Noise

2.1 State Standards

Chapter 375, Section 10(I) of the Department's rules states:

> *Sound Level Limits for Routine Operation of Wind Energy Developments*
>
> *The sound levels resulting from routine operation of a wind energy development measured in accordance with the measurement procedures described in subsection I(8) shall not exceed the following limits:*
>
> *(a) 75 dBA at any time of day at any property line of the wind energy development or contiguous property owned or controlled by the wind energy developer, whichever is farther from the proposed wind energy development's regulated sound sources; and*
>
> *(b) 55 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime limit"), and 42 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime limit") at any protected location.*
>
> *Tonal Sounds*
>
> *For the purposes of this subsection, a tonal sound exists if, at a protected location, the 10 minute equivalent average one-third octave band sound pressure level in the band containing the tonal sound exceeds the arithmetic average of the sound pressure levels of the two contiguous one-third octave bands by 5 dB for center frequencies at or between 500 Hz and 10,000 Hz, by 8 dB for center frequencies at or between 160 and 400 Hz, and by 15 dB for center frequencies at or between 25 Hz and 125 Hz. 5 dBA shall be added to any average 10 minute sound level ($Leq_{A\ 10\text{-}min}$) for which a tonal sound occurs that results from routine operation of the wind energy development.*

2.2 Local Standards

The Town of Roxbury has not enacted a separate noise ordinance.

The Town of Rumford, an adjacent town to Roxbury, *has* adopted a separate noise ordinance. While the Project is not located in Rumford, the Applicant reviewed the Town of Rumford's noise ordinance to determine the Project's compliance with that ordinance. The Town of Rumford's ordinance for audible sound from a Wind Energy Facility ["WEF"] states:

> *Sound Limits No site permit shall be issued if the pre-licensing information of sound study indicates that the proposed WEF will not comply with the following requirements, which are to*

2. Noise

apply everywhere within four thousand (4,000) feet of any WT, except on a Project Parcel(s) or on a Participating Parcel(s) which is subject to a Mitigation waiver which specifies different sound limits than those below. If pre-construction estimates of the post-construction sound levels exceed the limits below, then the WEF application will be denied; if these limits are exceeded after the WEF has been built, then the WEF will be in violation of this ordinance.

a. Audible Sound Limit

i. No WT, WES or WEF shall be located so as to generate post construction audible sound levels that exceed forty (40) dBA at night (7:00 p.m. to 7:00 a.m.) or fifty (50) dBA during the day (7:00 a.m. to 7:00 p.m.).

ii. A five (5) dB penalty is applied for tones as defined in the International Standards of the International Electrotechnical Commission's 61400-11.

While the Project is not located in Rumford, the Applicant's sound study demonstrates that the Project will comply with the Town of Rumford's audible sound limits.

2.3 Sound Modeling Approach

The predictive sound modeling was performed by Epsilon Associates, Inc. ("Epsilon"), a Massachusetts-based environmental engineering firm with extensive experience in modeling and measuring the sound from wind energy projects, and was designed to conform with State standards. The Project is wholly located in the Town's Mountain District, a Zoning District determined by the Town to be appropriate for wind energy development. The area surrounding the Project is primarily forested. Within roughly a mile and a half of the turbines, there are approximately 47 structures. These structures were verified, as accessible, by Kleinschmidt Associates, Inc. ("Kleinschmidt"), an environmental consulting firm with offices in Maine that provides regulatory, engineering and environmental services to energy companies and governmental agencies.

Each wind turbine blade is outfitted with a "low-noise trailing edge" ("LNTE") to decrease the overall sound from the wind turbine. This technology results in each turbine producing a maximum sound power level of 107 dBA when wind speeds reach 10 meters per second. For the sound modeling, the maximum sound power level of 107 dBA was increased by 2 dBA to account for uncertainty. The resulting sound levels summarized in Section 2.4 include the increased sound power level from the uncertainty adjustment.

For more details about the Sound Modeling Assessment, see Exhibit 2-A.

2.4 Sound Modeling Results Summary

The sound modeling results predict that there will be no violations of the State's 42 decibel "nighttime limit" at any occupied residence nor any "protected location" (as such term is defined in Chapter 375

and applicable to the nighttime limit). At the Project property lines, the sound levels are not projected to exceed 75 decibels. In addition, at the properties in Rumford, the sound from the Project is not projected to exceed 40 decibels.

The sound modeling results demonstrate compliance with the State's and Rumford's tonal section of the respective noise requirements outlined in Sections 2.1 and 2.2 above.

Therefore, RoxWind concludes that the Project is in compliance with the audible sound level limits and tonal requirements imposed by the Department and the Town of Rumford.

2.5 Sound Modeling Compliance Testing

The Project proposes to complete post-construction sound testing at locations #15 (upwind of the predominant wind direction) and #30 (downwind of the predominant wind direction). The compliance testing protocol is included with the Sound Modeling Assessment, Exhibit 2-A.

2.6 Sound Complaint and Response Procedure

Prior to the start of construction, the Project will notify abutters, the Town, and the Department of the details of its sound complaint response procedure. This information will include:

- a 24-hour contact to register complaints about sound from the Project.
- details requested when registering a complaint, including at a minimum:
    - the name and address of the complainant;
    - the date, time and duration of the sound event;
    - a description of the sound event, indoor or outdoor, specific location, a description of any audible sounds from other sources outside or inside the dwelling of the complainant.

RoxWind will analyze complaints that are accompanied by sufficient information as outlined in Chapter 375, Section 10(I)7(j).

2-A
Sound Level Assessment Report

SOUND LEVEL ASSESSMENT REPORT

RoxWind Project
Town of Roxbury, Maine

Prepared for:

RoxWind LLC
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Prepared by:

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March 20, 2018

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1.0 EXECUTIVE SUMMARY

RoxWind (the Project) is a proposed wind energy development (WED) composed of up to four (4) wind turbines in the Town of Roxbury, Maine. The Project is being developed by RoxWind LLC who has retained Epsilon Associates, Inc. (Epsilon) to conduct a sound level assessment for the proposed wind turbines for this Project.

