2017

KLUANE N'TSI (WIND) ENERGY PROJECT

Project description prepared for YESAB

KLUANE FIRST NATION N'TSI (WIND) ENERGY PROJECT

Project Description

Prepared for:

YESAB Haines Junction Designated Office

100 Steele Street

PO Box 2126, Haines Junction, Y0B 1L0

Prepared by:

Kluane First Nation and Kluane Community Development Corporation

PO Box 20

Burwash Landing, YT, YOB 1V0

867-841-4274

Contents

1.0 INTRODUCTION AND PURPOSE

The Kluane N'tsi (Wind) Energy Project (the Project), will be made up of three wind turbines with a total capacity of 285 kW. The project site is located between the Alaska Highway and Kluane Lake. Selection of the proposed location is based on available wind resource information, accessibility from existing transportation infrastructure and proximity to the nearby transmission system.

Figure. 1. Wind Project Site Location

This project is expected to provide about 570,000 kWh annually to the local diesel-electric grid, displacing about 160,000 litres of diesel per year, or about 27% of the diesel for Burwash Landing and Destruction Bay - making it the first medium penetration wind project in Canada's North.

The Kluane First Nation (KFN) and the community of Burwash Landing have expressed a need to reduce their dependency on cost-volatile diesel for their energy needs and to create an economic opportunity from selling renewable energy. KFN plans to create a single-purpose entity, which will own the wind project. As an Independent power producer (IPP), this entity will sell the wind-generated electricity to the utility company (ATCO).

Worldwide, wind energy is a proven technology and in Canada it is emerging as a significant new source of electricity. Wind power energy is a clean, renewable source of energy producing no pollutants, air emissions or hazardous waste, thus reducing our contribution to global climate change. Diesel combustion generates CAC emissions such as NOX, SOX and particulate matter, reducing visibility, contribution to acidification and leading to a number of adverse respiratory effects for animal and human populations.

Diesel exhaust also contains a number of substances that are potential carcinogens, including arsenic, benzene, formaldehyde, and nickel. Reducing the generation of diesel exhaust in the community will provide tangible and lasting benefits to the overall health of the community and residents. By limiting the transportation and handling of diesel, the project also reduces the risks and associated impacts of fuel spills, including potential contamination of soil and water. In addition to the environmental benefits associated with wind energy projects there are also substantial economic benefits to our rural community through investment and job creation.

This document details the potential impacts of this proposal to values around the project site as per the requirements of YESAA. Based on the proposed activities, birds and bats were identified as the valued environmental components and are the basis of the effects assessment detailed in this report. Continuous monitoring and adaptive management plans have been developed to mitigate any impacts.

2.0 PROPONENT INFORMATION

The wind generating plant will be owned and operated by Kluane Energy a corporation owned by Kluane First Nation. Energy will be sold to ATCO Electric Yukon and will offset the use of diesel for generating electricity. Kluane Energy is currently a retailer for gasoline, transportation diesel, aviation fuel and home heating fuel and lubricants delivered through its fuel station and store in Burwash Landing and delivery network.

Contact information for the Proponent's principal place of business and primary contact for communications regarding this YESAB Proposal are provided below:

Contacts:

Colin Asselstine

GM Kluane Community Development Corporation

PO BOX 20 Burwash Landing, YT Y0B 1V0

Phone: 867-841-4274 ext. 251

Email: gm@kluanecorp.ca

Kate Ballegooyen

Environment Officer & YESAA Coordinator

PO BOX 20 Burwash Landing, YT Y0B 1V0

Phone: 867-841-4274 ext. 233

Email: environment@kfn.ca

3.0 PROJECT DESCRIPTION

3.1 Overview

Wind studies have been undertaken in the Kluane area since the early 1980's by the National Research Council (NRC) in 1982 to 1984, the Yukon Government's Public Works Branch (PWB) in 1987 -1988 and the Yukon Energy Corporation (YEC) between 1995 – 1998. These studies have shown that the wind regime in the area is significant, and with the installation of wind turbines, is capable of producing enough electricity to displace over a quarter of the electricity requirements currently provided by the diesel generating system.

The project has gone through multiple planning efforts including obtaining funds for the feasibility work, building a project team, selecting the wind technology, securing the land, assessing environmental risks, building social license, securing a market, creating a business plan, and seeking finances. Overall project management, partner development, and research funding opportunities are on-going.

The wind turbines and the power technologies have been selected and we are now working to secure the finances for the project. When finances are secured we will apply for permits for a land lease, for NavCan and Transport Canada approvals, and for timber and other construction related approvals for the three-wind turbine installation.

KFN has been collaborating with ATCO on the wind project since 2011. An MOU between Kluane First Nation and ATCO was signed by both parties in September 2013. Negotiating an Energy Purchase Agreement (EPA) has begun.

The land that includes the wind project site land has been reserved through sponsorship by the Energy Solutions Centre in 2013. The wind project is on crown land and a long-term lease will be obtained from the Yukon Government once the finances become secured and the environmental assessment is finished. The size of the lease will be approximately 63 acres or more, this will be better defined during the land lease process.

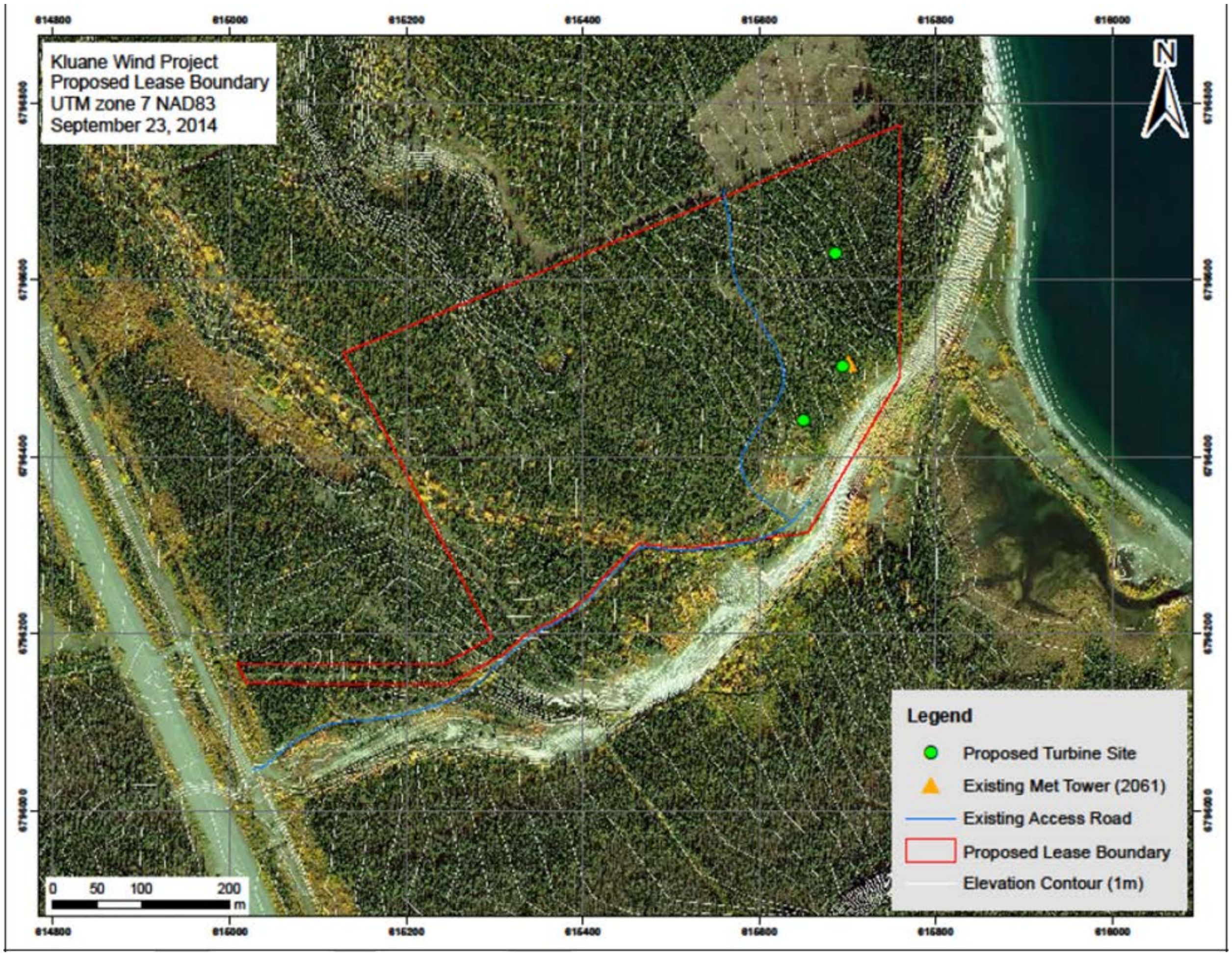


Figure 2. Proposed Wind Farm Lease Boundary and Turbine Site.

Recently, a wind monitoring tower was installed in September 2012 to measure the wind climate for the purpose of confirming wind energy potential. A 60 m tower was installed at the site and remains there today. A 220 m access path was cleared to the site and an area of 100 by 130 m was cleared of trees to make way for the installation of the meteorological tower.

A long-term lease is required from the Yukon Government as the new location of the wind project is on crown land. KFN has applied for a land-use application and permit alongside this environmental assessment process.

On-going avian and bat studies at the project site will continue. Bird biologist Dave Mossop will continue to monitor avian activity near the Kluane Wind Project site and provide observations and mitigation recommendations in order to reduce impacts on birds from collisions with tower, blades and guy wires. Wildlife Biologist Brian Slough will monitor the project site for bat activity and adaptively manage the site to reduce impacts to bats.

3.2 Construction

Major Project infrastructure components are discussed below and will be located within the lease site (Figure 2). They include:

1) Wind Turbine Generators (“turbines”)
2) Foundations
3) Access Roads
4) Operations and Maintenance Building
5) Permanent Meteorological Towers (existing)

Each turbine will be mounted on a concrete foundation. The tower will be 50 meters (m) tall, from the base to hub, with a rotor diameter of 24 m. The maximum blade tip height will reach 62 m. A single access road will be utilized from the Alaska Highway to the turbine areas (see Figure 2 below). A road currently exists but it will need to be upgraded. The road will require blading and gravel addition. It will not be made longer or wider. The power line installation will be managed by ATCO, and therefore is not a part of the scope of this project, and will require assessment under a separate application by ATCO.

An Operation and Maintenance building is required. It will house tools, signage, spare parts, lubricants, etc. This control building on site will likely be a 20’ shipping container. It will be insulated and heated, but won’t require a septic tank or running water. The construction phase of this development will occur over a two year period, 2017 and 2018 and will take place during the spring, summer and fall seasons.

The initial construction phase will occur in fall 2017 and will consist of clearing brush around the site and road upgrades. The second phase of construction will occur from April – October 2017 and will consist of foundation work and tower installation. Some fuel may be stored on site for the equipment (note that the gas station in Destruction Bay is about 4 km away from the site). Approximately 300 L of gas/diesel may be stored in tidy tanks on site.

The construction of the power transmission line will be managed by ATCO Electric, and a separate YESAA application will be made by ATCO; it is therefore not part of this project’s scope.There will be a control building on site which will likely be a 20’ shipping container. This will be insulated and heated, but won’t require a septic tank or running water.

There will be no changes or upgrades to the Met stations on site. KFN is considering making the guy wires more visible to birds, by placing bright ribbon or spray paint on the wires in an effort to reduce the risk of avian injuries and mortalities.

3.2.1 Access to be Upgraded

Access to the site is by way of a 1.5km long gravel road near km 1751 on the Alaska Highway. A short non-permanent access road will be constructed to enable ease of access and turing radius (fig. 4). After construction of the towers the road will be bermed until restoration. Existing road widths vary and are estimated at 4 m road widths may be increased by 1m to accommodate the necessary construction equipment. No watercourse crossings exist along the portion of the access road where upgrading is proposed.

Heavy equipment will be brought it to re-grade and provide gravel fill on some sections of the road to the site, and to the base of each tower. Final gravel volumes are estimated at ~160 m^3 of gravel. Road widening will be accomplished by hauling in gravel from existing quarries, most likely the Duke gravel pit. Regular highway gravel trucks and heavy machinery will be used to complete necessary upgrades (eg. 30-40 tonne excavators, bulldozer, grader, etc.). Access

Figure 3 Current road conditions. Site to be filled in and levelled.

upgrading will require road closure and other road users will be notified in advance of proposed road work. A couple low sections were identified in the existing road which would benefit from having culverts installed and build up with fill. The rest of existing road is passable but would benefit from being widened and crowned. Figure 4 shows the access road conditions and the lowest area.

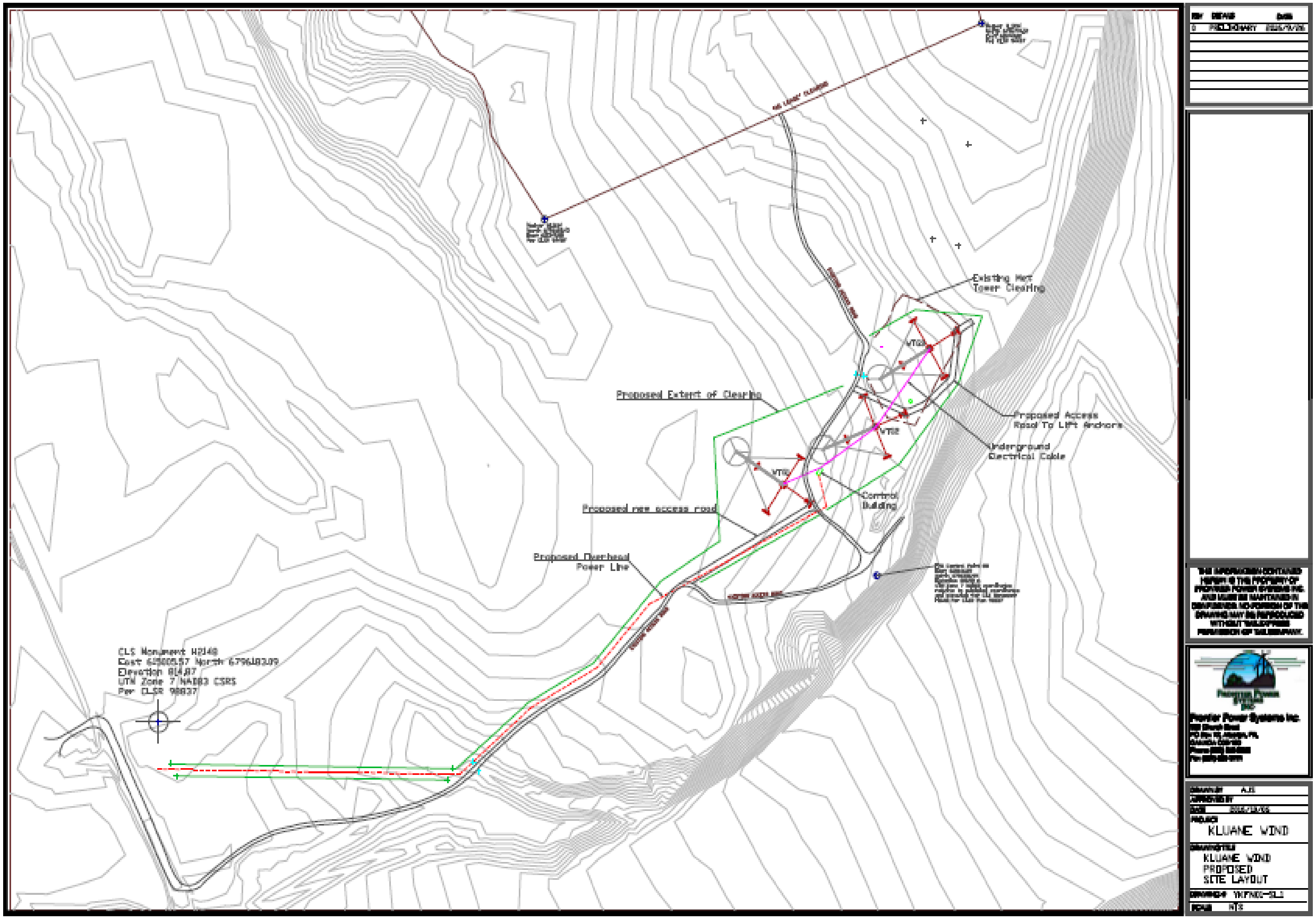


Figure 4. Site map and layout with new access road. Frontier Power, 2016.

3.2.2 Site Preparations

Trees will be cleared from the leased area around the turbine site (Fig. 4 outlines the area to be cleared in green). The power line right of way is already cleared from previous wind monitoring work done by Yukon Energy in the late 1990's, some brushing may be required. Cleared trees will be salvaged and the brush burned when burning permits allow. A 60 m radius around each turbine would be brushed and an area in between will be cleared for a total area of approximately 200 m2. Safety signs will be placed near the cleared area and around the perimeter. There would be three signs in total. A 30 m buffer around the heritage site will restrict work in that area.

