Appendix B

Noise Assessment Reports

GL Garrad Hassan

Document Details

Title	**Preliminary Wind Resource Assessment of the Watford Wind Farm**
Client	**Green Breeze Energy Inc.**
Document	**879/OT/01**
Author	**Chrystel Alzin and Ana Poenariu**
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Checked	**Éric Desrosiers**
Approved	**Clint Johnson**

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Introduction

Green Breeze Energy Inc. (Green Breeze) has requested that Helimax Energy Inc. ("GLGH"), a member of the GL group and part of the GL Garrad Hassan brand, conduct an independent preliminary assessment of the wind speed at the Watford Wind Farm, and provide a preliminary energy prediction. Also a preliminary constraint analysis has been undertaken in order to optimize the layout. The results of this work are reported here.

The proposed project is located in Lambton County, Ontario, approximately 4 km south-west of Watford, and 40 km east of Sarnia. The Watford project measurement campaign currently consists of one 60 m tall XHD-type meteorological mast. From analysis of topographic maps of the area, the proposed wind farm is situated in flat agricultural terrain punctuated with small woodlots, houses and barns, as seen in Figure 1.

GLGH staff visited the site on August 12, 2010. The area is comprised primarily of farm land with large fields. There are homes, farms and barns interspersed throughout the site, as well as small areas of low trees ranging from approximately 1.5 m to 8 m in height. The general terrain at the site can be described as simple. The topography and ground cover in the surrounding region are similar to the site. A panoramic view of the site from Mast GB29119 is shown in Figure 2.

This document provides a summary of the analysis of the wind regime at the meteorological mast, presents the setbacks applied to the exclusion zones, provides the optimize layout and then provides a high level estimate of the energy production of a turbine layout near the meteorological mast.

Measurement Equipment and Wind Data

The measurement campaign consists of one NRG turbular XHD-type meteorological mast 60 m in height. The mast, called Mast Minton, was installed September 5, 2008, and data have been provided for the period from September 2008 to July 2010.

The mast has been instrumented using NRG Systems sensors. The NRG logger has been programmed to record ten-minute mean, standard deviation, maximum and minimum of wind speed, wind direction, temperature and atmospheric pressure.

Visual checks of the mast indicate that the configuration is consistent with the commissioning reports [1] provided by Green Breeze. The details of the mast GB29119 configurations are given in the table below:

Instrument	Serial Number	Height [m]	Boom orientation (true North)
NRG #40 anemometer	77763	60	275°
NRG #40 anemometer	77764	60	185°
NRG #40 anemometer	77765	50	275°
NRG #40 anemometer	77773	50	185°
NRG #40 anemometer	78207	40	275°
W 200P wind vane	-	59	185°
W 200P wind vane	-	40	185°
Temperature sensor	-	2	-
Barometer	-	2	-

The wind data have been subject to a quality checking procedure by GLGH to identify records which were affected by equipment malfunction and other anomalies. Characteristic of this region, the instruments on the mast experienced some periods of icing, resulting in erroneous or inconsistent data during the winter months.

The following table summarizes the data recovery at the site mast at the upper anemometer measurement height.

Mast	Measurement Ht. [m]	Available data [years]	Valid data [years]	Data recovery rate [%]
GB29119	60	1.9	1.9	99

Long-term Mean Wind Speeds

Data have been recorded on the Watford site at Minten met mast with sensor heights up to 60 m. Data are available at Mast Minten for the period from September 2008 to July 2010. The calculation of the long-term wind regime at the site is described below:

- A wind speed and direction frequency distribution at Mast Minten at 60 m was derived from the measured data over the period from September 2008 to July 2010. This was performed by removing the mast effects at the upper anemometer measurements at 60 m. In order to extend the amount of valid data, missing wind speed data at individual sensors were synthesized from the other sensor located at the same height where possible. In this way, the data coverage at each sensor was maximized. For Minten Mast, the measured mean wind speed and direction frequency distribution described above was used in this analysis and is shown in the form of a wind rose in Figure 3.
- In order to extend the period of measurement at the Watford site, correlations were conducted from the Goderich and Ridgetown RCS meteorological stations, which are operated by Environment Canada. Correlations were also conducted from the Windsor A, Erieau and London A meteorological stations operated by the Environment Canada. Having considered the merits and the uncertainty associated with the use of each of the potential meteorological stations, GLGH considers that the Goderich and Ridgetown RCS stations are suitable sources of long-term reference data for the Watford Wind Farm site. Therefore this analysis relies on the combined adjustment predicted based on the 7 years of data available at these stations. This adjustment increases of 1.4% the annual observed wind speed at Mast Minten which results in a long-term mean wind speed of 6.4 m/s.
- The boundary-layer power law shear exponents were derived on an individual basis for Mast Minten. The ratios of the concurrent wind speed data recorded at multiple measurement heights at were used to derive the expected long-term mean power law shear exponent at the mast. These results were used to extrapolate the long-term wind regime for Minten to the hub height of 80 m. The following table presents the long-term mean wind speed at 60 m and at the proposed 80 m hub height.

Mast	Measurement height [m]	Long-term wind speed at measurement height [m/s]	Power-law shear exponent [α]	Long-term wind speed at 80 m [m/s]
GB29119	60	6.4	0.26	6.9

Setbacks applied and siting area

The site is on privately-owned land in south-western Ontario and is mainly constrained by the presence of several residences in the area.

The constraints analysis includes O.Reg. 359/09 setbacks and consultation zones – these have been officially adopted for the Province of Ontario on September 24, 2009 – as well as other best practice setbacks on other features when these are not addressed by the provincial REA regulations. Setbacks are areas to be avoided, whereas consultation zones are areas possibly available to position turbines if assessment shows no adverse impacts.

Within the project boundaries, setback areas have been defined based on O.Reg. 359/09 (REA), federal guidelines and best practices. The setback strategy for this project is found in the table bellow, which provides a detailed listing of the features considered in the constraints analysis, and the associated setbacks applied, where relevant.

	REA		Other (federal guidelines, best practices)	
	Setback	**Consultation zone**	**Setback**	**Consultation zone**
Human constraints				
Participating dwelling			At least 200 m and max PSL of 45 dB(A)	
Point of Reception (dwelling, campground, school, church, picnic site, cemetery, etc.) *	550 m			
Lot lines (between participating and non-participating lot)	Blade + 10 m (59 m)	Hub height (80 m)		
Lot lines (between 2 participating lots)			Avoided	
Other built structures (barns, silos, non-residential buildings, commercial, sports centers, recreation facilities, etc.)			200 m	
Airport, airfield, runway			200 m	4000 m
Industrial areas such as quarries, pits, dumps, etc.			Blade + 10 m (59 m)	Potential additional setback based on risk analysis (ice throw)
Roads and railways	Blade + 10 m (59 m)			Potential additional setback based on risk analysis (ice throw)
Trails			Blade + 10 m	Potential additional

			(59 m)	setback based on risk analysis (ice throw)
Communication towers, radars, navigational aids			150 m	Variable consultation zone size -- based on system type
Microwave links			Avoided	Buffer around link
Transmission Line, pipeline			Blade + 10 m (59 m)	
Biophysical constraints				
Provincially significant southern wetland	Avoided	120 m		
Provincially significant coastal wetland	Avoided	120 m		
Provincial park or conservation reserve **	Avoided	120 m		
Provincially significant northern wetland		120 m	Blade + 10 m (59 m)	
Provincially significant ANSI (earth science)		50 m	Blade + 10 m (59 m)	
Provincially significant ANSI (life science)		120 m	Blade + 10 m (59 m)	
Significant valleyland		120 m	Blade + 10 m (59 m)	
Significant woodland		120 m	Blade + 10 m (59 m)	
Significant wildlife habitat		120 m	Blade + 10 m (59 m)	
Lake except trout lake at or above development capacity	30 m	120 m		
Trout lake at or above development capacity	30 m	300 m		
Stream	30 m	120 m		
Seepage area	30 m	120 m		
Slopes > 15%			Avoided	
** Some parks or reserves do not prohibit commercial operations - TBD				

The constraints map shown in Figure 1 was validated during the site visit the 12th August 2010.