A sound level modeling analysis has been conducted for four proposed wind turbines. All wind turbines are proposed to be General Electric (GE) 3.8-130 units. The purpose of this assessment is to predict worst-case community sound levels in the vicinity of the Project when the wind turbines are operational and to compare the modeling results to applicable limits. Sound levels from a wind energy development in the State of Maine are most stringently limited, by regulation, to 42 dBA at night within 500 feet of protected locations on a property parcel.

Using the Project specific data provided by RoxWind LLC, the sound levels modeled at protected locations in the vicinity of the Project ranged from 22 to 41 dBA. Sound levels modeled within 500 feet of the protected locations were at or below 42 dBA with the exception of 500 feet from one (1) protected location. However, the modeled sound levels at the property line of this protected location are at or below 42 dBA. Modeled sound levels at the Project property line are well below 75 dBA. Modeled one-third octave-band sound levels at the three (3) nearest protected locations show no indication of tonal sound caused by the Project. Therefore, the Project meets the State of Maine regulations with respect to sound. Additionally, the Project meets the applicable local regulation in the neighboring Town of Rumford.

2.0 INTRODUCTION

The RoxWind Project to be located in the Town of Roxbury, Maine will consist of up to four (4) General Electric (GE) wind turbines. The proposed wind turbines are all GE 3.8-130 units with a hub height of 85 meters and a rotor diameter of 130 meters. No new electrical substation is proposed for the Project.

A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.[1] A few points are repeated herein. Wind turbine sound can originate from two different sources: mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine sound. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical sound. Aerodynamic sound has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction. Aerodynamic sound, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then typically remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

This report presents the findings of a sound level modeling analysis for the Project. The wind turbines were modeled with the Cadna/A software package using sound data from a GE technical document provided by RoxWind LLC. The results of this analysis are found within this report.

[1] Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Wind Turbine Acoustic Noise, June 2002, amended January 2006.

3.0 SOUND TERMINOLOGY

There are several ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. Relative to this characteristic, a change in sound levels of less than 3 dB is imperceptible to the human ear.

Another mathematical property of decibels is that if one source of sound is 10 dB (or more) louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.[2] It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone". The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as "dBA". Sound pressure levels for some common indoor and outdoor environments are shown in Figure 3-1.

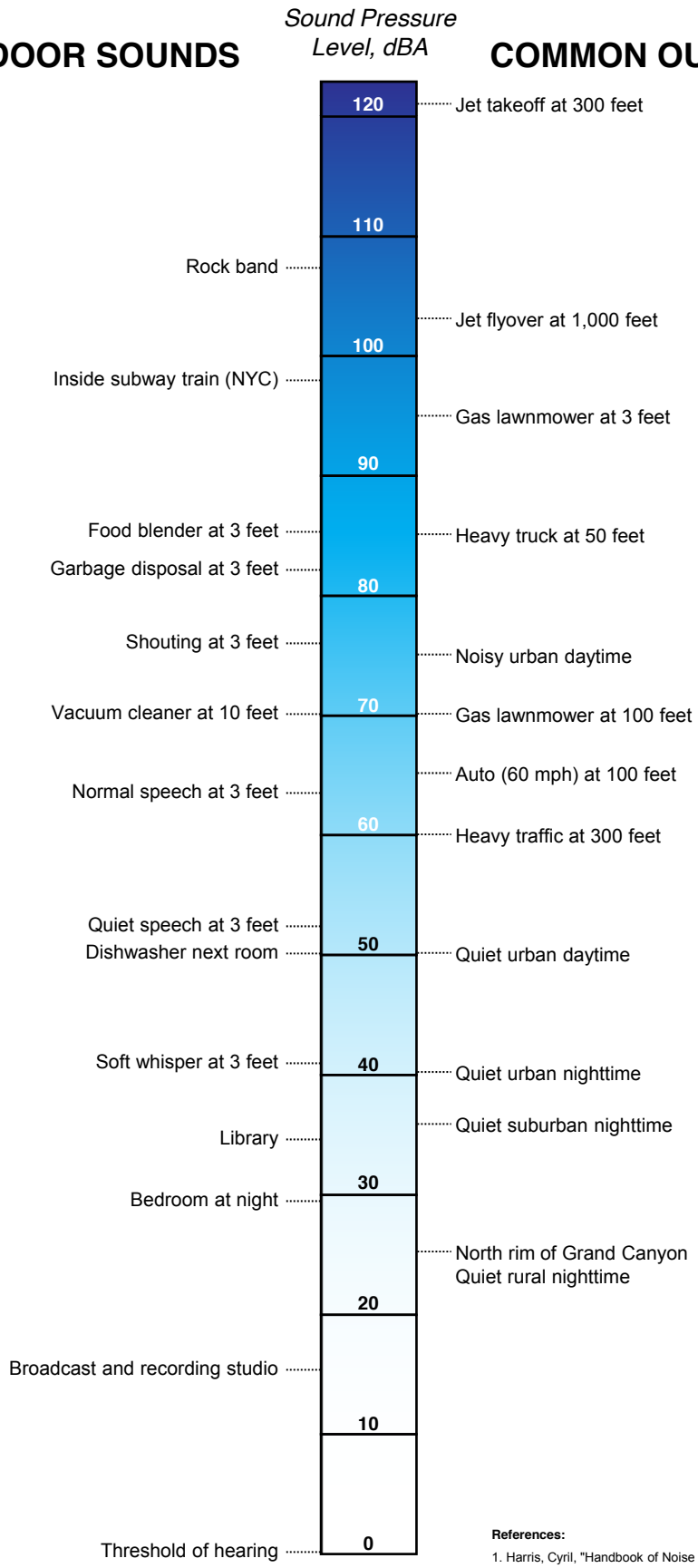
Because the sounds in the environment vary with time, many different sound metrics may be used to quantify them. There are two typical methods used for describing variable sounds. These are exceedance levels and equivalent levels, both of which are derived from a large number of moment-to-moment A-weighted sound pressure level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n, where "n" is a value (typically an integer between 1 and 99) in terms of percentage. Equivalent

[2] *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983 (R2006), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

levels are designated L_{eq} and quantify a hypothetical steady sound that would have the same energy as the actual fluctuating sound observed. Two sound level metrics that are commonly reported in community sound level documentation are described below.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during a measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent sound sources.

- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is commonly A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with time-averaged mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Figure 3-1

Common Sound Levels in the Environment

4.0 NOISE REGULATIONS

4.1 State of Maine Regulations

The proposed RoxWind Project in the Town of Roxbury, Maine is subject to the following sound level requirements in Section 10.I of the Maine Department of Environmental Protection (ME DEP) regulations which is applicable to grid-scale, and small-scale, wind energy developments (WEDs):

> *The sound levels resulting from routine operation of a wind energy development measured in accordance with the measurement procedures described in subsection I(8) shall not exceed the following limits:*
>
> *(a) 75 dBA at any time of day at any property line of the wind energy development or contiguous property owned or controlled by the wind energy developer, whichever is farther from the proposed wind energy development's regulated sound sources; and*
>
> *(b) 55 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime limit"), and 42 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime limit") at any protected location.*

Since wind turbines can operate under conditions resulting in maximum sound power during both the day and at night, the Project would need to comply during the period with more stringent limits, nighttime. Additionally, Section 10.G(16) of the regulation states that daytime hourly sound levels apply regardless of the time of day at a protected location if more than 500 feet from living and sleeping quarters within the protected location. Therefore, boundary lines of protected locations and, if there was an exceedance on the protected location, up to 500-foot buffer areas from sleeping and living quarters within a property boundary were evaluated in this analysis against the 42 dBA nighttime ME DEP limit.

In addition to the broadband sound level limits, the ME DEP regulations specify tonal limitations for the WED as follows:

> *…a tonal sound exists if, at a protected location, the 10 minute equivalent average one-third octave band sound pressure level in the band containing the tonal sound exceeds the arithmetic average of the sound pressure levels of the two contiguous one-third octave bands by 5 dB for center frequencies at or between 500 Hz and 10,000 Hz, by 8 dB for center frequencies at or between 160 and 400 Hz, and by 15 dB for center frequencies at or between 25 Hz and 125 Hz.*

Finally, Section 10.I(4) prohibits Short Duration Repetitive Sounds (SDRS). These events, greater than 5 dBA per occurrence, are rare and cannot be predicted through pre-construction sound level modeling. If SDRS were to occur, it would show up during post-construction compliance testing. Therefore, SDRS is not addressed further in this analysis.

4.2 Local Regulations

All wind turbines of the Project are located within the Town of Roxbury, Maine. Abutting the Town of Roxbury is the Town of Mexico in which no protected locations were provided for modeling. Epsilon is not aware of any noise regulations applicable to this Project in the two municipalities.

The Town of Rumford also abuts the Town of Roxbury. The Town of Rumford has a Wind Energy Facility Ordinance with noise limits applicable "everywhere within four thousand (4,000) feet" of any wind turbine. The audible sound level limit is provided below:

> *No WT, WES or WEF shall be located so as to generate post-construction audible sound levels that exceed forty (40) dBA at night (7:00 p.m. to 7:00 a.m.) or fifty (50) dBA during the day (7:00 a.m. to 7:00 p.m.).*

There are some property parcels within the Town of Rumford that are within 4,000 feet of a RoxWind wind turbine. Similarly as with the State of Maine regulation, the Project would need to comply during the period with more stringent limits, nighttime. Therefore, parcels within the Town of Rumford and within 4,000 feet of a wind turbine were evaluated in this analysis against the 40 dBA nighttime audible limit.

5.0 CONSTRUCTION NOISE

The majority of the construction activity related to the RoxWind Project will occur around each of the wind turbine sites. By its very nature, construction activity moves around the site. Full construction activity for each phase will generally occur at one wind turbine site at a time, although there will be some overlap at adjacent sites for maximum efficiency. There are generally three phases of construction at a WED – excavation, foundations, and turbine erection. Table 5-1 presents the sound levels for the louder pieces of construction equipment expected to be used at this site along with their phase of construction. Reference sound source information in Table 5-1 was obtained from either Epsilon field measurements or the FHWA's Roadway Construction Noise Model database.

Construction of the Project is expected to take nine months. The construction schedule begins with excavation work and construction of the access roads. Excavation work is expected to occur wholly within the hours set for daytime limits (7 am to 7 pm)[3]. Typically, all foundations will be poured before any turbine erection work begins. Concrete foundation work and turbine erection work could extend into the overnight hours depending on the weather and timing of a concrete pour which must be continuous.

The closest foundation to any property line is 618 feet and other foundations are over 1,000 feet from any property line. Table 5-1 below shows the projected sound levels at a distance of 50 feet from various types of construction equipment. None of these sound levels exceed the limits for daytime noise set forth in 10(C)(2)(b) based on the significant distances to all protected locations.

Table 5-1 Sound Levels for Construction Noise Sources

Phase	Equipment	Sound Level at 50 feet (dBA)
Excavation	Grader	85
Excavation	Bulldozer	82
Excavation	Front-end loader	79
Excavation	Backhoe	78
Excavation	Dump truck	76
Excavation	Roller	80
Excavation	Excavator	81
Excavation	Rock drill	89
Foundation	Concrete mixer truck	79
Foundation	Concrete pump truck	81

[3] As defined by Section 10.C(2)(b) of the ME DEP regulation for sound from construction of developments.

Table 5-1 Sound Levels for Construction Noise Sources (Continued)

Foundation	Concrete batch plant	83
Turbine erection	Large crane #1	81
Turbine erection	Large crane #2	81
Turbine erection	Component delivery truck	84
Turbine erection	Air compressor	78

6.0 FUTURE CONDITIONS

6.1 Equipment and Operating Conditions

The sound level analysis includes 4 wind turbines, all proposed to be GE 3.8-130 units. The GE 3.8-130 wind turbine has a hub height of 85 meters and a rotor diameter of 130 meters. A technical report from GE[4] was provided by RoxWind LLC which documents the expected sound power levels associated with the GE 3.8-130. According to this document, which included broadband and octave-band A-weighted sound power levels for various wind speeds, the maximum sound power level using the IEC 61400-11 methodology for the wind turbine model of 107.0 dBA occurs at wind speeds of 10 m/s (and above) at an 85-meter hub-height. These sound power levels are defined as "calculated apparent" by the turbine manufacturer and therefore do not include any additional uncertainty factor. Table 6-1 presents the modeled broadband and octave-band sound power levels for the wind turbine. Table 6-2 presents the one-third octave-band sound power levels used for the tonality analysis.

