Section 5

Noise

Section 5. Noise

5.1 State Standards

The Project must meet the following sound level limits as detailed in 06-096 CMR 375.10(I):

a) *75 dBa at any time of day at any property line of the wind energy development or continuous property owned or controlled by the wind energy developer, and*
b) *55 dBA between 7:00 am and 7 pm and 42 dBA between 7:00 pm and 7:00 am at any protected location.*
c) *If a tonal sound exists at a protected location, a 5 dBA shall be added to any average 10 minute sound level (LeqA 10-min) for which a tonal sound occurs that results from routine operation of the wind energy development.*
d) *If routine operation of a wind energy development produces short duration repetitive ("SDR") sound, a 5 dBA penalty shall be arithmetically added to each average 10-minute sound level (LeqA 10-min) measurement interval in which greater than 5 SDRS events are present.*

5.2 Sound Assessment

Applicant addressed the Site Law standards pertaining to the control of noise, 38 M.R.S. § 484(3), and the Department's pertinent rule in Chapter 375, § 10 by engaging Bodwell EnviroAccoustics to perform a Sound Level Assessment.

The Sound Level Assessment was conducted to predict expected sound levels from the proposed Project, and to compare the model results to the applicable requirements of Chapter 375, § 10. As further described in the Sound Level Assessment, the Project will comply with Department regulations applicable to sound levels from construction activities between 7:00 p.m. and 7:00 a.m. (nighttime hours), routine operation, and routine maintenance. Chapter 375, § 10 applies sound level limits at facility property boundaries and at "protected locations."[1] The closest protected location is 3,040 feet

[1] Pursuant to Chapter 375 § 10(G)(16), a Protected Location is: Any location, accessible by foot, on a parcel of land containing a residence or planned residence or approved residential subdivision, house of worship, academic school, college, library, duly licensed hospital or nursing home near the development site at the time a Site Location of Development application is submitted; or any location within a State Park, Baxter State Park, National Park, Historic Area, a nature preserve owned by the Maine or National Audubon Society or the Maine Chapter of the Nature Conservancy, The Appalachian Trail, the Moosehorn National Wildlife Refuge, federally-designated wilderness area, state wilderness area designated by statute (such as the Allagash Wilderness Waterway), or locally-designated passive recreation area; or any location within consolidated public reserve lands designated by rule by the Bureau of Public Lands as a protected location.

from the nearest turbine. At that location, the predicted hourly sound level from the Project is modeled to be 39.4 dBA, quieter than the 42 dBA nighttime sound level limit.

The sound level assessment summarizes the impacts at receptors in Table 6-1.

Receptor Point	Description and Approximate Distance to Nearest Twin Energy Turbine		Predicted Hourly Sound Level and Nighttime Sound Limit, dBA	
	Town - Description	**Distance (ft)**	**GE Turbines**	**Sound Level Limit**
R1	Roxbury – Residential Property Line <500' from Dwelling	6,105	31.7	42
R2	Roxbury – Residential Property Line >500' from Dwelling	1,530	46.6	55
R3	Roxbury – 500' from Dwelling	3,345	38.2	42
R4	Rumford – 500' from Dwelling	4,350	35.2	42
R5	Rumford – 500' from Dwelling	5,140	34.6	42
R6	Rumford – 500' from Dwelling	3,040	39.4	42
R7	Roxbury – 500' from Dwelling	5,990	32.1	42

Table 6-1. Predicted Sound Levels from Wind Turbine Operations at Receptor Points

As described in the Sound Level Assessment, ice and snow accumulation can increase turbine sound output. The proposed turbines will have sensors to monitor ice or snow accumulation remotely.

The Sound Level Assessment concludes:
Given the conservative modeling assumptions and +3 dBA uncertainty, sound levels from turbine operations are expected to be below model estimates. Based on the model estimate of 39.4 dBA at receptor R6, even if 50 percent of the operations sound level testing intervals indicated the presence of SDR or tonal sounds, Twin Energy would be within the 42 dBA nighttime limit. (Page 27)

At protected locations more than 500 feet from living and sleeping quarters within the above noted buildings or areas, the daytime hourly sound level limits shall apply regardless of the time of day…

As stated in the Sound Level Assessment, the Project will prepare an Operations Sound Testing Plan prior to commencing operations of the Project. The Project will test for sound compliance in the first year and once during each successive fifth year thereafter until the facility is decommissioned.

See the Sound Level Assessment in Exhibit 5-1.

5.4 Complaint Monitoring

Prior to the start of construction, the Project will notify abutters, the Town of Rumford, the Town of Roxbury, and the Department of the details of its sound complaint response procedure. A sample notice is included as Exhibit 5-2.

During construction and operations, the Applicant will provide a 24-hour call number for residents to register sound complaints. This call number will be staffed 24 hours a day, 7 days a week, and 365 days a year.

When a call is made to the 24-hour number, the following information will be collected:

a) Call Information: Date of Call, Time of Call
b) Caller Information: Name of Caller, Address of Caller
c) Sound Event Information: Date of Event, Time of Event, Duration of Event (minutes), Description of Sound Event, Sound Heard Indoors or Outdoors, Specific Location, Audible Sounds from Other Sources (and if those sounds are outside or inside)
d) Optional: Contact Information for Caller

The information will be entered into a log.

For all complaints where (a) through (c) above is complete, the Applicant will analyze the complaint and provide the details of the analysis, along with the original complaint, to the Department of Environmental Protection and the respective town on a monthly basis within 15 days after the prior month ends. The Applicant will also provide complaint findings back to the respective complaint filer if the caller provided contact information for follow up.

The analysis will include documenting:

1) the location and direction of the turbines nearest to the complaint location;
2) ground conditions in the area of the complaint location;
3) weather conditions at the time of the complaint including surface and hub height wind speed and direction; and
4) power output of nearest turbines.

In addition, the Applicant will plot the complaint locations and key information on a project area map to evaluate complaints for a consistent pattern of site, operating and weather conditions. This plot will be sent monthly to the Department of Environmental Protection, Roxbury, and Rumford, and available at the town halls for viewing. A comparison of these patterns to the compliance protocol will be used to determine whether testing under additional site and operating conditions is necessary and, if so, a testing plan will be developed and implemented that addresses the locations and the conditions under which a pattern of complaints had occurred. Appropriate steps will be taken to correct any operational or mechanical issues that interfere with compliance.

A sample sound complaint notice is included as Exhibit 5-2.

Exhibit 5-1
Sound Level Assessment

Sound Level Assessment
Twin Energy Wind Project
Oxford County, Maine

August 2023

Prepared for:
Twin Energy LLC

Prepared by:
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55 Ocean Drive
Brunswick, Maine 04011

Bodwell EnviroAcoustics LLC

1.0 Introduction

Bodwell EnviroAcoustics LLC (BEA) assessed sound levels expected to result from construction and operation of the Twin Energy Wind Project (Twin Energy or Project), a proposed 18.3 MW wind energy development to be located in the Town of Rumford in Oxford County, Maine. The Project will consist of three wind turbines and associated infrastructure, including an operations and maintenance building, collector and transmission lines, access roads, crane paths, and construction laydown areas.

The objective of this Sound Level Assessment is to evaluate sound levels from simultaneous operation of the proposed wind turbines at full-rated sound power output during nighttime stable atmospheric conditions. A terrain-based computer model was developed to calculate sound propagation and predict sound levels at various land uses in the vicinity of the Project. The predicted "worst-case" sound levels are compared to applicable sound limits at regulated *protected locations* as set forth by Maine Department of Environmental Protection (DEP) Site Location of Development regulations for Control of Noise (ref. 06-096 CMR c. 375.10). An evaluation of predicted sound levels to local sound limits established by the Town of Rumford is also provided.

This report describes the Twin Energy Wind Project and surrounding area, relevant state and local noise regulations, turbine sound performance, the details and results of the predictive sound model, evaluation of sound level compliance, and provisions for operations sound testing and sound complaint response.

2.0 Environmental Acoustics

The study of environmental acoustics primarily concerns the functions and effects that audible sounds (or noise) have in the outdoor environment and how changes to existing and new sound sources can impact that environment. From a geographic standpoint, this is an extremely diverse area of study ranging from wilderness to urban settings and from airborne and indoor sound to the underwater sound environments of oceans and lakes. Environmental acoustics is most commonly associated with assessing the noise impact of industrial, transportation, energy, or commercial land uses for suitability with nearby land uses. The following subsections provide an overview of acoustic terminology and characteristics of wind turbine noise.

2.1 Sound and Decibels

Sound is produced by many different sources that generate pressure fluctuations in air that the human ear often has the capability to detect as audible. Sound can also travel through other media such as water, metal, and structural components of a building. The types of sounds that humans experience every day can be divided into two distinct categories as natural and man-made sound. However, the range of sound subcategories is extensive.

There are many types of natural sounds audible to humans and other animals. The most common of these are wildlife (e.g. birds, frogs, mammals, insects), sounds generated by wind forces acting on terrain and vegetation, and sounds generated by water action such as ocean waves, falling rain, and river rapids. There are also many man-made sounds generated by industrial, transportation, energy and construction sources as well as sounds generated for warning signals or strictly for enjoyment such as music. Common residential sounds include outdoor recreation, yard maintenance, human voices, and amplified music.

The magnitude or loudness of sound waves is measured in units of pressure (pascals) that yield very large numbers that are difficult to interpret. For simplicity, the decibel unit, dB was developed to quantify sound pressure levels to reduce the exponential range of typical sound pressures. The dB unit equates to an exponential ratio of the actual sound pressure to a standard pressure, usually 20 micropascals. This is a logarithmic expression of the pressure ratio similar to the Richter scale for earthquakes so that a small change in sound level expressed in dB represents a larger change in the sound pressure. For example, a 10 dB change in sound level is a tenfold increase in sound pressure as pascals. However, this does not mean that the received sound is perceived as ten times as loud. A change in sound levels of 3 dB is a doubling of the sound pressure but is considered to be the threshold of change perceptible to human hearing. A change of 5 dB becomes quite noticeable and an increase of 10 dB is perceived as twice as loud.

The frequency or pitch of sound is expressed in Hertz (Hz) and is the number of sound waves passing a specific point each second, i.e. cycles per second. Frequencies generally considered audible to the human ear range from 20 to 20,000 Hz. Within this range, there are octave bands that represent a range of frequencies for purposes of sound characterization and calculating sound propagation and attenuation. Standard whole octave bands are centered on 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz. The center frequency of each octave is double that of the previous octave. Octave bands can be further divided (typically third octaves) and used to determine if a sound source generates an audible pure tone such as a whistle, buzzing or hum that may be more perceptible than a broad mixture of frequencies. Low frequency sound is typically considered to be at frequencies of 200 Hz and below. Within this range, infrasound has frequencies below 20 Hz and is not generally considered audible to humans except at very high decibel levels.

