**

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1.0 INTRODUCTION

Our firm was retained by *Yukon Government* (*YG*), *Department of Community Services – Land Development Branch* under a Standing Offer Agreement (No.2017/2018-2753) to conduct a geotechnical feasibility assessment of an area located in Carmacks, Yukon.

The study area, which measures 12 ha in size, is comprised of *Village of Carmacks* Lot #1 – Group 10 (CLSR 8887) as noted in Figure 1. The *Village of Carmacks* is located ~ 180 km north of Whitehorse along the North Klondike Highway # 2.

Authorization to proceed with the geotechnical assessment was granted by *YG – Community Services* - Project Manager, Mr.K.Fisher on September 24th, 2018. The work was subsequently conducted in accordance with our September 7th, 2018 proposal.

Our findings, which were based upon information retained during a literature review, site reconnaissance and laboratory work program, have been presented herein along with a description of our methodology.

2.0 SCOPE-OF-WORK

The purpose of our feasibility assessment was to characterize the terrain and potential sub-surface conditions of the lot through a literature review, site reconnaissance and laboratory work program such that the development potential of the proposed area could be assessed from a geotechnical perspective relative to country residential lot development.

Specifically, the intent was to delineate regions within the proposed area which may be suitable for development and provide general geotechnical recommendations regarding infrastructure development where development is deemed feasible.

As our assessment was preliminary in nature, it was understood that a more comprehensive geotechnical evaluation would be conducted through drilling/test pit methodologies to verify site-specific geotechnical parameters if the development potential was to be assessed in greater detail.

3.0 METHODOLOGY

Our methodology was comprised of a literature review, field work program and laboratory work program as described below.

3.1 Literature Review

A literature review was conducted to evaluate satellite imagery, a selection of aerial photos, topographical data and other technical resources which were readily available. This information was utilized to evaluate the regional conditions and detail the field work program by establishing GPS waypoints such that geotechnical points of interest could be better assessed during the site reconnaissance.

The following sources of information were reviewed;

Topographical Information

The regional topography was assessed by viewing a 1:50,000 scale topographical map (NTS – 115I01 Carmacks) and information available on the *YG- Water Placer Atlas* and *Yukon Geology* websites.

A selection of the *Yukon Geology* website showing the local contours (in 100 foot intervals) has been presented in Section 4.1, below.

Surficial Geology Map

A 1:100,000 surficial geology map (Map 1879A) entitled Surficial Geology, Tantalus Butte, Yukon Territory compiled by L.E.Jackson - *Geological Survey of Canada* provided a description of the anticipated surficial soil deposits.

A portion of this map and the corresponding limits of the study area has been provided in Section 4.5, below.

Bedrock Geology Map

A bedrock geology map, available through the *Yukon Geological Survey*, identified the regional bedrock types and characteristics within the study area. The map was entitled *Yukon Bedrock Geology Map* – *Yukon Geological Survey* – Open File 2016-1 - 1:1,000,000 scale compiled by M.Colpron, S.Israel, D.Murphy, L.Pigage, and D.Moynihan.

A more detailed delineation of these contacts was found on the *Yukon Geological Survey* website as noted in Section 4.6, below.

Aerial Photographs

A selection of aerial photographs was obtained from *YG – Energy, Mines and Resources* to allow for a more detailed assessment through airphoto terrain analysis. The following airphotos were available;

Flight Line	***Photo No.***	***Date***	***Comments***
A31970	14-16	July 8th , 2010	1:20,000
A28010	1-6	Aug.23rd, 1992	4,900' 1:6,000 scale
A27665	60-61	July 5th, 1990	12,000' altitude
A27477	235-236	June 22nd, 1989	25,500' altitude
A26590	4-6	August 16th , 1984	9.500'

A selection of these aerial photographs has been attached in Appendix A.

Satellite Imagery

A review of satellite imagery from *Google Earth* allowed for an assessment of the site conditions relative to the more recent imagery. The imagery which was available on the website was dated September 24th, 2008 and August 14th, 2012.

Village of Carmacks – Official Community Plan (OCP) – 2013

The OCP was partially based upon;

- a 1977 soil study which was conducted by the *Saskatoon Institute of Pedology*,
- a 1989 landscape management plan conducted by *UMA Engineering,* and
- a June 2001 flood-risk assessment conducted by *Norwest Hydraulic Consultants*.

This information was utilized by *Inukshuk Planning & Development Ltd.* to compile a development suitability map of the community which was originally included as part of the 2005 OCP. The Floodplain and Landscape Analysis Map included in Schedule C of the OCP classified the terrain in Carmacks as having either 'poor, fair or good development capability'. The poor rating was generally given to regions located within the limits of a 1 in 200 year (Yukon River) flood event or else in regions where steep slopes and/or shallow bedrock

was likely. The development capability of the study area as classified in Schedule C of the OCP has been denoted in Section 4.7, below.

The OCP indicated that the study area lies within a zone denoted as 'parkland' and 'country residential'.

Other Resources

The *Yukon Government – Water Placer Atlas* website was reviewed as it denoted the boundaries of various land dispositions, drainage regimes and other similar types of information. The corresponding boundaries of the study area have been illustrated on the *Water Placer Atlas* map attached in Section 4.1, below.

3.2 Field Work Program

The field work program was comprised of a site reconnaissance and hand sampling program. Specifically, our Sr.Soils Technician, Mr.G.Keitel conducted a foot traverse of the site on October 4th, 2018 to note the field conditions and geological features within the study area.

During the course of the traverse, three (3) near surface soil samples were retained by utilizing a hand shovel to allow for subsequent laboratory analysis as described in Section 3.3, below. These samples (#1-#3) were retained from the locations noted in Figure 2.

A supplemental site reconnaissance was conducted on October 8th by a combination of Mr.Keitel and the undersigned to allow for senior engineering assessment.

Fair weather was encountered at the time of the reconnaissance. Although daytime highs were in the order of + 7° C, given the time of season, frozen ground conditions prevailed.