Layout Optimization

Dwellings for the Watford were identified using base data from Canvec and MNR. During the site visit of the 12th of August 2010 the dwellings were validated and their number of stories noted. Typically, noise levels at 4.5m agl can be up to 2dBA higher than at 1.5m agl (1-storey house).

As defined in the MoE Noise Guidelines of October 2008, all residences were considered Points of Reception and had a setback of 550 m applied as per the O.Reg. 359/09. No residences were considered participants.

Maximum noise emission levels of the Samsung 2.5MW wind turbine 25XC [3] were included in the noise modeling for the Watford Project. This is in accordance with the MoE Noise guidelines of October 2008.

When modeled according to the ISO 9613 standard and the conditions specified in the MOE Interpretation document of 2008, the noise produced by the turbines, was found to be within the acceptable limits at all residences within 1500 m of the Watford project.

The layout was maximized in the following order of priority, as specified by the Client:

- An installed capacity of 4 turbines (WTG), using the Samsung 25XC (2.5 MW) wind turbine generator;
- Maximize the number of turbines on "contracted lands"
- Maximization of the energy yield (P50 Gross Energy Output);
- Optimization of distances between turbines in order to balance the level of complexity in construction vs. wake-related energy losses, while targeting the best wind resource areas;
- Due consideration of physical, environmental and social constraints.

Energy Estimation

Based on the assumed wind regime at the hub height of 80 m, site energy production was estimated by applying the turbine power curve provided by Green Breeze [2]. The energy production calculation assumes array losses, topographic effects, availability, electrical transmission efficiency, environmental losses, air density effects and other potential losses.

The projected energy production of a 4 wind turbine layout is summarized in the table below and represents an estimate of the average annual production expected over a one year period. The predicted long-term hub-height frequency distribution at Mast GB29119 was used to derive the wind frequency distribution at each turbines location.

Wind Farm Rated Power	**10.0**	**MW**
Gross Energy Output	29.9	GWh/annum
Wake effect	96.6	%
Topographic effect	99.8	%
Availability	94.0	%
Electrical efficiency	97.0	%
Turbine performance	99.7	%
Environmental	98.9	%
Curtailment	100.0	%
Net Energy Output	**26.0**	**GWh/annum**
Net Capacity	**29.6**	**%**

The table above includes potential sources of energy loss that have been estimated, assumed or not considered. It is noted that for this analysis the following general approach has been adopted:

Wake effects – A value of 96.6% has been assumed to estimate the potential wind farm wake effects.

Topographic effect – A value of 99.8% has been assumed to estimate the wind speed variation between site mast location and turbine locations.

Availability – A generic assumption has been made for availability ramp up and the availability which is expected in mature operation. The availability number presented is the average availability over the first 10 years of operation. The details of the track record of the specific turbine model, balance of plant infrastructure, local grid system and Operation and Maintenance arrangements have not been considered.

Turbine performance – The impact of the site specific wind flow conditions on the turbine power curve have not been evaluated. An estimation of high wind speed hysteresis losses has also not been undertaken. A value of 99.7% has been assumed to account for the above mentioned effects. The power curve assumptions made here are subject to change when a more detailed analysis is completed.

Environmental – An estimate of losses due to blade degradation, icing and other environmental losses has been made. A value of 98.9% has been assumed to account for these losses.

Curtailment – It has been assumed that no curtailment of the project is required and has not been considered within this analysis.

Conclusions and Recommendations

Wind data have been recorded at the Watford site for a period of 1.9 years. Based on the results from the analysis of this data the following conclusions are made concerning the site wind regime.

1. The following table presents the long-term mean wind speeds at the mast location at the anemometer measurement height and at hub height.

Mast	Measurement height [m]	Mean wind speed at measurement height [m/s]	Power-law shear exponent [alpha]	Mean wind speed at 80 m hub height [m/s]
Minten	60	6.4	0.26	6.9

2. Constraints not considered in the constraints analysis include, amongst others, those which could not be readily quantified or mapped, e.g. subjective issues such as social acceptability. Social acceptability is a significant source of uncertainty, and development of some promising areas might face local opposition due to concerns about effects of turbines on personal enjoyment and recreation (e.g. viewscapes, aesthetic issues and noise), concerns about property values and effects on avifauna.

   Certain physical constraints were also not taken into account. Geotechnical considerations have a direct bearing on the type and cost of substructures. However, this parameter is difficult to evaluate without site-specific data, and has therefore not been examined in the context of this study. Physical constraints not evaluated also include all types of residential, commercial and industrial buildings, except airports, hydro power and wind power facilities.

3. All dwellings comply with the noise condition, 40dBA. Due to the number of dwellings within the Project Area, noise considerations are a significant factor for the layout optimization exercise.

   When modeled according to the ISO 9613 standard and the conditions specified in the MOE Interpretation document of 2008, the noise produced by the turbines, was found to be within the acceptable limits at all residences within 1500 m of the Watford project.

4. The projected energy capture for the 10 MW wind farms based on Mast GB29119 is predicted to be 26 GWh/annum. These include estimates or assumptions for array losses, topographic effects, availability, electrical transmission efficiency, environmental losses, air density effects and other potential losses.

   The net energy predictions presented above represent the long-term mean, 50% exceedance level, for the annual energy production of the wind farm. These values are the best estimate of the long-term mean value to be expected from the project. There is therefore a 50% chance that, even when taken over very long periods, the mean energy production will be less than the value given in the table.

5. This energy assessment is based on an assumed layout of 4 Samsung 25XC 2.5MW wind turbines near the mast location for the Watford site.

The uncertainties in these preliminary estimates have not been quantified. The energy predictions presented in this report are preliminary and should be treated as such.

References

[1] Email send from Brent Hall, Green Breeze Energy, to Chrystel Alzin, GLGH,, 03 August 2010 "Dec2008HatchCommissioningReport.pdf".

[2] "Tech Spec_Zephyr_25xc_Rev B_Jun29_2010.doc," Samsung document, June 2010.