Sound levels in frequencies ranging from 500 to 2500 Hz are more audible to humans than frequencies below 100 Hz. The A-weighting scale was developed to express sound pressure levels in units of dBA to simulate the hearing response of humans. Under this weighting system, the sound pressure level at low frequencies is reduced based on its audibility to humans. The linear (no weighting) and C-weighting scales are often used to determine the relative contribution of low frequency sounds during a sound measurement. These low frequency sounds have reduced audibility to humans, hence the use and wide acceptance of the A-weighting network for noise standards. Figure 2-1 provides a graph that shows the reduction by frequency for A- and C-weighting scales.

Sound level measurements are also time-weighted to represent the relevant parameters or timeframes of interest or identify short duration events. The most common time weightings are “Fast” and “Slow”.

Fast-time weighting is based on 1/8 second intervals and is useful for determining rapid changes in sound levels. The slow-time weighting integrates the measured sound levels over a one-second period that reduces the rapid fluctuations for ease of observation.

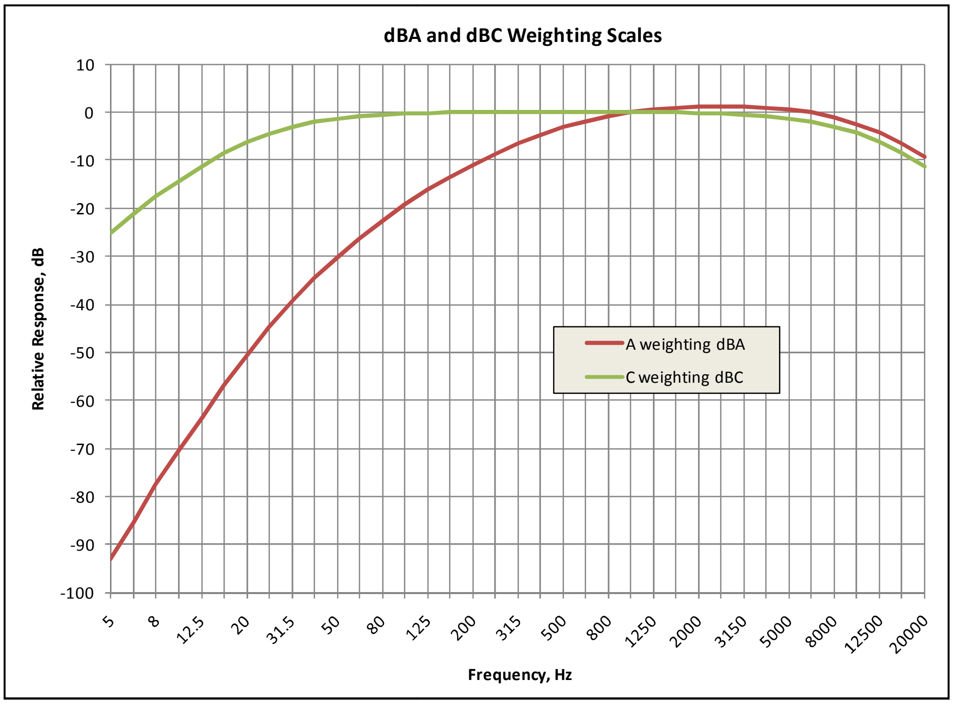

Figure 2-1. Weighting Curves for dBA and dBC Sound Levels

Similar to the amplitude and timing of ocean waves, sound pressure waves can vary considerably in amplitude and frequency. When using fast-time weighting, a sound level meter will measure a sound pressure level every 1/8 second which results in 480 measurements each minute and 28,800 measurements in an hour. Because it would be nearly impossible to evaluate over 28,000 measurements per hour, numerous statistical parameters have been developed for use in quantifying long-term sound level measurements. The most common is the A-weighted equivalent sound level or LAeq, which represents the time-varying sound level as a single dBA level by effectively spreading the sound energy across the entire measurement period. Other common parameters are percentile levels that represent the percentage of time that a specific sound level was exceeded. For example, the LA10 provides the sound level that was exceeded 10% of the time during the measurement period. This means that 10% of the measured sound levels were higher and 90% were lower than the measured LA10. Other commonly used percentiles include the LA50 or median sound level and the LA90 for which 90% of the measured sound levels are higher. The LA90 is often referred to as the background sound level as it eliminates most fluctuations from short term sound events such as aircraft flights and wind gusts. Figure 2-2 presents a graph that shows the measured sound pressure levels and the resulting equivalent (LAeq), LA10 and LA90 sound level parameters.

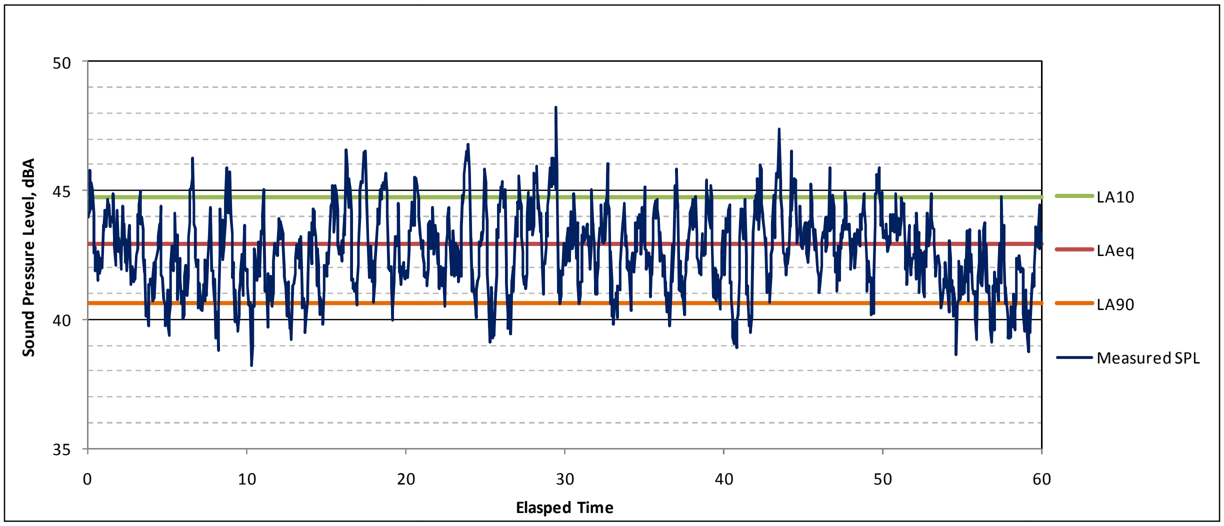

Figure 2-2. Measured Sound Pressure Levels and Statistical Parameters.

For purposes of quantifying industrial and other man-made sound sources, the term “sound power level” is used. The unit of sound power level is watts and the term is commonly expressed as Lw. When applied to sound power, the dB unit represents a logarithmic ratio of the source sound power to a reference sound power (10^{-12} watt). Sound power levels are determined by measuring the sound pressure level from a source at a specific distance and calculating the sound attenuation between the source and measurement location. The sound power level provides a mechanism for ranking and quantifying noise sources, such as wind turbines, in a consistent and standardized manner. It is commonly used in sound performance specifications and as a source input to sound level prediction models. By its nature, the sound power level cannot be measured directly and can be a source of confusion to the public as compared to sound pressure levels that are predicted and measured at community locations.

The combination of all existing sound sources, natural and man-made, at a specific location or in a community, is known as the ambient sound environment or soundscape. The amplitude and characteristics of the soundscape vary significantly depending on the amount of industrial and residential development, proximity to transportation uses such as highways and airports, and the presence of natural sounds such as wind, flowing water, and wildlife. In general, the more rural or undeveloped an area is, the lower the ambient sound levels will be. Ambient sound levels are usually higher during daytime hours than at night due to more traffic and human activity, higher wind speeds and other natural sounds during the day. At night, these daytime sources typically diminish and sound levels are reduced with the exception of some natural sounds, such as frogs (seasonal), and occasional strong winds and rain.

Noise is generally defined as unwanted sound. The perception of noise as an unwanted sound can vary significantly from individual and preferences concerning types of sound. A simple example of this is music. One person may enjoy a certain type of music that another may find extremely annoying. Some individuals find enjoyment and solitude in listening to natural sounds or the nighttime quiet of a rural area while others have little interest in such soundscapes.

The character of sound is determined by its loudness or amplitude and its pitch or frequency. Humans can detect a wide range of sound level amplitudes and frequencies as audible but are more sensitive to a specific range of frequencies. Consequently, the perceived loudness of sound also depends not only on its amplitude but on its frequency characteristics as well. For example, the sound of birds, frogs or flowing water is often perceived as quieter than man-made sounds at the same amplitude. The sound levels associated with some common noise sources and sound environments is presented as Table 2-1.

Indoor Setting	**Outdoor Setting**	**Sound Sources**	**Sound Pressure Level, dBA**
*Rock Concert**		*Jet Takeoff at 300 feet**	*120*
Ship Engine Room	*Loud Thunder**	*Rifle Blast at 100 feet*	*110*
*Movie Theater**		*Chain Saw high rpm at 5 feet* *Siren at 100 ft*	*100*
*Heavy Industrial Work Space**		*Lawn Mower high rpm at 10 feet* *Large Truck or Loader high rpm 50 feet**	*90*
Busy Airport	*Heavy Rain*	*Motor Boat high rpm at 100 feet*	*80*
Light Industrial Workspace	*Heavy Surf Beach** *Busy City or Highway*	*AC Unit at 5 feet* *Automobile 45 mph at 50 feet*	*70*
Busy Office/Conversation Room with TV	*Urban Daytime*	*Strong Wind in Trees** *Nighttime Frogs* *Airplane Flyover**	*60*
	Suburban Daytime/Urban Nighttime	*Bird Calls/Morning Chorus* *Small waves on shoreline*	*50*
Quiet Office *Library*	*Rural Area Daytime*	*Moderate Wind in Trees*	*40*
Sleeping Quarters at Night	*Rural Area Nighttime*	*Light Wind in Trees*	*30*
Idle Recording Studio	*Very Remote Area Nighttime* *Perceived Silence*		*20*
			10
		Threshold of Hearing	*0*

Table 2-1. Typical A-Weighted Sound Levels

Note: These are typical sound levels and subject to significant variation depending on the number of and distances from sound and transportation sources.

**Sound with prominent Low Frequency components*

Sources:
www.mvn.usace.army.mil/ss/osha600/s600/refer/menu14c.pdf
Measurements and Observations by R. Scott Bodwell, P.E.