The foundations of the towers will be built of rebar and concrete. The guy anchor foundations are approximately 1m x 1m x 6m long. The footing under the tower base is 3m x 4m and the pedestal (the part that protrudes up above grade) is about 1.5m x 1m. The guy radius is about 26m. The overall footprint of each tower is about 55m x 55m (3000m2 or 0.3 hectare). But only about 36m2 of this is under concrete. A loader will be needed to move equipment. A drilling truck will be needed to auger holes and to install anchors.

3.4 Operation

Regular site visits will be made to the turbines to perform maintenance and lubricate the wind turbines. The site will require ongoing brushing in multi-year intervals depending on the rate of growth.

3.5 Continuous Monitoring

KFN will complete pre-construction and post construction mortality monitoring for both birds and bats at the site. We are committed to adaptively manage this site for wildlife.

Bat Monitoring

KFN has worked with Brian Slough, a Yukon Wildlife Biologist to develop an adaptive management plan for bats around the site. KFN will continue to work with him to monitor bats during pre and post construction. Wind turbine mortality is a small percentage of the total mortality caused by collisions of migratory birds with human structures, however wind turbines are one of the largest sources of human-caused mortality of bats (Zimmerling and Francis 2016). Estimates of annual bat fatalities in North America are as high as 888,000 (17.2 bats/MW/year, or 34.4 bats/2 MW turbine) (Smallwood 2013).

Pre-construction bat survey protocol for Alberta has been described by Lausen et al. 2010 and will be followed. Paired bat detectors are set at ground level, and at least 30 m above ground, in the rotor swept area. Two direct recording Pettersson D500X full spectrum ultrasound detectors (Pettersson Elektronik AB, Uppsala, Sweden) will be used to passively detect record and store full spectrum bat echolocation calls. These detectors are among the best available for recording high quality bat calls (i.e., frequency and power) in real time. The recordings can be used for monitoring bat activity, and high quality search phase calls can be classified to species (SonoBat 4.2 software, Arcata, Calif.). Classification is automated; however, all call classifications will be manually vetted. (See Appendix B for more details).

Post-construction bat survey protocol for Alberta has been described by Barclay and Baerwald (2015). Acoustic surveys will continue until the assessment of the effects of wind turbine operation on bats can be ascertained.

Bat fatality surveys will be conducted, and likely combined with bird fatality surveys for expediency. These surveys are conducted within a 50-m radius of the base of the turbine. The recommended search frequency is once every 7 days during the monitoring season (April 15-September 15), and every 3-7 days during bat migration (August 1-September 10).

Bird Monitoring

The ornithologist working on our team has prepared a report updating bird counts taken on several observation sessions over the past three years. The report includes background information on wind towers and bird strikes, numbers of each species observed at the site, concerns regarding the originally proposed location for the wind turbines by the lake shore, actual collisions (with guy wires on our met tower) and anticipated (reduced) impacts for birds in locating lattice towers in the new location away from the lake shore. KFN has worked with Dave Mossop from Yukon College to monitor birds and adaptively manage the wind project site.

Post construction monitoring requires approximately 2 years of monitoring on a twice weekly basis beneath the turbines throughout the breeding and migratory periods, typically from May 1 through November 30.

3.6 Decommissioning/Refurbishment

Following the 25 year operation period, the project may be refurbished and continue to produce clean energy for Burwash Landing and Destruction Bay. When the Project is finally decommissioned, all above-ground components will be dismantled and removed. Some below-ground components such as foundations may remain in place to minimize disturbance if not posing a risk to the environment or potential land users. The road will not be decommissioned as it was present before construction and leads to the gun range and an agricultural lease.

4.0 DESCRIPTION OF EXISTING ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

4.1 Biophysical Environment

The project is located on the Kluane Plateau in the Ruby Ranges Ecoregion. This ecoregion is characterized by strong winds and low precipitation, with June and July being the wet seasons with 30 mm and 70 mm of precipitation, respectively. Temperatures range from a mean of -30 to -35 C in winter to 7 to 12 C in the summer, depending on the elevation. Approximately 35% of the ecoregion is forested, with the remaining area belonging to subalpine brush, alpine tundra, barrenland, and a small (1.4%) portion of mixed forest. The site is situated on a bench above Kluane Lake comprised of silt, sands and gravels, and which is predominantly spruce forest. Bordering the bench is a valley to the south containing a slough that drains into Kluane Lake.

Figure 5 Met tower and wind project site looking south.

4.2 Wildlife

Wildlife present in the area include grizzly bear, black bear, lynx, moose, wolves, caribou, mule deer, a variety of fur-bearing mammals and a variety of migratory and resident bird species. The site is situated within the Shakwak migration route. The site also overlaps a Wildlife Key Area (WKA) for grizzly bear. Kluane National Park and Reserve is the closest park to the site. The Kluane Wildlife Sanctuary is situated across the highway from the project site.

Dave Mossop has identified 91 species of birds in the general area. In 20 field trips he observed a total of 4,726 individual birds in the general area of the turbine site. Specific species of birds observed at the wind project site can be found in the preliminary assessment of bird strike potential at wind farm site – Burwash Landing, YT (2015) (Appendix A)

The following tables illustrate the species and their respective statuses under SARA, COSWEIC, Yukon Wildlife Act and the Migratory Birds Convention Act, which ***may*** be present in the project area.

Yukon Birds and Migratory Birds Convention Act	
Protected	**Not Protected**
Waterfowl, water birds, wading birds, shorebirds	Grouse, ptarmigan
Gulls, jaegers, terns, guillemots	Hawks, eagles, falcons, owls
Nighthawks	Cormorants and kingfishers
Hummingbirds	Ravens, crows, jays and blackbirds
Woodpeckers	Species introduced, i.e. not native to this continent
Songbirds	

Table 1. Yukon migratory birds that may breed or nest within the project area
Note: Adopted from YESAB ER #2012-0134.

Species at Risk	SARA Status	Schedule	COSEWIC Listing	Yukon Wildlife Act – Specially Protected	Yukon Wildlife Act – At Risk
Common Nighthawk	Threatened	1	Threatened		
Olive-sided Flycatcher	Threatened	1	Threatened		
Rusty Blackbird	Special Concern	1	Special Concern		
Short-eared Owl	Special Concern	3	Special Concern		Yes
Woodland Caribou Northern Mountain Population	Special Concern	1	Special Concern		
Grizzly Bear Northwestern Pop.	N/A	N/A	Special Concern		Yes
Wolverine Western Population	N/A	N/A	Special Concern		Yes
Gyrfalcon				Yes	

Table 2. Species specially protected or of special status that may be within project area.
Note: adopted from YESAB ER #2012-0134

Known and hypothetical bat species in Yukon are listed in Table 3. Only one of the highly vulnerable species of tree-roosting migratory bats, the Silver-haired Bat, is a hypothetical resident or migratory species at the Kluane Lake wind turbine project. It was found near Teslin in 2016 (D. van de Wetering and B. Slough, unpubl. data, 2017). If the species does occur in the Kluane area, it will likely be rare. The Little Brown Myotis will undoubtedly be common in the area as they are ubiquitous in Yukon south of 64°N latitude.

Species	Common Name	Yukon Distribution and Abundance	Wind Farm Vulnerabilty
Eptesicus fuscus	Big Brown Bat	Marginal in southern YT and SE AK	Low
Lasionycteris noctivagans	Silver-haired Bat	Marginal in southern YT and SE AK, NE BC, SW NT	HIgh
Lasiurus borealis	Eastern Red Bat	Not known to YT; found in NE BC and SW NT	High
Lasiurus cinereus	Hoary Bat	Marginal in SE YT	HIgh
Myotis californicus	California Myotis	Not known to YT; found in SE AK	Low
Myotis evotis	Long-eared Myotis	Expected in YT; known from NE BC and SW NT. Includes Keen's Myotis (*M. keenii*)	Low
Myotis lucifugus	Little Brown Myotis	Common through south and central YT	Low, but Endangered[1]
Myotis septentrionalis	Northern Myotis	Known from S YT	Low, but Endangered[1]
Myotis volans	Long-legged Myotis	Known from S YT	Low
Myotis yumanensis	Yuma Myotis	Not known to YT,; found in SE AK and may be in N BC (Atlin)	Low

Table 3. Potential bat species in the Kluane Lake wind farm study area.

Note: adapted from Slough and Jung 2007; recent observations and literature summarized in Slough 2015, C. Lausen, unpubl. data, 2017.

4.3 Socio-Economic Conditions

The project site is located between the Alaska Highway and Kluane Lake, and is 140m south of an agricultural lot. There is a shooting range to the south of the project site between the Lake and the slough. There is also a heritage site approximately 600 m to the southeast. The two nearest communities are Destruction Bay and Burwash Landing, at 5 km and 11 km distance respectively. According to the Yukon Bureau of Statistics population report from December 2015, the population of Burwash Landing is 107 and Destruction Bay is 50. The purposed project lies within KFN Traditional Territory. The project is found within trapline concession # 417.

The economy of the Kluane region relies heavily on the First Nation Self Government and resource exploration and development, including, forestry and mining. The Kluane region is a popular destination for a variety of outdoor recreation activities, such as hiking, mountain biking, camping, fishing, canoeing and boating. This project will add jobs to the community through wildlife survey work and operation and maintenance work.

5.0 IDENTIFICATION OF POTENTIAL ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS AND PROPOSED MITIGATION MEASURES

The Valued Ecosystem Components (VEC's) that may be affected by this project are: are:

1) Wildlife and Wildlife Habitat
2) Environmental Quality
   a) Noise
   b) Spills and Fuel storage
3) Socio-Economic (Views and Landscapes)
4) Heritage
5) Human Health and Safety

1. Wildlife and Wildlife Habitat

Effect: The main concern with wind turbines is the potential effect they have on avian species, and bats in this particular project**.** Wind energy developments have the potential to contribute to nocturnal migratory bird mortality. Ongoing bird studies indicate that there will be some risk to birds (including guyline collisions and lattice perching opportunities), particularly with the turbine site located adjacent to the shoreline, which many types of birds use as a migration corridor.
Soil Erosion from clearing trees and vehicles on site is another concern as it may affect wildlife habitat.

Mitigation: In response to these concerns, we have relocated the turbine site a minimum of 200 hundred metres away from the shoreline. The project continues to include a bird and bat monitoring component to help us address potential mitigation opportunities to alert birds that the towers and guylines are present. Nocturnal migrants that are attracted to lights and subsequently collide with turbines or wires may be influenced by the number, location, and type of lights used in the project area. Lighting may disrupt navigation or cause circling flights in nocturnally migrating birds. The site is far enough away from the airport that flashing lights are not needed and will not be used on the turbines. Further, guylines and wires will be made visible, wither with brightly coloured paint or flagging tape to reduce the number of collisions. KFN will complete post construction mortality monitoring for both birds and bats at the site. This typically requires approximately 2-3 years of monitoring on a twice weekly basis beneath the turbines throughout the breeding and migratory periods, typically from May 1 through November 30. KFN will also be producing an adaptive bat monitoring plan for this project, and expects to have it completed by March 2017.

No vegetative mat will be removed and clearing of trees will occur with hand tools, limiting the potential for ground disturbance and effects on habitat.

Significance: By implementing the monitoring plans, adaptive management plans and the above mitigative measures, the significance of the effects on wildlife and wildlife habitat should be low.

2. Environmental Quality (Noise)

Effect: The wind turbines will produce about 58 db of noise standing at the tower base. At 500 m away from tower, the noise level will be reduced to below 40 db, this equivalent to a quiet office, a residential area at night, or a library.
Mitigation: None

Significance: Low

3. Environmental Quality (Spills and Leaks)

Effect: There is a possibility for fuel spills and leaks during the construction phase of this project.

Mitigation: KFN has developed and will implement a Spill Contingency Plan prior to project start-up. Large Spill Kits (2) will be placed on site during construction. There will be a KFN on-site environmental monitor as well to ensure compliance.

Significance: Low

4. Socio-Economic (Views and Landscapes)

Effect: Obstruction of Viewscape

The site will barely be visible from the Alaska Highway. The met tower is in place now and is hard to spot from the highway. The turbines will be visible from the lake but partially blocked from the trees. The Met tower is visible from the nearby agricultural lease, but not from the area of development. Many people consider wind turbines graceful, but others find them intrusive. It has also been found that people who enjoy the sight of wind farms can bring financial benefits to the area. Ultimately, the best thing we can do to preserve our scenic natural spaces is to combat climate change, for which clean energy is desperately needed.

Mitigation: none

Significance: Low

5. Heritage

Effect: There is a heritage site approximately 600 m to the southeast. Heritage sites include cabins, caches, graves, bush camps and other human-made structures, features and objects that have been abandoned. Historic resources include artifacts related to heritage sites and human activities. The value of heritage resources rests within their context upon the land in which they are located, in essence, when they are in situ. Once disturbed or removed the value cannot be restored. Rivers and creeks are considered to have a higher than average likelihood of hosting heritage resources because they may have served as natural travel corridors, and/or hunting and fishing areas.

Humans have been present in the proposed project area for a relatively short period of time (100's to 1000's of years); therefore, heritage resources are essentially on or near the surface of the ground. Heritage resources also include paleontological artifacts, such as fossils, mummified or frozen remains, which may have significant scientific value. Project activities such as the moving of earth could uncover such resources, which are typically delicate and susceptible to rapid weathering and degradation.

Mitigation: The following mitigation measures will reduce, control and/or eliminate effects heritage resources:

- Development of a "Chance Find Procedure", training of all personnel in its implementation during site orientation.

Significance: Low

6. Human Health and Safety

Effect: The proposed project has the potential to adversely affect health and safety as a result of the use of heavy equipment), the use of petroleum and chemical products and wildlife encounters. Potential effects of the proposed project on human health and safety include:

- injury or death from the operation of heavy machinery
- wildlife encounters during site operations

Minor to serious injuries and even death may result from accidents, equipment malfunctions or failure to follow safety measures during the operation of the helicopter and heavy equipment. The proposed project is located in a relatively isolated area, its proximity to the Alaska Highway and to the community of Burwash Landing may facilitate easier and prompt access for treatment of injured personnel.

Mitigation

The following mitigation measures will reduce, control and/or eliminate effects worker health and safety:

- Implementation of sections of Federal and Yukon legislation (e.g. *Occupational Health and Safety Act*) and available best practice guidance from other jurisdictions relevant to operations at the site
- Management of wildlife attractants such as food and garbage in site. Ensure these attractants are hauled to town for proper disposal.
- Safety meeting on site before work each day to go over hazards and action plans

Significance: Low

6.0 CONSULTATION

The following describe the various forms of community and stakeholder consultation undertaken since 2011.

2011 Hector Campbell and Kirk Cameron from Yukon Energy Corporation presentation in GA January 2011 – wind mapping

2012 Energy Summit Wind Project Presentation – JP Pinard

2013 April Newsletter update on potential energy projects

2014 Newsletter update on wind project

2014 Wind Project Update in GA information distributed to citizens

2015 GA Poster board presentation – LRH Staff

2015 Wind Project Update in GA information distributed to citizens

2015 – DKRRC Open house poster board presentation

2016 GA poster board presentation – LRH Staff

April 19, 2016 Energy Summit Presentation – JP Pinard

April 2016 Newsletter submission. Wind project turbine training PEI

7.0 ADDITIONAL INFORMATION

Previous Work Completed

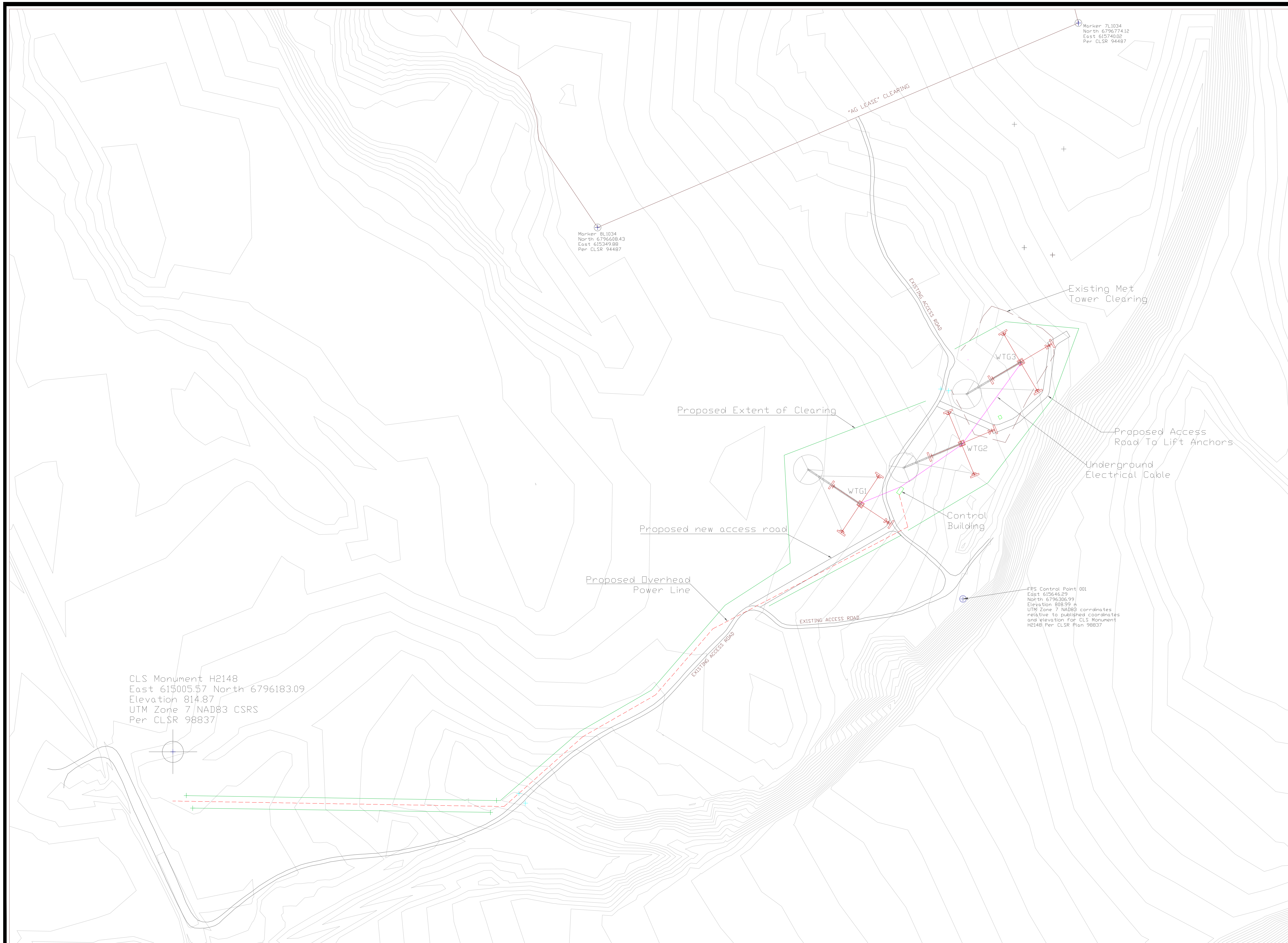
The bird study, started in the spring of 2012 by Dave Mossop (bird biologist with the Yukon Research Center), is ongoing (report submitted previously). Based on his recommendations, we have relocated the turbine site to farther away from the shoreline to reduce the risk of bird strikes.