Our observations during the field work program were documented through a combination of field notes, GPS waypoints and photographs. These observations have been summarized in Section 4.0 – Site Conditions.

3.3 Laboratory Work Program

A laboratory work program was conducted on October 8th, 2018 at our Whitehorse laboratory facilities in order to characterize the index properties and conditions of the retained soil samples.

In brief, each of the retained samples underwent moisture content analysis (ASTM D2216-92) to determine their natural moisture content. In addition, samples #1 & #2 underwent grain size distribution analysis (ASTM D422-633) to allow for characterization in accordance with the *Unified Soil Classification System*.

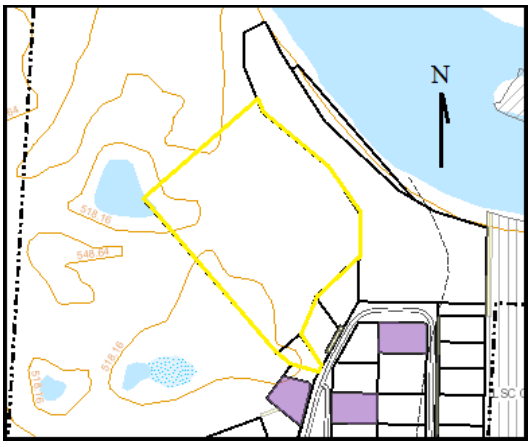
The results of the analysis were as follows;

Sample	***Moisture (%)***	***Silt (%)***	***Sand (%)***	***Gravel (%)***	***USCS***	***Description***
1	19.7	42.6	52.7	4.6	SM	Silty Sand
2	3.4	6.5	6.6	86.9	GP	Sandy Gravel trace Silt
3	326.2	NA	NA	NA	NA	Organics

4.0 SITE CONDITIONS

4.1 Study Area

The study area measures 12 ha in size and is comprised of *Village of Carmacks* Lot #1 – Group 10 (CLSR 8887) as noted in Figure 1.



The map retained from the *YG - Water Placer Atlas* website noted that the south-western periphery of the study area is bound by several ponds where swamp-like conditions are present. The south-eastern edge of the study area borders two existing residential lots. The Yukon River lies approximately 100 meters beyond the north-eastern periphery of the study area.

The topography of the study area is best described as undulating terrain which increases in elevation towards the north-west. The lower (south-western) elevations of the ponds parallel those of the Yukon River and measure in the order of 515 meters (asl). The higher elevations located in the north-western and eastern portions of the study area approach elevations in the order of 550 and 540 meters, respectively. As such, the elevation gain across the study area measures in the order of 35 meters. A central region, which trends approximately south-west to north-east, lies in the order of 15 to 20 meters below the higher terrain located to the north-west and east.

4.2 Physiographic Region

Carmacks is located in the Yukon Plateau-Central Ecoregion at the confluence of the Yukon and Nordenskiold Rivers. It lies at the southern fringe of the Dawson Range where mountains rise to elevations in the order of 1800 meters.

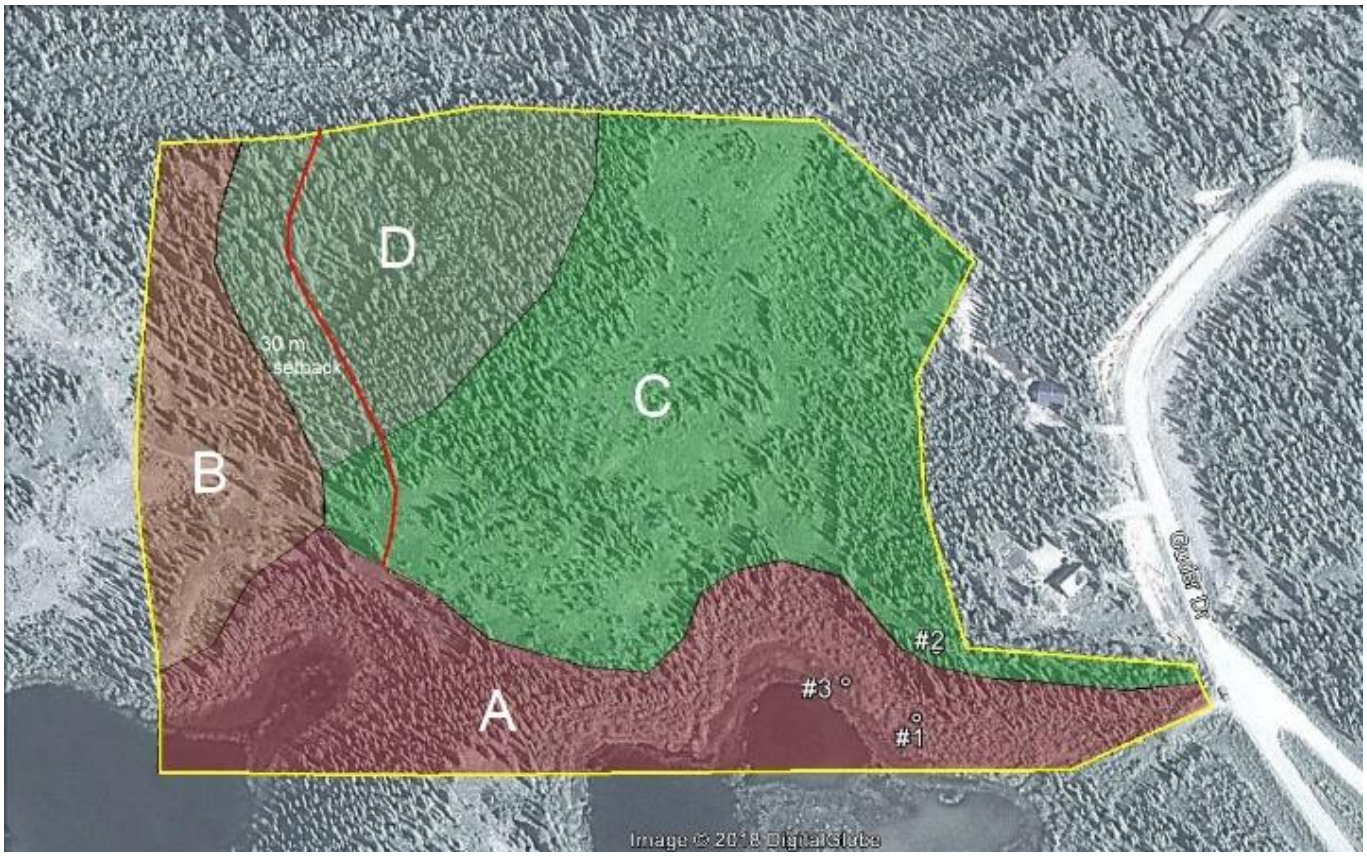
The prevailing elevations in the region of the study area range between 515 meters to 550 meters. The Yukon River lies at elevations near 517-518 meters. Regionally, elevations between the Yukon River and adjacent valley terraces vary by up to 300 meters.