2.2 Outdoor Sound Propagation

Sound travels through air at a speed of approximately 1126 feet per second or 768 miles per hour. Thus, it takes just over two seconds for a sound wave to travel a half mile. The number of sound waves that travel past a given point in one second is determined by its frequency or pitch. The sound pressure level decreases or attenuates as sound spreads out and travels over distance through the air. Attenuation results from distance, atmospheric absorption, and terrain effects. The rate of attenuation due to distance or spreading of the sound wave (i.e. divergence) is the same for all frequencies, which is approximately 6 dB per doubling of distance from a simple point source.

Table 2-2 provides the sound pressure level at various distances from a point source having a sound power level of 106 dBA. This relationship is shown graphically in Figure 2-3. The sound level reduction shown in Table 2-2 and Figure 2-3 is due only to distance attenuation and does not include attenuation from atmospheric absorption, terrain and foliage, or reflection from hard surfaces.

Source Sound Power Level, LwA = 106 dBA	
Distance, Feet	**Sound Pressure Level, dBA**
25	80
50	74
100	68
200	62
400	56
800	50
1600	44
3200	38

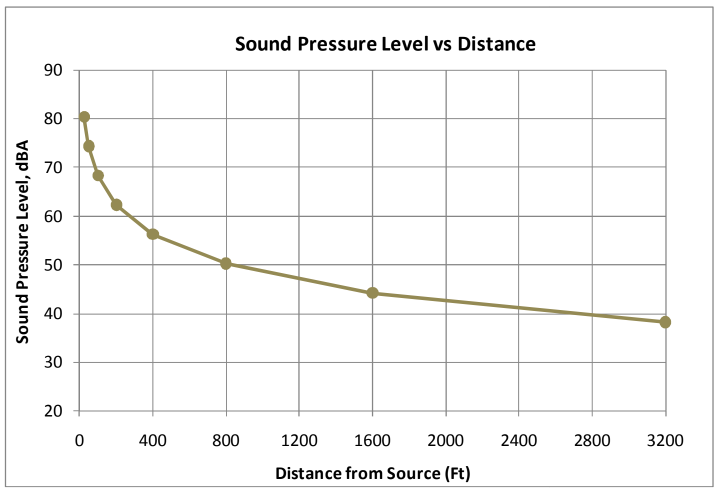

Table 2-2 & Figure 2-3. Attenuation of Sound Levels over Distance

Sound energy is absorbed by the atmosphere as it travels through the air. The amount of absorption varies by the frequency of the sound and the temperature and humidity of the air. More sound is absorbed at higher frequencies than at lower frequencies due to the relative wavelengths.

In addition to temperature and humidity, wind speed and direction can affect outdoor sound propagation. When sound travels upwind the sound waves can bend upward creating a “shadow” zone near the ground where sound levels decrease when compared to downwind sound propagation. Wind gradients, temperature inversions and cloud cover can cause refraction or bending of sound waves toward the ground resulting in less sound attenuation from terrain and ground cover over large distances.

Sound attenuation can also result from intervening terrain and certain types of ground cover and vegetation. An example of intervening terrain is a hill or ridge that blocks the horizontal sound path between a sound source and receiver. This same effect can result from buildings and other solid structures such as a sound barrier fence. Sound will also attenuate as it travels over soft ground cover or through vegetation such as trees and shrubs. The amount of ground and foliage attenuation depends on the characteristics of the ground cover and the height and density of vegetation. Conversely, reflective ground or the surface of a water body can cause reflection of sound and less overall attenuation.

When multiple sound sources are present in an area, the sound level contribution from each source must be added to determine of the combined sound level of all sources. Due to the logarithmic basis of the dB unit, adding sound levels is different than standard arithmetic. Adding two equal sound sources that each measure 50 dBA at a specific point will result in a combined sound level of 53 dBA. It will then take two more equal sound sources of 50 dBA each, or four total, to cause the sound level to increase by another 3 dBA. Thus, four equal sources at 50 dBA results in a total sound level of 56 dBA.

Specifications for calculating outdoor sound propagation have been developed by international standards organizations as well as individual countries based on empirical data developed over many years. These specifications form the basis for computerized sound level prediction models that allow calculation of outdoor sound propagation through the use of three-dimensional terrain models. The most widely used and accepted standard for calculating outdoor sound propagation is ISO 9613-2 Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation. This standard has been applied to accurately calculate the sound levels that result from operation of wind turbines and is the standard applied in this analysis. Further details concerning the sound level prediction model developed for Twin Energy to account for various site and weather conditions can be found in Section 6.3 of this report.

2.3 Wind Turbine Sound

When operating at or near full sound output, the primary sound source from a wind turbine is rotation of the rotor blades with more sound energy generated from the outer sections of the blade and blade tip. Less significant sources of sound from operation of wind turbines are mechanical noise from gears, electric motors and cooling equipment in the turbine nacelle.

An international standard has been developed as International Electrotechnical Commission (IE 61400-11 *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques* that provides specific and detailed procedures for determining the sound power level from wind turbines. The IEC standard was developed by industry and acoustic experts to establish a consistent and repeatable methodology with full documentation for determining the sound output of any type of vertical blade wind turbine. Manufacturers of utility-scale wind turbines follow this methodology to determine the sound output and uncertainty of their turbines for purposes of estimating community sound levels and providing performance guarantees to owners and operators of wind energy facilities.

There has been much advancement in the technology of wind turbines over the last 10 to 20 years. The first generation of utility wind turbines consisted of downwind rotors that were capable of generating significant levels of low frequency sound. Turbines with upwind rotors have replaced the early designs and drastically reduced low frequency sound emissions. Modern wind turbines are known to generate a "whoosh" type sound under certain operating and weather conditions that results from the passage of each blade. A short-term increase in sound levels often occurs on the down-stroke motion of the blade that is referred to as "amplitude modulation" and generally results in sound level fluctuations of 2 to 5 dBA for utility-scale wind turbines with occasional excursions above 6 dBA.[1] Amplitude modulation occurs at a mixture of audible frequencies and should not be confused with low frequency sound and infrasound.

Sound from wind turbines has been the subject of extensive research, conferences and publications over the past 15 to 20 years. There is considerable technical and related information available that addresses the characteristics, control and impact of sound from wind turbines. There is an abundance of well-researched and informative studies and reports from reputable institutions and individuals (e.g. Institute of Noise Control Engineering, Acoustical Society of America, National Renewable Energy Laboratory).

It is a common assertion that wind turbines generate significant and perhaps harmful levels of infrasound and low frequency sound. In relation to the modern generation of upwind turbines, there is little to no basis for this claim that can be found in any well-researched and impartial technical studies and literature. In fact, the consensus of the independent research community is that annoyance from wind turbine sound is primarily in the most audible mid to high frequencies and not from infrasound or low frequency sound.[2]

2.4 Noise Impact and Regulation

The noise impact that results from wind turbines depends on several factors, notably the change or increase in ambient or background sound levels that will result from turbine operation. For rural areas where hill or ridge top wind turbines are located, the ambient sound level at lower elevations and community locations varies by time of day, weather conditions, and to some degree, by season. Sound levels from wind turbines vary based on the wind speed and turbulence at the turbine hub and can range from no sound output during calm winds to full sound output when winds at the turbine hub reach approximately 20 miles per hour. Sound from wind turbines will be most noticeable during stable atmospheric conditions when surface winds are light and the winds aloft (at the turbine hub) remain high enough for full turbine sound output. At other times, when surface winds increase or when wind turbine output diminishes, the sound from operating wind turbines will be less noticeable.

During the planning stages of a wind energy project, considerable effort is made to accurately map land uses and the topography of the entire area potentially impacted by sound from wind turbine operation. Along with wind turbine sound level performance data, this information is used to develop a sound level

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[1] Operations Sound Testing, Oakfield Wind, 2016; Stetson II Wind, 2011, R.S. Bodwell, P.E.
Observations and analysis of sound level measurements for Mars Hill Wind Farm and Stetson Wind Project, R. S. Bodwell, P.E.; G.P. van den Berg, The Sounds of High Winds, 2006.

[2] B. Sondegaard, Noise and Low frequency noise from Wind Turbines, Inter Noise, 2014.
G.P. van den Berg, The Sounds of High Winds, 2006.
Danish Electronics, Light and Acoustics (DELTA), Low Frequency Noise from Large Wind Turbines, 2008.

prediction model for the project. The model inputs and settings are typically adjusted to produce conservative sound level predictions for wind turbine operation. These results are compared to various noise regulations and guidelines to assess the impact of the proposed wind energy project.

In 2012, the Maine legislature approved noise control regulations developed by the Maine DEP that are specific to wind energy developments. Chapter 375.10 Section I of Site Location of Development Law regulations specifies sound level limits for wind energy facilities as 55 dBA daytime and 42 dBA nighttime for hourly equivalent sound levels (LAeq) at protected locations such as residential properties. In most cases, the resulting sound levels at the residence will be lower. The Maine DEP regulation applies sound level limits on an hourly basis whereas compliance is evaluated by averaging sound levels over twelve or more ten-minute measurements with turbines operating at full-rated sound output. There are also special provisions and “penalties” that apply when the sound generated by a wind project results in tonal or short duration repetitive (SDR) sounds. These standards are described in more detail in the remainder of this report.

3.0 Project Description

Twin Energy is a three-turbine wind energy project proposed by Twin Energy LLC, managed by Palmer Management Corporation (Palmer), to be located in within the Town of Rumford in Oxford County. The proposed turbine sites are distributed on South Twin Mountain in Rumford, with associated infrastructure in both Rumford and the adjacent Town of Roxbury. The installed capacity of the Project is expected to be 18.3 Megawatts (MW). Figure 3-1 provides a Project Location Map that shows proposed Twin Energy turbines in relation to surrounding land uses.

The proposed turbines for Twin Energy will be General Electric GE-6.1-158 (or similar) wind energy generators. These machines were selected due to their nameplate capacity (6.1 MW), allowing Twin Energy to maximize the output of the site while minimizing the Project’s footprint. The turbine model will be on a 117-meter tower with a rotor diameter of 158 meters; each turbine’s total tip height will be 196 meters above grade.

In addition to the three turbines, Twin Energy proposes to construct the following:

- *Access Roads:* The Project is designed to utilize an existing access road that originates from Horseshoe Valley Road in Roxbury and heads east toward North Twin Mountain. At the top of the ridgeline, approximately 7,615 feet of new road will be constructed to access the three Twin turbines.
- *Crane Pads and Roads:* The Project will require crane pads to be developed for each turbine site. The pads are approximately 120 feet long x 70 feet wide. The wind turbine foundations will be just outside of these crane pads.
- *Interconnecting Equipment:* The Project is in the Independent System Operator – New England (“ISO-NE”) queue and is being studied. The outcome of the studies may impact the final interconnection point and will dictate the equipment required by Central Maine Power (“CMP”) and ISO-NE to interconnect and operate the facility. A feasibility study was completed in 2022

and Twin is working with CMP to finalize those designs. Components of the Project include the following:

  - *Collection Lines:* Among the turbines, Twin proposes to install underground communication and electrical infrastructure within the crane pad areas. Beyond the crane roads and pads, the lines will ascend a riser pole and be overhead, along the new access road toward the point of interconnection to tie into CMP's existing Section 137 line.
  - *Met Tower:* To comply with ISO-NE requirements, Twin proposes to erect a 10-meter tall met tower on South Twin to collect "live" meteorological data.
- *Operation and Maintenance (O&M) Facilities:* Twin proposes a communications building along Roxbury Notch Road (Route 120) near the point of interconnection. The building will be approximately 15 ft by 12 ft and house communications, control, and sensitive electronic equipment.

