

October 7, 2015

Jessica M. Damon, Project Manager
Division of Land Use Regulation
Maine DEP
106 Hogan Road, Suite 6
Bangor, ME 04401

Re: Independent Peer Review of the Sound Assessment for the Number Nine Wind Project

Dear Jessica:

Tech Environmental, Inc. (TE) has completed an independent peer review of the acoustic impacts of the 250-MW Number Nine Wind Project in Aroostook County with regard to Maine Site Location of Development (SLOD) Regulations. The Project consists of the Turbine Area and three sections of a 345-kV generator lead, the North Generator Lead Line (Sections 2a and 2b) and the Bridal Path Generator Lead Line (section 1).

The Turbine Area will consist of 119 Gamesa G114 wind turbines to be located at 129 permitted turbine sites on ridges and hills across several unorganized townships in the vicinity of Number Nine Lake and Presque Isle Lake.¹ The Sound Assessment assumed continuous operation of turbines on all 129 sites at full-rated sound power even though a maximum of 119 turbines are planned for construction. The G114 turbines will be one of two types, 2.0 MW or 2.1 MW, both with a 93 meter hub height and blade pitch control to reduce noise under high wind conditions.

The documents I received for this review are found in Section 5 of the SLOD Application, Number Nine Wind Farm:

- Bodwell EnviroAcoustics, LLC, “Sound Level Assessment, Number Nine Wind Farm, LLC, Aroostook County,” April 2015 (the “Bodwell Report”), as amended by an email communication with Scott Bodwell, September 29, 2015.
- Exhibit 1, Wind Turbine Sound Warranty from Gamesa Wind US, LLC.
- Commonwealth Associates, Inc., “Audible Noise Sound Level, Number Nine Wind Farm 345 kV Generator Lead Line,” 2015 (the “Commonwealth Report”).

A site visit was made to the Turbine Area and Number Nine Lake on October 6, 2015. Number Nine Lake is ringed by residences that will receive the highest sound level impacts from the Project.

¹ T10 R3 WELS, E Township, T9 R3 WELS, T8 R3 WELS, and St. Croix Township.

Review Standard and Receptors

The purpose of this peer review is to determine if the acoustic studies submitted with the Application are reasonable and technically correct according to standard engineering practices and if the proposed project will comply with the Department Regulations on Control of Noise (06-096 CMR 375.10), referred to herein as the “Maine Noise Regulations”. The nighttime sound limit at a Protected Location is 42 dBA (1-hour L_{eq}) and applies on portions of a Protected Location within 500 feet of a residence or other sleeping quarters, or at the property boundary of the protected location, whichever is closer to the dwelling. Beyond 500 feet, the daytime limit of 55 dBA applies 24 hours per day. There are also decibel penalties that apply when the sound generated by a wind energy development results in tonal or short duration repetitive sounds, as those terms are defined in the Maine Noise Regulations. No local noise regulations apply to the Project.

The two Protected Locations closest to the Turbine Area and subject to the 42 dBA nighttime sound limit² are Receptor C1, representing a dwelling on Number Nine Lake in T9 R3 WELS, which is 2,802 feet southwest of a turbine, and S2, representing a dwelling in Webbertown Township, which is 3,173 feet southwest of a turbine in St. Croix Township.³

Sound Power Levels Assumed for the Turbines

The sound power level (L_w) on a decibel scale⁴ is determined by the manufacturer through a series of prescribed field measurements using the International Standard IEC 61400-11 test method.⁵ The IEC-reported sound power level for a given hub-height wind speed is an average value, meaning there is a scatter of values about the average and the actual sound power level emitted in the field may either be lower or higher. To quantify that variability in values of L_w , the IEC provides a method for assessing L_w measurement uncertainty and unit-to-unit turbine production uncertainty, combining both into a total uncertainty “K” factor (IEC Technical Specification 61400-14)⁶. The IEC method defines the “Declared Sound Power Level” as $L_w + K$, and the sum represents an upper-bound sound power level that, under the stated wind speed conditions, will not be exceeded 95% of the time. The Declared Sound Power Level should be used in acoustic modeling to ensure the predicted sound pressure levels are conservative estimates and reasonably account for known uncertainties.

² The Project has entered into lease agreements with the owners of dwellings and/or camps, mostly seasonal, within the Project area. These recreational lease dwellings are subject to a sound easement and are not Protected Locations under the Department Regulations.

