Fort Liard Wind Site Potential Study

Prepared for

AURORA RESEARCH INSTITUTE
AURORA COLLEGE

by

Jean-Paul Pinard, P. Eng., PhD.
703 Wheeler St., Whitehorse, Yukon Y1A 2P6
Tel. (867) 336-2977, jpp@northwestel.net

and

Annika Trimble (Ed.), Aurora Research Institute
191 Mackenzie Road, Inuvik, NT X0E 0T0
Phone: (867) 777-3298, atrimble@auroracollege.nt.ca

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Executive Summary

This project is part of the assessment of potential sites for wind energy development in the Northwest Territories. This report provides an assessment of the wind speed potential that may exist near Fort Liard, particularly on the nearby Mt Coty.

For this study, the government of NWT has preselected a site of interest that is at 700 m above sea level (ASL) and about 6.3 km north-northwest of Fort Liard. The purpose of this study is to evaluate what the expected long term wind speeds are at this site and to determine whether to follow through to the next stages of investigating the wind potential for Fort Liard.

For most wind projects in the north, a long term annual mean wind speed of at least 6.0 m/s is desirable for considering their economics. Wind speeds at the Fort Liard airport (213 m ASL) show mean annual wind speeds of 2.76 m/s measured at 10 m above ground level (AGL). The dominant wind direct at the airport is from the northeast with a smaller component from the southwest. Weather balloon measurements from Ft Nelson and Norman Wells indicate the long term annual mean wind speeds at 700 m ASL are 5.6 and 7.0 m/s, respectively.

Wind modelling results from the AWS Truepower's WindNavigator website estimate 50 m (turbine hub height) wind speeds of 7.04 and 7.39 m/s at 600 and 700 m ASL, respectively, on the Mt Coty ridge. The model also indicates that the dominant winds are from the northeast.

While there is a small amount of uncertainty in the wind model and in projecting the measured winds to the Mt Coty ridge, the estimates indicate that the selected site has promise. It is recommended that a met station be installed at the site to measure the wind for two years. Icing is expected and it is recommended that heated instruments be used, which will require power at the site. There is a forest station at the peak of the ridge and it may be more effective to situate the wind monitoring station there.

Introduction

There is a desire to investigate the potential for developing wind energy for the remote diesel-powered community of Fort Liard. Fort Liard has a population of 536 (2011 statistic), and is in the southwest corner of the NWT along the Liard Highway (Figure 1). Fort Liard diesel electricity use forecast for 2016 through to 2019 was approximately 2,300,000 kWh/year (NTPC, 2016). The average load was 320 kW and peak was about 550 kW. Wind projects in the range of 500 to 1,000 kW would likely be recommended for this community and wind turbines with hub heights of 50 m may be most suitable.

For most wind projects in the north a long term annual mean wind speed of at least 6.0 m/s is desirable for considering their economics. Even more desirable is wind energy that is more plentiful during the winter months to meet the increased electricity demand. However, those stronger winter winds can be impacted by winter inversions at lower elevations.

Inversions occur during the winter months when normal atmospheric conditions (cool air above, warm air below) become inverted. Inversions trap a dense layer of cold air under a layer of warm air. Even very shallow valleys can act like a bowl, with cold, dense air pooling at the bottom. The snow-covered valley floors reflect rather than absorb the heat from the sun, preventing the normal vertical mixing of warm and cold air. The cold heavy air tends to prevent the stronger winter winds above from reaching down toward the surface. Therefore, elevation is an important consideration in wind energy investigations.

While the Liard Highway is at 310m ASL, the community is down in the valley next to the Liard River, at an elevation of 210 m ASL. Across the river there is Mount Coty which peaks at 823 m ASL (Figures 2, 3 and 4). Mount Coty is at the south end of the Liard Range, a long ridge that extends north-northwest from to the Mackenzie Mountains.

This study explores the local weather station data, regional upper air data, and wind modelling maps to determine an estimate of the long term annual mean wind speed at Mt Coty. Conclusions and recommendations for collecting wind data follow.

Sites for Wind Measurements

Mt Coty is a north-northwest-oriented ridge which reaches a height of 600 m ASL starting at about 5.3 km north-northeast of Ft Liard, and peaks to 823 m ASL at the location of a forestry lookout station, 7.5 km north-northwest of Fort Liard. The GNWT has preselected a site of interest for wind power on the Mount Coty ridge just south of its peak, located at 702 m ASL (Figure 3) and 6.2 km from Fort Liard. Both the 600 and 700 m ASL sites seem heavily forested, however, the forestry station appears to have open spaces around the main building (Figure 5). If the forestry station is not an option for wind monitoring, then an area may need to be cleared for a meteorological tower.