Twin Energy LLC has lease agreements with respective landowners for all potential turbine sites and the Project-owned interconnection and communication equipment as currently planned. In addition, Twin Energy has landowner agreements that include a provision that waives potential regulatory sound level limits from being applied within the parcel boundary.

Area topography features mountain ridges with relatively steep terrain and elevations up to 2,156 feet on South Twin Mountain. The ground elevations of the turbine sites range from approximately 1,960 to 2,140 feet. In addition to four-turbine RoxWind Project to the north, surrounding land uses consist of undeveloped and commercial forestry land, and rural residential properties. The nearest existing dwellings are located in Roxbury along Swain Farm Road to the west and at the end of a private road to the east in Rumford approximately one mile from Route 120. Figure 3-1 provides a topographic map showing the Twin wind turbine sites in relation to surrounding land uses including the RoxWind turbines to the north.

FIGURE 3-1. Project Location Map

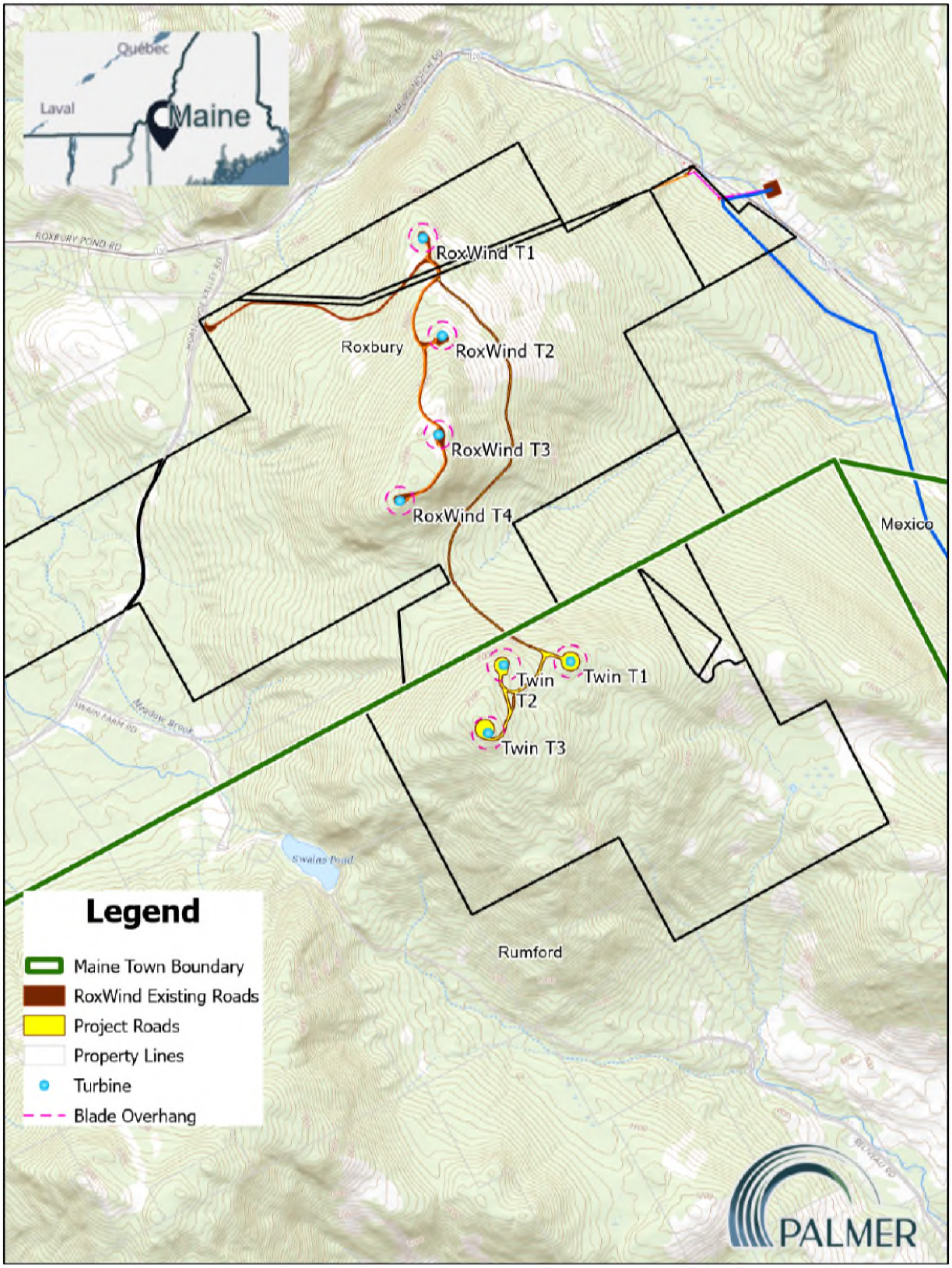


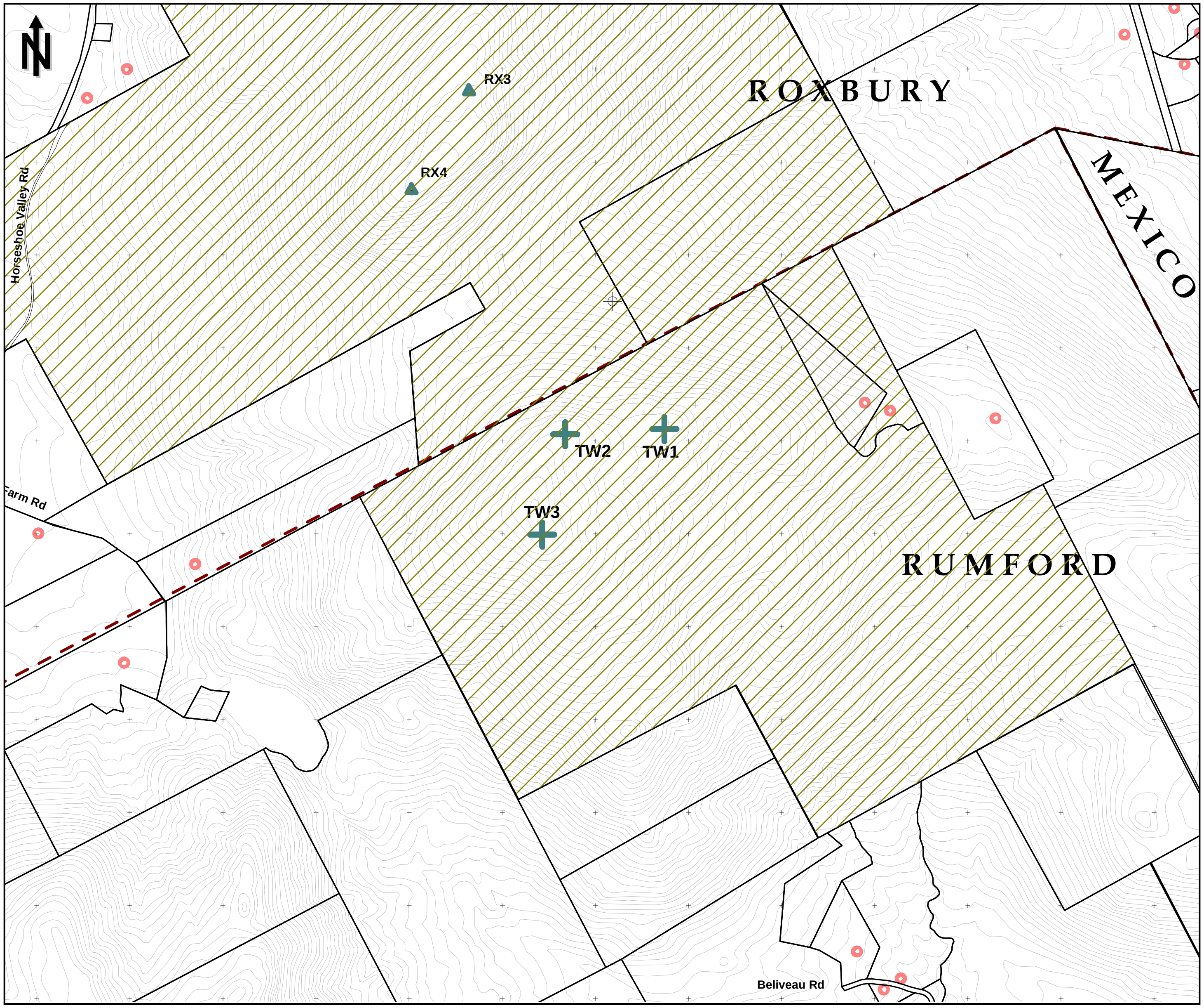
Figure 3-2 provides an area land use map of the proposed wind turbine sites, topographic contours, local tax map parcels, and dwellings/protected locations within 1.5 miles of a proposed Project wind turbine. The land use map was compiled in the Cadna sound modeling program from mapping files provided by Palmer. Parcels subject to leases and easements are indicated by hatching and include the nearest residential properties east of the proposed Twin turbine sites. Dwelling locations were mapped through use of aerial photography and field verified with the parcel associations confirmed from review of local tax assessor records. A review of municipal records did not find any other parcels within the mapping area with recently issued residential building permits or an approved residential subdivision. Additional discussion concerning leases and sound easements in relation to potentially applicable noise standards can be found in Section 5.0 of this report.

4.0 Wind Turbine Specifications

Twin Energy LLC proposes to erect three GE-6.1-158 wind energy generators (turbines) with a rated capacity of 6.1 megawatts (MW) to generate electric power for delivery to the power grid. The proposed GE-6.1-158 machines are pitch-regulated, upwind turbines with the turbine nacelles, mounted on tubular steel towers, that house the generator, gearbox, step-up transformer, and cooling and other mechanical equipment.

Sound performance ratings are determined from acoustic testing per IEC 61400-11 and proprietary computer models developed by GE Renewable Energy (GE). IEC 61400-11 is an international standard that establishes detailed procedures for measuring wind turbine sound and the methodology for calculating the turbine sound power level at various wind speeds. Turbine sound power levels are quantified as a “point source” for the stated purpose of conducting assessments of community sound levels resulting from wind turbine operation. The following provides a brief description of the specific characteristics of the proposed GE-6.1-158 turbine and rated sound performance, including third-octave band sound power levels as provided by GE.

