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TECHNICAL MEMORANDUM

Title: Noise Modeling and Impact Assessment

Project: Malvern Wind Project
Location: St. Elizabeth's Parish, Jamaica
Prepared For: BMR Energy
Prepared By: David M. Hessler, P.E.
Revision: A
Issue Date: June 23, 2014
Reference No: **TM-051614-A**

Attachments: Plot 1 Sound Contours of Project as Currently Planned

1.0 Introduction

As requested, we have developed a sound emissions model of the wind project currently planned near the Town of Malvern in St. Elizabeth's Parish, Jamaica. The objectives of the study were to calculate the project-only sound levels at residences or other potentially noise sensitive receptors around the project area based on the current site plan, evaluate the potential for adverse noise impacts and make any appropriate recommendations that might minimize those impacts.

2.0 Modeling Methodology

2.1 Turbine Sound Level

The starting point for any wind turbine noise modeling study is the sound level, or more specifically, the sound power level of the turbine model that will be used in the project. For this project 11 Vestas V112-3.3 MW turbines are currently planned. The maximum sound power level for this model is given by the manufacturer[1] as 107 dBA re 1 pW for all wind speeds equal to or greater than 8 m/s (measured at 10 m above ground level). According to Vestas, this sound level comes from field testing carried out in accordance with IEC 61400-11 *Wind Turbine Generator Systems – Acoustic Noise Measurement Techniques*.[2]

The overall A-weighted sound power levels as a function of wind speed at the IEC standard elevation of 10 m are tabulated below for reference.

Table 2.1.1
Vestas V112-3.3 MW Turbine Sound Power Level vs. Wind Speed
Mode 0, Wind Shear: 0.16

Wind Speed at 10 m Height, m/s	Sound Power Level, dBA re 1 pW
3	94.6
4	96.7
5	100.8
6	104.4
7	106.5
≥ 8	107.0

For modeling and assessment purposes, the nominal maximum value of 107 dBA re 1 pW has been used. The model predicts the *mean* sound level as measured over a long-term time frame as the most meaningful representation of the project's sound levels with the understanding that the actual level observed at any given moment may be somewhat higher or lower due to intervening atmospheric conditions.

The frequency spectrum associated with the design (maximum) sound power level, tabulated below, was not provided by Vestas but has been scaled up by 0.5 dB in each band from the known frequency distribution of the very similar V112-3.0 MW, which has an overall maximum sound power of 106.5 dBA re 1 pW.

Table 2.1.2
Sound Power Level Frequency Spectrum
used as a Modeling Input

Octave Band Center Frequency, Hz	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Maximum Sound Power Level, dBA re 1 pW	118	115	112	107	105	101	99	93	82	107

2.2 Modeling Methodology and Assumptions

Using the design sound power level spectrum in Table 2.1.2 above, project sound levels were calculated using the Cadna/A®, ver. 4.4.145, noise modeling program developed by DataKustik, GmbH (Munich). This software enables the project and its surroundings to be realistically modeled in three-dimensions. The modeling software is essentially an automated version of ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors*[3], which is the primary worldwide standard for such calculations.

Only the 11 proposed V112-3.3 MW turbines are represented in the model and the existing 4 units - of unknown make, model or sound power level - are not included.

Each turbine is represented as a point noise source at a height of 100 m above the local ground surface. Although the project is located near the crest of a large escarpment, which drops off steeply just to the west of the proposed turbine locations, the sound emissions model neglects terrain not only because the necessary topographical information was not readily available but also because all of the nearest potentially sensitive receptors are located on top of the plateau at a generally similar elevation to the project. There are no known residences to the west down the slope.

A ground absorption coefficient (from ISO 9613-2) of 0.8 has been used in the model since all of the intervening ground between the turbines and potentially sensitive receptors essentially consists of dense, jungle-like vegetation or open fields, both of which are considered acoustically "soft". The ISO ground absorption coefficient ranges from 0 for water or hard concrete surfaces to 1 for absorptive surfaces such as farm fields, woods or sand. To be conservative, no additional loss has been taken specifically for foliage.

The downwind sound level – the value measured in the IEC sound power level test - is assumed to exist in all directions simultaneously. This approach essentially represents a hypothetical situation where the wind is blowing from all directions at the same time making the predictions valid for any given wind direction.

In general, then, the model represents the project sound level at any given receptor point based on the following assumptions:

- **Maximum Sound Power Level** – the highest measured sound power level for this model turbine was used
- **Moderate Ground Absorption** – the actual absorptivity of the ground between the turbines and the nearest potentially sensitive receptors may be somewhat more absorptive than assumed

- **No Foliage Loss** – Any attenuation afforded by the dense vegetation in the site area is confined to ground effects and no additional loss is taken for foliage
- **Observer Outside** – the plotted sound levels occur outside; sound levels inside of any dwelling will be somewhat lower
- **Downwind Sound Level** – the downwind sound level is assumed to exist in all directions from every unit

It is important to reiterate that the sound level predicted by the model at any given point is the average level likely to be observed over a period of days or weeks. Field experience measuring operational projects indicates that the actual project sound level will commonly fluctuate +/- 5 dBA about the mean predicted level. In addition, higher excursions above the mean are possible for brief periods during periods of unusually gusty or unstable winds.