We have completed years of wind data monitoring at our met site and correlated this data with Burwash Airport wind data. The long term wind speed at 50 m above ground is 6.8 m/sec which shows that this site is well suited to produce wind power and consistent with our previous assumptions in the Business Plan.

Permits

NAV CANADA must assess and approve all proposals for land use near airports and air navigation infrastructure before construction begins to ensure that air navigation system safety and efficiency are not compromised by proposed land development. KFN previously approved for 60 m met tower

Land reserve was requested until project proponent is ready to lease the land. A long-term lease is required from the Yukon Government as the new location of the wind project is on crown land.



REV	DETAILS	DATE
0	PRELIMINARY	2016/9/26

Frontier Power Systems Inc.
392 Church Street
PO Box 72, Alberton, PE,
CANADA C0B 1B0
Phone (902) 853-2853
Fax (902) 853-3721

DRAWN BY AJS
APPROVED BY
DATE 2016/10/06
PROJECT KLUANE WIND
DRAWING TITLE KLUANE WIND PROPOSED SITE LAYOUT
DRAWING # YKFN01-SL1
SCALE NTS

PRELIMINARY ASSESSMENT OF BIRD STRIKE POTENTIAL AT WIND FARM SITE – BURWASH LANDIN, YT

INTERIM REPORT: 2012 TO 2014

March 2015

D. Mossop
Yukon Research Centre
Yukon College
dmossop@yukoncollege.yk.ca

Report to:

Kluane First Nation
Natural Resources Branch
Burwash Landing, YT
Environment@kfn.ca

Preliminary Assessment of Bird Strike potential at Wind Farm site– Burwash Landing, YT
Interim report, 2012 to 2014

D. Mossop
Yukon Research Center
Yukon College

Purpose: The Kluane First Nation is planning to install three wind turbines to produce electric power for the community. The elders of the community have expressed concern that the Burwash wind turbine site is within a known major bird migration corridor both spring and fall. A large percentage of the world population of trumpeter swans passes the site. As well a large assemblage of vulnerable birds of prey including the much localized race of buteo hawk, the Harlan's hawk, potentially use that route. A small amount of migration watch survey has been conducted in the past. It shows a sizeable movement of birds along the shoreline of Kluane Lake.

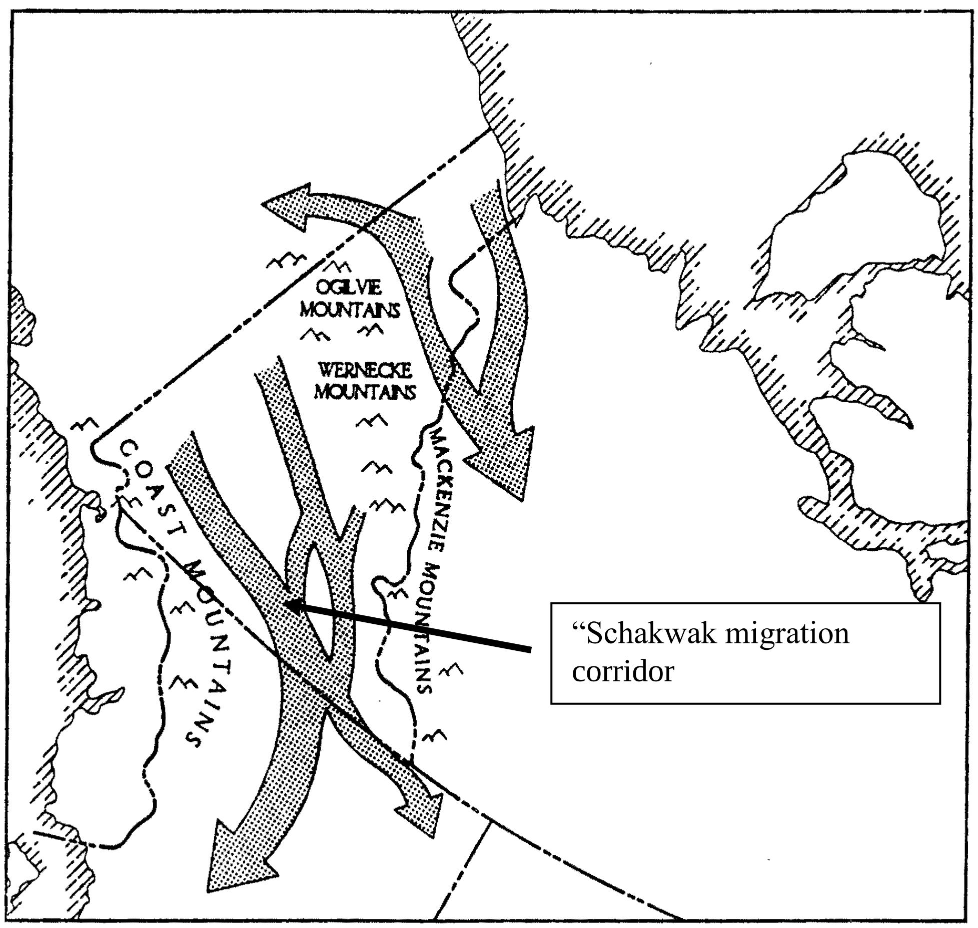


Fig 1: Major migration corridors across the Yukon; the Schakwak route, heavily used by birds principally moving to and from Alaska (and Siberia) lies directly astride the Burwash site.

The potential for bird deaths by collision is real. Even though its effect at the population level may possibly be negligible, its perceived effect could be devastating to the project. It is going to be necessary to plan this project very much as an experiment: (If the chosen site proves unfavorable, moving probably should be planned.)

In the fall of 2012 the author and students from Yukon College began a migration watch project with objectives to:

a) quantify the magnitude of bird movements past the site
b) measure altitudes and timing of movements: notably during fall and spring
c) quantify potential strikes
d) develop a monitoring protocol for tracking problems in the future.

Site work: Field work has involved weekly field trips of 2-3 days each timed to peak south and northward migration. Initial survey technique involved a fair amount of field testing to see what will be most effective for developing a longer term meaningful data set. We now have a full year's data covering one fall migration periods0 (2013) and thwo spring migration periods (2013 and 2014).

a) We did extensive preliminary ground assessment of the site to gain a general impression of bird habitats of the area, an idea of species richness, and potential attractive features that may attract and concentrate birds especially during migration.

b) We conducted standard site observation of bird movements: We were at the site observing for half hour sessions through daylight periods but focusing primarily on sunrise and sunset periods. All species were identified as they passed although smaller passerines sometimes had to be lumped into identifiable groups. We were comfortable that most water bird and bird of prey movements were quantified accurately by this method.

c) All bird movements through the site were mapped as accurately as possible including the flight direction and height. (The 60 meter Meterological ('Met") tower at the site was used to estimate height of passing birds.)

d) We conducted extensive ground search for bird carcasses below the site 'Met' research towers as well as others in the region (The Donjek microwave, the airport towers).

e) We constructed a semi-permanent observation camp accommodation at the site to allow easier round-the-clock observations.

Preliminary findings:

General assessment of the site: Clearly the site sits astride a well known major migration corridor for many thousands of birds moving mostly into Alaska and Siberia along the 'shakwak' migration route. The site is adjacent an attractive lagoon on the shore of Kluane lake that adds risk for birds transiting the site. We have identified 91 species of birds using the general area. In 20 field trips we have observed a total of 4,726 individual birds in the general area of the turbine site.

For most of the 2012 fall period, the research 'Met' tower had not been erected so assessing its effect on birds was really not possible. The spring and fall migration periods in 2013 were more informative. Unfortunately the spring of 2014 displayed an unusually protracted movement of birds and was less representative of what can be expected over the long term.

The 'Met' research tower with its 20 plus guy wires should pose a formidable obstacle to moving birds, particularly at night. It is hard to imagine a more critical test of the site in terms of its hazard to migrating birds.

Ground searches: We conducted four extensive ground searches at each site (the navigational tower near the town of Burwash and the research 'met' tower at the proposed turbine site) in 2012. In 2013 and 2014 we searched the navigational tower only once, we restricted ground searches mostly to the tower at the turbine site. In total we have searched that site 22 times

Bird specimens found in searches below towers_(F= feathers only)__

Species	Nav tower (n=5)	Turbine site(n=18)
Unid duck	1(F)	
Sharp-shinned hawk		1(F)
Hawk-owl	1	
Sharp-tailed grouse	1(F)	
Dark-eyed junco		1
Tree swallow	1	

Observed Impacts: The searches under the turbine site 'met' tower yielded only two specimens: (1 dark-eyed junco and feathers from one Sharp-shinned hawk. The navigational tower closer to Burwash Landing was apparently killing more birds (5 specimens).

However, at the turbine site we observed birds hit the ‘Met’ tower or wires 5 times (1 Canada goose, 1 American pipit, 1 Spruce grouse, 1 3-toed woodpecker, 1 American robin). None of these birds were injured or even lost feathers. (The guy wires on the present tower are extremely loose and birds were seen to simply bounce off unhurt.) Consequently our searches under the site tower are probably only indicative for suggesting mortality frequency that can be expected when the turbine towers are in place with far tighter wires.

Fig 2. Canada geese transiting the turbine site in near darkness, guy wires visible to the left. One of these birds collided with the wires but was not injured.

Bird movement observations past turbine site: We have now carried out half-hour observations from late September 2012 through May 2014. All were conducted in early morning or evening when bird migration movement was observed to be peaking. (By mid to late September, some major portion of migration by most species was found to be finished. In 2013 and 2014 we started observations earlier -- by the beginning of September and began spring observation in mid April.)

(Flight lines are estimates based on direct observation of birds passing the site. We used the 'Met' tower sections to help estimate height and guy wire bases to help estimate lateral track.

We now have logged 116 half-hour observation periods; and we have observed and mapped 304 transits of the site by 1,688 individual birds.

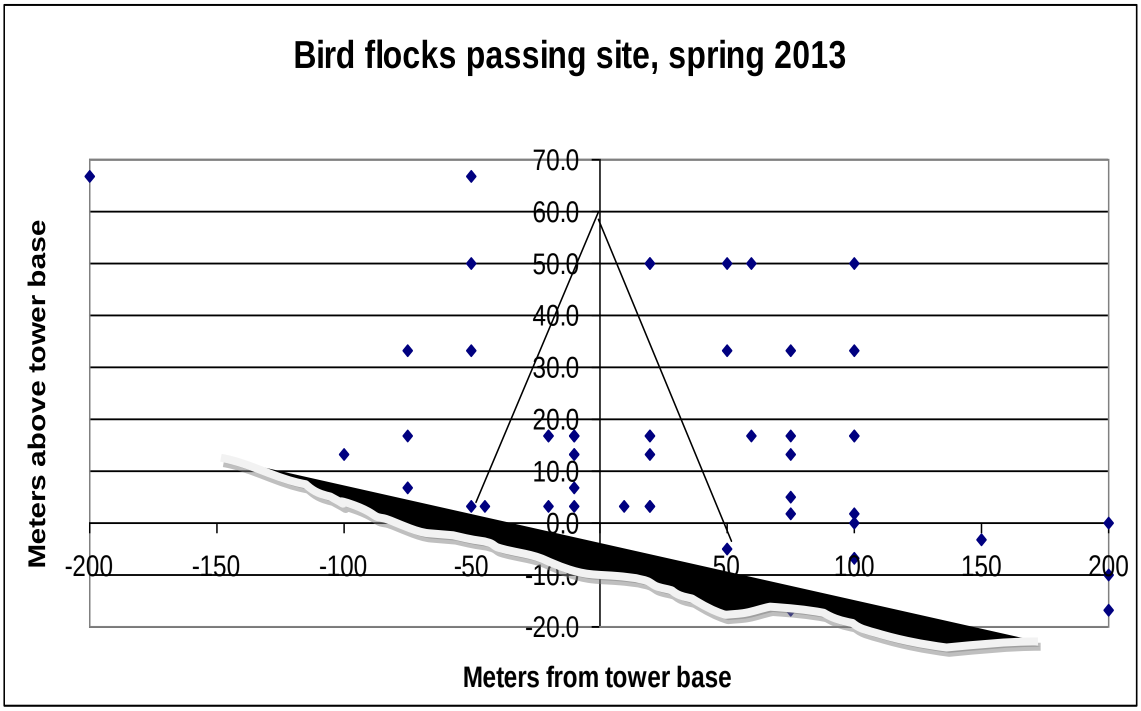
Birds per hour passing site: (at dusk, morning and evening)

	2012 fall	2013 spring	2013 fall	2014 spring
average	**75.6**	**98.3**	**18.6**	**5.1**
Range:	**18-290**	**2-322**	**0-174**	**0-35**

The average bird movement past the site lumping all summer and fall migration periods is 29.1 birds per hour: range, 0-322

<u>Bird species observed passing within 150 meters of turbine site</u>

	Fall 2012	Spring 2013	Fall 2013	Spring 2014
Trumpeter swan	26	6		14
Tundra swan		30		
Canada goose		210	137	
White-fr. Goose		4		10
Herring gull	8	5	51	8
Mew gull		1		11
Mallard		3		9
Wilson’s snipe		8		
Pectoral sandpiper		1		
Lesser Yellowlegs				1
Long-billed dowitcher		5		
Upland sandpiper		1		
Golden plover		1		
Bald eagle	2			
Harlan’s hawk			2	3
N. harrier	3	5	3	1
Sharp-shinnned hawk	4		7	
Merlin	3		2	
Peregrine falcon				1
Spruce grouse			2	1
Tree-toed woodpecker			1	
Northern flicker				5
Common redpoll	249	71	10	8
American pipit	18		12	
American robin	8		94	28
Common raven	16	9	3	36
Gray jay		2	2	2
Pine siskin	10			
White-winged crossbill	1			
Pine grosbeak				1
Dark-eyed junco	3	5		8
Lapland longspur		160	34	
Snow bunting		25		
White-crowned sparrow		1	1	
Tree sparrow	1			
Yellow-rumped warbler		12	1	5
Unidentified waterfowl		30	20	2
Unidentified shorebird			40	5
Unidentified song bird	107	70	20	3
Totals	**459**	**630**	**449**	**156**
	2012 fall	**2013 spring**	**2013 fall**	**2014 spring**



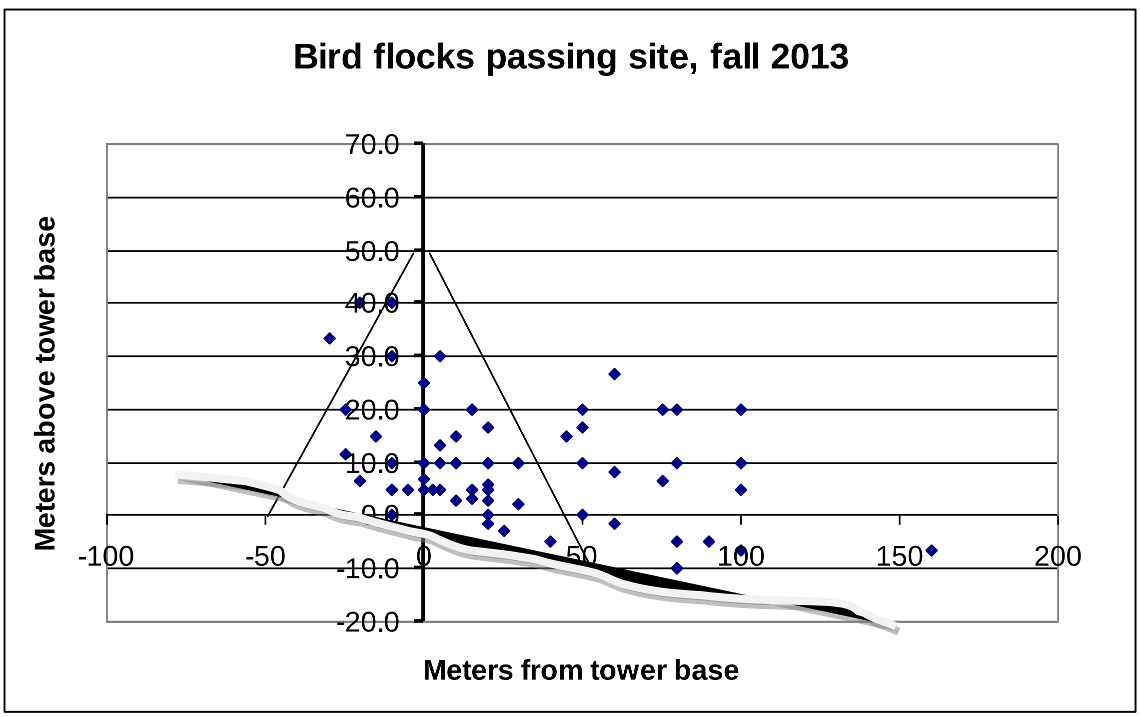


Fig 3. Observed bird transits of the site and the 'Met' tower; values based on estimates from the base of the tower at the site.