The regional terrain can be described as rolling, glaciated terrain, which is incised by broad, U-shaped valleys.

Orthogonal view from Google Earth facing north-west.

4.3 Site Description

The study area is comprised of four (4) distinct regions as noted below and in Figure 2.



Area A is dominated by low lying ponds which harbor peripheral areas where swamp-like conditions and vegetation are present (photo right).

Higher elevation terrain prevails in Areas B & C.

The slopes in Area B (photo below left) are extremely steep and predominately forested with deciduous trees.

The slopes in Area C (photo above right) by comparison are more gradual. The spruce trees in this region are sparse and interspersed with poplar trees.

Area D is lower in elevation relative to Areas B & C and concentrates surface drainage from these two regions of higher elevation. The forest in this area is moderately dense to dense and is generally comprised of spruce trees with a willow bush understory.

A series of hiking trails are present throughout the site (photo below right).

A short access road has been preliminarily constructed immediately south of the site stemming off Guder Drive as noted in Figure 2 (photo below left).

The remnants of an old cabin were noted adjacent to the eastern pond located in Area A.

4.4 Geomorphology

Glaciation

The terrain in this region of the Yukon was last glaciated during the McConnell Glaciation which occurred approximately 17,000 years ago. The glacial deposits which were deposited during the glacial recession which occurred during this time were subsequently incised by the Yukon River which deposited alluvial soils in predominately floodplain deposits along the adjacent shorelines.

Permafrost

The vegetation did not reveal any signs of permafrost. However, as Carmacks lies in a region of extensive discontinuous to sporadic permafrost, it could be encountered within the limits of the study area depending upon the local conditions.

Watercourses

Two ponds are located within the south-western realms of the study area.

The Yukon River, which flows to the north, is located ~105 meters north-east of the site. Data from a Hydrometric Station (Number 09AH001 YT Yukon River @

Carmacks) maintained by the *Government of Canada – Environment and Natural Resources* noted January 2018 river elevations of ~518 meters.

Surface Drainage

There were no signs of erosion within the study area which would be attributed to surface drainage. In general, surface drainage with the study area either flows towards the two ponds located within its south-western realms or else through the central region (Figure 2 – Area D) towards the north-east.

Groundwater

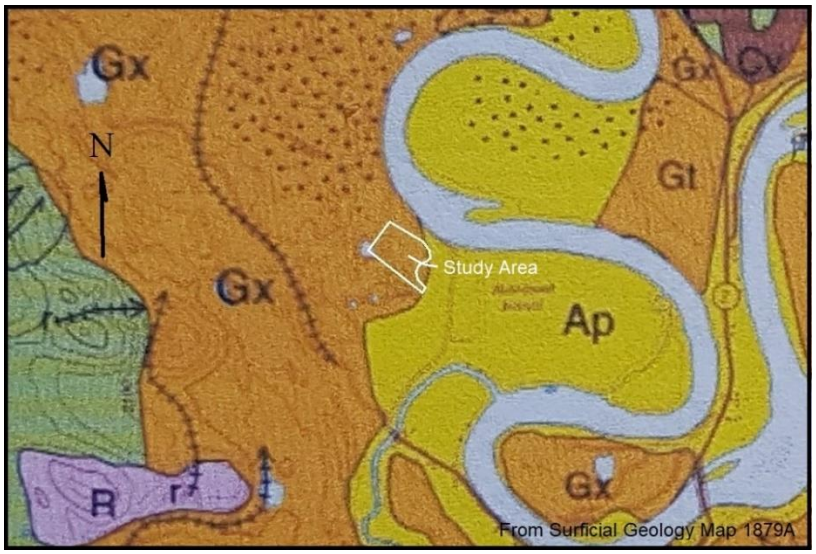
Given the study areas proximity to the Yukon River and presence of the ponds, groundwater likely underlies the site at elevations which parallel those of the river.

Bedrock

There was no indication of near surface bedrock during our literature review or site reconnaissance.

4.5 Surficial Geology

The distribution of surficial deposits within the study area has been illustrated in the (1:100,000 scale) surficial geology map Tantalus Butte - Yukon Territory - Map 1879A compiled by L.E.Jackson Jr., 1997. The approximate limits of the study area have been illustrated on a portion of the surficial geology map as noted below.



In brief, the map shows that the surficial deposits which are located within the study area are comprised of glaciofluvial complex deposits.