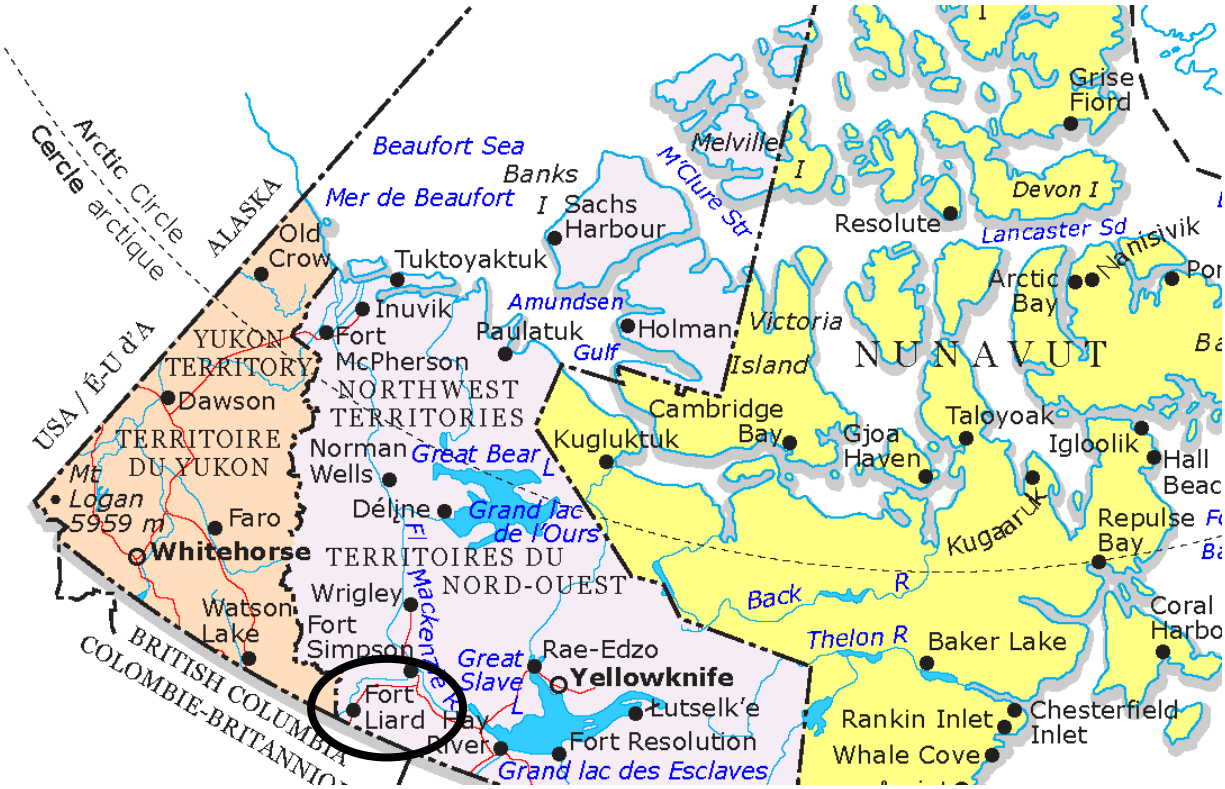

Figure 1: Fort Liard is located on the Liard River 540 km west-southwest of Yellowknife.