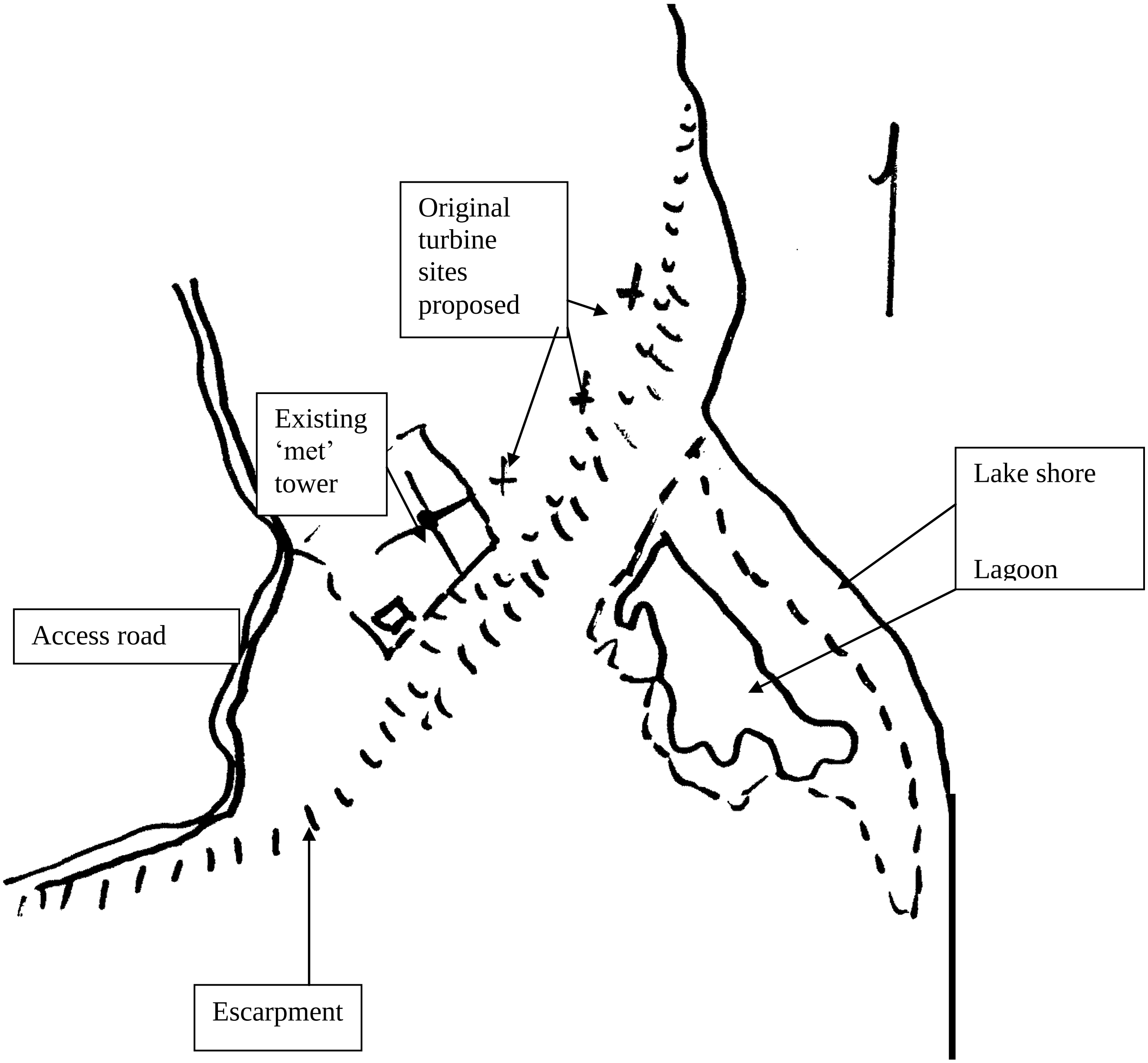


Fig 4. Field sketch site map used to plot bird movements past the study site.

Transits of the site by birds tended to be slightly lake-side of the 'Met' tower (average -24 meters to lake-side) but with a very large variation (Standard deviation: ± 63.4 meters). Height above the base of the 'Met' tower averaged 12 meters but again a large variation (Standard deviation ±21 meters).

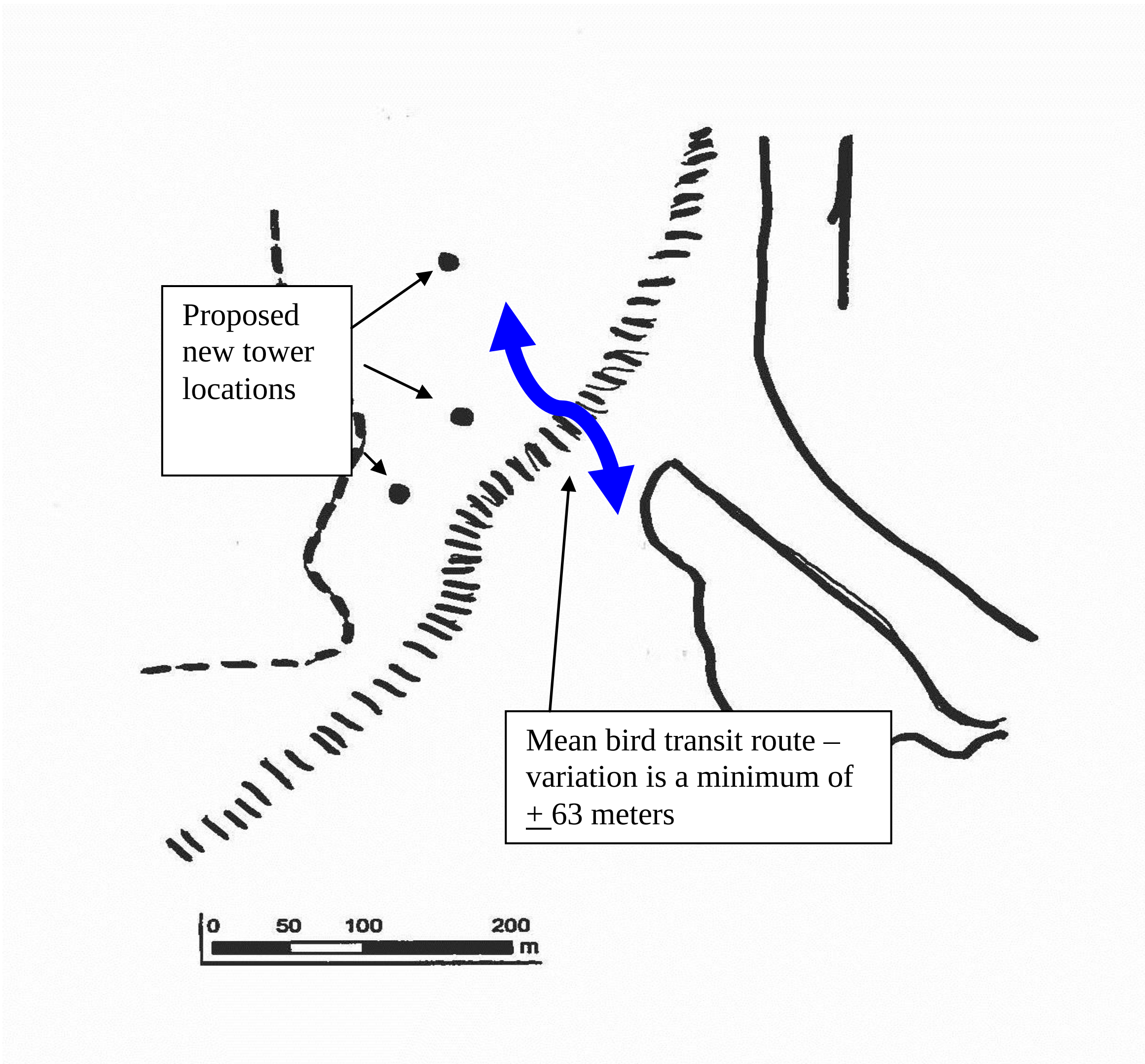


Fig 5, Turbine site location showing the mean transit route by birds observed 2012-14 and the proposed new tower locations.

Preliminary conclusions:

a) **Wire impact:** It is clear that impact with guy wires presents the most likely scenario at the site. In the dusk periods and on misty days the wires literally disappear from sight. Dusk and night movements of most birds tends to be the norm when wires cannot be seen even on clear nights.

b) **Location of towers:** There is some significant difference between flight lines observed spring and fall. In general spring migrants seemed to be moving past the site at higher altitude. The array of flight lines laterally seem to be basically the same; most passages are to the lake side of the site and most of the larger birds are transiting across the lower terrain between the lake and the site.

   (Note: based in part on the apparent risk to birds transiting the site, the plan to move the towers from locations as in fig 4, further from the lake as in fig 5, has been adopted). Moving the proposed tower sites away from the lake and uphill on the plateau above the escarpment should reduce (but not eliminate) the likelihood of impact.

   Interestingly many **water birds** (gulls, geese, swans) were observed to pass the site well below the top of the escarpment on which the turbines will be located. By far the majority of larger birds were passing on the lake-side of the tower and usually below the tower base. If this persists, they should be mostly safe from collision. Commonly water birds (gulls, geese, swans, some ducks) were transiting the area at tree-top level and tended to be attracted by the lagoon that is strategically located directly in front of the site. They tended to be moving along the lake shore except at this site when they often swept inland -- but seemed to maintain a flight line between the tower and the lake shore.

   In terms of numbers at risk, clearly small song birds outranked all others. Their height above ground level put them at risk from literally all the guy wires.

c) **Lattice tower construction:** It is known, that birds can be attracted to cleared sites and in particular it has been shown that birds of prey are attracted to "lattice" towers and seem to want to land on them. Birds of prey were the largest birds that were seen to transit the site well within the sweep of guy wires and could potentially present the greatest threat for impact. The species most at risk appear to be falcons (notably Merlin) and small accipiters (Sharp-shinned hawk). Both of these show fast, straight-line flight lines; others like Harlan's (Red-tailed) hawks and eagles tend to circle the site and unless they are attracted for some reason, are not likely to transit the wires.

d) **Lights:** Most observations of birds transiting the site were made in periods of dusk and darkness when wires and the tower itself were difficult to see. It is clear that the turbine towers located as they will be, on a commonly used flight path (in particular on the approach path to the Burwash Airport) will be required to carry lights. Constant, white lights are known to be confusing to birds; if used they can probably be expected to cause increased collisions.

Fig 6. The lagoon immediately below the escarpment where towers are planned is a powerful attractant for moving birds during spring and fall; they tend to traverse the site immediately to the right of the "met" tower.

Acknowledgements:
College students assisted on many field days and carried out observations: In 2012, Shannon Harvey and Car Rudinski, 2013: Sara Newton, Anne Aubin; 2014: Jesse Vigloitti, and Graeme Poile

Appendix: Bird species observed in the general area of the Burwash turbine site 2012-2014; relative abundance by percent of individuals observed.

2012-14	TOTAL ROLL UP	% OF TOTAL
AMERICAN WIGEON	1417	29.98
CANADA GOOSE	556	11.76
AM. GREEN-W.TEAL	263	5.56
AMERICAN ROBIN	225	4.76
SNOW GOOSE	201	4.25
LAPLAND LONGSPUR	186	3.94
AMERICAN PIPIT	182	3.85
MALLARD	169	3.58
GR. WHITE-FR. GOOSE	160	3.39
COMMON REDPOLL	138	2.92
NORTHERN PINTAIL	124	2.62
NORTHERN SHOVELER	65	1.38
DARK-EYED JUNCO	65	1.38
YEL-RUMPED WARBLER	60	1.27
HERRING GULL	58	1.23
COMMON RAVEN	58	1.23
HORNED LARK	50	1.06
TRUMPETER SWAN	46	0.97
SNOW BUNTING	45	0.95
MEW GULL	44	0.93
PECTORAL SANDPIPER	40	0.85
BOHEMIAN WAXWING	36	0.76
GRAY JAY	34	0.72
WILSON'S SNIPE	33	0.70
CACKLING GOOSE	26	0.55
TREE SWALLOW	26	0.55
WHITE-CRND SPARROW	24	0.51
NORTHERN HARRIER	23	0.49
RUBY-CRND KINGLET	23	0.49
AM.GOLDEN PLOVER	21	0.44
TUNDRA SWAN	20	0.42
LESSER YELLOWLEGS	19	0.40
RING-NECKED DUCK	18	0.38
KILLDEER	15	0.32
SWAINSON'S THRUSH	14	0.30
SHARP-SH. HAWK	13	0.28
VARIED THRUSH	13	0.28
LESSER SCAUP	12	0.25
SPOTTED SANDPIPER	12	0.25
LON-BILLED DOWITCHER	11	0.23
N.FLICKER	11	0.23
BUFFLEHEAD	10	0.21

PINE SISKIN	10	0.21
HARLAN'S HAWK	9	0.19
BANK SWALLOW	8	0.17
HARLEQUIN DUCK	7	0.15
RED-BR. MERGANSER	6	0.13
MERLIN	6	0.13
WHITE-W. CROSSBILL	6	0.13
AM. TREE SPARROW	6	0.13
BARROW'S GOLDENEYE	5	0.11
RUSTY BLACKBIRD	5	0.11
PINE GROSBEAK	5	0.11
WHITE-WINGED SCOTER	4	0.08
LEAST SANDPIPER	4	0.08
SPRUCE GROUSE	4	0.08
SHARP-T. GROUSE	4	0.08
NORTHERN GOSHAWK	4	0.08
GOLDEN EAGLE	4	0.08
BLACK-B. MAGPIE	4	0.08
WILSON WARBLER	4	0.08
RUDDY DUCK	3	0.06
UPLAND SANDPIPER	3	0.06
SEMIPALMATED PLOVER	3	0.06
BALD EAGLE	3	0.06
AMERICAN KESTREL	3	0.06
OL.-SIDED FLYCATCHER	3	0.06
SAVANNAH SPARROW	3	0.06
TOWNSEND'S SOLITAIRE	3	0.06
HORNED GREBE	2	0.04
RED-NECKED PHALAROPE	2	0.04
RUFFED GROUSE	2	0.04
THREE-TOED WODPECKER	2	0.04
GOLDEN-CRND SPARROW	2	0.04
FOX SPARROW	2	0.04
YELLOW WARBLER	2	0.04
BOREAL CHICKADEE	2	0.04
RED-NECKED GREBE	1	0.02
ARCTIC TERN	1	0.02
EURASIAN WIGEON	1	0.02
HUDSONIAN GODWIT	1	0.02
SOLITARY SANDPIPER	1	0.02
PEREGRINE FALCON	1	0.02
NORTHERN HAWK-OWL	1	0.02
BELTED KINGFISHER	1	0.02
SAY'S PHOEBE	1	0.02
CHIPPING SPARROW	1	0.02
LINCOLN'S SPARROW	1	0.02
BARN SWALLOW	1	0.02
VIOLET-GREEN	1	0.02

SWALLOW		
OR. CRND. WARBLER	1	0.02
BLACK C. CHICKADEE	1	0.02

Analysis of Bird Strike potential at Wind Farm – Burwash Landing, YT

Interim report, - Fall 2016

D. Mossop and Manon Fontaine
Yukon Research Center
Yukon College

Purpose: The Kluane First Nation is planning a wind turbine to produce electric power for the community. The elders of the community have expressed concern that the Burwash wind turbine site is within a known major bird migration corridor both spring and fall. A large percentage of the world population of trumpeter swans passes the site. As well a large assemblage of vulnerable birds of prey including the very localized race of buteo hawk, the Harlan's hawk, potentially use that route. A small amount of migration watch survey has been conducted in the past. It shows a sizeable movement of birds along the shoreline of Kluane Lake.