The surficial geology map legend describes these deposits as follows;

Glaciofluvial Ice Stagnation Complex Deposits (Gx)

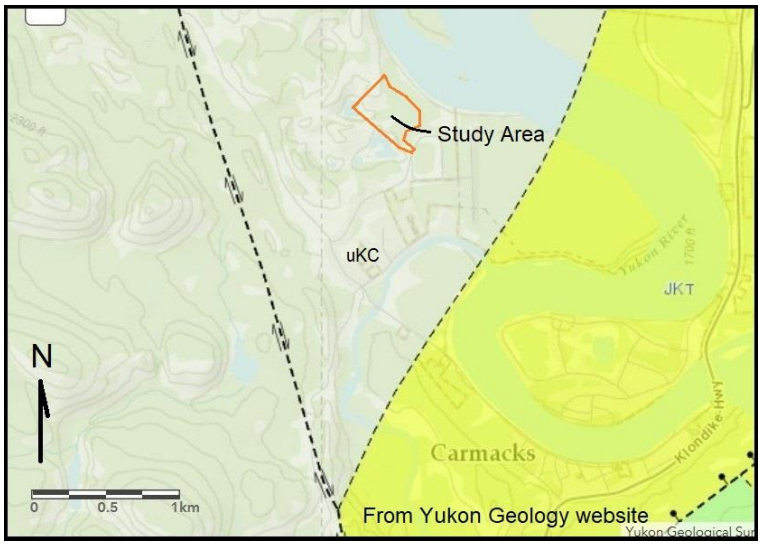
These deposits are typically comprised of poorly to moderately sorted sand and gravel diamictons, which have been deposited during equilibrium phases of

glacial retreat. These deposits can contain cobble to boulder sized materials and minor amounts of silt and clay. They exhibit thick to massive bedding which is commonly folded and faulted from depositional ice melt. The surface expression commonly consists of hummocks, kettles, eskers and crevasse filled ridges with minor elements of glaciofluvial plain, delta and terrace sediments.

4.6 Bedrock Geology

There was no indication of any near surface bedrock during our field work program.

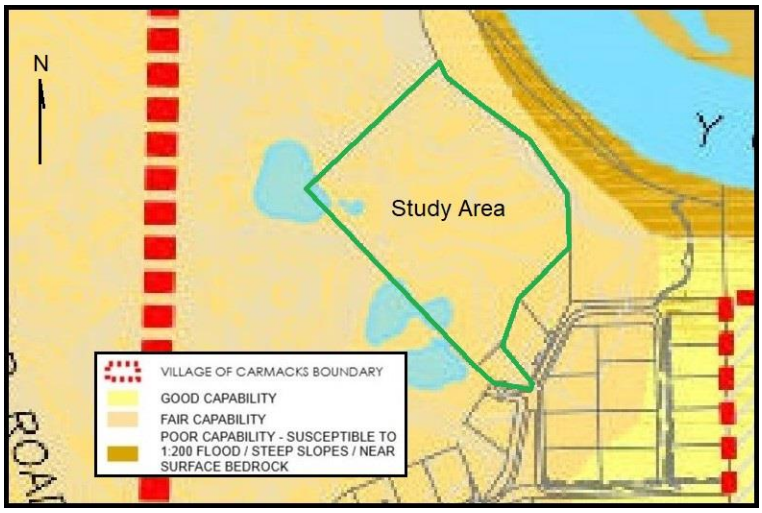
The geology map noted on the *Yukon Geology* website indicates that the site is underlain by a volcanic basalt (uKC) of the Little Ridge/Casino Formation. This rock is described as an augite/olivine basalt and breccia.



4.7 OCP Floodplain and Landscape Analysis

The study area was identified in Schedule C – Floodplain and Landscape Analysis of the Village of Carmacks - 2013 OCP as having a fair (development) capability. A poor rating was given for the terrain located north-east of the study area due to the Yukon River flood potential.

The approximate limits of the study area have been illustrated on the OCP map (right) for reference.



5.0 DISCUSSIONS

As the geotechnical development potential of the site will vary, we have for discussion purposes classified regions which exhibit similar potentials for development based upon the local types of terrain and anticipated subsurface conditions as illustrated in Figure 2. In general, the figure illustrates the relative development potential within each of the areas as being either 'Unfavorable, Suitable or Favorable'. A description of each of these levels of classification is as follows;

Unfavorable
Development within these regions is not recommended due to the presence of either poor soil conditions, shallow groundwater/bedrock, steep slopes or combination thereof. If development within these regions is required, it should be limited to supporting infrastructure as building construction would not be recommended.

Suitable
These regions should support building/infrastructure development however, additional site preparation will generally be required relative to regions which have been deemed to be favorable.

Favorable
Development within these regions should allow for unfettered lot development utilizing conventional construction methodologies.

Some variations between these regional boundaries can be expected in the field given the scale of mapping and local geomorphology. Where development is to be conducted, additional consideration will need to be given through a subsurface geotechnical evaluation such that local geotechnical design parameters can be determined relative to the soil and terrain conditions.

Development will require careful planning and design relative to building construction, septic field placement, road alignment and surface drainage management.

5.1 Development Potential

Based upon the information retained during our assessment, the development potential of the site will vary. If pre-grading operations are not conducted, then (building) development within the study area will be restricted to Areas C & D (as noted in Figure

2) where the conditions were deemed to be suitable relative to lot development. Additional consideration will be required as sloping terrain is located within these areas and as access through low-lying/wet regions in Area A will be required.

Building development within Areas A & B will not be feasible given the presence of low-lying/wet and extremely steep terrain, respectively. The conditions in these areas have been deemed to be unfavorable relative to lot development.

5.2 General Overview

From an overall lot development perspective, the construction of an access road to Areas C & D (where the site conditions have been deemed to be suitable for development) will be difficult. Specifically, the access road will need to be constructed through regions where poor soil conditions and shallow groundwater is present (Area A) and through regions (within Areas C & D) where side-slope construction is required. In addition, the amount of usable terrain will be limited as setbacks should be observed relative to the steep slopes located in the region. As such, a cost-benefit analysis should be conducted to better assess the suitability of lot development as the additional costs to construct access into the site would need to be assessed relative to cost recovery.

5.3 Subsurface Considerations

Some adjustments to individual building foundation and septic field designs may be required to accommodate site-specific conditions as the soil types and subsurface conditions will vary across the study area.

The results of the laboratory analysis indicted that organic, fine-grained and granular soils are present within the study area. While the granular soils which were encountered in Area C will generally allow for unrestricted development, the presence of the compressible organic and frost susceptible fine-grained soils encountered in Area A will make road construction in this area challenging. These deleterious soils will need to be removed from beneath road (and any building) load envelopes as part of construction. Additional construction challenges may be encountered in Area A as shallow groundwater is anticipated in this region.