³ On page 10, the Bodwell Report incorrectly lists a dwelling 2,260 feet from a turbine; the correct distance is 2,890 feet. That dwelling is on the parcel for receptor C1. The Protected Location receptor C1 is on the property boundary and is closer to the nearest turbine at a distance of 2,802 feet, as listed in Table 6-2.

⁴ The sound power level is defined as $10 \cdot \log_{10}(W/W_0)$, where W is the sound power of the source in Watts and W_0 is the reference power of 10^{-12} Watts. The sound power level (energy density) and sound pressure level (what we hear) are not the same, yet both are reported using a decibel levels scale. An acoustic model uses the sound power level of a wind turbine along with other assumptions to calculate the sound pressure level heard at a receiver located a certain distance from the wind turbine.

⁵ International Electrotechnical Commission, International Standard IEC 61400-11 Edition 2.1, “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques,” Geneva, 2006.

⁶ International Electrotechnical Commission, Technical Specification TS 61400-14, “Wind turbines – Part 14: Declaration of apparent sound power level and tonality values,” Geneva, 2005.

The applicant followed this procedure in modeling sound power levels that are the IEC reported maximum value for the Gamesa G114 turbine of 106.6 dBA plus an uncertainty K factor of 2.0 dBA. This sound power level corresponds to the turbine model with the higher electrical output rating of 2.1 MW. The applicant then added a 1.0 dBA modeling uncertainty factor for the ISO 9613-2 sound propagation method⁷ at an inland location, and thus a total sound power level of 109.6 dBA was modeled for the G114 turbines. The modeling uncertainty factor of 1 dBA is in the middle of the 0 to 2 dBA range for modeling uncertainty listed as a rebuttable presumption in sub-section I(7)(c)(9) of the Maine Noise Regulations.

Conservatism of the Combined Uncertainty Factor

Our review of the sound test reports for the Stetson I and II, and Bull Hill, wind energy facilities, where wind turbines are located on ridge top settings similar to Number Nine Wind, reveal use of the IEC reported sound power level plus uncertainty K factor and adding 1 dBA for modeling uncertainty is a conservative modeling approach for assessing wind turbine acoustic impacts.⁸ Thus, Bodwell EnviroAcoustics's combined uncertainty factors are appropriate and should accurately predict turbine sound levels.

Turbine Acoustic Model and Assumptions

Sound levels from the wind turbines were predicted using the Cadna\A acoustic model, the International Standard ISO 9613-2 sound propagation method, and a conservative ground absorption factor of $G=0.5$ that represents winter frozen-ground conditions. Water bodies were modeled as reflective surfaces with $G=0.0$. Standard day values for temperature and relative humidity⁹ (as they affect air absorption) were employed. These are the proper tools for accurately evaluating sound impacts. While the ISO method provides estimates of accuracy for mean source and receiver heights up to 30 m and the Number Nine Wind turbines are higher at 93 m, this acoustic modeling approach has been found to be accurate for utility wind turbine sounds on several past projects with similar hub heights; the method is judged to be accurate for the Number Nine Wind Project.

The project is located in an area of commercial forestland with rural residential and seasonal transient properties such as hunting camps and lakeside cottages. The majority of Protected Locations in the vicinity of the project are dwellings located around Number Nine Lake in T9 R3 WELS, labeled as receptors C1 through C6. Four other Protected Locations, dwellings in Westfield, Dudley and Webbertown, are within approximately one mile of a turbine and were also evaluated in the acoustic model; these are labeled as receptors N1, N2, S1 and S2. Four decibel contour maps were generated for Number Nine Wind to allow verification of predicted sound levels throughout the Project area.

⁷ International Organization for Standardization, Standard ISO 9613-2, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation," Table 5.

⁸ Tech Environmental, Inc., "Independent Peer Review of the Sound Level Assessment for the Oakfield Wind Project," September 1, 2011.

⁹ Temperature 10°C and relative humidity 70%.