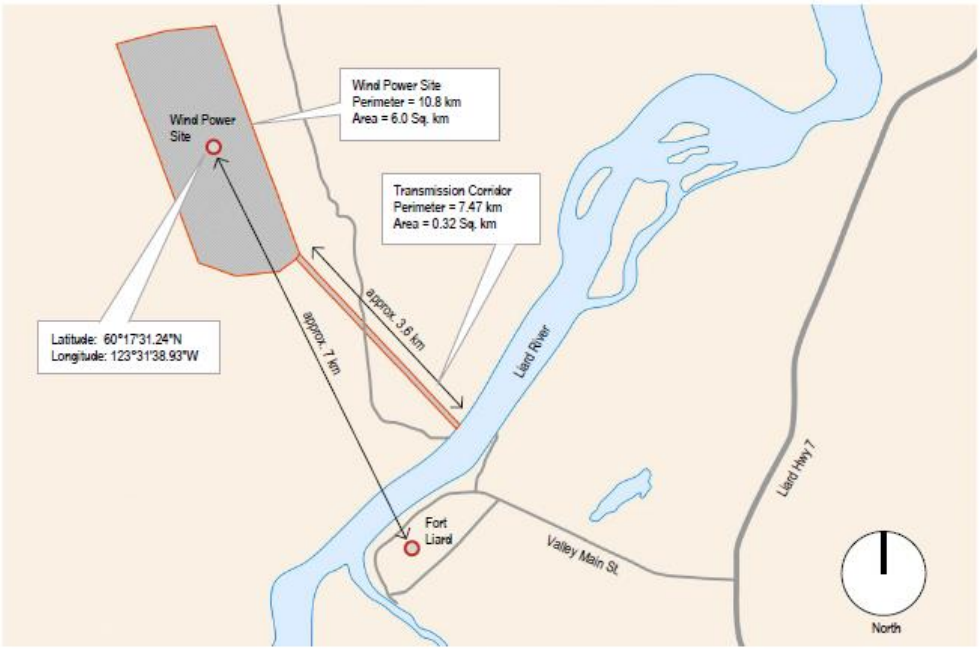

Figure 2: Map showing the preselected site for a potential wind project.

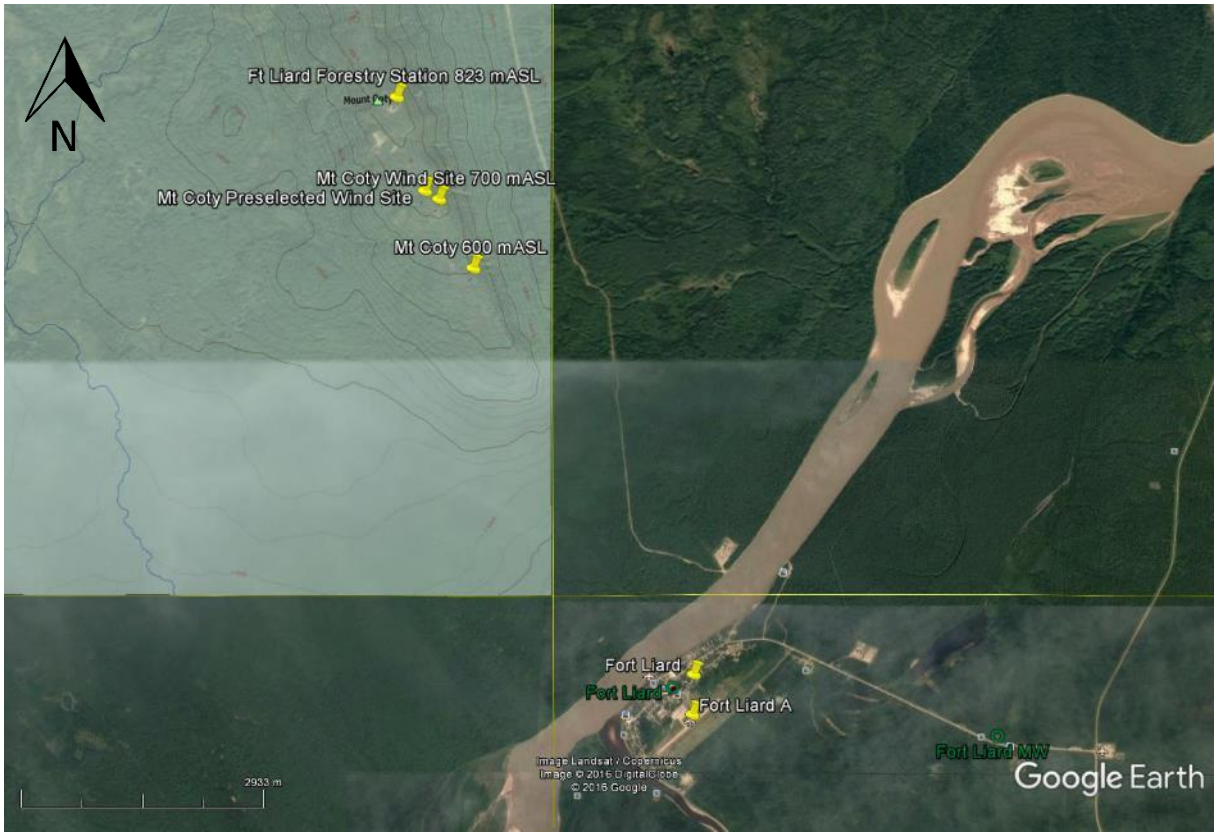

Figure 3: Map of Fort Liard and area showing Mt Coty and the Liard Highway. The Fort Liard Airport is next to the community and the weather station is indicated by "Fort Liard A". Mt Coty sites include the preselected GNWT site, and sites used in wind modelling at 600 m ASL and 700 m ASL.