Figure 3-2. Land Uses and Proposed Twin Energy Turbine Sites



LEGEND

Lease or Easement Parcel

Proposed Twin Wind Turbine

Existing RoxWind Turbine

Dwelling

Topo Contour Interval = 6 meters (~20 ft)

Coordinate Grid Spacing = 1000 ft

4.1 GE Wind Turbine Sound Levels

The GE-6.1-158 turbine rotor will be installed at a hub height of 117 meters above the ground elevation of the turbine base. The turbine cut-in wind speed is 3 meters/second (m/s) and the cut-out (pause) wind speed is 25 m/s at the turbine hub and the rotational speed of the turbine rotor is 10.1 revolutions per minute (rpm) at full-rated operation. The overall sound power level per IEC 61400-11 produced by the GE-6.1-158 ranges from 93.8 dBA at 4 m/s low rpm to 107.5 dBA at hub-height wind speeds of 10 m/s or higher. Table 4-1 provides sound levels at various hub height wind speeds ranging from 4 to 14 m/s calculated for whole (1/1) octave bands from 16 to 8,000 Hz. One-third octave band sound power levels for the GE-6.1-158 turbine in relation to hub height wind speeds are shown graphically in Figure 4-1[3,4]. As part of the Turbine Supply Agreement, GE will issue a Sound Warranty that warrants the rated Sound Power Level for the GE-6.1-158, with an expected uncertainty of +2.0 dBA.

Hub Height Wind Speed [m/s]		4	5	6	7	8	9	10	11	12	13	14
Frequency (Hz)	16	53.9	54.0	56.3	59.4	64.7	67.3	68.4	68.4	68.4	68.4	68.4
	32	67.4	67.3	69.6	72.8	78.2	80.7	81.8	81.8	81.8	81.8	81.8
	63	76.3	77.1	79.2	82.0	87.1	89.9	90.9	90.9	90.9	90.9	90.9
	125	83.0	85.0	87.1	89.0	92.4	94.4	95.2	95.2	95.2	95.2	95.2
	250	86.8	88.7	91.8	94.1	96.6	97.8	98.2	98.2	98.2	98.2	98.2
	500	87.2	87.7	91.7	95.5	98.3	100.0	100.5	100.5	100.5	100.5	100.5
	1000	87.6	87.0	90.6	95.1	98.5	101.5	102.8	102.8	102.8	102.8	102.8
	2000	86.4	86.4	88.7	92.4	95.7	99.3	101.0	101.0	101.0	101.0	101.0
	4000	80.9	82.2	84.0	86.6	88.2	91.1	92.7	92.7	92.7	92.7	92.7
	8000	65.1	67.2	69.6	72.4	71.2	72.8	73.8	73.8	73.8	73.8	73.8
Total Sound Power Level [dB]		93.8	94.5	97.6	101.0	104.0	106.4	107.5	107.5	107.5	107.5	107.5

Table 4-1. Sound Power Levels (LwA) for GE-6.1-158 Wind Turbine

4.3 Meteorological Conditions

Meteorological conditions have the potential to affect overall turbine sound levels and sound level fluctuations (e.g. amplitude modulation) from the passage of turbine blades. In addition to the hub height wind speed and direction by elevation, the primary meteorological factors affecting sound output are generally wind shear and turbulence intensity. These factors have been studied by long-term measurements of wind data at several inland ridge-top wind projects in Maine where sound testing has been conducted under high wind shear conditions in accordance with the Maine DEP testing protocol. Wind shear is typically higher during nighttime hours under stable atmospheric conditions and turbulence intensity trends higher during daytime temperature mixing. Wind resource studies indicate that average wind speeds are typically lowest during the summer months and highest during winter.

[3] GE Renewable Energy, Technical Documentation Wind Turbine Generator Systems 6.x-158 – 60 Hz with LNTE, Product Acoustic Specifications Rev. 03 – EN, 2022-08-01.

[4] GE Renewable Energy, Technical Documentation Wind Turbine Generator Systems 6.1-158 – 50/60 Hz, Calculated Power Curve and Thrust Coefficient, Rev.03 - EN, 2022-02-025.

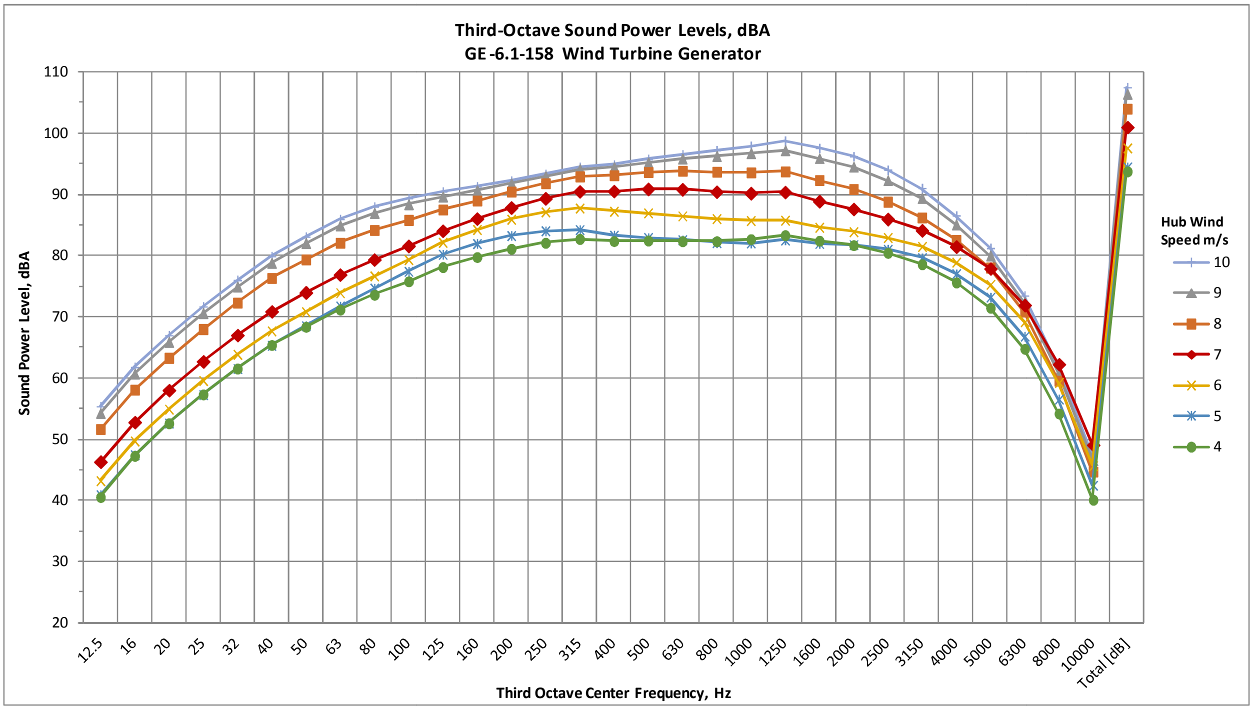


Figure 4-1. Sound Power Levels for GE-6.1-158 Wind Turbine by Hub Height Wind Speed

Available studies of wind resources and sound level measurements indicate that extremes in turbulence intensity and wind shear are unlikely to occur at most Maine wind projects with site characteristics similar to Twin Energy.[5] Within this premise, this Sound Level Assessment applies the widely recognized International Organization for Standardization (ISO) 9613-2 for outdoor sound propagation combined with model assumptions demonstrated by operations sound testing of Maine wind projects to be reliable for accuracy. Section 6.3 of this report provides further details concerning verification of the sound level prediction methodology.

During winter operations, accumulation of snow and ice on turbine blades can increase turbine sound output beyond the rated sound power levels while decreasing turbine power production. Information provided by Twin Energy indicates that the GE 6.1-158 wind turbines are equipped with monitoring sensors and are programmed through the turbine control system to pause operations during icing conditions.

[5] Operations Sound Testing at Hancock, Bingham, Bull Hill, Stetson, Oakfield and Weaver Wind Projects, R.S. Bodwell, P.E., 2009 to 2023.
Town of Oakfield Wind Energy Review Committee, 2011 Review of Evergreen Wind Power II, LLC's Proposed Wind Energy Facility, Final Report, 2011.
Stetson II Operations Sound Testing Peer Review, Warren L. Brown, EnRad Consulting, 2011.

5.0 Noise Standards and Guidelines

The following provides a description of State of Maine noise regulations for wind energy facilities including applicable sound level limits, model uncertainty, compliance determination and consideration of noise standards enacted by a local municipality. Relevant noise standards established by the Town of Rumford are also described.

5.1 Maine DEP Sound Level Limits

Maine DEP Chapter 375.10, Control of Noise, establishes hourly sound level limits for wind energy facilities based on time of day. Section I, Sound Level Standards for Wind Energy Developments, sets forth these sound limits that apply to routine operation of a wind energy development. Wind energy facility sound levels are measured in accordance with the site conditions and monitoring procedures described in subsection I(8).

Twin Energy is required to meet the following sound level limits (ref. Maine DEP 375.10.I(2)) during all routine operations:

(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; 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.

In contrast to other developments, sound level limits for wind projects do not depend on land use, local zoning and pre-construction sound levels. Although the Maine DEP noise regulation specifies a 75 dBA at the facility property line, the most restrictive limits apply at noise sensitive land uses that meet the definition of a “protected location”. A protected location is defined as:

> “Any location accessible by foot, on a parcel of land containing a residence or planned residence or approved residential subdivision, house of worship, academic school, college, library, duly licensed hospital or nursing home near the development site at the time a Site Location of Development application is submitted; or any location within a State Park, Baxter State Park, National Park, Historic Area, a nature preserve owned by the Maine or National Audubon Society or the Maine Chapter of the Nature Conservancy, The Appalachian Trail, the Moosehorn National Wildlife Refuge, federally-designated wilderness area, state wilderness area designated by statute (such as the Allagash Wilderness Waterway), or locally-designated passive recreation area; or any location within consolidated public reserve lands designated by rule by the Bureau of Public Lands as a protected location.
>
> At protected locations more than 500 feet from living and sleeping quarters within the above noted buildings or areas, the daytime hourly sound level limits shall apply regardless of the time of day.
>
> Houses of worship, academic schools, libraries, State and National Parks without camping areas, Historic Areas, nature preserves, the Moosehorn National Wildlife Refuge, federally-designated wilderness areas without camping areas, state wilderness areas designated by statute without camping areas, and locally-designated passive recreation areas without camping areas are

> considered protected locations only during their regular hours of operation and the daytime hourly sound level limits shall apply regardless of the time of day.
>
> Transient living accommodations are generally not considered protected locations; however, in certain special situations where it is determined by the Board that the health and welfare of the guests and/or the economic viability of the establishment will be unreasonably impacted, the Board may designate certain hotels, motels, campsites and duly licensed campgrounds as protected locations." (ref. MDEP 375.10 G(16))

Maine DEP Chapter 375.10 defines a "residence" as:

> "A building or structure, including manufactured housing, maintained for permanent or seasonal residential occupancy providing living, cooking and sleeping facilities and having permanent indoor or outdoor sanitary facilities, excluding recreational vehicles, tents and watercraft." (ref. MDEP 375.10 G(14))

The nighttime limit of 42 dBA applies on portions of a protected location within 500 feet of a residence or other sleeping quarters, or at the property boundary line of the protected location, whichever is closer to the dwelling. At locations greater than 500 feet from the residence or sleeping quarters, the 55 dBA daytime limit applies 24 hours a day. Sound from regular, routine maintenance of the wind project is subject to the same sound level limits as routine operation.