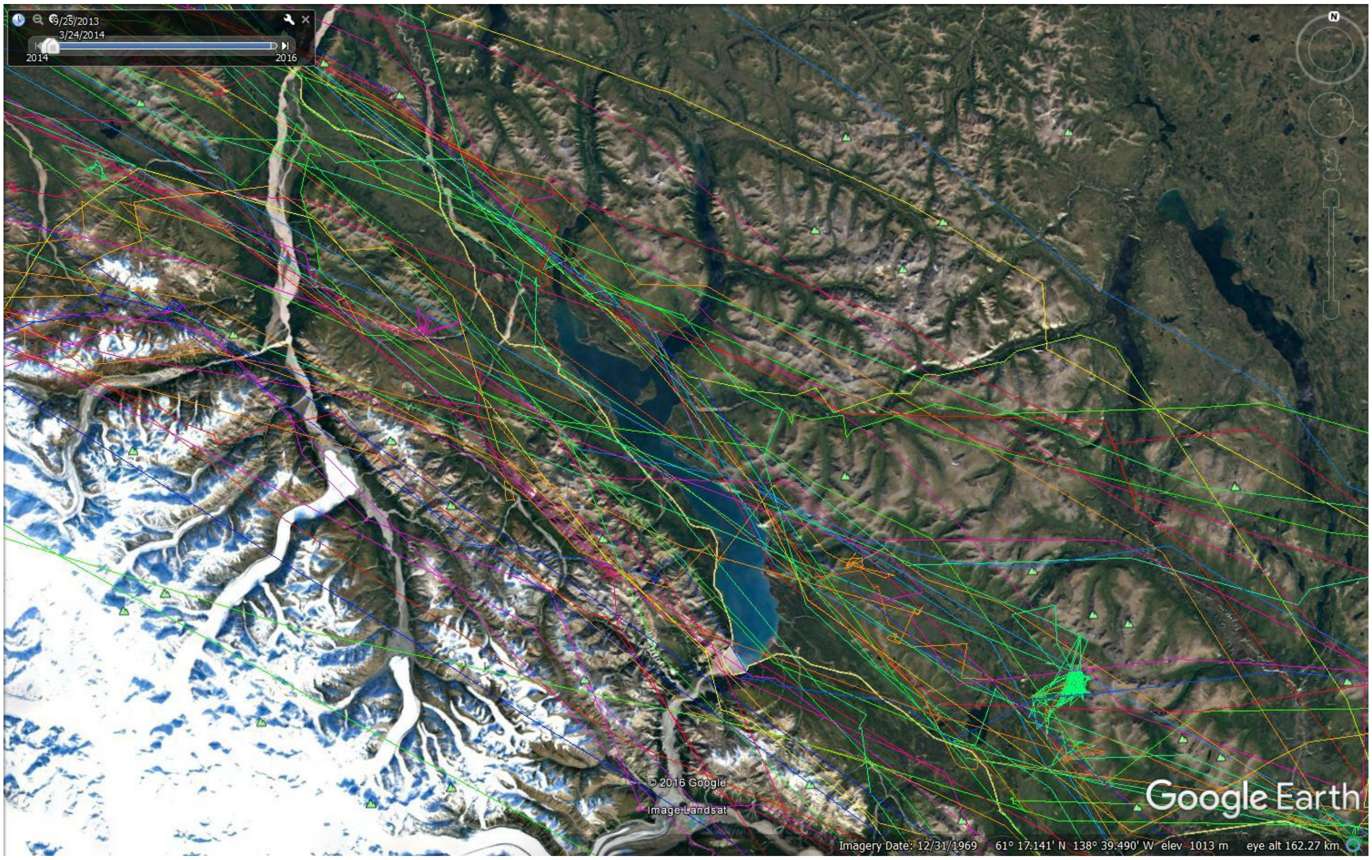
The potential for bird deaths by collision has been demonstrated. (See interim reports: 2013, 2015) Even though it is becoming clear the effect at the population level will likely be negligible, its perceived effect could be devastating to the project. It is going to be necessary to plan this project very much as an experiment: (The chosen site has already been adjusted out of the main observed path of passing birds.)

The 2016 field season: In the current year we carried out 24 hours of observation at the site on 8 days in the spring migration period and 6 days during the fall migration. The observations were consistent with those reported earlier and no further interim reporting on those data are justified. The plan for this phase of the work is to await further construction at the site.

Ground searches at the site have now been terminated; shrub vegetation has now grown to the point that search is virtually impossible.

The focus of this year's work has been in obtaining satellite tracks of birds radioed in Alaska and transiting the Burwash area. An agreement with the State of Alaska was obtained in late 2016. (These data, many thousands of dollars in value, have been made freely available to the project.)

Golden eagles are one of the species of greatest concern where impacts with towers and turbines are considered. Figures below show the tracks of 47 eagles passing through the Kluane, Shakwak migration route. Again this is not unexpected and we reported the concentration of bird movements through the general area earlier. These are the first confirmed data however, of the magnitude and concentration of the movement of eagles through the area. There are undoubtedly many thousands of eagles transiting the area annually.



The fascinating feature of these data is that in hundreds of hours of bird movement watch at the Burwash wind turbine site we have observed Golden eagles only 4 times and all were at high altitude over adjacent mountains.   It is becoming clear that many of these Alaska (and Siberian) species transiting the area are doing so along mountain ridges and at altitude and may be at almost zero risk from the proposed towers.

Earlier reports:

2013. Analysis of Bird Strike potential at Wind Farm – Burwash Landing, YT, Interim report,   - Fall 2013

2015 Preliminary assessment of bird strike potential at wind farm site – Burwash Landing, YT, interim: 2012 TO 2015

Bat Monitoring and Adaptive Management Plan for the Kluane Wind Project

Supplement to the Kluane First Nation YESAB Application

Prepared for:

Kluane First Nation
Box 20
Burwash Landing, YT Y0B 1V0

Prepared by:

Brian Slough, Wildlife Biologist
37-71 Aksala Drive, Whitehorse, YT Y1A 0M5
Email: slough@northwestel.net
Tel.: 867-333-9478

Submitted: March 6, 2017 (Draft for Review)

Introduction

Wind power is considered a clean alternative to fossil-fuel based energy generation, however there is evidence that wind farms are killing bats at a rate that may be negatively impacting bat populations (Cryan 2011, Hayes 2013, Smallwood 2013, Zimmerling and Francis 2016). Bats are killed either by direct collisions with turbine blades (Horne *et al*. 2008, Rollins *et al*. 2012), or by barotrauma (Baerwald *et al*. 2008). Barotrauma is apparently the result of rapid air decompression near wind turbines, which produces internal haemorrhaging in bats. There is still controversy as to whether the internal injuries are caused by barotrauma or by blade strikes and subsequent falling to the ground (Rollins *et al*. 2012). An estimated 50% more bats are killed than birds by wind turbines in North America (Smallwood 2013). The reasons for the higher mortality rate of bats is unclear, but may include blade collision avoidance behaviour by bats which does not avoid barotrauma, local prey abundance, bats investigating turbine monopoles as tree roosts, and bats investigating the high frequency sounds at nacelles (cover housing that houses all of the generating components in a wind turbine).The unique respiratory anatomy of birds is thought to be less susceptible to barotrauma than the anatomy of mammals such as bats (Baerwald *et al*. 2008).

Wind turbine mortality is a small percentage of the total mortality caused by collisions of migratory birds with human structures, however wind turbines are one of the largest sources of human-caused mortality of bats (Zimmerling and Francis 2016). Estimates of annual bat fatalities in North America are as high as 888,000 (17.2 bats/MW/year, or 34.4 bats/2 MW turbine) (Smallwood 2013). Zimmerling and

Francis (2016) estimated that 47,400 bats are killed at turbines each year in Canada (95% confidence limits: 32,100-62,700). This estimate is based on the 2013 installed wind energy capacity, which is estimated to increase 3.5-fold over the next 15 years.

Long-distance migratory tree bat species (Hoary, Silver-haired and Eastern Red bats) comprise up to 78.4% of bat fatalities at wind farms, although *Myotis* species, such the Little Brown Myotis, common to Yukon, may experience similar mortality rates if they fly long distances between summer roosts and winter hibernating sites (Arnett *et al*. 2008, Arnett and Baerwald 2013, Arnett *et al*. 2016). Fatalities of bats occur primarily during the fall migration period when bats aggregate for mating.

Based on monitoring results from wind farms in the Peace River Region of British Columbia, the Silver-haired Bat is most affected by turbines (Hemmera 2012, 2013; Stantec 2012). One Eastern Red Bat fatality confirmed the species presence in the Peace Region (Nagorsen and Paterson 2012). Further south in Alberta, Hoary and Silver-haired bats dominated wind farm fatalities (Baerwald and Barclay 2011).

Resident and Migratory Yukon Bats

Known and hypothetical bat species in Yukon are listed in Table 1. Only one of the highly vulnerable species of tree-roosting migratory bats, the Silver-haired Bat, is a hypothetical resident or migratory species at the Kluane Lake wind turbine project. It was found near Teslin in 2016 (D. van de Wetering and B. Slough, unpubl. data, 2017). If the species does occur in the Kluane area, it will likely be rare. The Little Brown Myotis will undoubtedly be common in the area as they are ubiquitous in Yukon south of 64°N latitude. While surveys have not been conducted in the Kluane Lake area north of Haines Junction, the species is common in all areas surveyed in southern Yukon and is found as far north as Dawson City. Other *Myotis* species such as the Northern Myotis, Long-eared Myotis, and Long-legged Myotis may be present in low numbers, and others found in southeast Alaska or southern Yukon east of the study area, including the California Myotis, Yuma Myotis and Big Brown Bat are other hypothetical species for the area. Keen's Myotis (*Myotis keenii*) found in northeastern BC and southeast Alaska, was once considered a separate long-eared bat species, but is now considered conspecific with the Long-eared Myotis (Lausen *et al*. 2016). The Little Brown Myotis and Northern Myotis are both endangered (COSEWIC 2013) due to the risk of mass mortality associated with the westward spread of the emerging disease white-nose syndrome, caused by the fungus *Pseudogymnoascus destructans*.

Table 1. Potential bat species in the Kluane Lake wind farm study area (adapted from Slough and Jung 2007; recent observations and literature summarized in Slough 2015, C. Lausen, unpubl. data, 2017).

Species	Common Name	Yukon Distribution and Abundance	Wind Farm Vulnerabilty
Eptesicus fuscus	Big Brown Bat	Marginal in southern YT and SE AK	Low
Lasionycteris noctivagans	Silver-haired Bat	Marginal in southern YT and SE AK, NE BC, SW NT	HIgh
Lasiurus borealis	Eastern Red Bat	Not known to YT; found in NE BC and SW NT	High

Lasiurus cinereus	Hoary Bat	Marginal in SE YT	HIgh
Myotis californicus	California Myotis	Not known to YT; found in SE AK	Low
Myotis evotis	Long-eared Myotis	Expected in YT; known from NE BC and SW NT. Includes Keen's Myotis (*M. keenii*)	Low
Myotis lucifugus	Little Brown Myotis	Common through south and central YT	Low, but Endangered[1]
Myotis septentrionalis	Northern Myotis	Known from S YT	Low, but Endangered[1]
Myotis volans	Long-legged Myotis	Known from S YT	Low
Myotis yumanensis	Yuma Myotis	Not known to YT,; found in SE AK and may be in N BC (Atlin)	Low

1. COSEWIC 2013

Pre-construction surveys and risk assessment

Pre-construction bat survey protocol for Alberta has been described by Lausen *et al*. 2010). Paired bat detectors are set at ground level, and at least 30 m above ground, in the rotor swept area. The turbine design preferred for the Kluane Wind Project is project is the Windmatic 17S, manufactured by Frontier Power Systems (Hatch 2016). It has 24 m rotors, mounted on a guyed 50-m tower. The rotor swept heights for this turbine is 26-74 m above ground. Two direct recording Pettersson D500X full spectrum ultrasound detectors (Pettersson Elektronik AB, Uppsala, Sweden) will be used to passively detect, record and store full spectrum bat echolocation calls. These detectors are among the best available for recording high quality bat calls (i.e., frequency and power) in real time. The recordings can be used for monitoring bat activity, and high quality search phase calls can be classified to species (SonoBat 4.2 software, Arcata, Calif.). Classification is automated; however, all call classifications will be manually vetted.

Obtaining additional information on local bat populations, movements and habitat use, is valuable for assessing potential impacts. Local residents will be surveyed for known roost sites in the area to determine if the wind energy development is located between roosting and foraging habitats. The lagoon immediately below the escarpment is expected to be a prime bat foraging habitat in the area. Mist netting could enhance the survey process; however, it is not always appropriate for assessing bat activity at proposed wind energy developments since many bats fly above mist net heights, and fatalities occur at blade heights.

Meteorological data will be used to correlate weather conditions with variation in estimates of bat abundance and activity. Temperature, wind speed and direction, and barometric pressure are all useful data that are being collected at the site. Rapid changes in barometric pressure which occur during incoming weather fronts may correlate with waves of migrating bats.

The acoustic data are typically reported as a mean and variance of bat passes per detector night, where a detector night is based on detectors operating a half-hour after sunset to a half hour before sunrise. The critical migratory period when fatalities peak is August 1 to September 10. Data can also be expressed as bat passes per MW of electricity generated per detector night.

The existing meteorological tower is not expected to contribute to bat mortality, as it has for birds (Mossop 2015). Wires and guy lines are 'visible' to echolocating bats and easily avoided.

The results of pre-construction bat surveys should prompt these actions as recommended by the Alberta Department of Environment and Sustainable Resource Development (2013):

- The recommendation for less than one migratory bat pass per night (equal to an estimated less than 4 annual mortalities per turbine) is for post-construction monitoring and avoidance of areas of concentrated bat activities.
- Bat mortality issues are likely with one to two migratory bat passes per detector night (equal to 4-8 mortalities per turbine), and Environment Yukon should be consulted regarding pre-siting mitigation and options for adaptive management.
- More than 2 migratory bat passes per detector night (equal to greater than 8 mortalities per turbine) again triggers consultation with Environment Yukon on pre-siting mitigation and, depending on the results of carcass surveys, post-construction mitigation options should be implemented in a stepwise fashion as necessary.

Hein *et al*. (2013) found that prediction of risk prior to construction of a wind facility is highly variable and imprecise and acoustic data may not necessarily predict bat fatality. Species that are attracted to wind turbines, would use the site differently afterward than they did during pre-construction surveys.

Post-construction surveys and assessment

Post-construction bat survey protocol for Alberta has been described by Barclay and Baerwald (2015). Acoustic surveys should continue until the assessment of the effects of wind turbine operation on bats can be ascertained.

Bat fatality surveys should be conducted, and likely combined with bird fatality surveys for expediency. These surveys are conducted within a 50-m radius of the base of the turbine. The recommended search frequency is once every 7 days during the monitoring season (April 15-September 15), and every 3-7 days during bat migration (August 1-September 10). Searchers should follow line transects separated by 5-10 m. Fatalities are reported as fatalities per turbine per year and as fatalities per MW capacity per year.

Adaptive Management

Four to 8 fatalities per turbine per year of migratory bat species should lead to discussions with Environment Yukon about possible mitigation and further monitoring. Operational mitigation may not be necessary at this point. While there is no accepted bat fatality threshold to trigger operational mitigation, 8 fatalities or more per turbine per year is considered a high risk to bat populations. Additional considerations, such as bat population estimates, national (i.e., COSEWIC) status assessment of bat species, cumulative fatalities from all wind turbines in the development, and the proximity to other wind power developments are factors to consider when adopting mitigative measures.

Bat activity is reduced at higher wind speeds (greater than 6 m/s; see Arnett *et al*. 2016), so increasing cut-in speeds, for example from 4 to 5.5 metres per second can significantly reduce bat fatalities at wind turbines (by up to 93%) (Baerwald *et al*. 2009, Arnett *et al*. 2011). The cut-in speed of the Windmatic 17S can be modified in the turbine control system (A. Sandler, pers. comm., 2017).

Feathering the pitch angle of the turbine blades to 90° and parallel to the wind, and lowering the required generator speed for energy production also reduce bat fatalities (Baerwald *et al*. 2009, Young *et al*. 2011, report cited in Arnett *et al*. 2016). This mitigation option was termed low-speed idling by Baerwald *et al*. (2009). The Windmatic 17S turbine uses a fixed pitch stall regulated configuration which cannot be easily changed (C. Brothers, pers. comm., 2017).

Such operational mitigation methods may have small economic impacts to the proponent and may even extend the life of turbines. Studies that disclose power loss and economic costs of operational mitigation suggest that less than 1% of annual power is lost when mitigation is employed during high-risk periods for bat fatalities (Arnett *et al*. 2016).

Other methods of mitigating bat fatalities, such as broadcasting electromagnetic signals from radar units, or broadcasting ultrasound to interfere with bat ultrasonic calls, have not been adequately tested, and are not widely used (reviewed in Arnett *et al*. 2016).

Additionally, since bat activity is nocturnal (the period of activity is predicted to be 4 to 8 hours depending on the time of the year at the Kluane Lake wind turbine site) and seasonal (usually from mid-April to mid-September in Yukon), operational mitigation would only required for a brief period of the night for about 5 months, or possibly only during the migratory period (August 1 to September 10) each year.