The acoustic modeling results are conservative due to the following assumptions:

1. Sound from 129 wind turbine sites were modeled, even though only 119 turbines will be constructed, and the G114 2.1 MW model with the higher sound power level was modeled.
2. All wind turbines were assumed to be operating simultaneously and at the design wind speed, corresponding to maximum sound power.
3. All wind turbine sound power levels correspond to the IEC 61400-11 maximum rated sound power level plus a combined uncertainty factor of 3.0 dBA.
4. The acoustic model assumed the most favorable conditions for sound propagation, corresponding to a ground-based temperature inversion, such as might occur on a calm, clear night, or during a downwind condition with a moderate wind speed.
5. No attenuation from trees or other vegetation was assumed.
6. Winter frozen ground conditions were assumed for minimal ground absorption ($G=0.5$) and a reflective surface ($G=0.0$) was assumed for surface water bodies.
7. Excess attenuation from wind shadow effects and daytime air turbulence were ignored.

Turbine Acoustic Modeling Results

With 129 turbines operating at maximum sound power output, the modeling results in Table 6-2 of the Bodwell Report reveal Number Nine Wind will comply with the daytime sound level limit of 55 dBA at all Protected Locations, but will exceed the nighttime sound level limit of 42 dBA at six of the Protected Locations (receptors C1 through C6), all of which are on Number Nine Lake. The applicant is proposing curtailment of nighttime turbine operations near Number Nine Lake to achieve compliance. This plan, detailed in Table 6-1 of the Bodwell Report, consists of placing five wind turbine sites into Noise Reduced Operation (NRO) at night, using Gamesa NRO modes N1 through N5 for various turbines, which reduce sound power levels by 1.0 to 5.6 dBA. The maximum predicted nighttime sound levels with NRO mitigation are presented in Table 6-2 of the Bodwell Report and range from 36.3 dBA at receptor N1 in Westfield to 42.0 dBA at receptor C6 on Number Nine Lake in T9 R3 WELS. All six residential receptors on Number Nine Lake have nighttime sound levels within 1 dBA of the Maine Noise Regulation's nighttime limit of 42.0 dBA.

The acoustic modeling results demonstrate Number Nine Wind complies with the daytime (55 dBA) and nighttime (42 dBA) limits, and with the project boundary 75 dBA limit, in the Maine Noise Regulations. Since the applicant designed the nighttime NRO operations plan so that the predicted maximum sound level at a Protected Location is exactly at the 42.0 dBA limit, the situation suggests the need for compliance sound testing at more than one Protected Location along Number Nine Lake,

Tonal Sounds

The Bodwell Report (page 26) states that an analysis of the 1/3-octave band sound power level spectrum for the G114 turbine, which is claimed as proprietary by Gamesa and not provided in the Bodwell Report, reveals no potential for creating a Tonal Sound, as defined in the Maine Noise Regulations. Although this claim could not be independently confirmed, similar size wind turbines have shown no potential for producing a “tonal sound” and the claim is likely correct. Compliance sound testing will need to verify this assumption.

Short Duration Repetitive Sound (SDRS)

The definition of SDRS in the section of the Maine Noise Regulations that pertains to Wind Energy Developments is an impulse sound that is 5 dBA or greater “on the fast meter response above the sound level observed immediately before and after the event.” Typically this modulation of the turbine mid-frequency sound (the audible “swish-swish”) has an amplitude range of 2 to 5 dBA, with occasional 6 dBA peaks. The 5-dBA penalty for SDRS is applied to each 10-minute period in which more than five SDRS events occur. The three years of sound testing at the nearby Bull Hill Wind Project reveal SDRS events are uncommon and their effect on the averaged 10-minute $L_{A_{eq}}$ sound level used to assess compliance is typically less than 1 dBA. Given that there is no margin between projected maximum nighttime sound levels along Number Nine Lake and regulatory limits for this project, SDRS effects may increase the measured nighttime L_{eq} sound levels above 42 dBA at one or more Protected Locations, in which case the Project will be required to modify the NRO plan to provide additional nighttime sound reduction. Compliance sound testing will need to carefully document all SDRS events to verify the level of SDRS for this Project.

Construction Noise

Construction of the Number Nine Wind Project will produce sound levels similar to those generated during roadway construction, and much of the heavy equipment is similar. Daytime construction activity is not subject to the limits in the Maine Noise Regulations. Any nighttime construction activity will need to comply with the nighttime limit in the Maine Noise Regulations.

Post-Construction Sound Level Testing

To ensure that the sound level predictions submitted by the applicant are accurate for the wind turbines actually installed, and to ensure compliance with the Maine Noise Regulations, including the provisions regarding SDRS and tonal sound, the Department will require post-construction sound monitoring for the project.