Construction during daytime or daylight hours, whichever is longer, is exempt from the Maine DEP sound limits by Maine statute (ref. 38 MRSA 484). Sound from nighttime construction that occurs beyond daytime or daylight hours is subject to the nighttime limits that apply to routine operation. More information concerning construction of Twin Energy is presented in Section 6.1 of this report.

Sound associated with certain equipment and activities is exempt from the Maine DEP noise regulation. Examples that may be associated with the proposed project include:

- Registered and inspected vehicles traveling to and from the project
- Forest management, harvesting and transportation
- Snow removal and landscaping
- Emergency maintenance and repairs, warning signals and alarms
- Major concrete pours when started before 3:00 pm
- Sounds from a regulated development received at a protected location when the generator of the sound has been conveyed a noise easement for that location
- A force majeure event and other causes not reasonably within control of the owners or operators of the development

The Maine DEP sound limits do not apply to noise received within the project/lease boundary or where Twin Energy has obtained a sound easement. As set forth by Maine DEP 375.10, Section C.5.s, a landowner may grant a noise (sound) easement that exempts the project from Maine DEP noise limits for the specific development, parcel of land, and term covered by the agreement.

5.2 Tonal and Short Duration Repetitive (SDR) Sounds

Maine DEP Chapter 375.10 Section I requires that 5 dBA be added to tonal and short duration repetitive (SDR) sounds, as defined below, when determining compliance with hourly sound level limits. Further details and an assessment of these types of sound for Twin Energy are presented in Section 6.5 of this report.

5.2.1 Tonal Sounds

For wind energy facilities, a tonal sound exists if, at a protected location, the 10-minute equivalent 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. When a tonal sound occurs from routine operation of the wind energy development, 5 dBA is added to the 10-minute equivalent sound level ($Leq_{A\ 10\text{-}min}$) for purposes of demonstrating compliance with the applicable daytime and nighttime sound level limits (ref. Maine DEP 375.10.I(3)).

5.2.2 Short Duration Repetitive (SDR) Sounds

An SDR sound is a sequence of repetitive sounds clearly discernible as an event resulting from the development and causing an increase in the sound level of 5 dBA or greater on the fast meter response above the average minima sound levels observed immediately before and after the event. An SDR sound event for wind turbines can potentially result from the downstroke of a wind turbine blade at an interval of approximately 1.8 seconds for the GE-6.1-158 at full rpm. When routine operation of a wind energy development produces SDR sounds, a 5 dBA penalty is arithmetically added to each 10-minute LAeq ($Leq_{A\ 10\text{-}min}$) measurement interval during which greater than five SDR sound events are present (ref. Maine DEP 375.10.I(4)).

5.3 Compliance with the Sound Level Limits

Compliance with the applicable sound level limits for wind energy developments is usually demonstrated by operations sound testing as described in Section 7.0 of this report and in accordance with the following criteria:

(a) Sound level data shall be aggregated in 10-minute measurement intervals within a given compliance measurement period under the atmospheric and site test conditions set forth in subsection I(8).

(b) Compliance will be demonstrated when the arithmetic average of the sound level of twelve or more 10-minute measurement intervals (i.e. average of twelve 10-min measurement intervals) in a given compliance measurement period is less than or equal to the applicable sound level limits.

(c) Alternatively, if a given compliance measurement period does not produce a minimum of twelve, 10-minute measurement intervals under the atmospheric and site conditions set forth in subsection I(8), the wind energy development may combine six or more contiguous 10-minute measurement intervals from one 12 hour (7:00 am to 7:00 pm daytime or 7:00 pm to 7:00 am nighttime) compliance measurement period with six or more contiguous 10-minute intervals from another compliance measurement period.

Compliance is demonstrated when the arithmetic average of the combined 10-minute measurement intervals is less than or equal to the applicable sound level limit. The 10-minute intervals are measured under the required site operating and atmospheric conditions and include any applicable adjustments for the presence of tonal and SDR sounds (ref. Maine DEP 375.10.I(5)).

5.4 Local Standards

When a development is located in a municipality that has duly enacted a quantifiable noise standard that (1) contains limits that are not higher than the Maine DEP limits by more than five dBA, and (2) limits or addresses the types of sounds regulated by the Maine DEP, then the Maine DEP is to apply the local standard rather than the Maine DEP standard. When noise produced by a facility is received in another municipality, the quantifiable noise standards of the other municipality must be taken into consideration (ref. Maine DEP 375.10.B.1). The proposed wind turbines for Twin Energy are located in the Town of Rumford and other facilities in the Town of Roxbury.

As part of its Land Use Ordinance, the Town of Rumford enacted Chapter 308, Wind Energy Facilities (WEF) Ordinance that, in addition to other siting criteria, establishes noise standards applicable to wind energy facilities in Rumford. The current posted WEF Ordinance (rumfordme.org) states that it was adopted by Town Meeting of 6-14-2016 and amended 6-13-2017. WEF Ordinance Chapter 308-15, Control of noise, applies the same sound level limits and other provisions for wind energy projects as Maine DEP 375.10. This includes daytime and nighttime sound limits, adjustments for tonal and SDR sounds, submission requirements and criteria for demonstrating sound compliance. The Rumford WEF Ordinance also sets forth the same criteria that the lower nighttime limit of 42 dBA applies within 500 feet of a dwelling/sleeping quarters on a protected location. Over 500 feet from sleeping quarters, the daytime limit of 55 dBA applies during all hours of the day.

As set forth in Maine DEP 375.10, the local quantifiable noise standards of any town where sound emissions will be received must also to be taken into consideration and would apply for the types of sound regulated provided the limits do need exceed Maine DEP sound limits by more than 5 dBA. This would include the Town of Roxbury, which has not enacted a quantifiable noise standard. Therefore, the Maine DEP noise regulations apply within Roxbury.

5.5 Sound Model Factors and Uncertainty

Maine DEP and Rumford noise rules require the predictive model used to calculate sound levels produced by wind turbines to be designed to represent the "predictable worst case" impact on adjacent properties. In particular, the predictive model is required to include the following (ref. Maine DEP 375.10.I(7)(c) and Rumford WEF 308-15.C.):

a. The maximum rated sound power output (IEC 61400-11) of the sound sources operating during nighttime stable atmospheric conditions with high wind shear above the boundary layer and consideration of other conditions that may affect in-flow airstream turbulence;

b. Attenuation due to geometric spreading, assuming that each turbine is modeled as a point source at hub height;

c. Attenuation due to air absorption, ground absorption and reflection, three-dimensional terrain and forestation;

d. Attenuation due to meteorological factors such as but not limited to relative wind speed and direction (wind rose data), temperature/vertical profiles and relative humidity, sky conditions, and atmospheric profiles;

e. Inclusion of an "uncertainty factor" adjustment to the maximum rated output of the sound sources based on the manufacturer's recommendation; and

f. Inclusion, at the discretion of the Maine DEP [Planning Board], of an addition to the maximum rated output of the sound sources to account for uncertainties in the modeling of sound propagation for wind energy developments. This discretionary uncertainty factor of up to 3 dBA may be required by Maine DEP based on the following conditions: inland or coastal location, the extent and specificity of credible evidence of meteorological operating conditions, and the extent of evaluation and/or prior specific experience for the proposed wind turbines. Subject to the Maine DEP's discretion based on the information available, there is a rebuttable presumption of an uncertainty factor of 2 to 3 dBA for coastal developments and of 0 to 2 dBA for inland developments.

6.0 Project Sound Emissions

The following provides an assessment of sound levels associated with construction and operation of Twin Energy.

6.1 Construction Sound Levels

Construction of Twin Energy will involve the use of heavy machinery to clear and grade areas for access roads and turbine pads, erect wind turbine towers, and assemble the nacelle and turbine blades. This equipment will include heavy trucks, excavators, loaders, bull dozers, cranes, portable generators and compressors among other machines. Construction staging yards will also be established in designated areas for storage of equipment, materials, and wind turbine components.

Depending upon whether aggregate material can be found on site or transported to the project, there may also be equipment operating at the project site to excavate gravel, crush rock and process aggregate. Sound levels generated by mobile construction and portable processing equipment are likely to range from 75 to 95 dBA at 50 feet. Due to the size and configuration of the project site, most of this equipment will be well distributed and not focused in a single area.

Maine DEP sets forth sound limits for daytime construction based on the duration of the construction activity ranging from 87 dBA (12 hours) to 105 dBA (1 hour or less) at a protected location. However, operation of heavy equipment for site work and other major construction activity between 7 am and 7 pm or during daylight hours, whichever is longer, is not subject to the Maine DEP noise control regulation per Maine statute (ref. 38 MRSA Section 484). Construction activity during nighttime, non-daylight hours must comply with the nighttime limits applicable to routine facility operation.

The Town of Rumford WEF establishes the same sound limits for daytime construction activities, however, the exemption per Maine statute for daylight hours is not specified. Therefore, the nighttime sound limits applicable to facility operation would apply for construction activity in Rumford between 7 p.m. and 7 a.m. For daytime periods, sound levels from construction are not expected to approach the applicable Rumford sound limits due distances from protected locations. The Rumford WEF also includes a provision for higher sound levels during nighttime hours with a duly issued permit by the Code Enforcement Officer for up to 90 days and longer with approval of both the Code Enforcement Officer and Planning Board. Per Maine DEP and the Rumford WEF, all construction equipment must also comply with applicable federal noise regulations and include environmental noise control devices in proper working condition as originally provided by the equipment manufacturer.

Outdoor construction activity involving heavy equipment and significant sound sources is expected to occur between the hours of 7 a.m. and 7 p.m. All construction activity between 7 p.m. and 7 a.m. ("nighttime hours") must comply with nighttime limits for routine facility operation applicable at regulated protected locations.