5.4 Terrain Considerations

The presence of steep to moderate slopes which are located within Areas C & D and the relatively low-lying nature of Area D will require careful planning and design

relative to building construction, septic field placement, road alignment and surface drainage management.

A conceptual road alignment with a 30-meter right-of-way has been illustrated in Figure 3 for discussion purposes.

The majority of the existing road stub which extends west off Guder Drive will not be suitable for use given its alignment and distance relative to higher elevation ground located in the southern realms of Area C.

Given the nature of the sloping terrain, lot sizes should be increased to allow for adequate backslopes, load envelopes and setbacks relative to anticipated building sites, road/driveway accesses and septic field installations.

Road construction will be challenging as the anticipated alignment will involve side-slope construction. The impact of the right-of-way width (which will need to accommodate road side-slopes and back-slopes) and setbacks will need to be considered relative to the availability of developable areas.

5.5 Geotechnical Evaluation

A subsurface geotechnical evaluation should be conducted through test pit/drilling methodologies to verify the local subsurface conditions and outline geotechnical design parameters regarding site development. The evaluation should assess the soils suitability for use as accepting soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems*.

The stability of any steep slopes located within and/or adjacent to the study area should be assessed to determine whether or not they may pose a hazard relative to anticipated site development.

A site-specific geotechnical evaluation should be conducted utilizing standard penetration test (SPT) methodologies at any proposed building location such that the maximum net allowable bearing capacity and founding soil conditions can be determined prior to building construction.

6.0 RECOMMENDATIONS

6.1 General

The following recommendations have been provided to outline the envisioned geotechnical requirements for site development in the regions identified in Figure 2. However, as our recommendations are preliminary in nature, additional consideration may be required once the geotechnical parameters have been determined following a subsurface geotechnical evaluation (test pit/drilling and laboratory work programs).

6.2 Building Foundations

Buildings should be constructed utilizing footing and monolithic (slab-on-grade) types of concrete foundation systems. Some adjustments to the individual designs may be required to accommodate site-specific conditions as the soil types, local terrain and subsurface conditions will vary across the study area.

Building construction should be limited the regions denoted as Areas C & D. The setback limits within these areas should be observed.

Given the proximity to the Yukon River, further evaluation would be required if basements are to be considered for residences constructed in Area D as shallow groundwater may be present in the region.

Although permafrost is not anticipated, additional consideration could be given if encountered as the use of conventional building foundations should not be allowed in these circumstances.

6.3 Surface Works

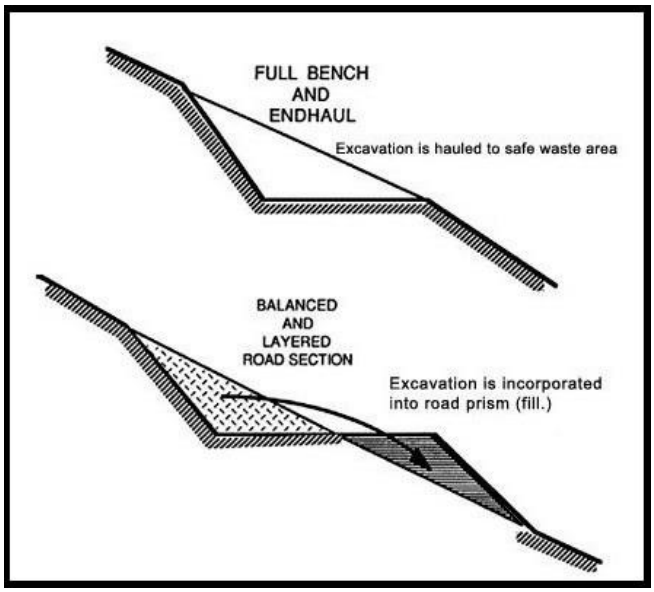
The construction of roads and surface utilities should be feasible throughout the study area. While the road structure would need to be determined based upon the subgrade conditions and expected traffic loads, we anticipate the granular components of the road structure would measure in the order of 0.7-1.0 meters thick.

Additional consideration will be required where access roads are constructed across slopes or through Area A (off Guder Drive). The poor soil conditions and shallow groundwater which are anticipated in Area A may require additional sub-excavation, the use of geotextile fabric and generally, an increased (2-3 m) thickness of road

structure. Depending upon the access road alignment, the construction of embankments may be required through cut/fill construction methodologies.

A proposed road alignment which illustrates a 30-meter right-of-way width has been shown in Figure 3 for discussion purposes.

Road construction will be challenging as the anticipated alignment will involve side-slope construction. Ideally, the road subgrade should be comprised of a full bench as differential settlement can be expected where balanced cut/fill operations are conducted (as illustrated in the diagram to the right).



The impact of the right-of-way width (which will be considerable to accommodate road side-slopes and back-slopes) and setbacks will need to be considered relative to availability of developable areas. Specifically, consideration should be given relative to anticipated driveway alignments and how they will tie into the primary access road.

6.4 Subsurface Utilities

The anticipated soils should allow for subsurface utility installation. However, additional consideration may be required during the design and construction phases if groundwater, large boulders and/or bedrock is encountered.

While the soils would need to be assessed during future geotechnical evaluations to determine their suitability for use as accepting soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems* based upon the information retained during our assessment we anticipate that the soils should prove to be suitable for use.

6.5 Geotechnical Setbacks

Building development should not be allowed within ~30 meters of the toe of the steep slope located in the north-western (Area B) realms of the site and the crest of the steep

slope located on the north-eastern periphery of the site. While building construction within these setback areas should not be allowed, the construction of access roads and ancillary areas could be considered.

6.6 Additional Assessments & Evaluations

Additional assessments and evaluations should be conducted to verify site-specific design parameters as follows;

Geotechnical Evaluations

A subsurface geotechnical evaluation should be conducted through test pit and/or drilling methodologies to verify the local subsurface conditions and outline geotechnical design parameters regarding site development.