[3] Email send from Brent Hall, Green Breeze Energy, to Chrystel Alzin, GLGH, 13 August 2010 "25xc noise prediction.pdf"

Hub height wind speed [m/s]	Electrical power [kW]
3	0
4	106
5	238
6	432
7	708
8	1072
9	1489
10	1886
11	2202
12	2384
13	2469
14	2492
15	2500
16	2500
17 - 25	2500
Hub height	80 m
Rotor diameter	99.8 m
Rotor swept area	7 823 m^2
Rated Rotor speed	14.35
Air Density	1.235 kg/m^3
Operational temperature range	-30 °C to +40 °C
Cut-in ten-minute mean wind speed	3.5 m/s
Cut-out ten-minute mean wind speed	21 m/s
Restart ten-minute mean wind speed	19 m/s

Table 1 Performance data for the Samsung 2.5MW wind turbine 25XC

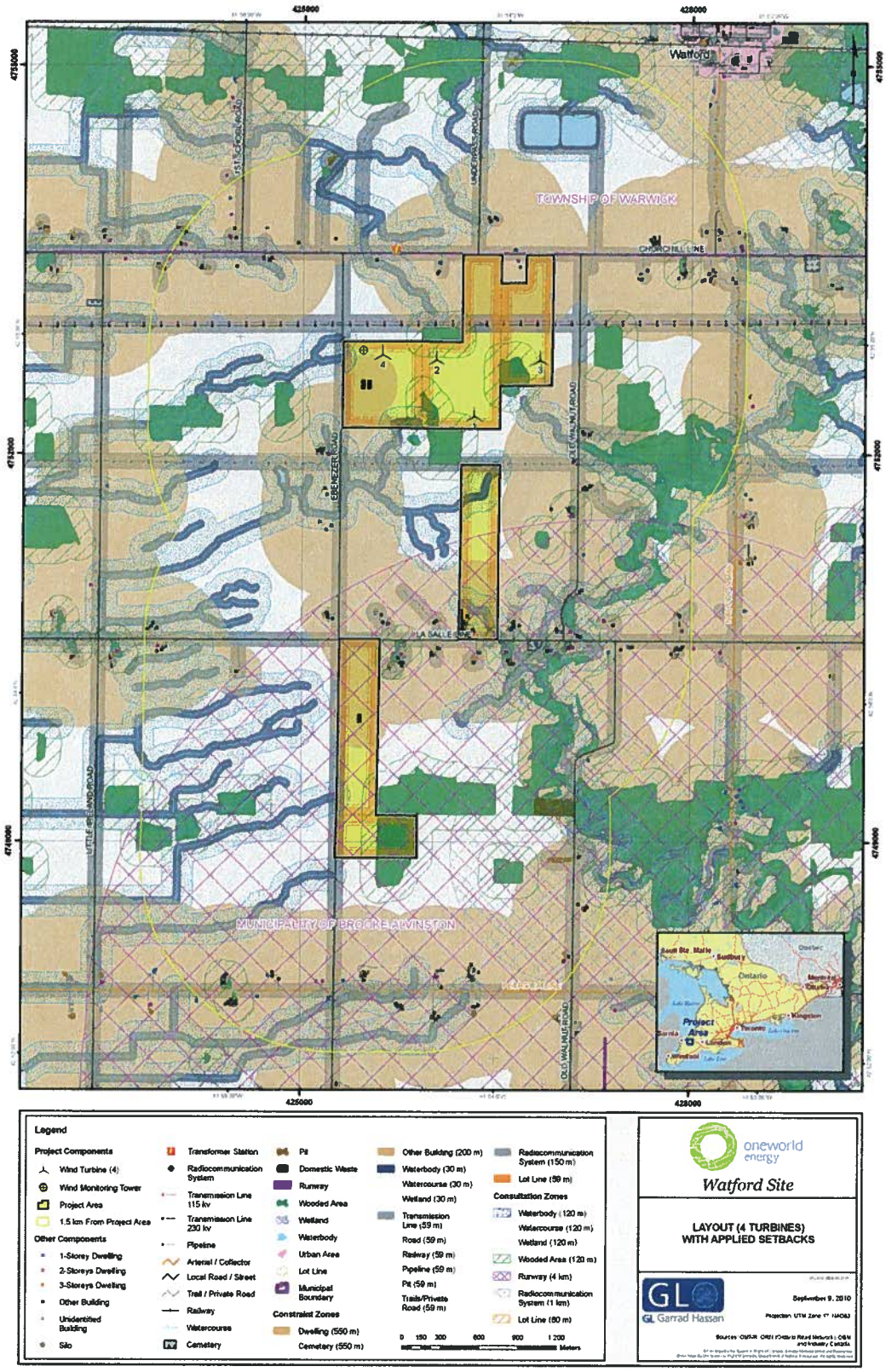

Figure 1: Map showing the mast location and turbines of the Watford Wind Farm and the constraints.