Table 6-1 Modeled Wind Turbine Sound Power Levels

		Sound Power Levels per Octave-Band Center Frequency [Hz]								
Turbine Model	Broadband dBA	31.5	63	125	250	500	1k	2k	4k	8k
		dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
GE 3.8-130	107.0	76	88	97	100	101	102	99	88	66

Note: These levels do not include the 2 dB manufacturer's uncertainty factor.

Table 6-2 Wind Turbine One-Third Octave-Band Sound Power Levels

One-Third Octave Band	GE 3.8-130 Sound Power Level (dB)
25	66
31.5	70
40.0	74
50	78
63	82
80	86
100	89
125	92

Note: These levels do not include an uncertainty factor.

[4] General Electric Company, Technical Documentation Wind Turbine Generator Systems 3.8-130 – 50/60 Hz Product Acoustic Specifications, 2016.

Table 6-2 Wind Turbine One-Third Octave-Band Sound Power Levels (Continued)

One-Third Octave Band	GE 3.8-130 Sound Power Level (dB)
160	93
200	94
250	95
315	95
400	96
500	96
630	97
800	97
1,000	97
1,250	97
1,600	96
2,000	94
2,500	91
3,150	87
4,000	82
5,000	75
6,300	66
8,000	54
10,000	40

Note: These levels do not include an uncertainty factor.

6.2 Modeling Methodology

The noise impacts associated with the proposed wind turbines were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

Inputs and significant parameters employed in the model are described below:

- *Project Layout:* A project layout dated February 8, 2018 was provided by RoxWind LLC. The four proposed wind turbines were input into the model and are shown in Figure 6-1. Global coordinates of these wind turbines are provided in Appendix A of this report.

- *Modeling Locations:* A modeling receptor dataset dated January 30, 2018 was provided by RoxWind LLC. The dataset included assumed protected locations within 1.5 miles of any of the four wind turbines. The 47 protected locations were input into the Cadna/A model and modeled as discrete points at a height of 1.5 meters (~5 feet) above ground level to mimic the ears of a typical standing person. These locations are shown in Figure 6-1. Approximate tax parcels[5] are also included in the figure.

- *Terrain Elevation:* Elevation contours for the modeling domain were directly imported into Cadna/A which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey.

- *Source Sound Levels:* Octave-band sound power levels for the GE 3.8-130 wind turbine provided in the technical report (presented above in Table 6-1) were input to the model. These sound levels represent maximum operational sound level emissions and are independent of wind direction.

- *Uncertainty factor:* No uncertainty factor was provided in the GE technical document; however, earlier documentation of other GE wind turbine types has provided an uncertainty factor of 2.0 dBA. Based on the earlier documentation, experience with other wind turbine manufacturers, and WED sound modeling, an uncertainty factor of 2.0 dBA was assumed and added to the sound power level for each modeled wind turbine.

- *Discretionary uncertainty factor:* Per the ME DEP regulation, it is "the Department's discretion based on the information available," that an additional uncertainty factor "of 0 to 2 dBA" be applied to sound level modeling for inland WEDs. The sound modeling results in this report reflect a discretionary uncertainty factor of 0 dBA. A 2.0 dBA sound level modeling uncertainty factor (described above) has shown good

[5] Parcel data were provided by RoxWind LLC in digital format. Alignment with other features of the figure does not perfectly reflect actual positioning of the parcel boundaries based on a review of a property map from the Town of Roxbury prepared by Sackett & Brake Survey, Inc.

correlation with post-construction measurements at WEDs in Epsilon's experience; therefore, no additional factor has been applied.

- *Ground Attenuation:* Spectral ground absorption was calculated using a G-factor of 0.5 which corresponds to "mixed ground" consisting of both hard and porous ground cover. This method yields more conservative results (i.e., higher sound levels) as the vast majority of the area is actually forest.

The highest wind turbine sound power level for each wind turbine type including uncertainty and adjustment factors (109.0 dBA) was input into Cadna/A to model wind turbine generated sound pressure levels during conditions when worst-case sound power levels are expected. Sound pressure levels due to operation of all four wind turbines were modeled at 47 protected locations in the vicinity of the Project. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart to allow for the generation of sound level isolines.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the Cadna/A model to ensure conservative results (i.e., higher sound levels), and are described below:

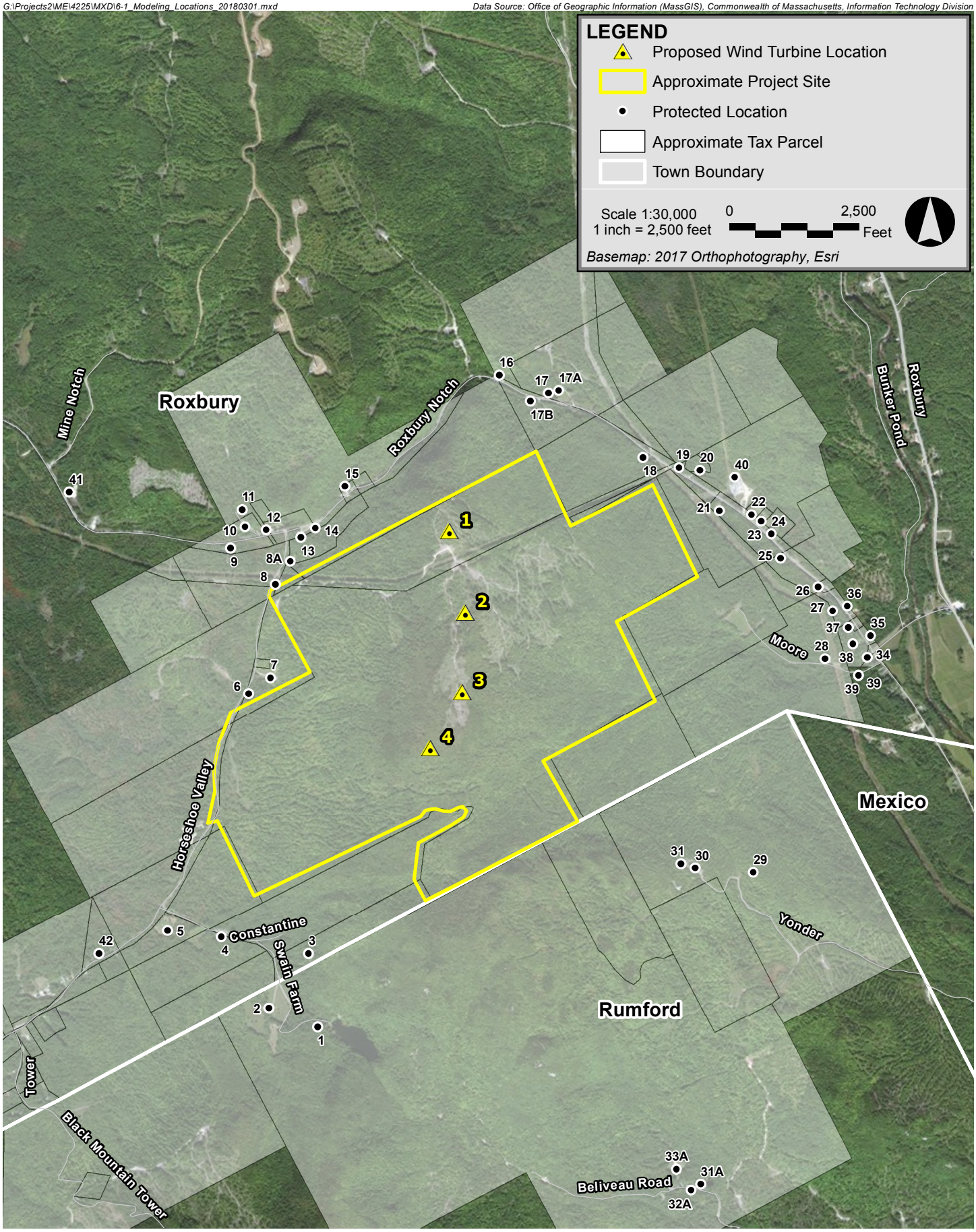
- All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts.
- As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.
- Meteorological conditions assumed in the model (temperature = 10°C & relative humidity = 70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.
- No additional attenuation due to forestation, air turbulence, or wind shadow effects was considered in the model.

6.3 Broadband Sound Level Results

Table B-1 in Appendix B shows the predicted "Project-Only" broadband (dBA) sound levels under conditions specified in the previous section. The table presents sound levels at the 47 discrete points (protected locations) in the vicinity of the Project included in the analysis. These sound levels range from 22 to 41 dBA. In addition to these discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 6-2. The figure displays 500-foot buffer areas applicable to each protected location as well as approximate tax parcels.

6.4 Tonality Analysis

Sound pressure level calculations using the Cadna/A modeling software which incorporates the ISO 9613-2 standard is limited to octave-band sound levels; therefore, a quantitative evaluation of one-third octave-band sound levels using the modeling software was not possible. Alternatively, spreadsheet calculations were performed for the three (3) closest protect locations (#15, #14, and #13) to the wind turbines. These three locations also correspond to the highest Cadna/A-modeled discrete points. If no impacts are shown for these locations, then other more distant locations will show even lower sound levels and thus no tonal impacts. Only drop-off with distance and atmospheric absorption were included in the calculations. Atmospheric absorption values were taken from ANSI/ASA S1.26-2014 for a temperature of 10°C and 70% relative humidity. This standard only provides absorption values for one-third octave bands of 50 Hz and above, therefore, no atmospheric absorption occurs below 50 Hz. No ground absorption was assumed.