Figure 4: Photo of the Fort Liard airport with two Environment Canada weather stations, and Mount Coty in the background.

Figure 5: Aerial image of the forestry station located at the peak of Mount Coty at 823 m ASL.

Analysis of Nearby Wind Measurements

Wind measurements used for this study are from the surface station at the Fort Liard airport, and from the upper air, or weather balloon, stations in nearby Fort Nelson and Norman Wells.

Wind speed measurement at the Fort Liard airport were downloaded from the Environment Canada website for the years 2012 to 2016. The weather station measurements show mean annual wind speeds of 2.76 m/s at 10 m height and 213 m above sea level. The strongest winds appear to be during the months of January to May with April being the highest at 3.5 m/s, and July the lowest at 2.12 m/s. The dominant wind direct at the airport is from the northeast with a smaller component from the southwest. This follows the Liard River valley at this location. Both graphs are shown in Figure 6.

Weather balloons released by Environment Canada gather wind data several hundred meters above the ground, and contribute to the data used by the wind modelling program. The nearest weather balloon station is Fort Nelson, which is located 170 km south-southwest of Fort Liard. The Norman Wells station is about 580 km north-northwest of Fort Liard. The upper air measurements released at Fort Nelson and the Norman Wells were compiled and the long term annual mean wind speeds at 700 m ASL were calculate to be 5.6 and 7.0 m/s for Fort Nelson and Norman Wells, respectively. At 700 m ASL the dominant winds above both Fort Nelson and Norman Wells are from the northwest. These two locations are south and north, respectively, of the Mackenzie Mountains, which are the dominant land forms northwest of

Fort Liard. Because of this dominant mountain range it is expected that the main wind direction will not be from the northwest but more aligned with the local valley in the lee of the Mackenzie Mountains.

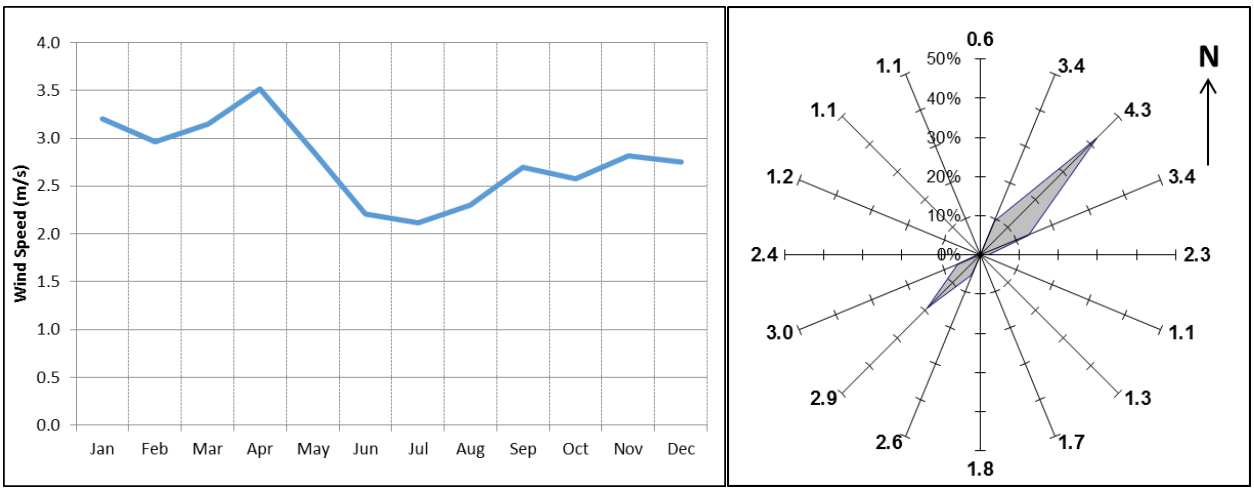

Figure 6: Monthly average wind speed and wind rose at the Fort Liard airport weather station for the years 2012 to 2016. The tower is 10 m tall and located at the airport, which is at 213 m ASL.