The Bodwell Report suggests compliance testing be done at receptors C1 and C6 on Number Nine Lake, receptor C6 having the highest predicted nighttime sound level of 42.0 dBA. I recommend that the second test location be receptor C3 across the lake from C6, and not C1, which is relatively close to C6. This will ensure testing is done on both the east and west shores of the sound-reflective lake surface. A verification of compliance at Receptors C6 and C3 will ensure the Project complies at all other Protected Locations.

Generator Lead Line Acoustic Modeling

A separate analysis of the 245-kV Generator Lead Line sound impacts is presented in the Commonwealth Report for three sections: Section 1(Bridal Path); Section 2a (Northern) and Section 2b (Northern). Generator Lead Lines are part of a grid-scale wind energy development, as defined in 35-A MRSA § 3451, and thus the Lead Lines are subject to the Chapter 375(10)(I) nighttime sound limit of 42 dBA at Protected Locations, with adjustment for Tonal Sounds in subsection I(3) of the Maine Noise Regulations.

The Commonwealth Report presents predicted sound levels at the Lead Line right-of-way (ROW), and at 500 feet from the ROW, for both dry and wet corona discharge conditions. The TRALIN module of the CDEGS program using the EPRI/GE calculation method was employed, and this model provides reasonably accurate estimates of broadband sound impacts in dBA for the stated conditions. In discussing the results, the Commonwealth Report (page 2) states “the sounds generated by these generator lead lines are within the sound limits for quiet areas at regulated protected locations as set forth in Section 10 of Chapter 375 of the Main DEP Rules.” Curiously, the Commonwealth Report never states what they assumed as the limit, so we do not know if they used 45 dBA or 42 dBA as the nighttime sound limit at nearby Protected Locations. As discussed above, the applicable limit for Lead Line sound is 42 dBA.

Corona discharge under the worst case (wet conditions) can produce a tonal sound at 120 Hz, thus in the 125 Hz 1/3-octave band, that is 20 dB above the sound level in adjacent octave bands.^{10,11} Such a tone would qualify as Tonal Sound, as that term is defined in the Maine Noise Regulations. Thus, the 5-dBA penalty for Tonal Sound may apply to the Lead Lines. The Commonwealth Report fails to discuss or analyze this issue. In reviewing the projected worst case Lead Line sound levels, I added 5 dBA to account for a Tonal Sound penalty.

For Section 2a, the Commonwealth Report (page 1) predicts a maximum sound level of 36.8 dBA at the ROW, which drops to 24.5 dBA at ROW+500 feet. Adding a 5-dBA penalty, the maximum ROW sound level is 41.8 dBA, which complies with both the property line limit of 75 dBA and the nighttime sound limit of 42 dBA for Protected Locations. Thus, even if a Protected Location is near the ROW or has a common boundary with the ROW and the dwelling is within 500 feet, Lead Line Section 2a complies with all applicable sound limits.

For Section 1, the predicted maximum sound level at the ROW is 37.4 dBA. If a 5-dBA penalty is added, then the total sound level on the ROW is 42.4 dBA, which is slightly above the 42 dBA nighttime sound limit. The question then arises whether there are any parcels containing a residential dwelling that have a property boundary coincident with the ROW and for which the dwelling is 500 feet or less from the ROW? A review of the Section 1 Lead Line maps reveals six possible residential parcels that meet these criteria.

¹⁰ Muhr, M. et al., “Sound analysis and PD measurement of HV transmission lines,” Institute of High Voltage Engineering and System Management, Graz, Austria, 2004.

¹¹ Straumann, U. and Semmler, M., “Mechanism of Tonal Emission from High-Voltage Transmission Lines,” Swiss Federal Institute of Technology, High Voltage Laboratory, 2005.