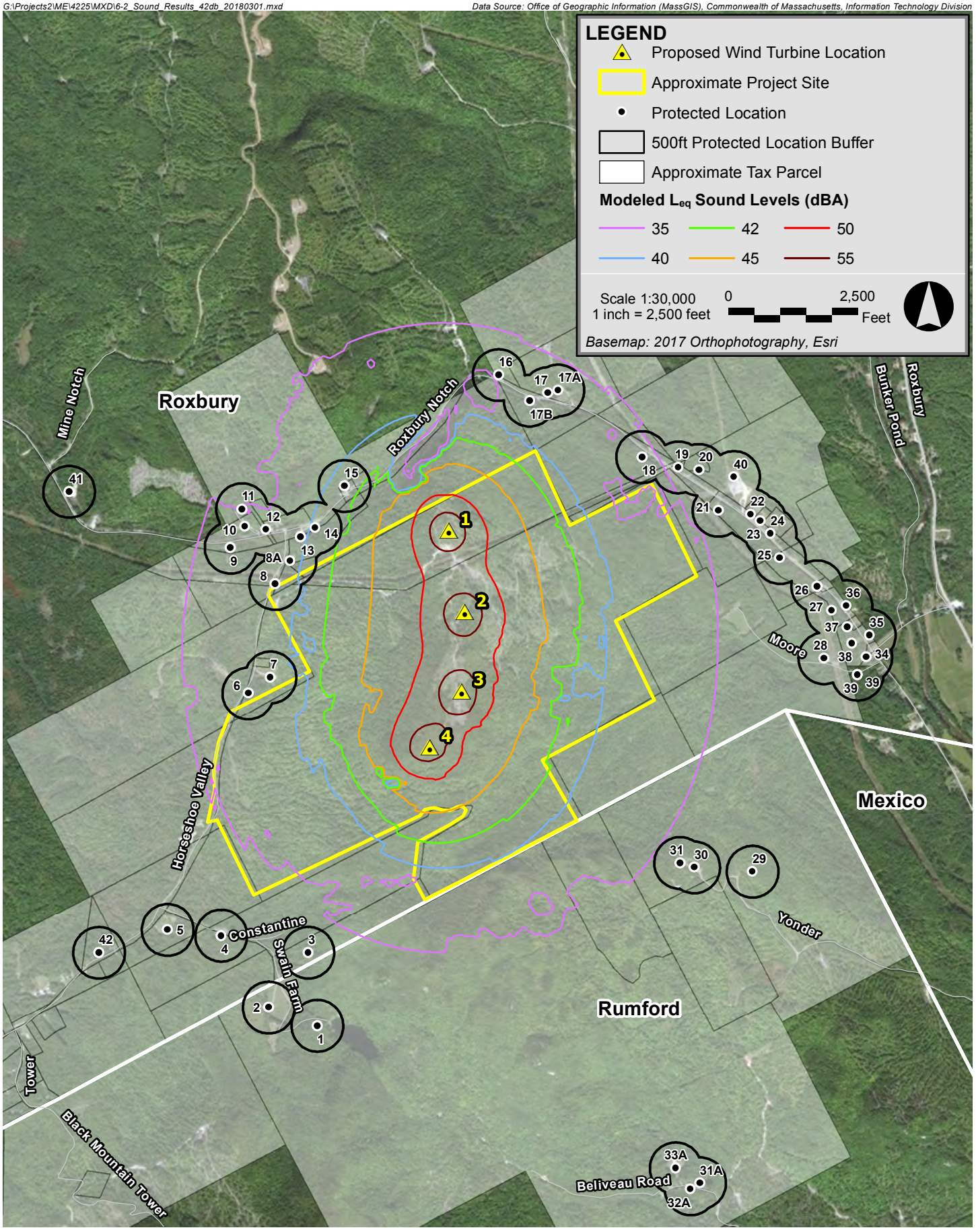


RoxWind Roxbury, Maine

Epsilon ASSOCIATES INC.

Figure 6-1

Sound Level Modeling Locations



RoxWind Roxbury, Maine

Epsilon Associates Inc.

Figure 6-2

Sound Level Modeling Results

7.0 EVALUATION OF SOUND LEVELS

7.1 Modeled Sound Levels

All modeled sound levels, as output from Cadna/A and presented in Appendix B, are A-weighted equivalent sound levels (L_{eq}, dBA). These levels may be used in evaluating measured sound pressure levels over typical averaging durations (i.e., 10 minutes or 1 hour).

7.2 State of Maine

7.2.1 Broadband Evaluation

The Project is subject to the requirements contained in the ME DEP noise regulation for WEDs. The most stringent sound level limit in this regulation for a WED is during the nighttime, 42 dBA. The predicted worst-case sound levels from the RoxWind Project are below the 42 dBA limit at all modeled protected locations. A review of the table in Appendix B shows the highest sound level to be 41 dBA at Location #15. It can be derived from Figure 6-2 that sound levels modeled at the property line of any protected location or, in the alternative, within 500 feet of any living and sleeping quarter within a protected location are at or below 42 dBA.[6,7] Therefore, the Project meets the broadband requirements with respect to sound in the regulation.

7.2.2 Tonal Evaluation

In addition to limiting broadband sound levels from WED, Maine has established requirements pertaining to tonal sounds. The state's definition of a tone requires the evaluation of one-third octave-band sound levels. Results of the tonal analysis and an evaluation against the limits are provided in Table C-1 of Appendix C for the three (3) nearest protected locations to any wind turbine. The spreadsheet modeling indicates no frequency tones as defined by the State of Maine regulation and therefore meets the requirements. If the closest locations meet the tonal requirements, then the more distant locations will have even lower impacts, and thus also meet the tonal sound requirement.

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[6] At one (1) location (#15), modeled sound levels <u>on</u> the property parcel which defines the protected location are at or below 42 dBA although 500 feet away on another parcel, the sound level would be higher.

[7] A property map from the Town of Roxbury prepared by Sackett & Brake Survey, Inc. has been reviewed and shows the property parcel of protected location #15 (Town of Roxbury Parcel #30) to be entirely north of Route 120.

8.0 POST-CONSTRUCTION CONSIDERATIONS

Attached to this report, as Appendix D, is a compliance measurement protocol per Section 10.I(8) of the ME DEP regulation. Compliance sound level measurements will be performed at no fewer than two (2) locations. These locations are expected to represent the protected locations (a) with the highest-modeled sound level and (b) downwind of the prevailing wind direction (approximately northwest winds). These proposed measurement locations are modeled protected locations (a) #30 and (b) #15, respectively. Both locations are identified in Figure 6-2. Additional details regarding the compliance measurements are provided in the appendix.

At least 30 days prior to commissioning the Project, RoxWind LLC will submit a complaint response protocol with details described in Section 10.I(7)(j) of the ME DEP regulation.

9.0 CONCLUSIONS

A comprehensive sound level analysis was conducted for the proposed RoxWind Project in the Town of Roxbury, ME. Up to four wind turbines are proposed for this Project. Sound levels resulting from the operation of these four wind turbines were calculated at 47 discrete modeling points (protected locations), and isolines were generated from a grid encompassing the area surrounding the wind turbines using the proposed layout. The sound levels modeled at protected locations in the vicinity of the Project ranged from 22 to 41 dBA. Modeled one-third octave-band sound levels show no indication of tones caused by the Project. The Project meets the State of Maine regulations with respect to sound and the applicable local regulation in the neighboring Town of Rumford.

Appendix A
Wind Turbine Coordinates

Table A-1

Wind Turbine ID	Coordinates UTM NAD83 Zone 19N	
	X (m)	Y (m)
1	371671.76	4942589.02
2	371765.42	4942109.33
3	371748.24	4941642.94
4	371559.14	4941313.32

Appendix B

Predicted Wind Energy Development Sound Levels at Discrete Modeling Points

Table B-1

Receptor ID	Coordinates UTM NAD83 Zone 19N		Project-Only Sound Level (dBA)
	X (m)	Y (m)	
1	370904.08	4939668.64	31
2	370617.83	4939776.20	31
3	370850.79	4940099.90	33
4	370337.28	4940200.01	32
5	370021.44	4940234.25	31
6	370496.85	4941628.36	37
7	370627.83	4941722.81	38
8	370655.92	4942273.02	39
8A	370745.01	4942407.66	39
9	370392.60	4942487.28	36
10	370478.84	4942613.29	37
11	370460.17	4942714.36	35
12	370603.42	4942593.67	38
13	370806.18	4942551.53	40
14	370892.55	4942603.81	40
15	371063.77	4942851.09	41
16	371973.09	4943505.01	37
17	372263.00	4943398.33	37
17A	372324.69	4943414.04	36
17B	372156.04	4943354.39	37
18	372819.01	4943021.33	36
19	373033.49	4942960.86	34
20	373154.58	4942946.04	34
21	373268.87	4942705.38	34
22	373458.83	4942683.63	33
23	373516.11	4942645.34	32
24	373576.15	4942571.36	32
25	373631.16	4942426.67	28
26	373851.15	4942259.42	31
27	373937.13	4942117.86	31
28	373892.65	4941835.46	31
29	373470.33	4940577.37	32
30	373125.81	4940602.51	33
31	373042.94	4940628.67	34
31A	373160.94	4938740.66	22
32A	373104.89	4938704.67	22
33A	373017.10	4938828.80	23
34	374140.46	4941841.18	30
35	374160.81	4941971.70	30
36	374023.56	4942143.50	31
37	374029.34	4942020.83	31
38	374056.02	4941923.20	30
39	374089.69	4941739.18	30
39	374089.69	4941739.18	30
40	373360.55	4942904.27	33
41	369440.58	4942817.22	30
42	369617.33	4940099.02	29