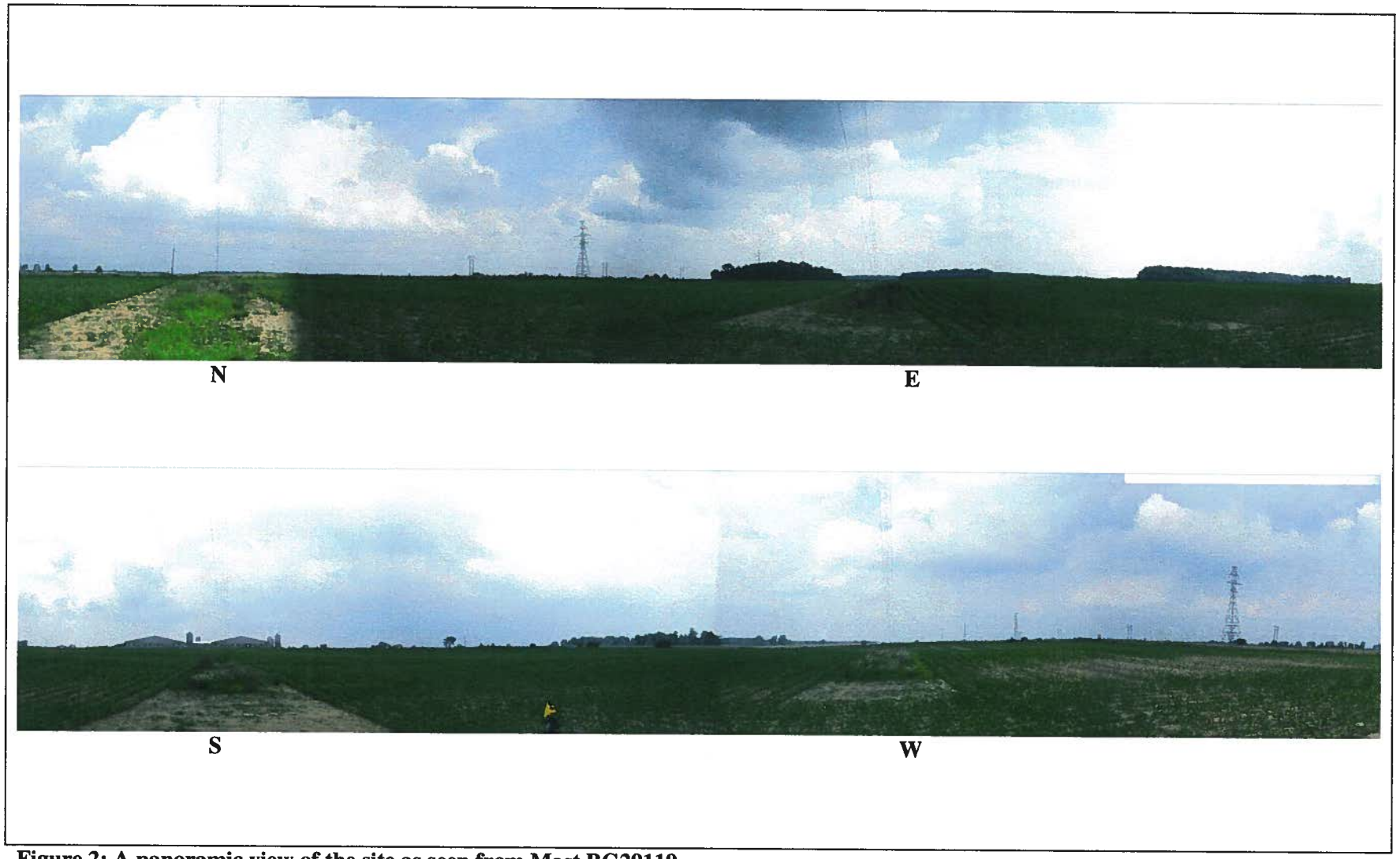

Figure 2: A panoramic view of the site as seen from Mast BG29119

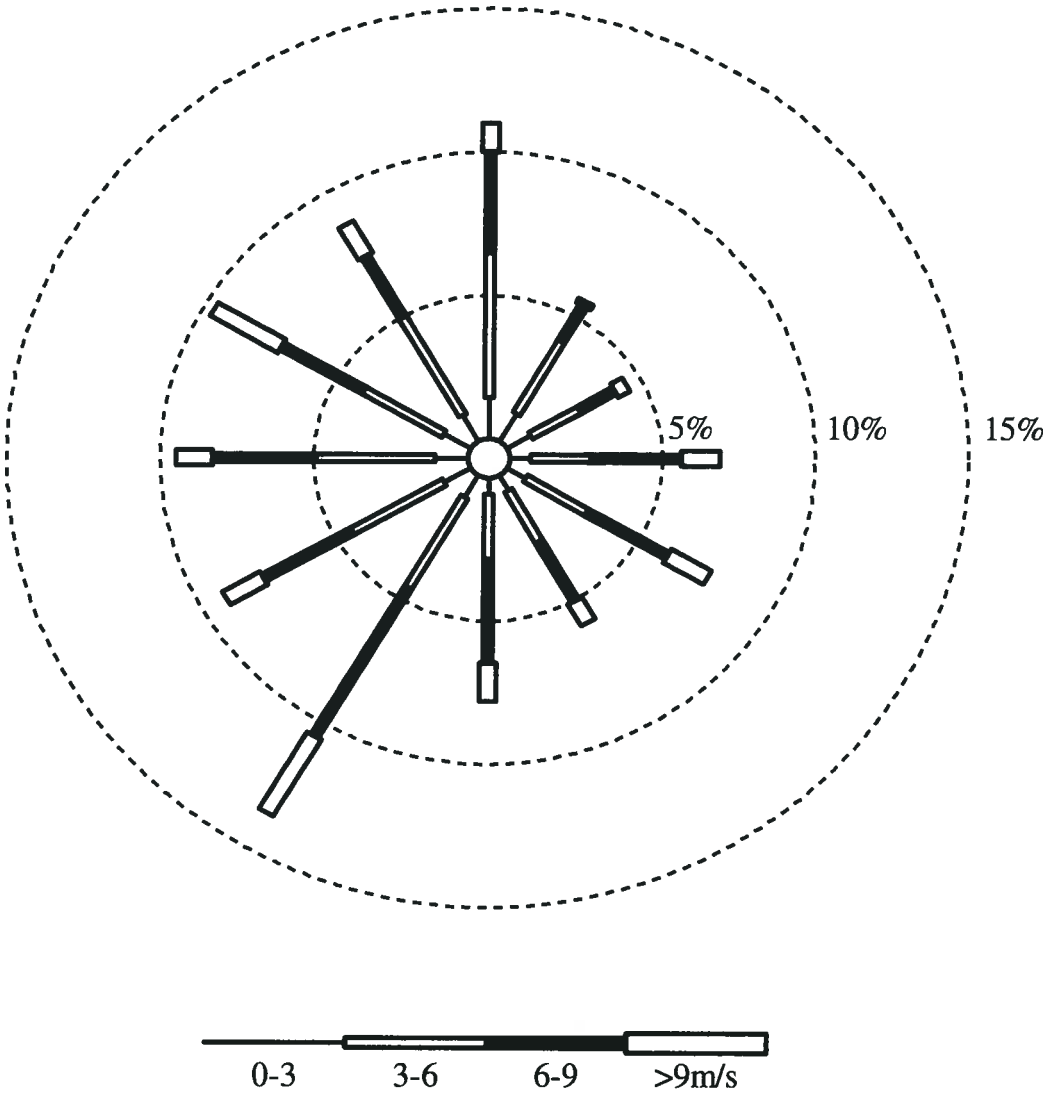

Figure 3: Measured annual wind rose at Mast Minten at 60 m

GL Garrad Hassan

NOISE IMPACT ASSESSMENT

WATFORD WIND FARM, ONTARIO

Client	Green Breeze Energy Inc.
Contact	Brent Hall
Document No.	879/OT/04
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Status	Final
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REVISION HISTORY

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A	15 February 2011	Initial issue for review
B	16 February 2011	Minor changes
C	23 February 2011	Final Issue

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Helimax Energy Inc. (GL GH), a member of the GL Group and part of the GL Garrad Hassan brand, was retained by Green Breeze Energy Inc. (the "Client") to prepare a Noise Impact Assessment ("NIA") of the proposed Watford Wind Farm (the "Project") in accordance with the Ontario Ministry of the Environment's ("MOE") requirements.

Noise levels at dwellings are calculated on the basis of the approved methodology (ISO 9613-2). The Project is located in the Lambton County, Ontario, approximately 4 km south-west of Watford, and 40 km east of Sarnia.

The Watford Wind Farm is composed of four (4) 2.5 MW model 25XC turbines manufactured by Samsung. The collector system will be underground and will connect to Hydro One's distribution lines on Ebenezer Rd. There is no substation on site as the Project will be connected to the 27.6-kV distribution system.

The purpose of this NIA is to meet the requirements of Ontario Regulation 359/09 which requires that a detailed noise impact assessment be prepared according to the MOE guidelines of October 2008. Specifically, to fulfill these requirements, the objective of this assessment is twofold:

1. Confirm the sound level limit requirements for the Project by providing an assessment of the existing baseline environmental noise conditions in the vicinity of the wind farm;

2. Predict the noise levels generated by the Project at all Points of Reception within 1.5 km of the turbines.

2 GENERAL DESCRIPTION OF THE WIND FARM SITE

2.1 General Characteristics

The Project is located in the Municipality of Brooke Alvinston, Ontario and the northern boundary of the Project is next to the Municipality of Warwick, Ontario. The Municipalities of Brooke Alvinston and Warwick cover respectively 311 square km and 290 square km of land and are home to approximately 3,000 and 3,945 permanent residents.

Figure 2-1: Land Features of the Watford Wind Farm Site

The Project comprises four (4) Samsung 2.5 MW model 25XC turbines and its nameplate capacity is thus 10 MW. The wind turbines have been strategically sited on land to which the Client holds a land lease with a landowner. Electricity generated by the turbines will be fed to an underground collector system which will be connected to the new adjacent 27.6-kV distribution line running close to the Project, on Ebenezer Rd.

The area is primarily agricultural and consists of expansive fields. Homes, farms and barns are interspersed throughout the site, as well as small woodlots with trees ranging from 1.5 to 8 m in height. The topography and ground cover in the surrounding region are similar to those of the site itself.

2.2 Points of Reception

Receptor locations (i.e. Points of Reception or "PoR") for the Project were identified using base data from the Ministry of Natural Resources Land Information Warehouse and Directory, Canvec and Google Earth., Their locations were validated during a site visit that occurred on August 12, 2010. The height of each PoR were taken to be 1.5 m, 4.5 m and 7.5m representing one-storey, two-story and three-story building respectively. All PoRs, as per the definition of the MOE, were considered in this NIA.