3.0 Model Results

The maximum sound contours associated with the project during windy conditions (8 m/s or higher winds) are shown in **Plot 1**. The nearest potentially sensitive receptors in all directions are highlighted in the figure along with the specific project sound level predicted at each location.

Based on field experience testing completed wind projects in rural areas[4], the potential noise impact of the project may be roughly interpreted from the plot as follows:

Sound level ≥ 45 dBA:	Possibility of complaints
Sound level between 45 and 40 dBA:	Generally acceptable but scattered complaints possible
Sound level between 40 and 35 dBA:	Project audible, complaints possible but very unlikely
Sound level < 35 dBA:	Project only intermittently audible or inaudible, complaints highly unlikely

In general, the potential noise impact of the project appears rather mild in the sense that the vast majority of the homes in the vicinity of the project lie outside of the 40 dBA contour (purple contour line) where the probability of complaints is usually quite low. However, as is typical with many wind projects, there are several receptor points inside of the 40 dBA line at the north and south ends of the project where sound levels are generally expected to be in the 41 to 43 dBA range. The only point of any significant concern is a single residence to the northwest of the northern-most unit were a sound level of about 48 dBA is calculated.

In terms of regulatory noise limits, a set of recommended sound levels (tabulated below) for various land use zones was published by the Government of Jamaica in 1999[5].

Table 3.0.1
Recommended Time Based Zonal Noise Limits, dBA
(Recommendations for National Noise Standards for Jamaica, 1999)

Zone	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Industrial	75	70
Commercial	65	60
Residential	55	50
Silence	45	40

While the first three zones are fairly self-explanatory, a Silence Zone is defined as a special area "where peace, tranquility and extreme quiet is essential to the intended use of the land. The land use category would include, but not be limited to, hospitals, educational institutions and courts."

In this instance, where the nearest potentially noise sensitive receptors are residences and schools, the relevant design goals would essentially be a nighttime maximum of 50 dBA at residences to minimize the potential for sleep disturbance and a daytime limit of 45 dBA at schools, since schools are only in session during the day.

As illustrated in the sound emissions plot all of the residences near the Project would be beyond the 50 dBA contour and all schools, such as Munro College to the southeast, would be beyond the 45 dBA contour. Consequently, during normal operation the Project is expected to maintain compliance with the Jamaican noise standards.

4.0 Noise Mitigation

Although the national noise standards are expected to be met and the potential for an adverse impact from noise is considered fairly low, complaints or issues with noise cannot be completely ruled out. Consequently, if not already a standard feature, it would be advisable to purchase or otherwise ensure that the two or three units on the north and south ends of the project are equipped with the option to operate in low noise mode so that some recourse exists should any serious complaints arise. Normally, a reduction of between 3 and 5 dBA relative to standard operation (Mode 0) can be achieved by engaging the blade control software that essentially trades a small reduction in electrical output for quieter operation.

If such a technology is not yet available for these proposed turbines, the Project owner should directly engage with these landowners and discuss other potential mitigation options.

5.0 Conclusions

The sound emissions from the proposed Malvern Wind Project have been modeled based the manufacturer's maximum sound power level and projected over the immediate site vicinity. In general, the sound levels from the Project are expected to comply with the recommended national noise standards for residences (at night) and educational institutions (during the day). Moreover, it was found that all of the more populated areas around the project, such as the Town of Malvern, essentially lie outside of the 40 dBA sound contour, meaning that the sound emissions from the project are unlikely to be noticeable in those areas. Nevertheless, some residences are close enough to the turbines that complaints about noise cannot be ruled out. As a precaution, it is suggested that the two or three units on the north and south ends of the turbine string should have the capability to run in low noise mode should any complaints arise. The projected baseline levels, without mitigation, are generally low enough that the moderate reduction of between 3 and 5 dBA normally achievable with low noise operation should go a long way towards alleviating any complaints. If low noise operation is not possible for technical reasons on the turbines ultimately selected for the Project, the Project owner should work with neighbors, if, in fact, any complaints arise, to develop alternate mitigation measures.