Appendix C
Tonality Analysis

Table C-1

Receptor ID	One-Third Octave Band Center Frequency (Hz)	25	**31.5**	40	50	**63**	80	100	**125**	160	200	**250**	315	400	**500**	630	800	**1000**	1250	1600	**2000**	2500	3150	**4000**	5000	6300	**8000**	10000
	Tonal Limit	-	15	15	15	15	15	15	15	8	8	8	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	-
15	Received Sound Pressure Level (dB)	49	48	48	47	47	47	46	46	44	43	41	39	37	36	35	34	32	30	27	23	16	7	0	0	0	0	0
	Average Sound Pressure Level of Contiguous Bands	-	48	47	47	47	47	46	45	44	43	41	39	37	36	35	33	32	30	26	22	15	8	3	0	0	0	-
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	-1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	-1	-3	0	0	0	-
	Below Tonal Limit?	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
14	Received Sound Pressure Level (dB)	48	48	47	46	46	46	46	45	44	43	40	38	37	35	34	33	31	29	26	21	14	3	0	0	0	0	0
	Average Sound Pressure Level of Contiguous Bands	-	48	47	47	46	46	46	45	44	42	41	38	37	35	34	33	31	29	25	20	12	7	2	0	0	0	-
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	-1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	2	-4	-2	0	0	0	-
	Below Tonal Limit?	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
13	Received Sound Pressure Level (dB)	48	47	47	46	46	46	45	44	43	41	40	38	36	35	33	32	30	28	25	20	12	0	0	0	0	0	0
	Average Sound Pressure Level of Contiguous Bands	-	47	47	46	46	46	45	44	43	41	40	38	36	35	33	32	30	28	24	18	10	6	0	0	0	0	-
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	-6	0	0	0	0	-
	Below Tonal Limit?	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-

Appendix D
Sound Level Compliance Measurement Protocol

RoxWind Project
Roxbury, ME

Sound Level Compliance Measurement Protocol

March 20, 2018

Introduction

This protocol describes the methodology involved in measuring the operational sound levels of the RoxWind Project. This Project is currently being developed by RoxWind LLC. RoxWind will be a wind power generation facility consisting of up to 4 wind turbines located within Roxbury, Maine. Based on the proposed layout dated February 8, 2018, the proposed wind turbines will all be GE 3.8 megawatt (MW) wind turbines. The GE 3.8 MW wind turbines have a hub height of 85 meters and a rotor diameter of 130 meters. Locations of the proposed wind turbines are presented in Figure 1 of this protocol.

As part of this effort, a sound level compliance measurement program by qualified personnel will follow the commencement of the Project. At a minimum, personnel will be full members of the Institute of Noise Control Engineering (INCE). The purpose of this protocol is to describe the measurement methodology, identify acoustical and meteorological equipment proposed, and briefly describe the manner of data collection and reporting. Procedures identified in the Maine Department of Environmental Protection's Section 10.I.(8) Sound Level Standards for Wind Energy Developments were used in the development of this measurement protocol.

Compliance data from the operation of the Project will be submitted to the Department, at a minimum:

(a) Once during the first year of facility operation;

(b) Once during each successive fifth year thereafter until the facility is decommissioned;

(c) In response to a complaint regarding operation of the wind energy development as set forth in subsection I(7)(j) of the rule and any subsequent enforcement by the Department; and

(d) For validation of an applicant's calculated sound levels when requested by the Department.

Sound Level Measurement Methodology

The ME DEP regulation requires compliance measurement at protected locations that are most likely affected by sound from the wind energy development and to take the prevailing

wind direction into consideration. Broadband A-weighted (dBA) and one-third octave-band (dB) sound levels will be measured at minimum of 2 locations in the vicinity of the Project to collect compliance sound level data. The protected location with the modeled[1] greatest sound level from the Project was location #15. This protected location is identified in Figure 1 of this protocol and is upwind of the prevailing wind direction. A second location has been preemptively selected downwind of the prevailing wind direction for the area (northwest). This is modeled protected location #30 and is identified in Figure 1 of this protocol. Testing at these locations presumes permission from the landowner can be obtained. If this is not possible, then alternate testing locations will be discussed with the Department.

Measurement Equipment

Instrumentation utilized in the compliance measurement program will abide by the requirements in the ME DEP regulation, Section 10.I(8)(b). The sound level measurements will be made using Larson Davis (LD) model 831 sound level meters (or equivalent). The model meets "Type 1 Precision" requirements set forth in American National Standards Institute (ANSI) S1.4-1983 standard for sound level meters. The meters will log values of various broadband A-weighted (dBA) sound level measurement parameters including the L_{eq}, L_{max}, L_{10}, L_{50}, and L_{90} in 10-minute intervals. One-third octave-band sound levels will be measured during each period as well. The microphones will be tripod-mounted at a height of 1.5 meters (5 feet) above ground. A 7-inch windscreen will be placed on all microphones.

The measurement equipment will be calibrated in the field before and after the survey with the manufacturer's acoustical calibrator which meets the standards of IEC 942 Class 1L and ANSI S1.40-1984. All calibrations will be within $\pm$1.0 dB from the most recent calibration otherwise the data collected during that period will be discarded. The meters are calibrated and certified as accurate to standards set by the National Institute of Standards and Technology by an independent laboratory within the past 12 months.

Audio recordings will supplement the sound level data from the measurement microphones and will be time synced with the corresponding equipment.