The MOE Interpretation indicates that any point on the premises of a person within 30 m of a residence or camping area is considered to be part of a Point of Reception. However, a residence located on the same premises as the wind turbine (s) is not a PoR as defined by the MOE noise guidelines. Further, residences financially associated with the Project were considered "Participants". In this instance, these receptors are considered part of the wind energy facility, and thus the MOE noise limit does not apply.

For the purposes of this NIA, the vacant lots were not taken into account.

The coordinates of each PoR are listed in the Appendix D.

3 DESCRIPTION OF RECEPTORS

There are 18 dwellings considered as Points of Reception located within a radius 1,500 m of a wind turbine.

3.1 Receptor Classes

The MOE categorizes Points of Receptions into three classes: 1, 2 and 3. Class 1 refers to an acoustic environment typical of a major center where the background noise is dominated by the urban hum. These areas are highly urbanized and have moderate to high noise levels throughout the day and night. Class 2 areas have an acoustic environment characterized by low ambient sound levels between 19:00 and 07:00, whereby the evening and night time levels are defined by natural sounds, infrequent human activity and no clearly audible sounds from stationary sources (e.g. industrial and commercial facilities). Class 3 areas are typical of rural and/or small communities (i.e. with populations of less than 1,000) and an acoustic environment that is dominated by natural sounds with little or no road traffic.

Within the study area the main sources of ambient sound that currently exist include:

- Vehicular traffic noise on the local concession and side roads, some of which are gravel roads;
- Occasional sounds due to agriculture activities;
- Occasional sounds due to anthropogenic domestic activities; and
- Natural sounds.

Based on these conditions, **all Points of Reception are considered as having a Class 3 acoustical environment.**

3.2 Determination of Applicable Noise Limits

As stated in the MOE guidelines, the noise limits for a wind farm are set according to the existing MOE noise guidelines in NPC-205/NPC-232 while taking into account the background noise generated by wind.

For a Class 3 area, the sound level limits as defined by the MOE Interpretation are described in the sections below.

3.2.1 Wind Turbine Installations in Class 3 Area (Rural), Wind Speeds Below 6 m/s

The lowest sound level limit expressed in terms of L_{eq} is: i) 40 dB(A); or ii) the minimum hourly background sound level established in accordance with Publications NPC-232/NPC-233, whichever is higher.

3.2.2 Class 3 Area (Rural), Wind Speeds Above 6 m/s

The lowest sound level limit expressed in terms of L_{eq} is: i) the wind-induced background sound level, expressed in terms of ninetieth percentile sound level (L_{A90}) plus 7 dB; or ii) the minimum hourly

background sound level established in accordance with Publications NPC-205/NPC-232/NPC-233, whichever is higher.

The applicable noise limits should be those defined by the MOE as summarized below in Table 3-1. A sample calculation of how noise modeling was determined for each receptor appears in Appendix B where intermediate and cumulative A-weighted sound pressure levels from each turbine are provided.

Table 3-1: Summary of Noise Limits for Points of Reception (Class 3)

Wind Turbine Noise Criterion NPC-232 [dB(A)]	Wind Speed [m/s]				
	6	**7**	**8**	**9**	**10**
	40	43	45	49	51

4 DESCRIPTION OF SOURCES

4.1 Turbine Description

The Samsung 2.5 MW model 25XC is a horizontal-axis turbine with a three-bladed upwind rotor, a rotor diameter of 100 m, and a hub-height of 80 m.

Table 4-1 presents the general specifications of the wind turbine.

Table 4-1: Turbine Description – Samsung 2.5 MW model 25XC

Model	Samsung 2.5 MW model 25XC
Design	Steel, tubular, white; 4 sections
Rated power	2 500 kW
Hub height	80 m
Rotor diameter	99.8 m
Rotor swept area	7 823 m^2
Nominal operational interval	14.35 rpm
Number of blades	3
Cut-in wind speed	3.5 m/s
Cut-out wind speed	21 m/s
Nominal wind speed	14.5 m/s

Each turbine is active yaw and pitch regulated and features variable-speed control with an asynchronous generator. Full technical specifications as provided by the manufacturer can be found in Appendix F. Coordinates of all turbines are listed in Appendix C.

The Project consists of four (4) wind turbines. Each turbine will have a pad mount transformer at its base. The collector system will all be buried on site and will connect to Hydro One's lines on Ebenezer Rd. There is no substation on site as the Project will be connected to the distribution system of 27.6 KV through a switching station.

4.2 Adjacent Wind Farm Project

Based on discussion with the Client, GL GH assumed that there are no planned wind farms within 5 km of this Project.

5 WIND TURBINE NOISE EMISSION RATING

5.1 Noise Emission Rating for Watford Wind Farm

Broadband at 6 to 10 m/s wind speeds (measured at 10 m agl) and 1/3 octave band sound power levels were provided by Samsung and can be found in Appendix E. Table 5-1 summarizes the turbine noise emissions as reported by the manufacturer for 10 m/s wind speed.

For this NIA, the maximum sound power level of the turbine was used for all wind speeds, i.e. 107.9 dBA. The following table provides the 1/3 octave band sound power levels.

Table 5-1: Samsung 2.5 MW model 25XC Wind Turbine Acoustic Emission Summary

	Octave Band Sound Power Level (dBA)									
	Manufacturer's Emission Level					Adjusted Emission Level				
Wind Speed (m/s) at 10m a.g.l.	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**
Frequency (Hz)										
63	N/A	N/A	N/A	N/A	76.4	76.4	76.4	76.4	76.4	76.4
125	N/A	N/A	N/A	N/A	87.3	87.3	87.3	87.3	87.3	87.3
250	N/A	N/A	N/A	N/A	96.4	96.4	96.4	96.4	96.4	96.4
500	N/A	N/A	N/A	N/A	102.6	102.6	102.6	102.6	102.6	102.6
1000	N/A	N/A	N/A	N/A	102.8	102.8	102.8	102.8	102.8	102.8
2000	N/A	N/A	N/A	N/A	100.8	100.8	100.8	100.8	100.8	100.8
4000	N/A	N/A	N/A	N/A	98.7	98.7	98.7	98.7	98.7	98.7
8000	N/A	N/A	N/A	N/A	90.5	90.5	90.5	90.5	90.5	90.5
A-Weighted	99.1	102.9	106.2	107.3	107.9	107.9	107.9	107.9	107.9	107.9

6 NOISE IMPACT ASSESSMENT

The sound pressure level at each Point of Reception for the aggregate of all wind turbines associated with the Watford Wind Farm were calculated based on the ISO 9613-2 method. Simulations were run for the maximum PWL of the turbine, considering octave band noise levels, the hub height of the turbines and the height of each Point of Reception.

The ISO 9613 standard provides a prediction of the equivalent continuous A-weighted sound pressure level at a distance from one or more point sources under meteorological conditions favourable to propagation from sources of sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, commonly occurring at night.

The method consists of octave-band algorithms (i.e., with nominal mid-band frequencies from 63 Hz to 8 kHz) for calculating the attenuation of the emitted sound. The algorithm takes into account the following physical effects:

- Geometrical divergence – attenuation due to spherical spreading from the sound source;
- Atmospheric absorption – attenuation due to absorption by the atmosphere; and
- Ground effect – attenuation due to the acoustical properties of the ground.