Site-specific geotechnical evaluations should be conducted utilizing standard penetration test (SPT) auger drilling methodologies at all proposed building locations such that the maximum net allowable bearing capacity and founding soil conditions can be determined prior to building design and construction.

A slope stability assessment should be conducted to determine the potential hazards related to the stability of the slopes which are located within and adjacent to the study area.

Site Grading, Surface Drainage and Erosion Control Plan

Site grading, surface drainage and erosion control plans should be formulated once conceptual designs have been established to ensure surface waters are adequately controlled.

CSP culverts should be utilized to ensure drainage is unimpeded where access roads/driveways are constructed.

Drainage in steep areas should be controlled utilizing silt fencing, straw bales and/or other similar types of erosion control measures if deemed necessary.

Site Survey

A detailed site survey (minimum 2-meter contour intervals) should be conducted to allow for additional geotechnical evaluation as the scale of mapping available at the time of our assessment was not sufficient to note site-specific variations in the topography.

Environmental Site Assessment(s)

A Phase I Environmental Site Assessment (ESA) should be conducted to determine whether or not there may be any potential environmental liabilities associated with the study area.

Natural Hazard Assessment

A natural hazard assessment should be conducted by qualified personnel to assess the forest fire potential if development is to proceed.

Hydrogeological Assessment

A hydrogeological study should be conducted if water wells are to be installed within the study area. The intent of the study should be to assess the impacts a well (or wells) would have upon the underlying aquifer and delineate any potential liabilities.

7.0 CONCLUSIONS

Development Potential

Based upon the information retained during our assessment, the development potential of the site will vary. If pre-grading operations are not conducted, then (building) development within the study area will be restricted to Areas C & D (Figure 2) so long as 30-meter building setbacks are observed from the toes/crests of nearby slopes. Additional consideration will be required as the access road will need to be constructed across sloping terrain (Areas C & D) and low-lying/wet regions (Area A). Building development within Areas A & B will not be feasible given the presence of low-lying/wet and extremely steep terrain, respectively.

Given the nature of the sloping terrain, lot sizes should be increased to allow for adequate backslopes, load envelopes and setbacks relative to anticipated building sites, road/driveway accesses and septic field installations. Some adjustments to individual building foundation, road structures and septic field designs may be required to accommodate site-specific conditions as the soil types and subsurface conditions will vary across the study area.

From an overall lot development perspective, the construction of an access road to Areas C & D (where the site conditions have been deemed to be suitable for development) will be difficult. Specifically, the access road will need to be constructed through regions where poor soil conditions and shallow groundwater is present (Area A) and through regions (within Areas C & D) where side-slope construction is required. The impact of the right-of-way width (which will need to accommodate road side-

slopes and back-slopes) and building setbacks will need to be considered relative to the availability of developable areas. As such, a cost-benefit analysis should be conducted to better assess the suitability of lot development as the additional costs to construct access into the site would need to be assessed relative to cost recovery.

Additional consideration will be required through a subsurface geotechnical evaluation such that the geotechnical design parameters associated with the study area can be characterized in greater detail.

Setbacks

At this stage, standard 30-meter setbacks should be observed for building construction relative to the steep slope located in the north-western region (Area B) and the crest of the slope located in the north-eastern realms (Areas C &D) of the study area (as noted in Figure 2).

Building Foundations

The anticipated glaciofluvial complex deposits should allow for residential building construction utilizing conventional (footing and monolithic-slab types of) foundation systems.

Surface Utilities

The construction of roads and ditches utilizing conventional cut/fill construction methodologies will be feasible following adequate site preparation. However, road construction will be challenging as the anticipated alignment will need to cross regions where poor soils and shallow groundwater are anticipated (Area A). In addition, given the nature of the undulating terrain, side-slope construction will be required (in Areas C & D). The impact of the right-of-way width (which will need to accommodate adequate side-slopes and back-slopes) will need to be considered relative to lot development and driveways.

A conceptual road alignment which illustrates a 30-meter right-of-way has been illustrated in Figure 3 for discussion purposes.

Subsurface Utilities

While the soils would need to be assessed during future geotechnical evaluations to determine their suitability for use as accepting soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems* based upon the information retained during our assessment we anticipate that the soils should prove to

be suitable for use. Additional consideration may be required during the design and construction phases if groundwater, large boulders and/or bedrock is encountered.

Site Grading, Surface Drainage and Erosion Control Plan

Site grading, surface drainage and erosion control plans should be formulated once conceptual designs have been established to ensure surface waters are adequately controlled.

8.0 LIMITATIONS

This report is intended for the sole use of *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 comments contained herein reflect our best judgment in light of the information available to our firm at the time of our assessment. They are based upon our collation of available literature, observations made during our site reconnaissance, recognition of geomorphic features and generally accepted engineering practices.

Given the nature of our assessment and scale of mapping, the information contained herein will not be sufficient to assess all factors that may have an effect upon design and construction and so this should be considered from a project management perspective. As such our findings should be supplemented through subsequent geotechnical evaluations and other technical studies as may be required.

Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions have not been made or implied other than for discussion purposes. The anticipated conditions have also been discussed, but only to the extent that they may influence design decisions. Suggestions of construction methods contained herein express our opinion and are not intended to direct contractors on how to carry out construction. Any reference to structures, roads or overall use of the study area have been made for discussion purposes only. The actual use will need to be determined during the planning and design processes.

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

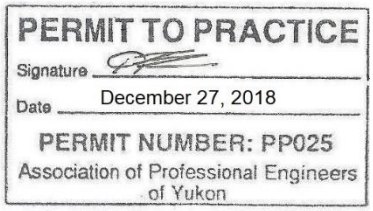
9.0 CLOSURE

Thank you for providing our firm with the opportunity to conduct this geotechnical feasibility assessment.