For the following parcels, which appear to be Protected Locations with a property line coincident with the Section 1 Lead Line ROW, the maximum sound level with a Tonal Sound penalty will be above the 42 dBA nighttime limit:

1. Map 31, Chase (Houghton Map 27, Lot 29)
2. Map 30, Howland (Houghton Map 33, Lot 14)
3. Map 27, Holston (Houghton Map 50, Lot 3)
4. Map 25, Turney (Linaeus 1232)
5. Map 20, McGuire (Linaeus 516-4)
6. Map 16, Lakeville Shores (Linaeus 27)

For Section 2a, the Commonwealth Report predicts a maximum sound level of 50.4 dBA at the ROW, which drops to 38.1 dBA at ROW+500 feet, and states (on page 3) Section 2b has no Protected Locations within 500 feet of the ROW. If a Tonal Sound penalty applies to Section 1a, then the maximum sound level is 43.1 dBA at ROW+500 feet and above the 42 dBA nighttime limit. From the maps provided for Lead Line Section 2a, I cannot see potential Protected Locations at and beyond 500 feet and thus I do not know if there are any Protected Locations along Section 1a with a maximum sound level (including a 5-dBA penalty) above 42 dBA.

In summary, the Commonwealth Report fails to analyze the Generator Lead Lines for Tonal Sound as required by the Maine Noise Regulations. I believe a Tonal Sound penalty of 5-dBA may apply to the Lead Lines for Number Nine Wind. Despite the lack of tonal sound analysis, the information provided shows compliance for Section 2a because it's ROW maximum sound level (38.1 dBA) is more than 5 dBA below the 42-dBA nighttime limit. Section 1 appears to have six Protected Locations that will have a maximum sound level above 42 dBA if the Tonal Sound penalty applies. Insufficient information is available to determine if Section 2a complies with the 42 dBA sound limit. SGC Engineering, LLC, the authors of the Commonwealth Report, need to provide the Department with additional information that addresses these deficiencies.

Summary

A peer review was done of Section 5 of the SLOD Application for Number Nine Wind Farm, which consists of the Bodwell Report for the Turbine Area and the Commonwealth Report for the Lead Lines.

The Bodwell Report results confirm the Gamesa G114 wind turbine maximum sound power levels, with a conservative uncertainty factor, were used in the analysis; the acoustic model and its assumptions are appropriate; the sound receiver locations are appropriate; the decibel contour maps adequately cover the potential impact area; and the maximum sound levels comply with the Department Regulations on Control of Noise (06-096 CMR 375.10(I)). No additional acoustic studies of the Turbine Area are required for permitting of the project.

The Commonwealth Report results confirm an appropriate acoustic model was applied for maximum corona discharge noise from the Generator Lead Lines and the sound receiver locations represented by the ROW are appropriate to assess worst case impacts for nearby Protected Locations. The

Commonwealth Report, however, fails to analyze the Generator Lead Lines for Tonal Sound as required by the Maine Noise Regulations. I believe a Tonal Sound penalty of 5-dBA may apply to the Lead Lines for Number Nine Wind. Despite the lack of tonal sound analysis, the information provided in the Report shows compliance for Section 2a because its ROW maximum sound level (38.1 dBA) is more than 5 dBA below the 42-dBA nighttime limit. Section 1 appears to have six Protected Locations that will have a maximum sound level above 42 dBA if the Tonal Sound penalty applies. Insufficient information is available to determine if Section 2a complies with the 42 dBA sound limit. SGC Engineering, LLC, the authors of the Commonwealth Report, need to provide the Department with additional information that addresses these deficiencies.

For the reasons stated above, I conclude that the Turbine Area acoustic study submitted with the SLOD Application is reasonable and technically correct according to standard engineering practices and the Department Regulations on Control of Noise (06-096 CMR 375.10), but the Generator Lead Line acoustic study is incomplete.

Recommendations

The Department should request additional information from the applicant to address the deficiencies in the Generator Lead Line acoustic study outlined above. That information is needed before the peer review can be completed.

Assuming the Lead Line issues are addressed, I recommend that any permit the Department may ultimately issue for Number Nine Wind require compliance testing at Locations C3 and C6 on the east and west shores of Number Nine Lake, respectively. Given that there is no margin between projected maximum nighttime sound levels along Number Nine Lake (42.0 dBA) and regulatory limits for this project (42 dBA), SDRS effects may increase the measured nighttime L_{eq} sound levels above 42 dBA at one or more Protected Locations, in which case the Project will be required to modify the NRO plan to provide additional nighttime sound reduction. Compliance sound testing will need to carefully document all SDRS events to verify the actual level of SDRS for this Project.

Thank you for the opportunity to provide an independent peer review of the Number Nine Wind Project application.

Sincerely yours,

TECH ENVIRONMENTAL, INC.



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Senior Principal
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