ISO-9613-2 parameters were set as follows:

- Ambient air temperature: 10°C;
- Ambient barometric pressure: 101.32 kPa;
- Humidity: 70%;
- Source ground factor: 0.7;
- Middle ground factor: 0.7;
- Receptor ground factor: 0.7; and

Additional calculations concerning propagation through foliage were not performed in this NIA, implying that the values calculated for sound attenuation are likely to be conservative in areas where there is foliage present in the line of sight between any turbine and a Point of Reception. The estimated accuracy of the ISO 9613 method, as stated in ISO 9613-2, is ± 3 dB.

The wind turbine noise emission ratings used for each octave band were those specified in Table 5-1. The noise impact was calculated for each Point of Reception and Participant located within 1,500 m of a turbine, and the calculated noise level was then compared with the applicable noise limit for each receptor as stated in Table 3-1.

Noise levels were calculated at 7.5 m agl for 3-storey Points of Reception, 4.5 m agl for 2-storey, and 1.5 m agl at 16 points along a 30-m radius circle for each 1-storey Point of Reception. For the latter, the highest of these 16 values was chosen and presented in the table of noise levels.

7 WIND TURBINE NOISE IMPACT ASSESSMENT SUMMARY TABLE

7.1 Results

The noise level at each critical Point of Reception within 1,500 m of a turbine of the Watford Wind Farm, for wind speeds between 6 m/s and 10 m/s, is tabulated in Table 7-1. For each receptor, the following information is provided:

- The distance to the closest wind turbine;
- For receptors at 1.5 m a.g.l., the sound pressure level presented for wind speeds from 6 m/s to 10 m/s is the maximum noise level on the circumference of a 30-m radius circle centered on the receptor;
- For receptors at 4.5 m, the sound pressure level presented for wind speeds from 6 m/s to 10 m/s is the noise level at the receptor location at its respective height;
- The sound level limit for that receptor according to the MOE noise guidelines at each wind speed from 6 m/s to 10 m/s;
- Whether or not the noise levels at the receptor comply with the MOE guidelines (for continued reference, compliance is confirmed for all receptors).

The closest distance between a wind turbine and a Point of Reception for this project is 681 m between turbine T3 and Point of Reception 45.

The results show that the Watford Wind Farm complies with the applicable MOE environmental noise guidelines at all wind speeds modelled (i.e., 6, 7, 8, 9 and 10 m/s). Noise iso-contour map illustrating the contribution of the Watford Wind Farm is shown in Appendix A (40 dBA iso-contour).

Table 7-1: Wind Turbine Noise Impact Assessment Summary – Watford Wind Farm

Point of Reception ID	Height of Receptor [m]	Distance to Nearest Turbine [m]	Nearest Turbine [ID]	Calculated Sound Pressure Level at Receptor [dB(A)] at selected Wind Speed in m/s					Sound Level Limit [dB(A)] at selected Wind Speed in m/s					Compliance With Limit (Yes/No)
				6 or <	7	8	9	10	6 or <	7	8	9	10	
4	1.5	749	2	39.3	39.3	39.3	39.3	39.3	40	43	45	49	51	Yes
5	4.5	760	3	39.9	39.9	39.9	39.9	39.9	40	43	45	49	51	Yes
6	1.5	847	3	37.4	37.4	37.4	37.4	37.4	40	43	45	49	51	Yes
7	1.5	1037	3	33.2	33.2	33.2	33.2	33.2	40	43	45	49	51	Yes
8	4.5	1207	3	33.4	33.4	33.4	33.4	33.4	40	43	45	49	51	Yes
9	4.5	1291	3	31.8	31.8	31.8	31.8	31.8	40	43	45	49	51	Yes
10	4.5	1466	3	29.2	29.2	29.2	29.2	29.2	40	43	45	49	51	Yes
18	4.5	1115	3	37.1	37.1	37.1	37.1	37.1	40	43	45	49	51	Yes
19	4.5	1484	1	30.9	30.9	30.9	30.9	30.9	40	43	45	49	51	Yes
20	4.5	1178	1	33.5	33.5	33.5	33.5	33.5	40	43	45	49	51	Yes
43	4.5	872	1	38.6	38.6	38.6	38.6	38.6	40	43	45	49	51	Yes
44	1.5	1377	1	32.3	32.3	32.3	32.3	32.3	40	43	45	49	51	Yes
45	1.5	681	3	39.0	39.0	39.0	39.0	39.0	40	43	45	49	51	Yes
46	4.5	855	3	39.3	39.3	39.3	39.3	39.3	40	43	45	49	51	Yes
47	4.5	1105	4	36.2	36.2	36.2	36.2	36.2	40	43	45	49	51	Yes
48	1.5	1051	4	35.3	35.3	35.3	35.3	35.3	40	43	45	49	51	Yes
49	1.5	1404	4	31.0	31.0	31.0	31.0	31.0	40	43	45	49	51	Yes
44A	1.5	1174	1	34.3	34.3	34.3	34.3	34.3	40	43	45	49	51	Yes