References

Arnett, E.B., and E.F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. Pages 435-456 *in* R.A. Adams and S.C. Peterson, editors. Bat evolution, ecology, and conservation. Springer, New York, New York, USA.

Arnett, E.B., E.F. Baerwald, F. Mathews, L. Rodrigues, A. Rodrigues-Duran, J. Rydell, R. Villegas-Patraca, and C.C. Voigt. 2016. Impacts of wind energy development on bats: A global perspective. Pages 295-323 *in* C.C. Voigt and T. Kingston, editors. Bats in the Anthropocene: Conservation of bats in a changing world. 10.1007/978-3-319-25220-9_1. Springer Open (ebook).

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fielder, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.R. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61–78.

Arnett, E.B., M.M.P. Huso, M.R. Schirmacher, and J.P.Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9:209–214.

Baerwald, E.F., G.H. D'Amours, B.J. Klug, and R.M.R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18:695–696.

Baerwald, E.F., J. Edworthy, and R.M.R. Barclay. 2009. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management 73:1077–1081.

Brothers, C. 2017. General Manager, Frontier Power Systems, Charlottetown, PEI. Email communication with B. Slough, 24 January 2017.

Brown, W. K., and B. L. Hamilton. 2002. Draft report: bird and bat interactions with wind turbines Castle River Wind Farm, Alberta. Report for VisionQuest Windelectric, Inc., Calgary, Alberta, Canada.

Brown, W. K., and B. L. Hamilton. 2006a. Bird and bat monitoring at the McBride Lake Wind Farm, Alberta, 2003–2004. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada.

Brown, W. K., and B. L. Hamilton. 2006b. Monitoring of bird and bat collisions with wind turbines at the Summerview Wind Power Project, Alberta, 2005–2006. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada.

COSEWIC. 2013. COSEWIC assessment and status report on the Little Brown Myotis Myotis lucifugus, Northern Myotis *Myotis septentrionalis* and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxiv + 93 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Cryan, P.M. 2011. Wind turbines as landscape impediments to the migratory connectivity of bats. Environmental Law Vol. 41:355–370. https://www.lclark.edu/live/files/8520-412cryan. Accessed 1 April 2012.

Hatch. 2016. Kluane Community Development Corporation, Kluane Lake Wind-Diesel Project, Business Plan. 28 pages. [Confidential]

Hayes, M.A. 2013. Bats killed in large numbers at United States wind energy facilities. Bioscience 63:975-979.

Hemmera. 2012. Raptor and Migratory Bird and Bat Monitoring 2011. Prepared for Bear Mountain Wind Ltd. Vancouver (BC): Hemmera. 613-001.11.

Hemmera. 2013. Quality Wind Project – Bird and Bat Monitoring 2013 Annual Report. Prepared for Capital Power Corporation. Edmonton (AB): Hemmera. 670-002.09.

Horn J.W., E.B. Arnett, and T.H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72:123–132.

Lausen, C.L., Burles, D., Blejwas, k., Nagorsen, D., Govindarajulu, P., and L. Friis. 2016. Long-eared bat taxonomy: Nuclear genetic evidence eliminates the species status of Keen's Myotis (*Myotis* *keenii*). Presented at the Annual Meeting of the Society for Northwestern Vertebrate Biology, Coeur d'Alene, ID, February 22-26, 2016.

Mossop, D. 2015. Preliminary assessment of bird strike potential at wind farm site – Burwash Landing, YT. Interim Report: 2012 to 2014. Prepared for Kluane First Nation, Natural Resources Branch, Burwash Landing, YT. Yukon Research Centre, Yukon College. 15 pages.

Nagorsen, D.W., and B. Paterson. 2012. An update on the status of Red Bats, *Lasiurus blossevillii* and *Lasiurus borealis*, in British Columbia. Northwestern Naturalist 93:235–237.

Rollins, K.E., D.K. Meyerholz, G.D. Johnson, A.P. Capparella, and S.S. Loew. 2012. A forensic investigation into the etiology of bat mortality at a wind farm: barotrauma or traumatic injury? Veterinary Pathology 49:362–371.

Sandler, A. C. 2017. Frontier Power Systems, Charlottetown, PEI. Email communication with B. Slough, 25 January 2017.

Slough, B.G. 2015. Analysis and summary of full spectrum bat echolocation calls from the Nisutlin River Delta NWA, 2014. Unpublished Report. Prepared for Canadian Wildlife Service, Environment Canada, Whitehorse, YT. 9 pages.

Slough, B.G., and T.S. Jung. 2007. Diversity and distribution of the terrestrial mammals of the Yukon Territory: a review. Canadian Field-Naturalist 121:119-127.

Smallwood, K.S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:1089-1097.

Stantec. 2012. Dokie Wind Energy Project: 2012 Operational Wildlife Monitoring Final Report. Prepared for Dokie General Partnership. Burnaby (BC): Stantec Consulting Ltd.

Zimmerling, J.R., and C.M. Francis. 2016. Bat mortality due to wind turbines in Canada. Journal of Wildlife Management 80:1360-1369.

March 28, 2017

ISSUED FOR USE
FILE: ENG.WARC03183-01
Via Email: gm@kluanecorp.ca

Kluane Community Development Corp.
Box 61
Burwash Landing, YT Y0B 1H0

Attention: Mr. Colin Asselstine, General Manager

Subject: Geotechnical Evaluation – Kluane Wind Project
Approximately Kilometre 1688 – Alaska Highway, YT

1.0 INTRODUCTION

1.1 General

Kluane Community Development Corporation (KCDC) retained Tetra Tech Canada Inc. (Tetra Tech) to complete a geotechnical evaluation for a proposed wind power generation project on Kluane Lake at approximately Kilometre 1688 of the Alaska Highway. Mr. Colin Asselstine authorized the work by way of signed Services Agreement dated February 8, 2017.

1.2 Scope of Services

As presented in the Services Agreement submitted to KCDC on December 5, 2016, Tetra Tech's scope of services for this project includes the following:

- Complete a geotechnical testpitting program consisting of five testpits to characterize the subsurface at the project site; and
- Prepare a geotechnical report.

1.3 Project Location

The location of the project is presented in Figure 1. The project site is located to the northeast of the Alaska Highway, at approximately Kilometre 1688, between the highway and Kluane Lake.

2.0 REVIEW OF HISTORICAL INFORMATION

Tetra Tech reviewed available historical geotechnical information from the project site. The historical information has been used to supplement the geotechnical data collected during the 2017 site investigation. Historical borehole locations are presented in Figure 1.

Tetra Tech Canada Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

3.0 GEOTECHNICAL SITE INVESTIGATION

The geotechnical site investigation was completed on February 17, 2017. Boreal Engineering of Whitehorse, YT was retained by KCDC to excavate five testpits (TP17-01, -02, -03, -04, and -05) at the project site, as shown on Figure 1. The testpits were advanced to depths ranging between 4.8 and 5.2 m below ground surface. Prior to commencing the site investigation, KCDC confirmed that testpit locations were not near any underground utilities.

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

Upon completion of each tespit, the UTM coordinates were recorded with a handheld GPS and the testpits were backfilled with the excavated material.

4.0 SITE CONDITIONS

4.1 Surface Features

At the time of the geotechnical site investigation the project site was snow covered. TP17-01, and -05 were excavated in the vegetated area adjacent to the existing access road. TP17-03 and -04 were excavated in the large cleared site of the existing wind data collection tower. TP17-02 was excavated in the vegetated area adjacent to the cleared site of the existing wind data collection tower. Vegetation at the project site consisted of brush and coniferous trees. The topography of the site was uneven, but overall the site is sloping down to the east (towards Kluane Lake).

4.2 Subsurface Conditions

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

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

Table 1: Summary of Subsurface Soil Conditions

Soil Type	Strata Depth Range (m)				
	TP17-01	**TP17-02**	**TP17-01**	**TP17-01**	**TP17-01**
SILT	Surface to 1.3 m	Surface to 1.2 m	Surface to 1.4 m	Surface to 1.2 m	Surface to 0.9 m
SILT and SAND	-	-	1.4 – 3.0	-	-
SAND and GRAVEL TILL	1.3 – 5.0	1.2 – 5.2	3.0 – 4.8	1.2 – 5.2	0.9 – 5.0
END of TESTPIT	5.0	5.2	4.8	5.2	5.0

4.3 Groundwater Conditions

Groundwater was not encountered in any of the testpits.

4.4 Permafrost and Seasonal Frost

Permafrost was encountered in TP17-03 between approximately 1.4 and 4.2 m below ground surface.

Seasonal frost was encountered in each testpit, to depths ranging from 1.3 to 2.0 m below ground surface. Based on the soil profile and regional climate data, the maximum depth of seasonal frost can be assumed to be around 3.0 m below ground surface.

4.5 Bedrock

Bedrock was not encountered in any of the testpits.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Wind Turbine Footings

5.1.1 Site Preparation

Based on the results of the testpitting program, Tetra Tech considers the site appropriate for the installation of wind turbines supported by shallow foundations. Site preparation should be completed in accordance with the following recommendations:

- The existing ground beneath tower footings should be excavated to the underlying sand and gravel till. Based on the results of the testpitting program, this depth can range between 0.9 and 3.0 m;
- The excavations should be completed such that there is minimal disturbance to the native till encountered at the excavation bases. Tetra Tech recommends the excavation sidewalls be sloped no steeper than 3H:4V, and that any overhanging cobbles or large debris be removed from the sidewalls. Shoring methods should be used if steeper sidewall slopes are desired;
- The base of the excavations must be horizontal so that engineered fill pads of uniform thickness are created to support the towers, if footings are near surface. Buried footings may be cast directly onto the undisturbed till surface;
- Upon completion of the excavation, the exposed subgrade should be inspected by a qualified geotechnical engineer to confirm that suitable ground conditions have been encountered and to provide additional recommendations, if necessary;
- The native material overlying the sand and gravel till is not suitable for reuse and should be removed from the site following its excavation;
- The approved subgrade should be backfilled with 80 mm pit run gravel, placed in 300 mm lifts, moisture conditioned, and compacted to at least 98% Standard Proctor Maximum Dry Density (SPMDD);
- Where concrete will be cast, a minimum 150 mm thick layer of 20 mm crushed basecourse should be placed immediately below the underside of the concrete element. The basecourse should be moisture conditioned, and compacted to at least 98% SPMDD. This will provide a smooth, level bearing-surface on which to cast the

concrete element. The recommended gradations of both 80 mm pit run gravel and 20 mm basecourse are provided below in Table 2;

- The excavation must be protected from the inflow of surface water at all times; and
- Foundation elements should be not be cast directly onto or over seasonally frozen soils.

Table 2: Recommended Gradation for Granular Fill Materials

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

5.1.2 Foundation Design and Construction

5.1.2.1 Limit States Design

The 2015 edition of the National Building Code of Canada (NBCC 2015) stipulates that foundation design must be carried out using Limit State Design (LSD) methods. Under LSD, a minimum of two loading cases must be considered by geotechnical and structural designers; the Ultimate Limit State (ULS) and the Serviceability Limit State (SLS). The ULS and SLS bearing resistances are calculated differently. The ULS bearing resistance is the maximum pressure that can be applied to the soil without causing bearing failure. The SLS bearing pressure is the maximum allowable pressure required to limit the settlement to a tolerable amount. Both the ULS and SLS bearing resistances are highly dependent on soil properties and footing geometry, including the footing size, shape, and burial depth.

Resistance factors are applied to the calculated (unfactored) resistances to determine the maximum allowable factored design load. Geotechnical resistance factors for design of shallow foundations against vertical bearing failure (ULS), horizontal displacement (sliding under lateral loading), and overturning, per the NBCC 2015, are provided in Table 3.

Table 3: Geotechnical Resistance Factors - Shallow Foundations

Item	Resistance Factor
Vertical Bearing Resistance (ULS)	0.5
Sliding (ULS)	0.8
Overturning (ULS)	0.5

5.1.2.2 Foundation Recommendations

Buried footings are considered to be an acceptable foundation system for the wind turbines. As such, design and construction of the foundation should be undertaken in accordance with the following recommendations:

- For the purpose of design, Tetra Tech has assumed a footing thickness of 0.3 m and a minimum depth of cover of 0.9 m from finished grade to the underside of the footing for the wind tower foundations;
- Unfactored bearing resistances are provided based on minimum footing dimensions of 1.0 m square spread footings supporting the wind turbine. If significantly different footing sizes are preferred for this project, or if higher bearing resistance is required to support the design building loads, Tetra Tech should be notified to review and adjust the calculated bearing resistances, as necessary; and
- Unfactored bearing resistances for the wind turbine foundations are provided below in Table 4. SLS bearing pressures have been calculated based on 25 mm of tolerable elastic settlement, which is generally sufficient to limit total and differential settlement to tolerable levels.

Table 4: Unfactored Bearing Resistances

Limit State	Spread Footings 1.0 m Square
ULS	690 kPa
SLS	685 kPa

5.1.2.3 Seasonal Frost Protection

Seasonal ground frost-related movement is common in cold climates and occurs when three conditions are satisfied: the ground temperature is below freezing, frost-susceptible, fine-grained soils are present, and the soil pore space is near 100% saturation.

The native till at the project site is considered to be non-frost-susceptible because of its low moisture content. The overlying soils are considered to be frost-susceptible; however, these soils will be excavated and replaced with non-frost-susceptible granular fill. Therefore, additional frost protection will not be required for the wind turbine foundations.

5.2 Guy Anchors

5.2.1 Site Preparation

Site preparation for the installation of guy anchors should be completed in accordance with the following recommendations:

- The existing ground at guy anchor locations should be excavated to the depth directed by the structural engineer. The excavations should be completed such that there is minimal disturbance to the native till encountered at the excavation bases. Tetra Tech recommends the excavation sidewalls be sloped no steeper than 3H:4V, and that any overhanging cobbles, boulders, or large debris be removed from the sidewalls. Shoring methods should be used if steeper sidewall slopes are desired;
- The base of the excavations should be horizontal so that guys anchors are installed on a level surface;
- Upon completion of the excavation, the exposed subgrade should be inspected by a qualified geotechnical engineer to confirm that suitable ground conditions have been encountered and to provide additional recommendations, if necessary;
- Tetra Tech understands that the excavated native material will be used as backfill above the guy anchors, therefore it should be stockpiled nearby following its excavation. The approved subgrade should be backfilled with the native material, placed in 300 mm lifts, moisture conditioned, and compacted to at least 95% (SPMDD);

- Where concrete will be cast or placed, a minimum 150 mm thick layer of 20 mm crushed basecourse should be placed immediately below the underside of the concrete element. The basecourse should be moisture conditioned, and compacted to at least 98% SPMDD. This will provide a smooth, level bearing-surface on which to cast the concrete element. The recommended gradation of 20 mm basecourse is provided in Table 2 in Section 5.1.1;
- The excavation must be protected from the inflow of surface water at all times; and
- If the guy anchor elements are to be cast in place, they should be not be cast directly onto or over seasonally frozen soils.

5.3 Site Grading

The ground elevation at finished grade around wind turbine foundations and guy anchors should be at least 0.2 m above the surrounding grade to maintain positive drainage away from the buried concrete elements. Ponding and/or infiltration of water adjacent to the towers or guy anchors should be prevented, as this could have detrimental effects on the performance of the foundation systems.

5.4 Concrete

Concrete should be cast onto a clean, level, compacted, granular bearing surface. It is important that no loose and/or disturbed material be allowed to remain on the bearing surface. As noted above in Section 5.1, foundation bearing surfaces should consist of 20 mm crushed basecourse, moisture conditioned and compacted to at least 98% SPMDD.

Tetra Tech recommends that all concrete be designed, mixed, placed, and tested in accordance with the most recent edition of the Canadian Standards Association (CSA) Standard CAN/CSA-A23.1 and A23.2. According to these standards, concrete should be designed to at least satisfy the minimum durability requirements as defined by the exposure class.

The exposure class of the concrete is dependent on the presence or lack of chlorides, sulphates, freezing and thawing conditions, and the soil saturation. Based on the aforementioned conditions, the governing exposure class for the foundation system will be “F-2”. If the concrete will be exposed to any specialized chemicals used in the operation and maintenance of the new water treatment plant, it is recommended that Tetra Tech be given the opportunity to review the concrete class recommendation.

If winter construction is considered, Tetra Tech should be contacted and given the opportunity to review the contractor’s winter concrete placement procedures.

5.5 Soil Unit Weight and Moisture Content

The bulk unit weight of the sand and gravel till at the project site is approximately 2250 kg/m^3, with a moisture content between 2.0 and 10.0%. The bulk unit weight of the surficial silt at the project site is approximately 1800 kg/m^3, with a moisture content between 8.0 and 30%. The moisture contents of the samples collected during the geotechnical site investigation are presented in detail on the testpit logs attached to this report in Appendix B.

5.6 Angle of Internal Friction

The angle of internal friction of the sand and gravel till is approximately 30˚. The angle of internal friction of the surficial silt is approximately 25˚.