Wind Modelling

The AWS Truepower's WindNavigator wind model map was used to estimate the wind speeds on the Mount Coty ridge. The modelling tool uses topography, roughness, and vegetation surface data, as well as 15 years of global reanalysis, weather balloon, and weather station data for mesoscale simulation on a 2.5 km grid. The mesoscale data is then simulated at a microscale level with 200 m grid resolution using local terrain elevation and surface roughness and adjusted using local weather station data (in this case this would be the Fort Liard airport station). The numerical modelling tool is accessible with an account through their website at https://dashboards.awstruepower.com/wsa.

For validation, some of the wind speeds calculated by the wind model were compared to measurements at the Snare and Jackfish towers located on the Snare grid in the Yellowknife area. The validation results are described in Pinard (2017). The wind model had slightly overestimated the wind speeds compared to on-site measurements, but results were well within the uncertainty of ± 0.35 m/s that is indicated by AWS Truepower.

Since the most appropriate turbines for a local wind project would be 30 or 50 m tall, wind speeds were calculated at 30 m and 50 m above ground level, for various elevations along the Mt Coty ridge. According to the wind model, the long term wind speed at the 700 m ASL site was calculated to be 7.39 m/s at 50 m AGL (Figure 7). At the same site the model calculated a wind speed of 6.91 m/s at the 30 m hub height. At the lower site at 600 m ASL, the calculated wind speed was 7.04 m/s at 50 m AGL. Choosing the 700 m ASL location as the site of choice for further investigation, one can make a conservative conclusion that

the wind speeds there are expected to be at least 6.56 m/s (6.91 – 0.35 m/s) and 7.04 m/s at 30 and 50 m ASL, respectively. For comparison, the modelled wind speeds are also shown for the forestry station at 823 m ASL and those are shown in Table 1.

The model also estimates that the windiest months at the 700 m ASL site are from September to March with December being the fastest at about 8 m/s and April and July being the slowest at about 6.9 m/s (at 50 m AGL). The model calculated a wind rose that indicates the most dominant winds are from the north-northeast with a smaller component from the southwest. Both dominant wind directions are nearly perpendicular to the ridge. Both graphs are shown in Figure 8.

Table 1: Comparison of long term annual mean wind speeds calculated from the wind model at different locations on Mount Coty.

	Mt Coty 600 m ASL Site		Mt Coty 700 m ASL Site		Mt Coty 823 m ASL Site	
Turbine Hub Height	30 m	50 m	30 m	50 m	30 m	50 m
Estimated Long Term Mean Wind Speeds	6.54 m/s	7.04 m/s	6.91 m/s	7.39 m/s	6.93 m/s	7.42 m/s
Conservative estimate (model uncertainty accounted for)	6.19 m/s	6.69 m/s	6.56 m/s	7.04 m/s	6.58 m/s	7.07 m/s