6.2 Wind Turbine Sound Power Levels

As described in Section 4.0 of this report, wind turbine sound power levels were provided by GE based on sound testing per IEC 61400-11 and proprietary computer models.

The GE Product Acoustic Specification for the GE-6.1-158 turbine indicates that the full-rated sound power level for routine operation is 107.5 dBA. For modeling purposes, adding the assumed turbine uncertainty of +2 dBA to the full-rated sound output yields an equivalent sound power level of 109.5 dBA for the proposed GE turbine model. At a hub height of 117 meters (384 feet) above the ground, the resulting elevations of the turbine hubs (modeled point sources) range from approximately 2,340 to 2,520 feet above msl, with base elevations ranging from approximately 1,960 to 2,140 feet.

GE provided third-octave band and overall sound power levels for turbine operation at various wind speeds for use in the sound level prediction model. The resulting octave band sound levels calculated for a hub wind speed of 10 m/s or above, yielding the highest sound level predictions, were used in the sound model for the GE turbines. An adjustment of +2 dBA was applied for the specified sound level plus stated uncertainty for the overall sound power level of 109.5 dBA. As described in Section 6.3, an additional +1 dBA was added to the turbine sound power levels for model accuracy.

6.3 Sound Prediction Model

A sound prediction model was prepared to calculate sound levels from daytime and nighttime operation of Twin Energy. The predictive sound model was created using Cadna/A software developed by DataKustik of Germany. Cadna/A provides the platform to construct topographic surface models of an area for calculating sound propagation over terrain from multiple sound sources such as wind turbines. Mapping of proposed turbine locations, topography, roads, parcels, land uses, and water bodies was provided by Twin Energy and imported to Cadna/A in order to calculate the resulting sound levels within the study area and at receptor points representing protected locations. The surface model was derived from topographic contours at 6-meter (~20 ft) intervals as provided and used to determine approximate turbine base elevations.

As noted in Section 3.0, the Project will include overhead and underground transmission lines and a project met tower. Neither transmission lines nor the met tower are expected to be significant sound sources.

Sound model predictions are calculated in accordance with International Organization for Standardization (ISO) 9613-2, an international standard for calculating outdoor sound propagation. This method calculates sound levels as though all receiver points are located downwind simultaneously from the sound sources, which is for calculation purposes and not a physical possibility. According to ISO 9613-2, the calculation method is also equivalent to sound propagation for a "well-developed moderate ground-based temperature inversion." The stated accuracy of the ISO 9613-2 method is $\pm$3 dBA for a source and receiver mean height of 5 to 30 meters and a distance of 100 to 1000 m. The mean height between Twin wind turbine hubs (117 meters) and receivers (1.5 meters) is closer to 59 meters with receivers up to 1,800 m from the nearest turbine site. However, use of Cadna/A applying ISO 9613-2 has been found accurate for prediction of turbine sound levels from inland Maine wind projects at distances similar to the receiver/receptor points.[6]

Cadna/A allows flexibility in defining model settings and adjustments related to sound sources, calculation methods, ground absorption and other factors. As noted in Section 5.5, conservative assumptions are utilized per the Maine DEP wind noise rule to predict the high range of wind turbine sound levels under a wide variety of site and weather conditions at other projects. Sound measurements of turbine operations at numerous Maine wind projects have been evaluated to verify that these predictive models are "calibrated" to actual sound levels for reliable model predictions.

Model settings are selected to calculate ground attenuation using the spectral method per ISO 9613-2 and using a default ground absorption factor of 0.5 to represent a mix of hard and soft ground. Surface water bodies, if present within the study area, are assigned a ground absorption factor of 0.0, similar to hard ground, for an acoustically reflective surface. Attenuation resulting from intervening terrain and

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[6] K. Kaliski and E. Duncan, Propagation Modeling Parameters for Wind Power Projects.
Town of Oakfield, Wind Energy Review Committee, Final Report.
R.S. Bodwell, Operations Sound Testing: Rollins Wind, Stetson II Wind, Bull Hill Wind, Oakfield Wind, Bingham Wind, Hancock Wind, Weaver Wind

atmospheric absorption using standard day conditions (temperature 10^{o}C, relative humidity 70%) is also calculated. No attenuation is calculated due to trees or other foliage, which could act to reduce sound levels at protected locations and surrounding area.

Results from other wind energy facilities in Maine, where turbines are located on similar ridge top settings, indicate that the high end of the measurement range can be predicted by adding the manufacturer's sound power level uncertainty of +2 dBA and +1 dBA for the demonstrated model accuracy per ISO 9613-2 in accordance with Section I of Maine DEP 375.10. For Twin Energy, that equates to a total +3 dBA added to the rated turbine sound power levels for predictive model calculations.

6.4 Predicted Sound Levels

From the project sound model, wind turbine sound levels during full operations are calculated for a height of 5 feet above ground level as specified by Maine DEP 375.10. To evaluate compliance with applicable sound limits, sound levels are calculated and presented specifically for selected community receptor points. "Receptor points" represent the protected locations in each direction from Twin Energy with the greatest potential to exceed the Maine DEP or Town of Rumford sound level limits. In addition, sound level contours are calculated to provide model predictions at all locations within the study area. A grid spacing of 10 meters by 10 meters and height of 5 feet above ground are used to calculate the sound level contours.

Sound level predictions for Twin Energy are calculated with all proposed wind turbines operating at full-rated sound power output, and the addition of +3 dBA for modeling the GE-6.1-158 turbines based on a turbine manufacturer uncertainty of +2 dBA and model accuracy of +1 dBA. Sound level isopleths at 1 dBA intervals are calculated for the entire study area and are presented in Figure 6-1 along with calculated sound levels at the selected receptor points. Figure 6-1 also shows the turbine locations, parcel boundaries, dwelling locations, public and private roads among other land uses. Parcels within the study area either owned or leased by Twin Energy LLC (project boundary) or that are subject to a sound easement are indicated by hatching. Maine DEP and Rumford sound limits do not apply at parcels within the project boundary or that are under a landowner agreement with a sound easement.

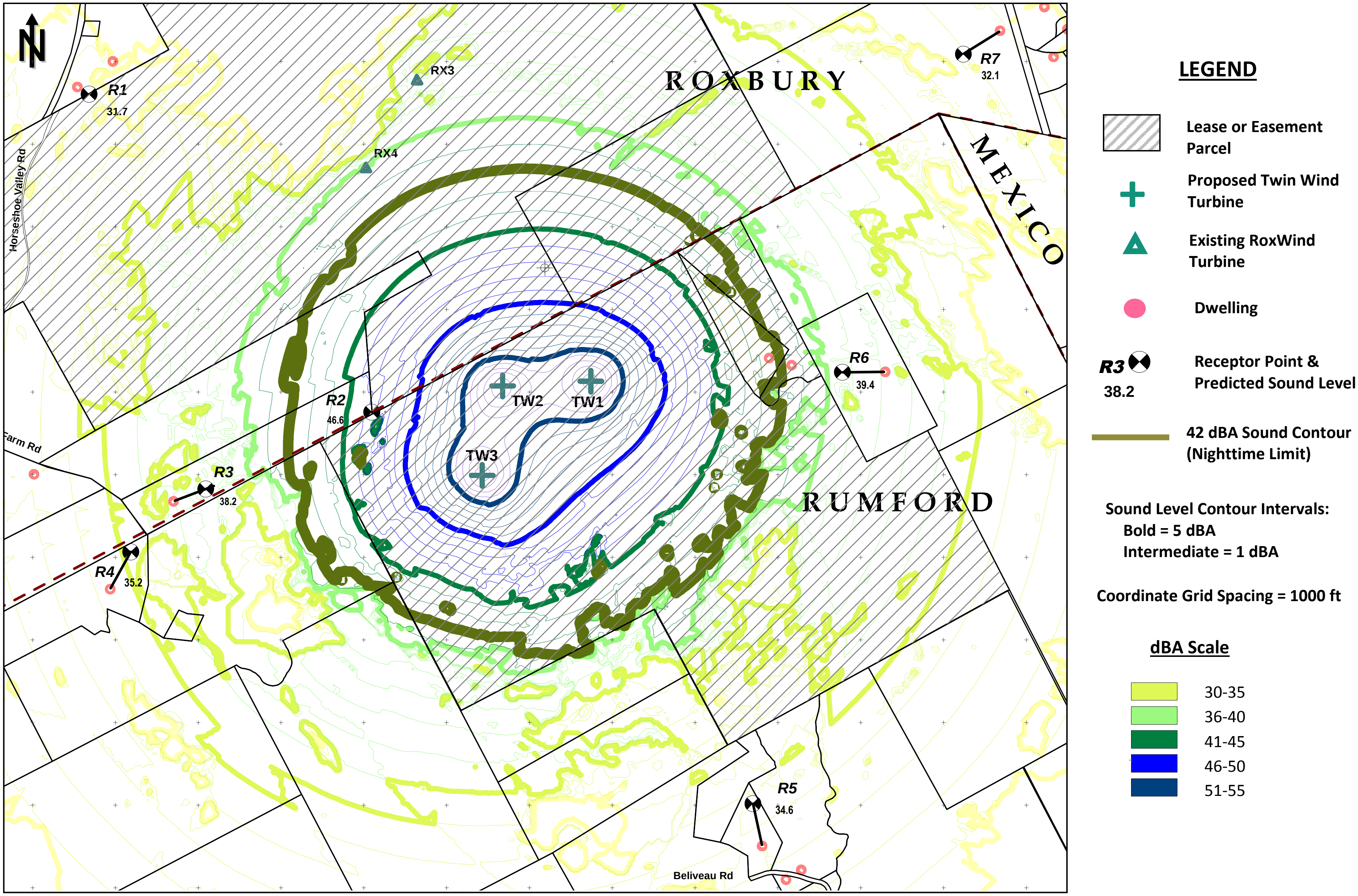
A summary of predicted sound levels at the receptor points for daytime and nighttime operation of the proposed GE-6.1-158 turbines is provided in Table 6-1. This table also provides a description of the receptor point, distance to the nearest turbine and the applicable sound level limit.

Receptor points representing the nearest protected locations to Twin Energy are positioned at the residential property line and up to 500 feet from the associated dwelling where the lower nighttime sound limit applies. With discretionary settings and uncertainty included in the Twin Energy predictive model (i.e. +3 dBA added to the full-rated turbine sound power level), the resulting sound level at the nearest residential property line (Receptor R2) is 46.6 dBA and 8.4 dBA below the Maine DEP and Rumford daytime limit of 55 dBA. At receptor points within 500 feet of a dwelling, the predicted sound levels range from approximately 32 to 39 dBA and are 3 to 10 dBA below the applicable Maine DEP and Rumford 42 dBA nighttime limit.