5.7 Coefficients of Active and Passive Earth Pressure

Active and passive earth pressures are the two stages of stress in a soil. The active earth pressure coefficient can be calculated using Equation 1, and passive earth pressure coefficient with Equation 2:

$$k_a = \frac{1-\sin\emptyset}{1+\sin\emptyset} \qquad \text{(Equation 1)}$$

$$k_p = \frac{1+sin\,\emptyset}{1-sin\,\emptyset} \qquad \text{(Equation 2)}$$

Using the angles of internal friction presented in Section 5.6 and Equations 1 and 2, the active and passive earth pressure coefficients calculated for the native soils at the project site are provided in Table 5:

Table 5: Coefficients of Earth Pressure

Earth Pressure Coefficient	Sand and Gravel Till **Φ = 30˚**	Surficial Silt **Φ = 25˚**
Active	0.33	0.41
Passive	3.0	2.5

5.8 Permafrost

The project site is located in a zone of discontinuous permafrost, as such permafrost should be expected during excavation for the turbine foundations and guy anchors. Due to its low moisture content (less than 10 %) and corresponding lack of excess ice, the sand and gravel till can be considered thaw-stable. The surficial silts are considered thaw-unstable. Where permafrost was encountered in the silt and sand overlying the till in TP17-03, the frozen material contained excess ice and had a high moisture content (greater than 30 %). As discussed in Sections 5.1 and 5.2, Tetra Tech recommends that turbine foundations and guy anchors be installed on the thaw-stable sand and gravel till, following the removal of the surficial silts.

6.0 CONSTRUCTION TESTING AND MONITORING

All foundation design recommendations presented are site-specific and based on the assumption that an adequate level of construction monitoring during foundation and guy anchor excavation and installation will be provided, and that all construction will be carried out by a suitably qualified, experienced contractor. An adequate level of construction monitoring also provides opportunity to verify that the recommendations based on geotechnical data obtained from the testpits are applicable to the entirety of the site. Appropriate Quality Assurance and Quality Control testing should be undertaken during construction to confirm that construction is completed in accordance with the recommendations provided in this report.

Furthermore, it is recommended that Tetra Tech be given the opportunity to review the details of the final design related to the geotechnical aspects of the foundation, prior to construction. Past experience has shown that this action may prevent inconsistencies, poor performance, and/or increased costs that may lead to disputes.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Kluane Community Development Corporation and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Kluane Community Development Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech Canada Inc.'s Services Agreement. Tetra Tech's General Conditions are provided in Appendix A of this report.

8.0 CLOSURE

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

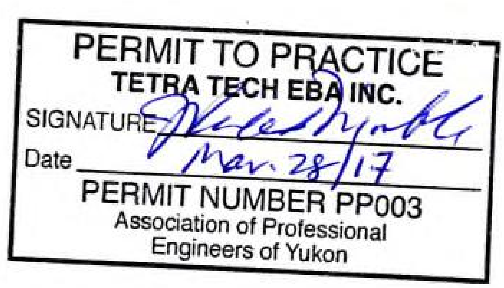
Respectfully submitted,
Tetra Tech Canada Inc.

Prepared by:
Taidhg Mulroy, E.I.T.
Geotechnical Engineer, Arctic Region
Direct Line: 867.668.9241
taidhg.mulroy@tetratech.com

Reviewed by:
J. Richard Trimble, M.Sc(Eng), P.Eng., FEC
Principal Consultant, Arctic Region
Direct Line: 867.668.9216
richard.trimble@tetratech.com

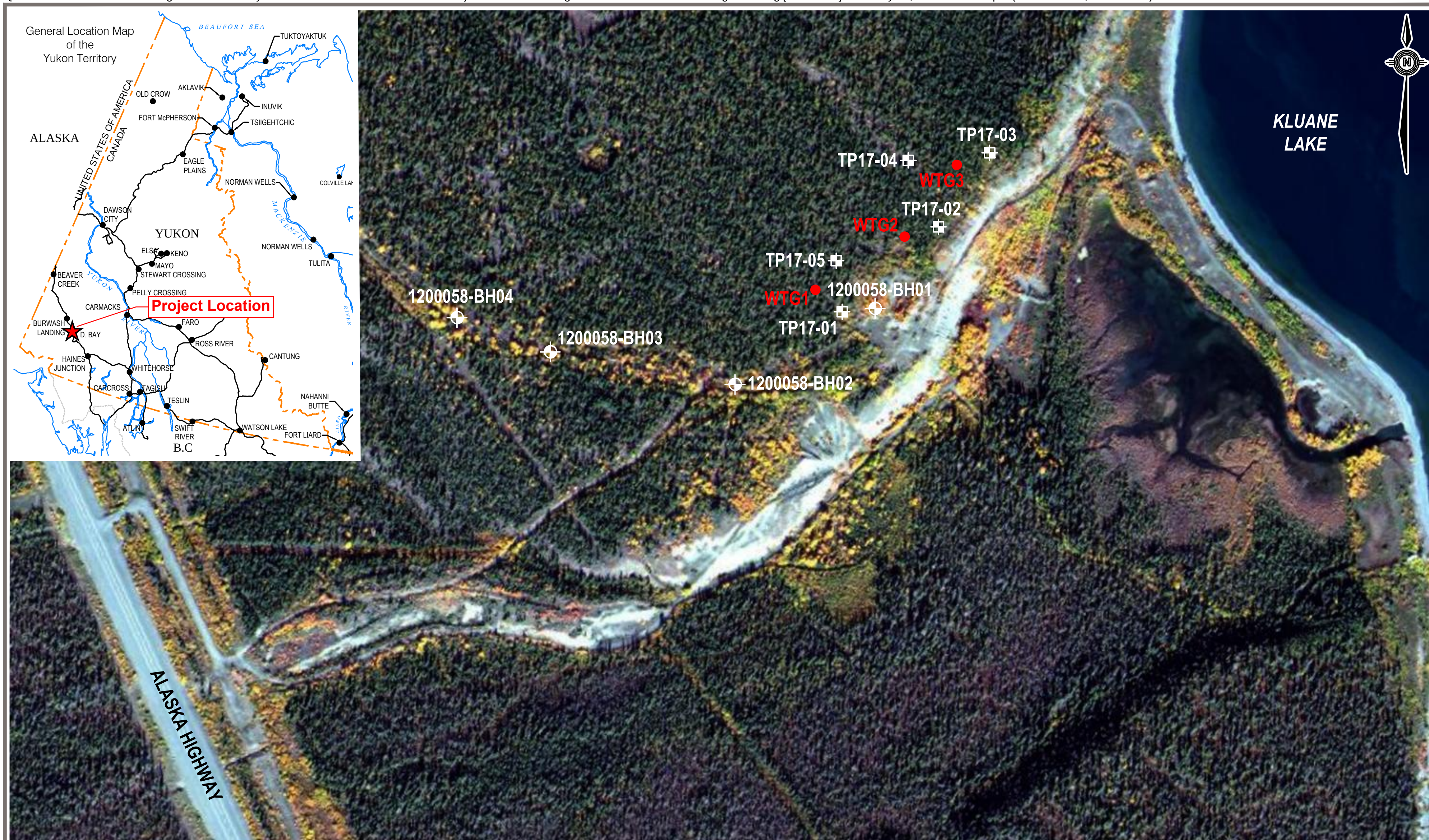
/chr

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



FIGURES

Q:\Whitehorse\Data\0201drawings\Destruction Bay\ENG.WARC03183-01 Kluane Wind Project Geotech Investigation\ENG.WARC03183-01 Fig.1-R0.dwg [FIGURE 1] February 23, 2017 - 3:39:42 pm (BY: BUCHAN, CAMERON)



LEGEND

- TESTPIT LOCATION
- HISTORICAL BOREHOLE LOCATION
- PROPOSED WIND TURBINE LOCATION

0 250m

Scale: 1:5,000 @ 8.5"x11"

CLIENT

TETRA TECH

KLUANE WIND PROJECT GEOTECHNICAL EVALUATION
DESTRUCTION BAY / BURWASH LANDING, YUKON

SITE PLAN SHOWING TESTPIT LOCATIONS

PROJECT NO.	DWN	CKD	REV
ENG.WARC03183-01	CB	TM	0

OFFICE	DATE
EBA-WHSE	February 23, 2017

Figure 1

APPENDIX A

TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

1.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of TETRA TECH's Client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH's Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the report, if required, may be obtained upon request.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH's instruments of professional service); only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

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

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

1.3 ENVIRONMENTAL AND REGULATORY ISSUES

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

1.4 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.5 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.6 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of testholes and/or soil/rock exposures. Stratigraphy is known only at the locations of the testhole or exposure. Actual geology and stratigraphy between testholes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.7 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.8 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.9 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.10 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.11 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.12 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.13 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.14 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

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

APPENDIX B

TESTPIT LOGS AND LABORATORY TEST RESULTS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

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

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

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

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

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

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

GENERAL DESCRIPTIVE TERMS

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

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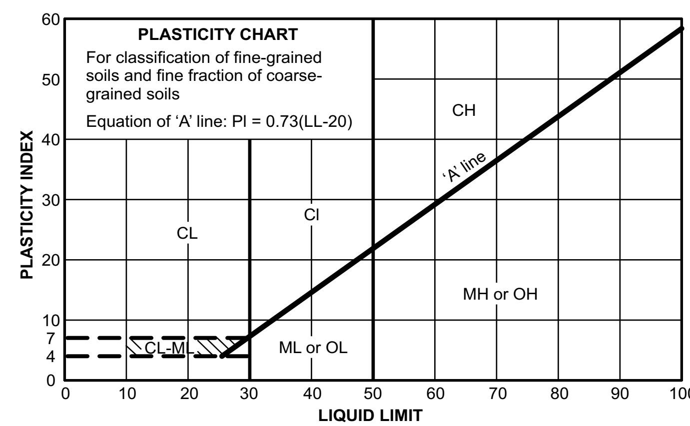
MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass 75 µm sieve: GW, GP, SW, SP More than 12% pass 75 µm sieve: GM, GC, SM, SC 5% to 12% pass 75 µm sieve: Borderline classification requiring use of dual symbols	$C_U = D_{60} / D_{10}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
	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 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 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 above 'A' line and plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS	Liquid limit <50	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity			
		Liquid limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
	CLAYS Above "A" line on plasticity chart negligible organic content	Liquid limit <30	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays			
		Liquid limit 30-50	CI	Inorganic clay of medium plasticity, silty clays			
		Liquid limit >50	CH	Inorganic clay of high plasticity, fat clays			
	ORGANIC SILTS AND CLAYS	Liquid limit <50	OL	Organic silts and organic silty clays of low plasticity			
		Liquid limit >50	OH	Organic clays of medium to high plasticity			
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils	* Based on the material passing the 75 mm sieve † ASTM Designation D 2487, for identification procedure see D 2488 USC as modified by PFRA		

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION
N	Nf	Poorly-bonded or friable
	Nbn	No excess ice, well-bonded
	Nbe	Excess ice, well-bonded

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION
V	Vx	Individual ice crystals or inclusions
	Vc	Ice coatings on particles
	Vr	Random or irregularly oriented ice formations
	Vs	Stratified or distinctly oriented ice formations

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions
	ICE	Ice without soil inclusions (greater than 25 mm thick

NOTES:

1. Dual symbols are used to indicate borderline or mixed ice classifications.
2. Visual estimates of ice contents indicated on borehole logs ± 5%
3. This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil ☐ Ice ■

Kluane First Nation

Borehole No: **TP17-01**

Project: Kluane Wind Project	Project No: WARC03183-01
Location: TP1	Ground Elev: 813 m
Burwash Landing/Destruction Bay, YT	UTM: 615588 E; 6796364 N; Z 7 NAD83

Method: Excavator

Depth (m)	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Elevation (m)
0	SILT - some sand, frozen, dark brown, some roots and organic inclusions in upper 0.5 m	Seasonally Frozen				813
	- light brown, trace organic inclusions		Grab	SA01	8.5	
1						812
	GRAVEL and SAND (TILL) - some silt, trace clay, trace cobbles, trace boulders, rounded to subrounded, well graded, frozen, grey		Grab	SA02	4.5	
2	- dry, compact (est.)	Unfrozen				811
			Grab	SA03	6.8	
3						810
			Grab	SA04	3.1	
4						809
			Grab	SA05	2.3	
5	END of TESTPIT at 5.0 m (Target Depth)					808
6						807
7						806
8						805
9						804
10						803

Plastic Limit / Moisture Content / Liquid Limit: 20 40 60 80

TETRA TECH

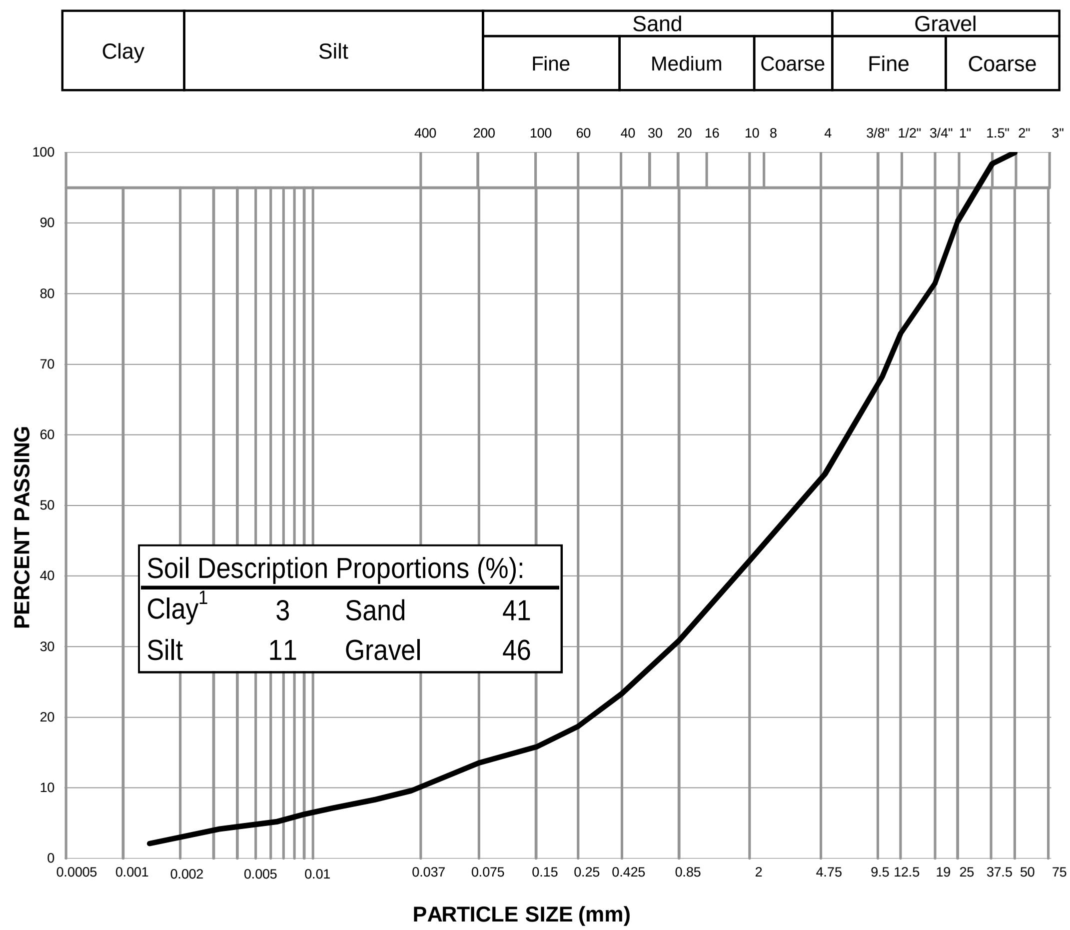
Contractor: Boreal Engineering	Completion Depth: 5 m
Drilling Rig Type: CAT 330D L	Start Date: 17 February 2017
Logged By: TM	Completion Date: 17 February 2017
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Kluane Wind Project	Sample No.:	SA04
Project No.:	ENG.WARC03183-01	Material Type:	
Site:	Kluane Lake - North Shore	Sample Loc.:	TP17-01
Client:	Kluane First Nation	Sample Depth:	3.4 m
Client Rep.:	Colin Asselstine	Sampling Method:	Grab
Date Tested:	March 1, 2017 By: AT	Date sampled:	
Soil Description[2]:	GRAVEL and SAND - some silt, trace clay	Sampled By:	TM
		USC Classification:	Cu: 187.0
Moisture Content:	3.1%		Cc: 2.4

Particle Size (mm)	Percent Passing
75	
50	100
38	98
25	90
19	81
12.5	74
10	68
5	54
2	42
0.85	31
0.425	23
0.25	19
0.15	16
0.075	13.5
0.0332	9.6
0.0214	8.3
0.0126	7.1
0.0090	6.3
0.0065	5.2
0.0032	4.2
0.0014	2.1



Soil Description Proportions (%):			
Clay[1]	3	Sand	41
Silt	11	Gravel	46

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: [signature] P.Eng.