References

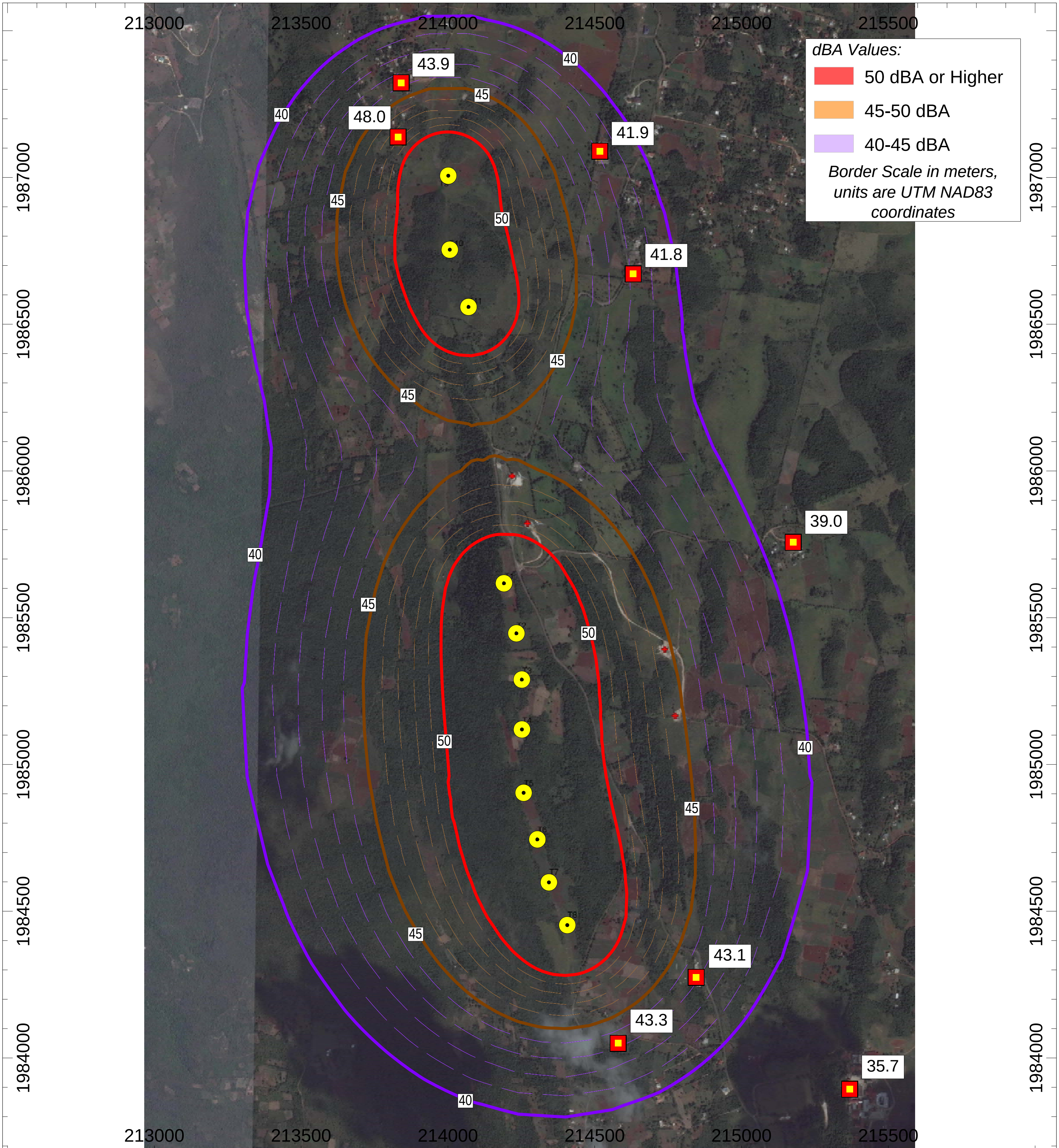
[1] E-mail communication dated May 14, 2014 from Kenneth Young at Vestas.

[2] International Electromechanical Commission (IEC) 61400-11:2002(E) *Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques*, Second Edition 2002-12.

[3] International Organization for Standardization, ISO 9613-2 *Acoustics – Attenuation of Sound during Propagation Outdoors*, Part 2, "A General Method of Calculation", Geneva, 1989.

[4] Hessler, D. M., Hessler, G. F., "Recommended noise level design goals and limits at residential receptors for wind turbine developments in the United States", *Noise Control Engineering Journal*, J. 59 (1), Jan-Feb 2011.

[5] Jamaica National Noise Standards, Recommendations for National Noise Standards for Jamaica, 1999.



Project: **Malvern, Jamaica**	*Description:*	*Legend:*
Prepared for: **BMR**	**Plot 1**	Turbine Location
Date: June 23, 2014 / *Drawing #:* MJ-Rev-G-1-1	**Predicted Sound Contours (dBA) of Vestas V112-3.0 MW Turbines with an Omnidirectional 6 m/s Wind**	Nearby Receptor

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