Since this is a wind turbine project, the wind speed during the noise study is significant in importance. Per the ME DEP regulation, a 10-meter anemometer will be deployed with the appropriate measurement specifications. Hub-height wind speed will also be acquired from the wind energy development to correlate with sound level data and surface wind speeds. Additional meteorological parameters, e.g. temperature, precipitation, etc., will be downloaded from the closest National Weather Service station for the entire program. All equipment will be sited to comply with Section 10.I(8)(d).

[1] Refer to the Sound Level Assessment Report prepared by Epsilon Associates, March 20, 2018.

Measurements of operational, sound, audio and meteorological data shall occur as set forth in subsection I(8)(e)(7 through 10). Measurement shall be obtained during weather conditions when the wind turbine sound is most clearly noticeable, generally when the measurement location is downwind of the wind energy development and maximum surface wind speeds < 6 miles per hour (mph) with concurrent turbine hub-elevation wind speeds sufficient to generate the maximum continuous rated sound power from the nearest wind turbines to the measurement location.

In some circumstances, it may not be feasible to meet the wind speed and operations criteria due to terrain features or limited elevation change between the wind turbines and monitoring locations. In these cases, measurement periods are acceptable if the following conditions are met:

(a) The difference between the LA_{90} and LA_{10} during any 10-minute period is less than 5 dBA; and

(b) The surface wind speed (10 meter height) (32.8 feet) is 6 mph or less for 80% of the measurement period and does not exceed 10 mph at any time, or the turbines are shut down during the monitoring period and the difference in the observed LA_{50} after shut down is equal to or greater than 6 dBA; and

(c) Observer logs or recorded sound files clearly indicate the dominance of wind turbine(s).

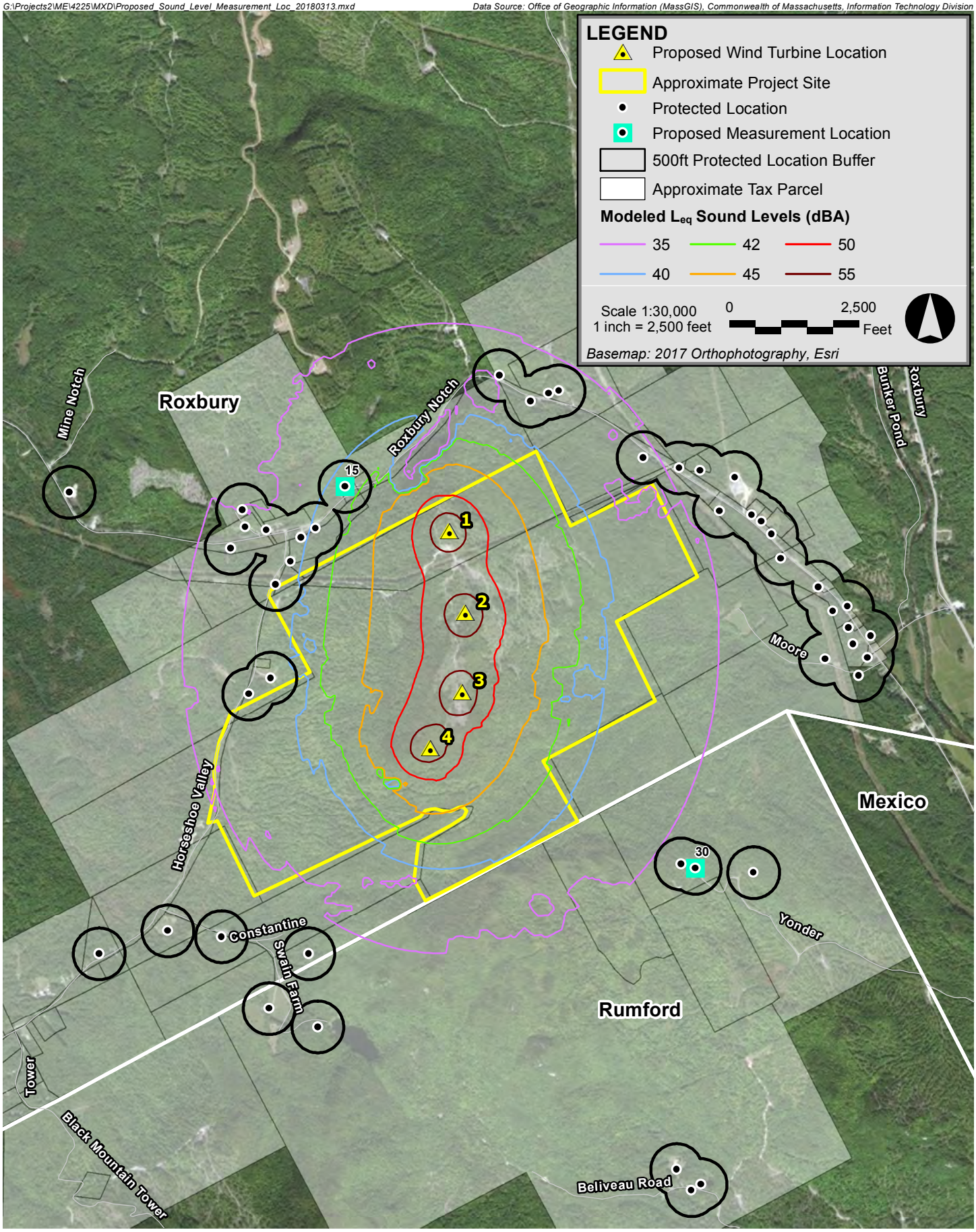
Measurement intervals affected by increased biological activities, leaf rustling, traffic, high water flow, aircraft flyovers or other extraneous ambient noise sources that affect the ability to demonstrate compliance will be excluded from all compliance report data. The intent will be to obtain 10-minute measurement intervals that entirely meet the specific criteria.

Every effort will be made so as to exclude the contribution of sound from other development equipment that is exempt from this regulation while conducting measurements of the wind energy development under compliance testing.

Results/Report

Results from the compliance sound level measurement program(s) will be presented to the ME DEP in a compliance report(s) that will include, at a minimum, the items presented in Section 10.I(8)(f) of the regulation.

Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



RoxWind Roxbury, Maine

Epsilon Associates Inc.

Figure 1

Proposed Sound Level Measurement Locations