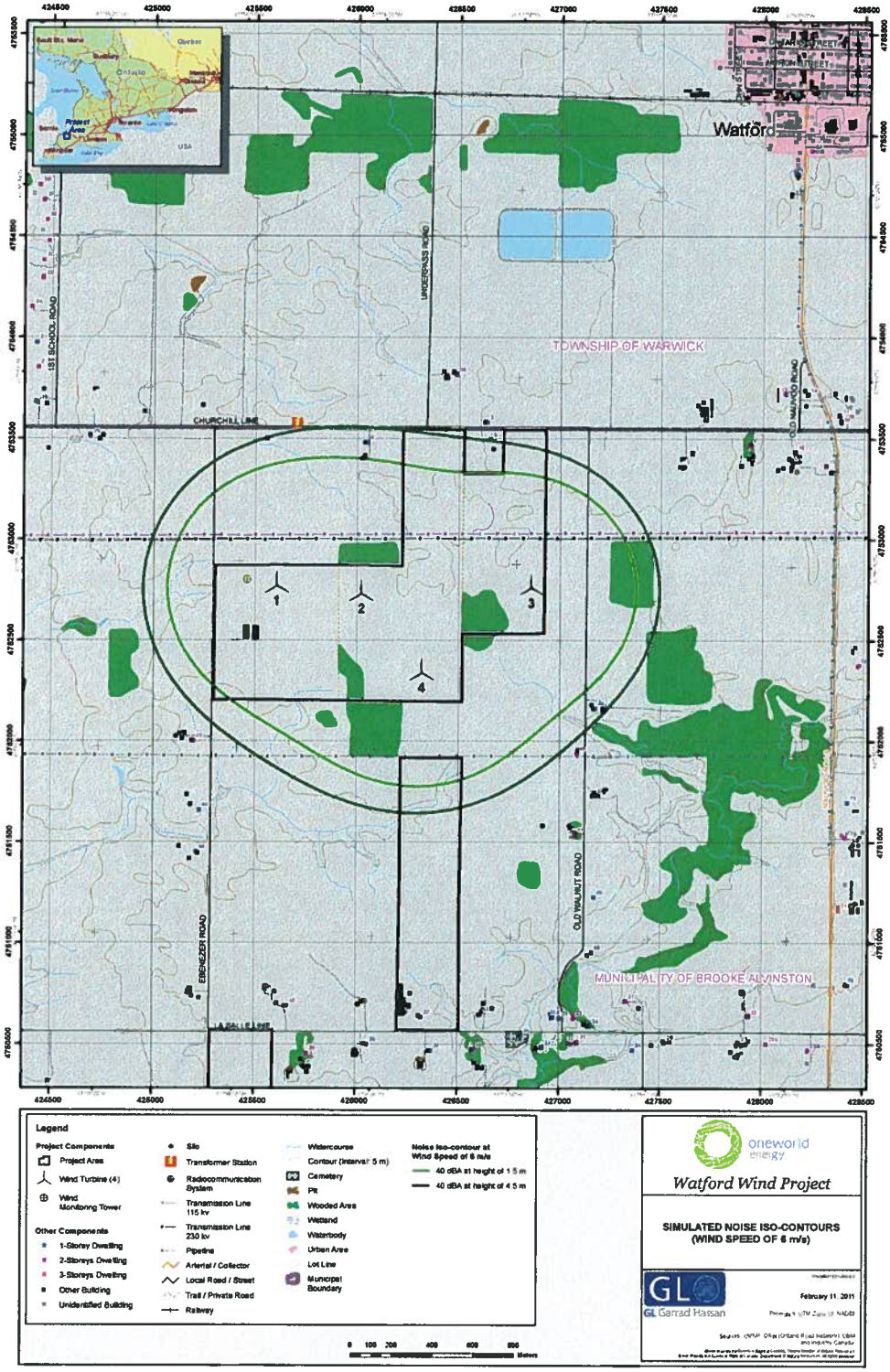
8 CONCLUSION

Based on the approach presented in this NIA, the noise produced by the Samsung 2.5 MW model 25XC wind turbines was found to be within the acceptable limits at all Points of Reception within 1,500 m of a turbine from the Watford Wind Farm for wind speeds of 6, 7, 8, 9 and 10 m/s.

9 REFERENCES

[1] Turbine layout confirmed by email, by Brent Hall, Green Breeze, to Chrystel Alzin, GL GH, 25 January 2011.

Appendix A Noise Iso-contour Maps



Appendix B Sample Calculation for Noise Modeling

Resulting A-weighted sound pressure level at a Receptor

The calculation of cumulative receptor noise levels from wind turbines uses the methodology of ISO 9613-2, "*Acoustics — Attenuation of sound during propagation outdoors: Part 2: General method of calculation*". These calculations are conducted with CadnaA *(which is an implementation of ISO 9613-1 and ISO 9613-2).*

As an example, in this appendix, the results are presented at Receptor 4 and at the maximum power sound level. The following conditions were used:

- Turbine locations (Appendix C);
- Receptor locations (Appendix D).

Turbine characteristics:

- Hub-heights: 80 m Samsung 2.5 MW model 25XC;
- Broadband and the octave band sound power levels (see Table 5-1);
- Tonal penalty from WF turbine file: 0.0 dB(A);
- Ambient air temperature: 10°C;
- ambient barometric pressure: 101.32 kPa;
- Relative humidity: 70%;
- Wind speed (10 m agl): 10 m/s;
- Source ground factor: 0.7 (soft ground);
- Middle ground factor: 0.7; and
- Receptor ground factor: 0.7

The following table presents an example result and intermediate values of the calculations as the A-weighted sound pressure levels at an example receptor, due to each turbine and each octave band. The net result, the A-weighted sound pressure level at the example receptor 4 for all bands and all turbines within 1,500 m of the example receptor is 39.3 dB(A).

Pressure Levels at Receptor 4 at maximum PWL

Turbine ID	Distance [m]	Octave Band Sound Pressure Levels at Receptor 120 dB(A)]								Total A-Weighted Sound Pressure Level by Turbine and for all Octave Bands [dB(A)]
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
T1	837	10.1	15.4	22.3	29.2	31.0	24.7	2.8	-73.1	34.2
T2	749	11.2	16.8	23.5	30.5	32.4	26.6	6.9	-61.3	35.6
T3	1079	7.8	12.6	19.8	26.5	27.8	20.0	-7.6		31.0
T4	1169	7.2	11.9	19.1	25.7	26.9	18.6	-10.8		30.1
Total A-Weighted Sound Pressure Level										**39.3**

Appendix C Coordinates of Turbines

Coordinates of turbines to be installed in the Watford Wind Farm are listed below:

Turbine ID	Easting $[m]^2$	Northing $[m]^2$
1	425609	4752769
2	426024	4752730
3	426859	4752760
4	426320	4752340

1. Coordinate system is UTM Zone 17, NAD83 datum.

Appendix D Coordinates of Points of Reception

Coordinates of all modeled Points of Reception within 1,500 m of a wind turbine for the Watford Wind Farm (UTM17-NAD83 projection) are given in the tables below:

Point of Reception ID	Easting [m]	Northing [m]
4	426053	4753478
5	426655	4753492
6	426640	4753578
7	427657	4753422
8	427725	4753601
9	427940	4753465
10	428162	4753432
18	426490	4753812
19	424433	4753674
20	424691	4753508
43	425200	4751999
44	425216	4751449
45	427179	4752159
46	427089	4751937
47	427079	4751537
48	427175	4751729
49	427175	4751226
44A	425231	4751658

Appendix E Sound Power Level of the Turbine

Estimated Sound Power Level

Noise level, L_{WA} [dBA re 1pW]

Wind speed [m/s] at hub height	3	4	5	6	7	8	9	10
Sound power $L_{WA,P}$ [dBA]	81.7	89.0	94.6	99.1	102.9	106.2	107.3	107.9

Sound power level in 1/3octave band [dBA] at 10m/s in hub height

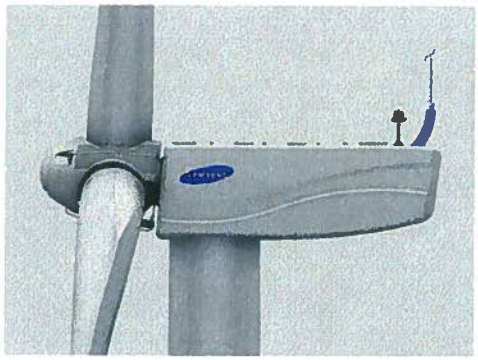
Frequency [Hz]	Sound power level [dBA]
50	64
63	70
80	75
100	78
125	82
160	85
200	88
250	91
315	94
400	96
500	98
630	99
800	98.5
1000	98
1250	97.5
1600	97
2000	96
2500	95
3150	94
4000	93
5000	92
6300	89
8000	84
10000	79

Appendix F Technical specifications of the turbine

Extract of the Technical Specifications of Samsung 2.5 MW model 25XC Wind Turbine;

TECHNICAL DOCUMENTATION FRONT SHEET

TECHNICAL DATA
OF SAMSUNG 2.5MW WIND TURBINE [25xc]
(COLD CLIMATE VERSION)



* All data are subject to change due to technical development to be notified in writing by Seller and approved by Buyer

B	17/06/10	Model changed from 24xc to 25xc	J.H Kim	C.H Son	K.H Kim	
A	14/05/10	First issue	J.H Kim	C.H Son	K.H Kim	
Rev.	**DATE** (DD/MM/YY)	**Description of revision**	**Prepared**	**Checked**	**Approved**	

Buyer : Green Breeze Energy

Seller : SAMSUNG

Project name : **Zephyr, Brooke-Alvinston 10MW Project**

Site :	Scale :	Type of document :
Watford, Ontario, Canada	10MW	Technical document

Contractors document identification:

Project no.	Discipline	Document no.	Rev.
6PF0002	Project Management	WPDSF0000-0	B

1. General description of the wind turbine

This document summarizes technical data and descriptions of the Samsung 2.5 MW onshore wind turbine model for cold climate, SHI 25xc.