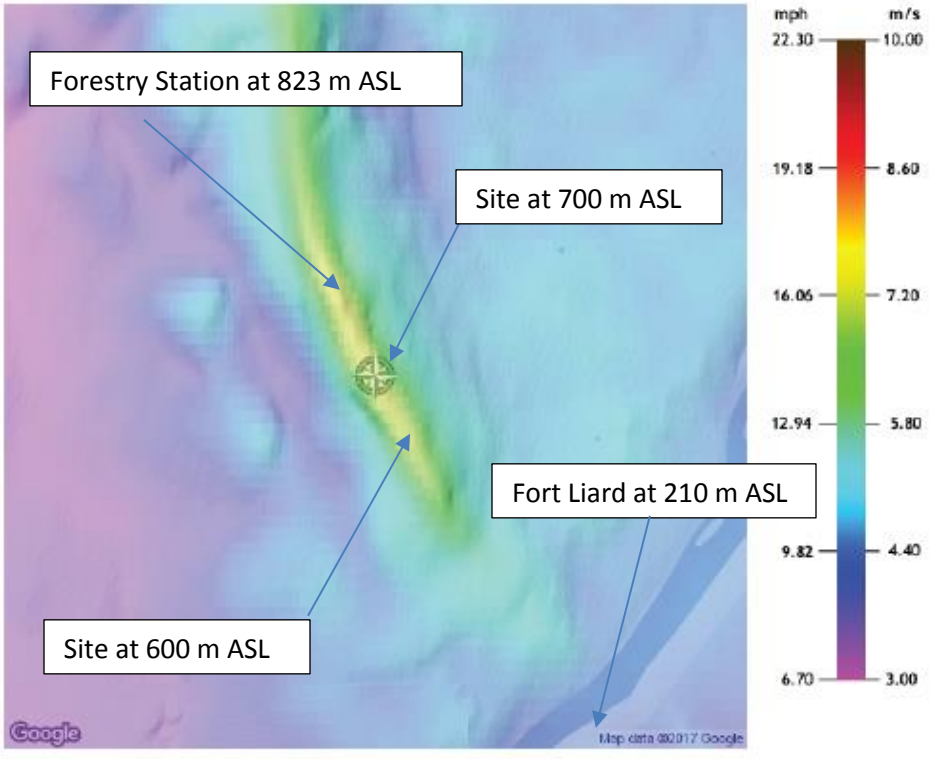

Figure 7: Mean annual wind speed map at 50 m hub height on Mount Coty. The selected site at 700 m ASL on Mount Coty is calculated to be 7.39 m/s at a 50 m AGL.

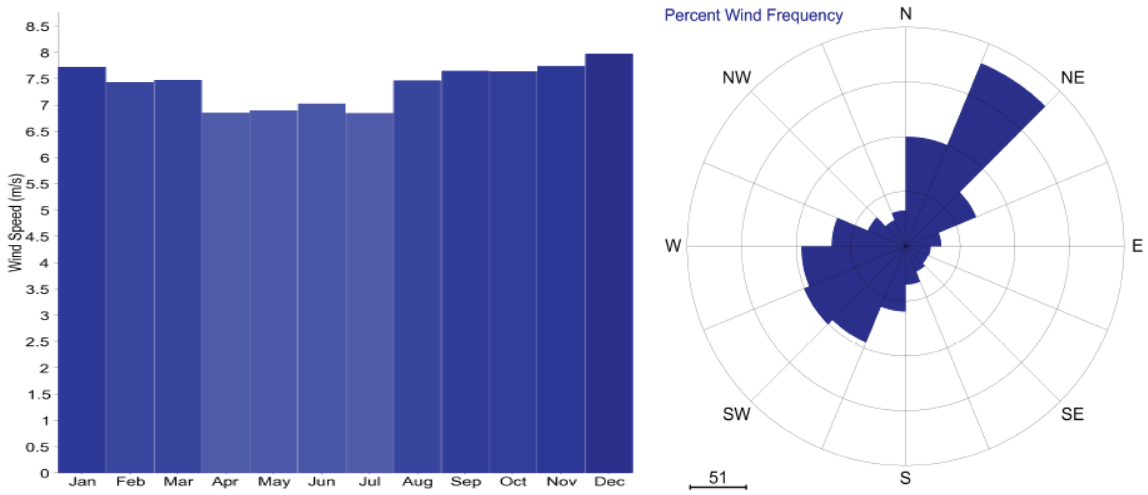

Figure 8: Monthly mean wind speeds and wind rose and for 50 m hub height at the 700 m ASL site shown in Figure 7. Wind speeds are highest in the winter months, and dominant winds are from the northeast.

Conclusions and Recommendations

The upper air measurements indicate a wide-ranging difference in wind speeds at the 700 m ASL site for Mt Coty. The wind model indicates some uncertainty in the calculated long term wind speeds. Comparison of the modelled wind speeds with two site measurements concluded that the wind model calculation are within the uncertainty and slightly optimistic. A conservative estimate of the wind speed on Mount Coty at the site of interest, at 700 m ASL, would be at least 6.56 and 7.04 m/s at 30 and 50 m AGL, respectively. These wind speeds should be economically viable for the development of a wind farm at Mount Coty, though costs would need to be explored further to properly assess financial viability of a wind project.

It is recommended that measurements be carried out to confirm the wind speed estimates at Mount Coty. The site at 700 m ASL appears to be heavily forested and would need additional clearing. The forestry station is within an area cleared of forest and could be a good candidate for a meteorological tower. The site on Mount Coty will likely have icing and so heated wind instruments would be required.

References

NTPC, 2016, **NTPC General Rate Application 2016/19**. Yellowknife, NT.

Pinard, JP, and Annika Trimble (Ed.), 2017, **Yellowknife Area Wind Potential.** Prepared for Aurora Research Institute, Inuvik, NT.

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