Receptor Point	Description and Approximate Distance to Nearest Twin Energy Turbine		Predicted Hourly Sound Level and Nighttime Sound Limit, dBA	
	Town - Description	Distance (ft)	GE Turbines	Sound Level Limit
R1	Roxbury – Residential Property Line <500’ from Dwelling	6,105	31.7	42
R2	Roxbury – Residential Property Line >500’ from Dwelling	1,530	46.6	55
R3	Roxbury – 500’ from Dwelling	3,345	38.2	42
R4	Rumford – 500’ from Dwelling	4,350	35.2	42
R5	Rumford – 500’ from Dwelling	5,140	34.6	42
R6	Rumford – 500’ from Dwelling	3,040	39.4	42
R7	Roxbury – 500’ from Dwelling	5,990	32.1	42

Table 6-1. Predicted Sound Levels from Wind Turbine Operations at Receptor Points

Figure 6-1. Predicted Sound Levels from Full Routine Operation of Twin Energy



Note: Sound level predictions include +3 dBA added to the rated turbine sound power levels for uncertainty and model accuracy.

6.5 Tonal and Short Duration Repetitive (SDR) Sounds

The Maine DEP noise rule and Rumford WEF Ordinance requires that 5 dBA be added to the measured 10-minute equivalent sound level at a protected location (receptor point) if sound from a development generates either: 1) a tonal sound or 2) more than five SDR sound events over a ten-minute measurement interval. Although the presence of these types of sounds is determined by operations sound testing, the following assesses the potential for these sounds from operation of Twin Energy.

6.5.1 Tonal Sounds

The third-octave sound data provided in the GE-6.1-158 Acoustic Specification and shown herein as Figure 4-1, indicate that the GE turbine does not generate tonal sound. The GE Turbine Supply Agreement (pending) is expected to warrant the overall sound power level 107.5 dBA of the proposed turbines and may further warrant that the turbine will not produce tonal sounds as defined by Maine DEP 375.10 and the Rumford WEF Ordinance. From the turbine third-octave sound data provided for the GE-6.1-158, the proposed wind turbines are not expected to generate regulated tonal sounds during routine operation.[7]

6.5.2 Short Duration Repetitive (SDR) Sounds

For wind turbines, short duration changes in sound levels occur with the rotational movement of individual turbine blades. This is commonly referred to as "amplitude modulation" with the highest sound levels generally recognized to occur on the down stroke of each turbine blade. The turbine acoustic specifications provided for the GE-6.1-158 turbines do not specifically address the sound level change that occurs due to amplitude modulation.

Measurements of operating wind turbines at other projects in Maine and published literature concerning amplitude modulation from wind turbines indicate that sound level fluctuations during the blade passage of wind turbines typically range from 2 to 5 dBA (see also Section 2.3), with occasional but infrequent events reaching 6 dBA or more. Overall, operations sound testing of Maine inland wind projects indicates that SDR sound events are relatively uncommon even under stable atmospheric conditions, high wind shear and other factors identified in technical studies as having the potential to increase amplitude modulation.[8] Operational sound testing of Twin Energy will evaluate the potential presence of SDR sound events and, if present to a sufficient degree, apply the required penalty for determining compliance.

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[7] GE Renewable Energy, Technical Documentation Wind Turbine Generator Systems 6.x-158 – 60 Hz with LNTE, Product Acoustic Specifications Rev. 03 – EN, 2022-08-01.

[8] R.S. Bodwell, Operations Sound Testing: Rollins Wind, Stetson II Wind, Oakfield Wind.
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6.6 Overall Sound Levels

The predictive modeling results indicate that with all turbines operating at full-rated sound output, Twin Energy will comply with all applicable Maine DEP and Rumford sound level limits. At the most restrictive receptor point R6, the predicted sound level of 39.4 dBA is 2.6 dBA below the applicable 42 dBA nighttime limit. Given the conservative modeling assumptions and +3 dBA uncertainty, sound levels from turbine operations are expected to be below model estimates. Based on the model estimate of 39.4 dBA at receptor R6, even if 50 percent of the operations sound testing intervals indicated the presence of SDR or tonal sounds, Twin Energy would be within the 42 dBA nighttime limit.

Operations sound testing of wind turbines during winter periods has demonstrated that turbine sound output can increase under conditions when turbine blade icing or heavy snow accumulation occurs. These test results indicate that a moderate to heavy icing condition can increase sound levels by 5 to 10 dBA. However, information from Twin Energy indicates that proposed GE wind turbines will be programmed to pause operations during periods with snow or ice accumulation on the turbine blades.

7.0 Sound Level Testing

The purpose of sound level testing is to confirm by measurement that sound levels emitted by Twin Energy are at or below the sound level limits applicable to the project.

7.1 Project Construction

Construction of Twin Energy is planned to occur primarily during daytime hours when sound levels generated by construction activity are exempt from the Maine DEP sound level limits by Maine statute. Further, daytime construction sound levels are expected to be well below the Town of Rumford sound limits for construction of wind energy facilities. Consequently, no sound level testing is planned for the construction phase of the project. If nighttime construction occurs, such construction activity is required to comply with nighttime sound level limits for routine operation and maintenance of the project.

7.2 Wind Turbine Operations

Sound level testing of wind turbine operations is a complex and critical component of the proper and responsible operation of a wind energy facility. The most difficult aspect of wind turbine sound testing is to perform the required measurements under appropriate site and weather conditions. Operation of wind turbines at full sound output requires a significant wind speed of 10 m/s acting on the turbine hubs for an extended period of time. Often when hub wind speeds are at the required levels, surface winds will also be high enough to cause extraneous sound levels from wind forces acting on terrain and vegetation. These extraneous sounds can mask noise from turbines making it difficult to isolate and quantify sound levels from operation of the wind project.

However, under certain conditions, the winds aloft along the project ridge and wind turbine hubs can remain strong while the surface winds at lower elevations near protected locations can diminish to light or nearly calm. These conditions most often occur during nighttime periods are commonly referred to as a "stable atmosphere" and are the best conditions under which to measure the sound level contributions of wind turbines for several reasons. First, the ambient (non-wind turbine) sound levels from surface wind and daytime activities are reduced so that the sound levels from wind turbines become more prominent and easier to quantify. Second, technical literature concerning wind turbine noise emissions indicates that the potential for amplitude modulation (and resulting potential for SDR sounds) increases with rotor-plane wind shear, which typically increases under stable atmospheric conditions. Therefore, full sound output under stable atmospheric conditions is favorable for measuring wind turbine sound levels to evaluate for the presence of SDR sounds.

On early Maine inland wind projects, R.S Bodwell, BEA worked closely with the Maine DEP and EnRad Consulting, former acoustical consultant to Maine DEP, to develop a rigorous, detailed operations testing protocol for measuring sound levels from wind turbines in Maine. This operations sound testing protocol was refined by Enrad and adopted as Subsection I(8) of Maine DEP 375.10 noise regulations for wind energy developments. The purpose of this protocol is to facilitate measurement of wind turbine sound levels under worst-case operating conditions to evaluate compliance with Maine DEP sound level limits, including appropriate adjustments for tonal and SDR sounds.

Prior to operation of Twin Energy, an Operations Sound Testing Plan will be prepared to identify sound test locations and other testing details. These test locations will be selected based on post-construction site conditions and accessibility to represent receptor points R3 and R6 as the nearest protected locations where Maine DEP and Rumford nighttime sound level limits apply. Further, if tonal sounds occur or amplitude modulation reaches the Maine DEP threshold of 5 dBA for more than 5 events in a 10-minute test interval, a 5 dBA "penalty" will be added to the measured 10-minute equivalent sound levels (LAeq or $Leq_{A\ 10\text{-}min}$). Compliance will be evaluated based on the arithmetic average of the measured LAeq sound levels for a minimum of twelve, 10-minute measurement intervals most closely meeting the protocol criteria during compliance test period. In the unlikely event that tonal or SDR sounds occur more frequently than anticipated, operating adjustments can be made to ensure that turbines are operating within the applicable sound limits, including any penalties for SDR and tonal sounds.

The Maine DEP and Town of Rumford require operations sound testing during the first year and each fifth consecutive year of wind turbine operations. In order to achieve the required wind and site conditions, operations sound testing is typically performed during late October through mid-December.

8.0 Complaint Response Protocol

Twin Energy will develop and implement a formal protocol for addressing sound complaints from local residents during wind turbine operations. The purpose of this protocol is to ensure that local residents are informed of how to report a sound complaint and that each sound complaint is fully documented and resolved in a consistent manner. Similar to complaint response protocols approved by Maine DEP for other wind power projects, Twin Energy will establish guidelines for reporting, documenting, investigating, reporting and responding to sound complaints as set forth by Maine DEP 375.10 Section I.(7)(j).

9.0 Summary of Findings

This Sound Level Assessment establishes sound level limits to be applied to Twin Energy and provides sound level predictions for full daytime and nighttime turbine operations using a terrain-based computer model. Model settings adhere to Section I of Maine DEP 375.10 and the Rumford WEF Ordinance with accuracy demonstrated operations sound testing of similar grid-scale wind energy facilities in Maine.

The Maine DEP and Town hourly sound level limits of 55 dBA daytime and 42 dBA nighttime apply at residential protected locations, with nighttime limits applicable within 500 feet of a dwelling. Sound level predictions indicate that with all wind turbines operating simultaneously at full capacity, Twin Energy will meet Maine DEP and Rumford daytime sound level limit of 55 dBA at all protected locations, and the Maine DEP and Rumford nighttime limit of 42 dBA within 500 feet of dwellings on nearby protected locations.

The Sound Level Assessment establishes procedures for sound level testing of turbine operations to evaluate compliance with applicable sound level limits, including methods for measurement and analysis of tonal and SDR sounds.

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Exhibit 5-2
Sound Complaint Notice

Dear Neighbor,

Twin Energy LLC has established a 24-hour complaint hotline to register noise complaints about the project. Complaints may be registered about the project's noise during construction and operation of the project.

The phone number is [TO BE DETERMINED] and is live.

When a noise complaint call is received, the following information will be requested and recorded:

a) Call Information: Date of Call, Time of Call
b) Caller Information: Name of Caller, Address of Caller
c) Sound Event Information: Date of Event, Time of Event, Duration of Event (minutes), Description of Sound Event, Sound Heard Indoors or Outdoors, Specific Location, Audible Sounds from Other Sources (and if those sounds are outside or inside)
d) Optional: Contact Information for Caller

In order for Twin to analyze any noise complaints, it's important that the caller provides responses to all of the questions prompted on the call. If the caller provides follow up contact information, Twin will contact the caller directly after concluding its analysis of the conditions on site during the registered sound event.

If questions arise about the 24-hour complaint hotline or the project in general, please contact us through our website: www.twinenergyrumford.com

Thank you,