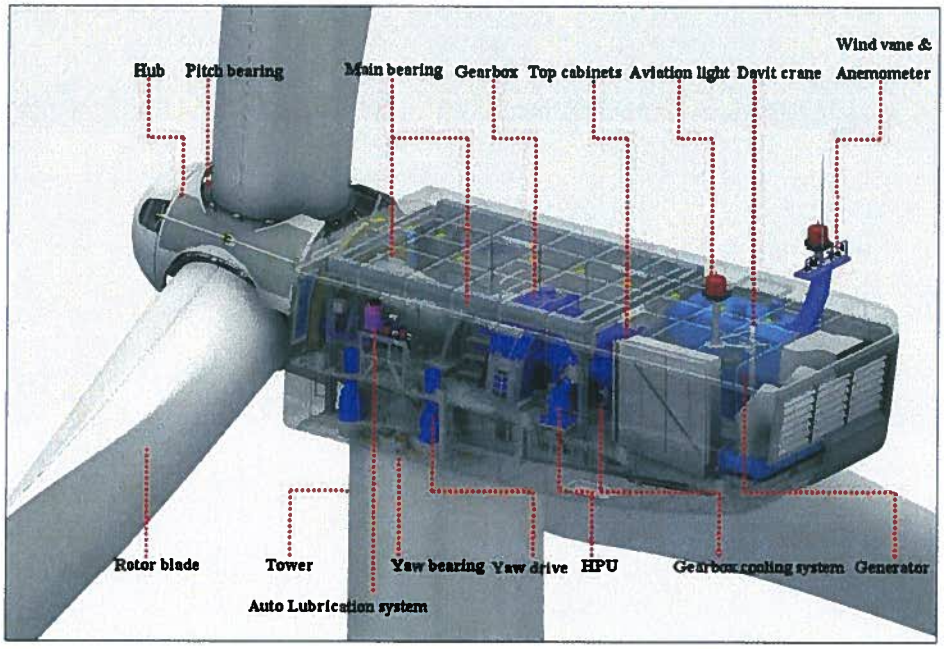
1.1. Desgin concept

2.5 MW wind turbine is designed for wind class IIIA and cold climate conditions. The wind turbine design concept is based on a pitch regulated blade operation, double main bearings supporting rotor shaft, 3-stage gear box with flexible coupling and permanent magnet synchronous generator, an active yaw and rotor brake with rotor lock disk.

1.2. Operating data

Parameter	Value
Rated power	2.5 MW
Model	SHI 25xc
Rotor diameter	99.8 m
Hub height	80 m
Rotor swept area	7,823 m^2
Rotational direction	Clockwise looking from upwind side
Power regulation	Pitch regulated with variable speed
Rated rotor speed	14.35 rpm
Rated tip speed	75 m/s
Cut-in wind speed	3.5 m/s
Cut-out wind speed	21 m/s
Design lifetime	20 years
Hertz	60 Hz
Version	Cold climate version

1.3. Wind turbine overall layout



*Technical information is subject to change with written notice and approval of buyer.

3. Performance data

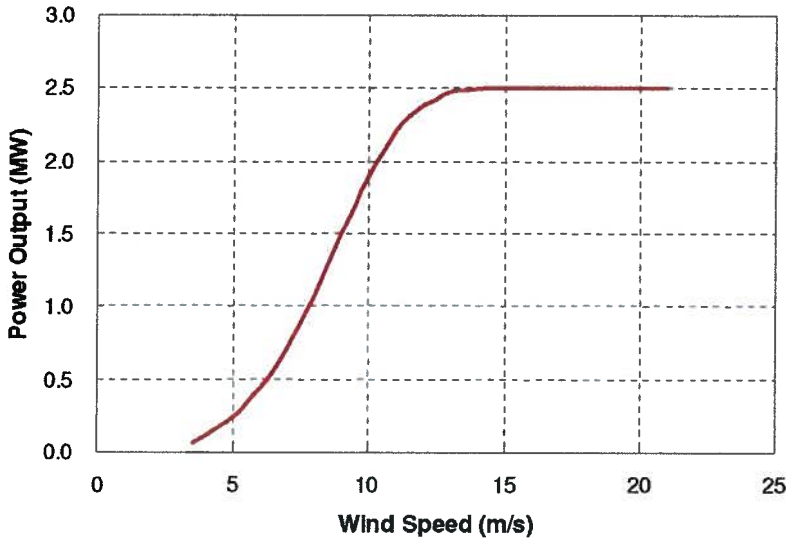
The estimation of the provided power curve is thus valid subject to the following conditions

Air density	1.235 kg/m^3 from measured data
Wind shear exponent	0.22 from measured data
Measured turbulence	12.82 % at 15 m/s from measured data
Flow inclination	0 deg

3.1. Power curve (calculated)

The power output is estimated between the wind turbine and the electrical connection to ensure that only the net active power (i.e. reduced by self-consumption) is accounted.

Wind speed [m/s]	Power Output [kW]	Wind speed [m/s]	Power Output [kW]
3.5	61	12.5	2,421
4.0	106	13.0	2,469
4.5	165	13.5	2,484
5.0	238	14.0	2,492
5.5	327	14.5	2,500
6.0	432	15.0	2,500
6.5	560	15.5	2,500
7.0	708	16.0	2,500
7.5	878	16.5	2,500
8.0	1,072	17.0	2,500
8.5	1,279	17.5	2,500
9.0	1,489	18.0	2,500
9.5	1,694	18.5	2,500
10.0	1,886	19.0	2,500
10.5	2,059	19.5	2,500
11.0	2,202	20.0	2,500
11.5	2,301	20.5	2,500
12.0	2,384	21.0	2,500



3.2. Thrust coefficient

Wind speed [m/s]	Thrust coefficient	Wind speed [m/s]	Thrust coefficient
3.5	0.9164	12.5	0.3603
4.0	0.8419	13.0	0.3153
4.5	0.8259	13.5	0.2786
5.0	0.8254	14.0	0.2480
5.5	0.8260	14.5	0.2222
6.0	0.8257	15.0	0.2000
6.5	0.8257	15.5	0.1810
7.0	0.8256	16.0	0.1645
7.5	0.8256	16.5	0.1501
8.0	0.8257	17.0	0.1374
8.5	0.8087	17.5	0.1262
9.0	0.7763	18.0	0.1163
9.5	0.7445	18.5	0.1075
10.0	0.7134	19.0	0.0997
10.5	0.6830	19.5	0.0926
11.0	0.6001	20.0	0.0863

11.5	0.4897	20.5	0.0806
12	0.4164	21.0	0.0754

3.3. Noise data

Wind speed at hub height [m/s]	3	4	5	6	7	8	9	10
Sound power $L_{WA,P}$ [dBA]	81.7	89.0	94.6	99.1	102.9	106.2	107.3	107.9

4. De-rating in case of high air density

The rated generator speed is reduced when the measured air density is above 1.250 kg/m3. The rated speed points are determined by interpolation based on the following table.

Air density, kg/m3	Rated generator speed, rpm	Rated electrical power, MW
1.225	1642	2.5
1.250	1642	2.5
1.452	1478	2.25