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

Respectfully Submitted,

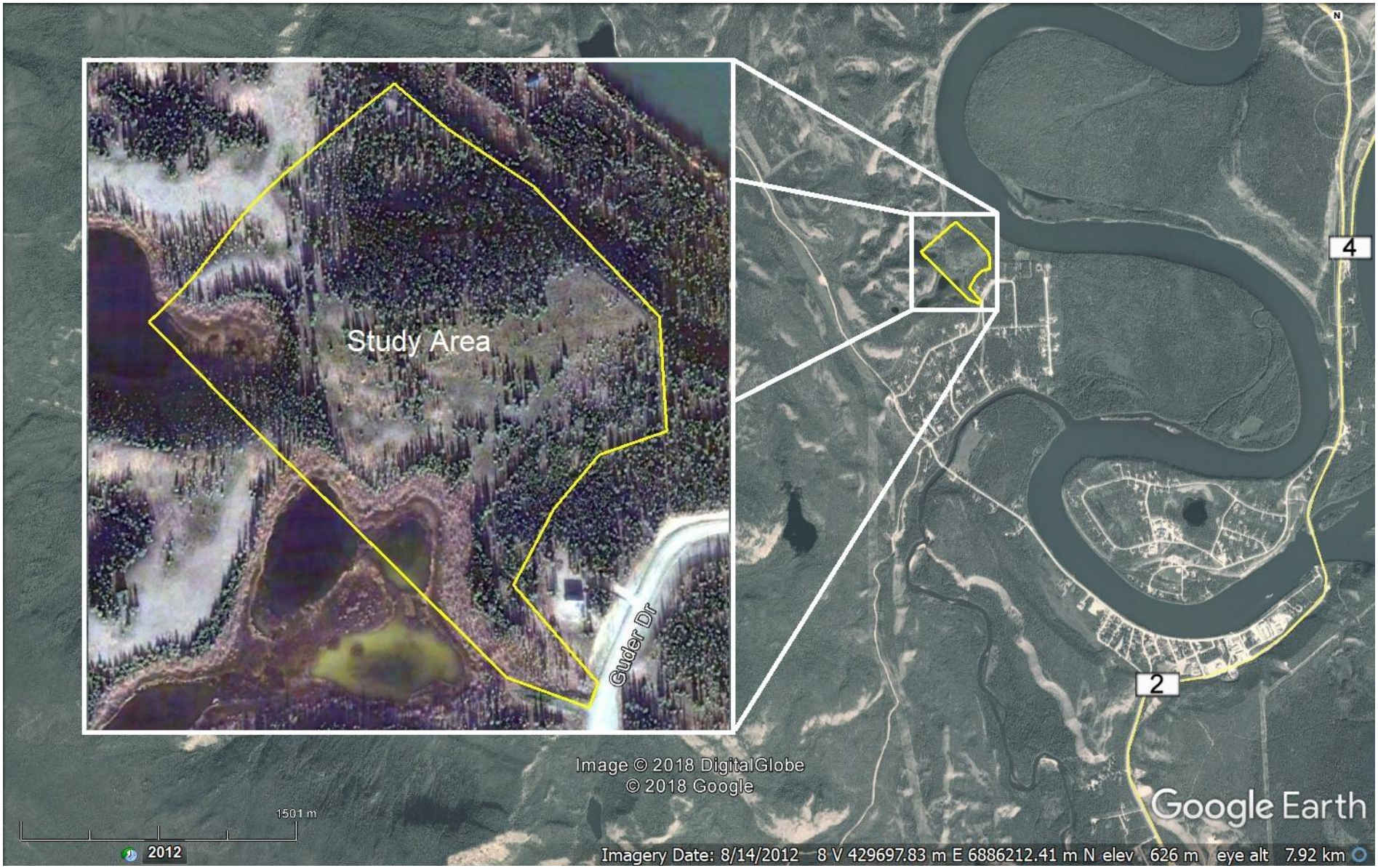
CHILKOOT GEOLOGICAL ENGINEERS LTD.



Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

Geotechnical Feasibility Assessment
Proposed Country Residential Development – Carmacks, Yukon – 2018
Figure 1 – Location of Study Area



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

Compiled Dec 4th, 2018 by T.Dhara, P.Eng.

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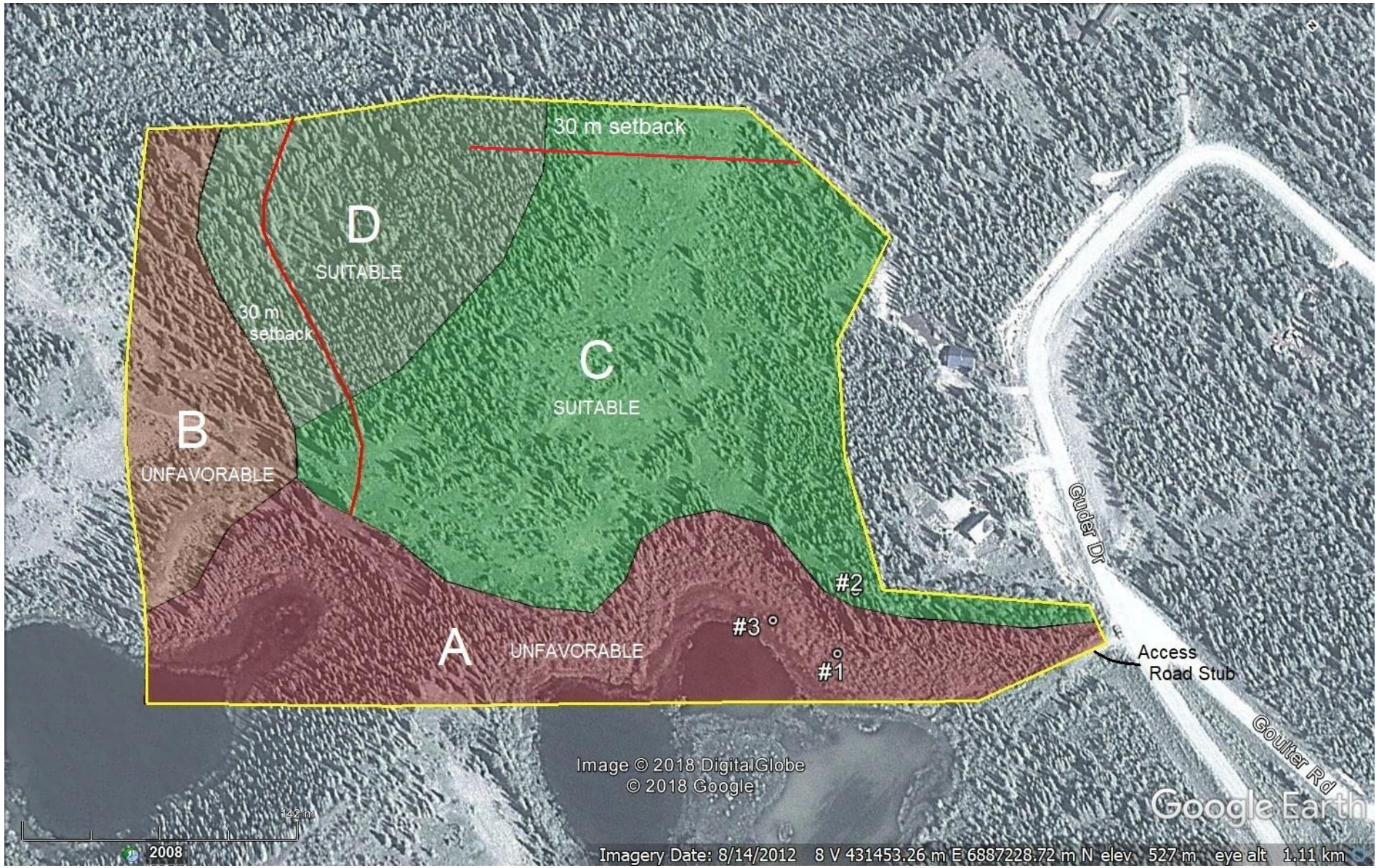
Figure 2 – Development Potential