Kluane First Nation

Borehole No: **TP17-02**

Project: Kluane Wind Project	Project No: WARC03183-01
Location: TP2	Ground Elev: 810 m
Burwash Landing/Destruction Bay, YT	UTM: 615676 E; 6796442 N; Z 7 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Excavator	SILT - trace sand, frozen, light brown, some roots and organic inclusions, organic odour	Seasonally Frozen					810
		- light grey		■	SA21	14.4	●	
1								809
		SAND (TILL) - silty, gravelly, trace clay, trace cobbles, trace boulders, well graded, frozen, grey - dry, compact (est.)						
2		- some cobbles	Unfrozen	■	SA22	9.4	●	808
3								807
				■	SA23	6.5	●	
4								806
				■	SA24	6.5	●	
5				■	SA25	6.5	●	805
		END of TESTPIT at 5.2 m (Target Depth)						
6								804
7								803
8								802
9								801
10								800

TETRA TECH

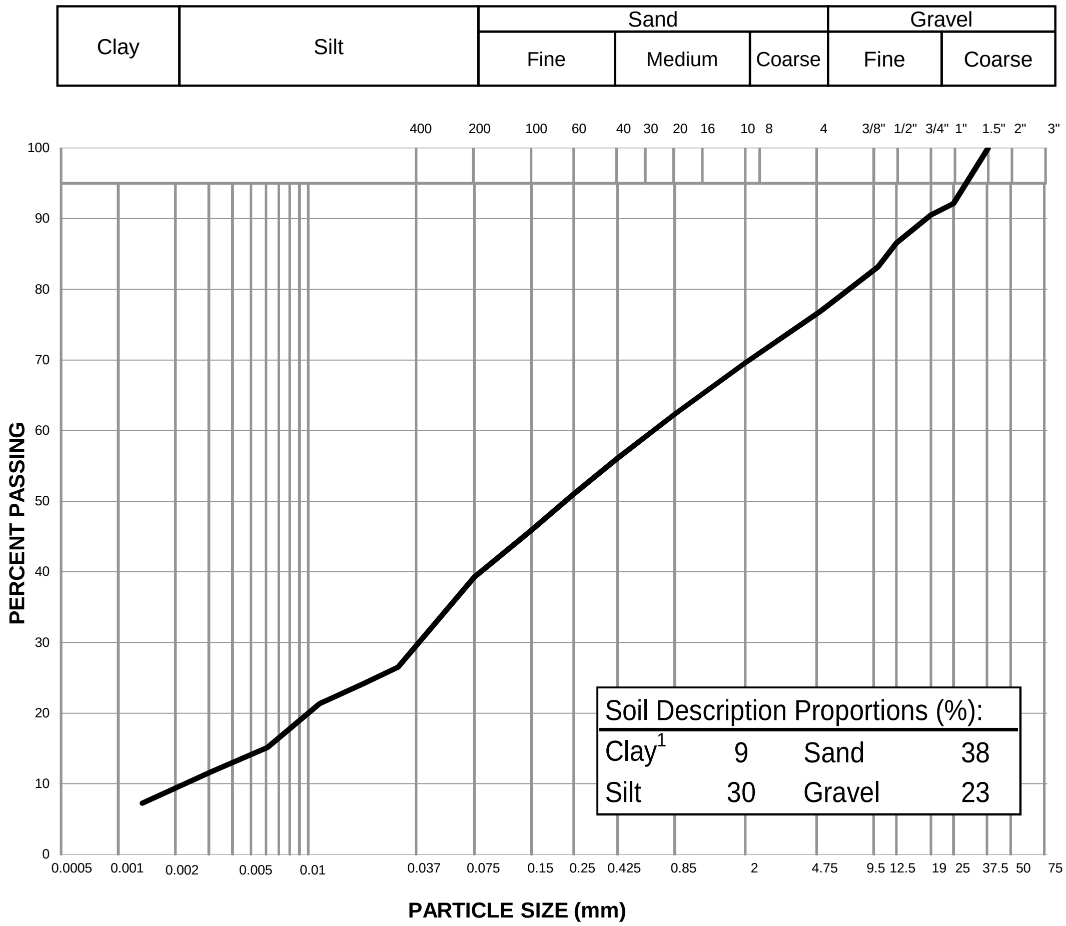
Contractor: Boreal Engineering	Completion Depth: 5.2 m
Drilling Rig Type: CAT 330D L	Start Date: 17 February 2017
Logged By: TM	Completion Date: 17 February 2017
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Kluane Wind Project	Sample No.:	SA23
Project No.:	ENG.WARC03183-01	Material Type:	
Site:	Kluane Lake - North Shore	Sample Loc.:	TP17-02
Client:	Kluane First Nation	Sample Depth:	3.5 m
Client Rep.:	Colin Asselstine	Sampling Method:	Grab
Date Tested:	March 1, 2017 By: AT	Date sampled:	
Soil Description[2]:	SAND - silty, gravelly, trace clay	Sampled By:	TM
		USC Classification:	Cu: 286.2
Moisture Content:	6.5%		Cc: 1.1

Particle Size (mm)	Percent Passing
75	
50	
38	100
25	92
19	91
12.5	87
10	83
5	77
2	70
0.85	62
0.425	56
0.25	51
0.15	46
0.075	39.2
0.0297	26.5
0.0193	24.1
0.0115	21.3
0.0084	18.2
0.0061	15.1
0.0031	11.7
0.0013	7.2



Soil Description Proportions (%):			
Clay[1]	9	Sand	38
Silt	30	Gravel	23

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: _______________ P.Eng.

TETRA TECH

Kluane First Nation

Borehole No: **TP17-03**

Project: Kluane Wind Project	Project No: WARC03183-01
Location: TP3	Ground Elev: 805 m
Burwash Landing/Destruction Bay, YT	UTM: 615723 E; 6796510 N; Z 7 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Elevation (m)
0	Excavator	SILT - sandy, frozen, greyish brown, some roots and organic inclusions in upper 0.4 m	Seasonally Frozen				805
				■	SA16	26.1	
1							804
		- dry, soft (est.)	Unfrozen				
		SILT and SAND - trace clay, well graded, frozen, brown	Permafrost - Nbe				
				■	SA17	40.9	
2							803
		- trace gravel		■	SA18	37.9	
3		SAND (TILL) - gravelly, silty, trace clay, trace cobbles, trace boulders, well graded, frozen, grey					802
4				■	SA19	13	801
		- dry, dense (est.)	Unfrozen				
				■	SA20	8.4	
		END of TESTPIT at 4.8 m (Target Depth)					
5							800
6							799
7							798
8							797
9							796
10							795

Plastic Limit — Moisture Content — Liquid Limit: 20 40 60 80

TETRA TECH

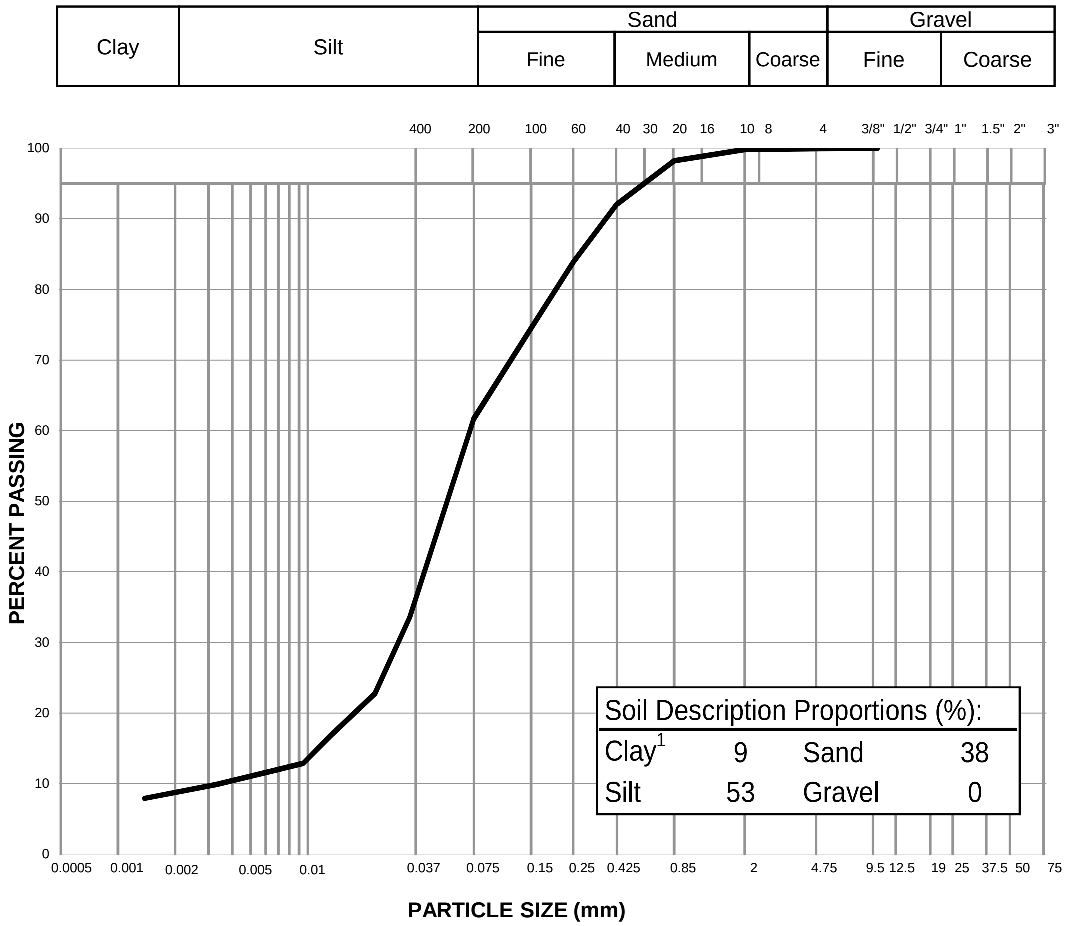
Contractor: Boreal Engineering	Completion Depth: 4.8 m
Drilling Rig Type: CAT 330D L	Start Date: 17 February 2017
Logged By: TM	Completion Date: 17 February 2017
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Kluane Wind Project	Sample No.:	SA18
Project No.:	ENG.WARC03183-01	Material Type:	
Site:	Kluane Lake - North Shore	Sample Loc.:	TP17-03
Client:	Kluane First Nation	Sample Depth:	2.7 m
Client Rep.:	Colin Asselstine	Sampling Method:	Grab
Date Tested:	March 1, 2017 By: AT	Date sampled:	
Soil Description[2]:	SILT and SAND - trace clay	Sampled By:	TM
		USC Classification:	Cu: 20.7
Moisture Content:	37.9%		Cc: 3.7

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	100
0.85	98
0.425	92
0.25	84
0.15	74
0.075	61.7
0.0345	33.6
0.0225	22.7
0.0132	16.8
0.0095	12.8
0.0067	11.9
0.0033	9.9
0.0014	7.9



Soil Description Proportions (%):			
Clay[1]	9	Sand	38
Silt	53	Gravel	0

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: P.Eng.

TETRA TECH

Kluane First Nation

Borehole No: **TP17-04**

Project: Kluane Wind Project	Project No: WARC03183-01
Location: TP4	Ground Elev: 811 m
Burwash Landing/Destruction Bay, YT	UTM: 615649 E; 6796503 N; Z 7 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Excavator	SILT - trace sand, frozen, light brown, trace roots organic inclusions	Seasonally Frozen		SA11	10	●	811
1		SAND and GRAVEL (TILL) - silty, some cobbles, trace clay, trace boulders, well graded, rounded to subrounded, frozen, grey						810
2		- dry, compact (est.)	Unfrozen		SA12	4.7	●	809
3		- some clay			SA13	5.9	●	808
4					SA14	6.9	●	807
5					SA15	6.3	●	806
5.2		END of TESTPIT at 5.2 m (Target Depth)						
6								805
7								804
8								803
9								802
10								801

TETRA TECH

Contractor: Boreal Engineering	Completion Depth: 5.2 m
Drilling Rig Type: CAT 330D L	Start Date: 17 February 2017
Logged By: TM	Completion Date: 17 February 2017
Reviewed By: JRT	Page 1 of 1

Kluane First Nation

Borehole No: **TP17-05**

Project: Kluane Wind Project	Project No: WARC03183-01
Location: TP5	Ground Elev: 814 m
Burwash Landing/Destruction Bay, YT	UTM: 615582 E; 6796411 N; Z 7 NAD83

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Excavator	SILT - trace to some sand, frozen, light brown, some roots and organic inclusions	Seasonally Frozen					814
1		SAND and GRAVEL (TILL) - some silt, trace cobbles, trace clay, well graded, rounded to subrounded, frozen, grey		Grab	SA06	20.4	●	813
2		- dry, compact (est.) - some cobbles, trace boulders	Unfrozen	Grab	SA07	5.3	●	812
3				Grab	SA08	2.6	●	811
4				Grab	SA09	5.8	●	810
5		END of TESTPIT at 5.0 m (Target Depth)		Grab	SA10	6.3	●	809
6								808
7								807
8								806
9								805
10								804

TETRA TECH

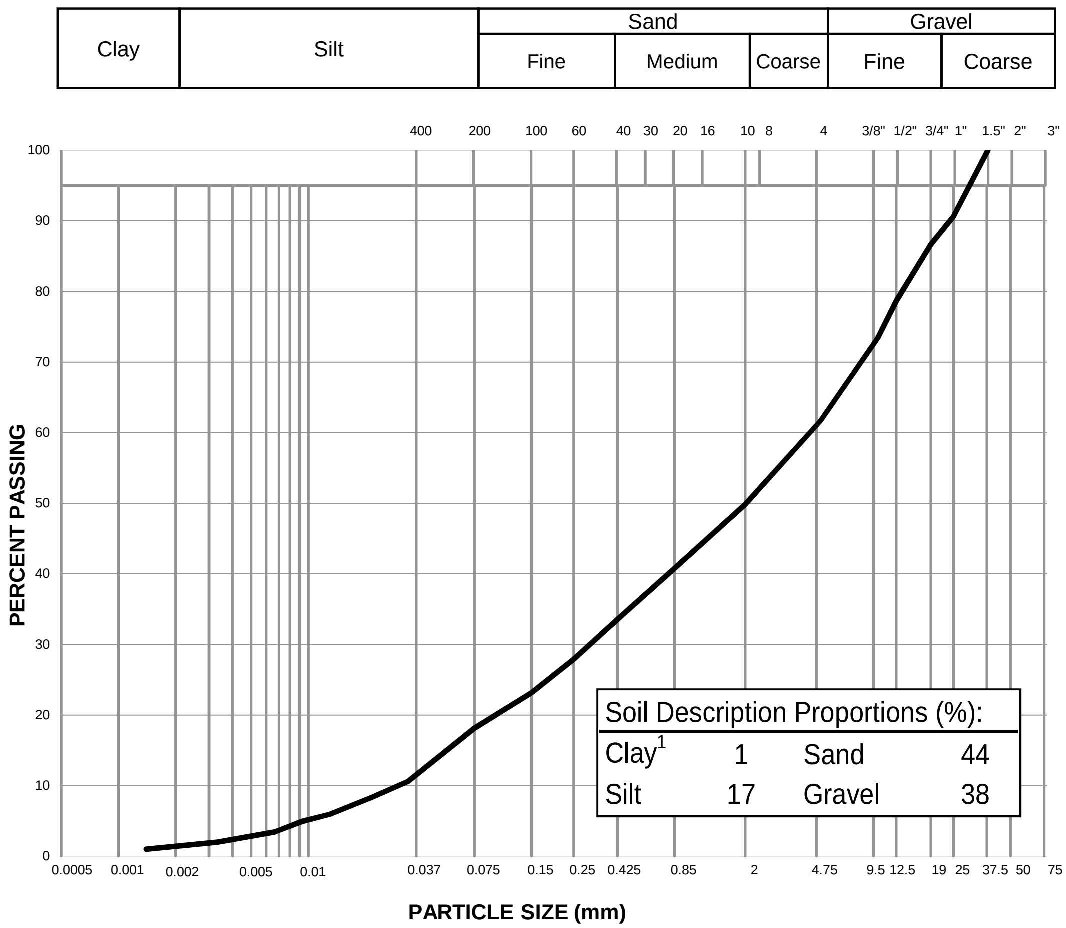
Contractor: Boreal Engineering	Completion Depth: 5 m
Drilling Rig Type: CAT 330D L	Start Date: 17 February 2017
Logged By: TM	Completion Date: 17 February 2017
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Kluane Wind Project	Sample No.:	SA08
Project No.:	ENG.WARC03183-01	Material Type:	
Site:	Kluane Lake - North Shore	Sample Loc.:	TP17-05
Client:	Kluane First Nation	Sample Depth:	2.8 m
Client Rep.:	Colin Asselstine	Sampling Method:	Grab
Date Tested:	March 1, 2017 By: AT	Date sampled:	
Soil Description[2]:	SAND and GRAVEL - some silt, trace clay	Sampled By:	TM
		USC Classification:	Cu: 150.5
Moisture Content:	2.6%		Cc: 0.7

Particle Size (mm)	Percent Passing
75	
50	
38	100
25	91
19	87
12.5	79
10	73
5	62
2	50
0.85	41
0.425	34
0.25	28
0.15	23
0.075	18.1
0.0336	10.6
0.0218	8.4
0.0130	5.9
0.0093	4.9
0.0067	3.5
0.0033	2.0
0.0014	1.0



Soil Description Proportions (%):

Clay[1]	1	Sand	44
Silt	17	Gravel	38

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: [signature] P.Eng.