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

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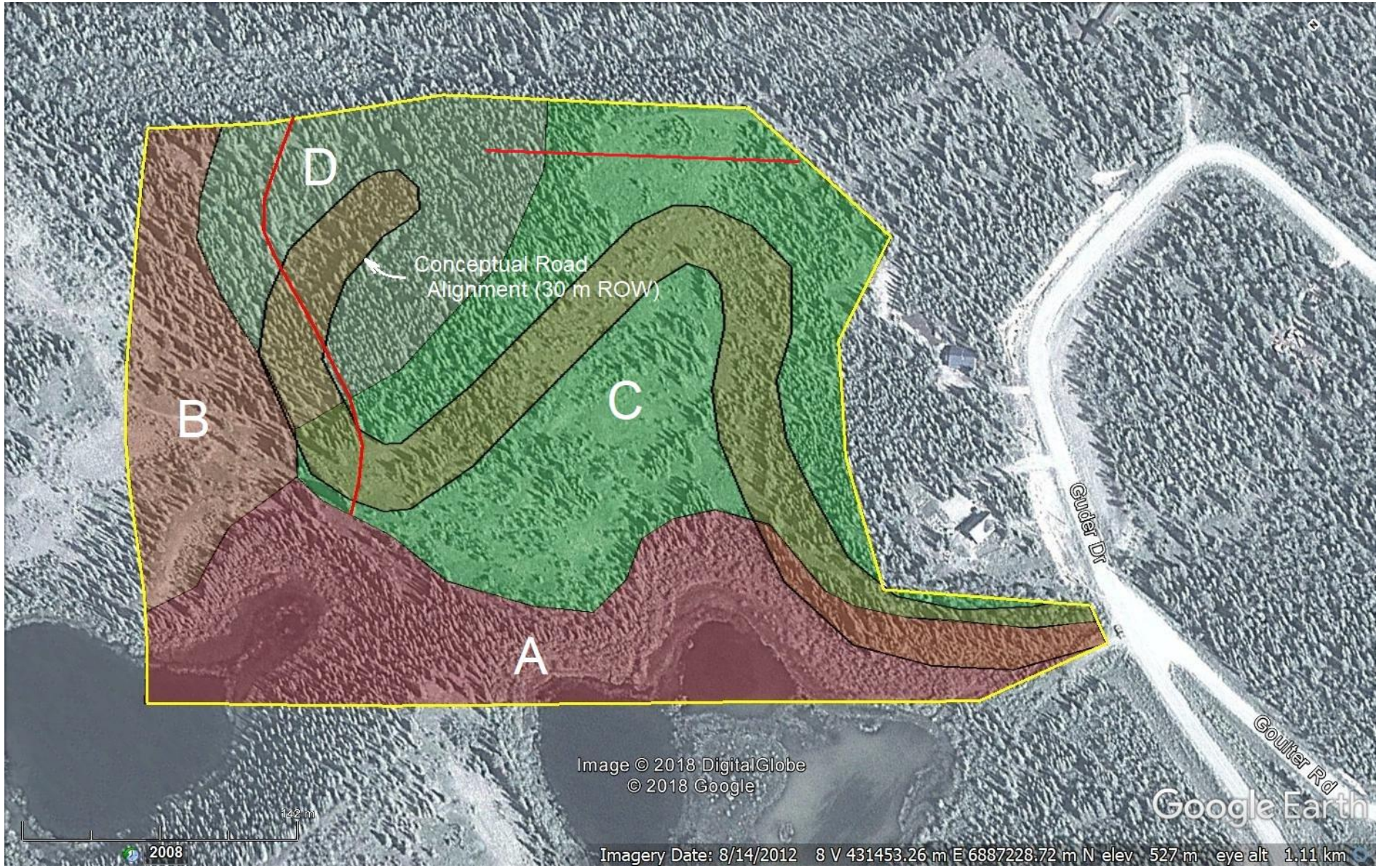
Figure 3 – Conceptual Road Alignment



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

Compiled Dec 5th, 2018 by T.Dhara, P.Eng.

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Appendix A – Airphoto A 31970 #15 (July 8, 2010)

Airphoto - A31970 #15 – Limits are approximate Compiled November 21st, 2018 by T.Dhara, P.Eng.