Section 5. NOISE

The Applicant retained Bodwell EnviroAcoustics, LLC to conduct sound level modeling in the Project area. The report (Exhibit 5-1) assumes the simultaneous operation of 33 turbines (including spare locations) in “worst-case” conditions and models the Vestas V150 4.2 turbine based on a hub height of 125 meters and taking into account the elevations at each sited turbine location. Sound level predictions include an addition of 3 dBA to account for manufacturer and model uncertainty and are mapped with contours providing a comparative assessment of sound projections and existing MDEP standards. In addition, the study identifies 9 receptor points, based on locations nearest to existing structures and dwellings that were anticipated to yield the highest sound readings during turbine operations. The modeling shows compliance with the 42 dBA nighttime standard at each receptor point.

The report also evaluates and demonstrates compliance with the Town of Columbia sound limits.

5.1. CONSTRUCTION SOUND

Construction of the Downeast Wind Project will occur during daytime hours when construction-related noise is exempt from Maine DEP and Town of Columbia standards. If nighttime construction occurs it will be in compliance with nighttime sound standards.

5.2. OPERATIONS SOUND MONITORING

In accordance with MDEP standards sound testing and reporting of results will commence in the first year of turbine operations and continue at routine intervals throughout the life of the Project. An Operations Sound Testing Plan will be developed to identify sound test locations and preferred conditions for monitoring turbine sound output and provided to the MDEP prior to commercial operation. For preferred wind and site conditions, such monitoring typically occurs between late October and mid-December.

EXHIBIT 5-1: SOUND LEVEL ASSESSMENT

Sound Level Assessment
Downeast Wind Project
Washington County, Maine

March 2021

STATE OF MAINE
R. SCOTT
BODWELL
No. 7834
LICENSED
PROFESSIONAL ENGINEER

Prepared for:
Downeast Wind LLC

Prepared by:
R. Scott Bodwell, PE
Bodwell EnviroAcoustics, LLC
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 Downeast Wind Project a proposed 126 MW wind energy development to be located in the Town of Columbia and the unorganized areas of MD T18 and MD T24 in Washington County, Maine. The Project will consist of up to 30 wind turbines and associated infrastructure, including an operations and maintenance building, collector and transmission lines, substation with step-up transformer, access roads, crane paths, and construction laydown areas.

The objective of this Sound Level Assessment is to evaluate sound levels from simultaneous operation of all proposed turbines at full-rated sound power output during nighttime stable atmospheric conditions. A terrain-based computer model is 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). A comparison of predicted sound levels to sound limits established by the Town of Columbia is also provided.

This report describes the Downeast 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 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.

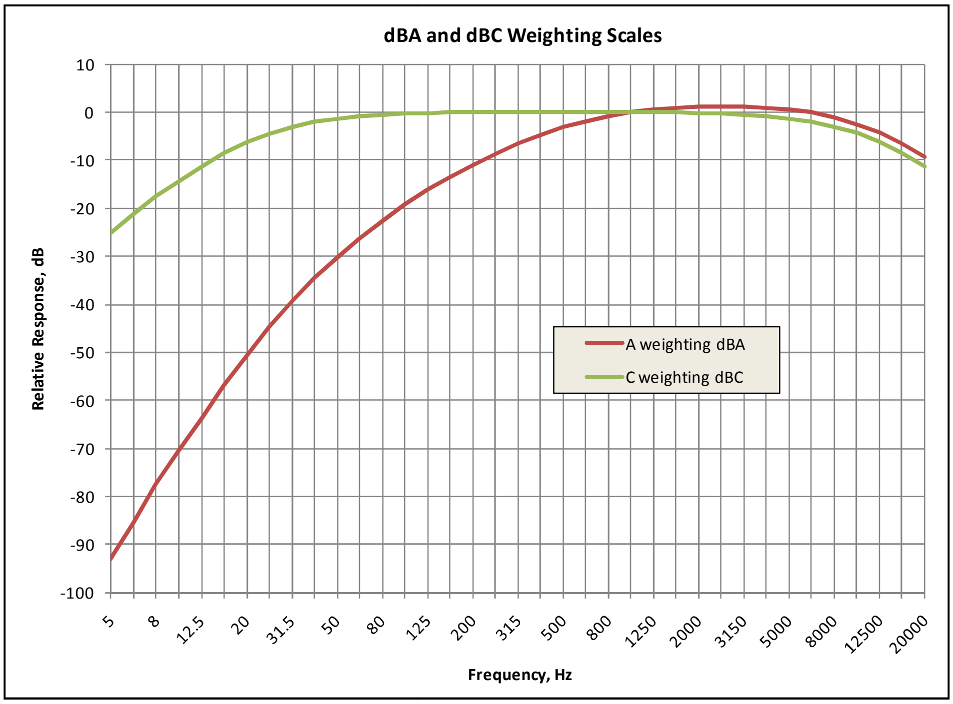


Figure 2-1. Weighting Curves for dBA and dBC Sound Levels

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.

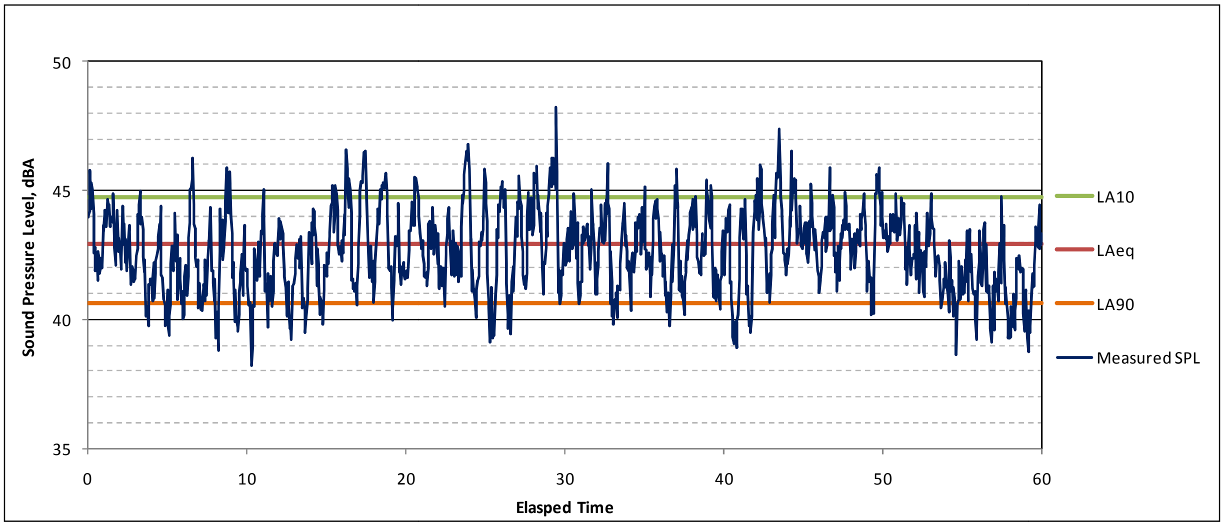


Figure 2-2. Measured Sound Pressure Levels and Statistical Parameters.

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

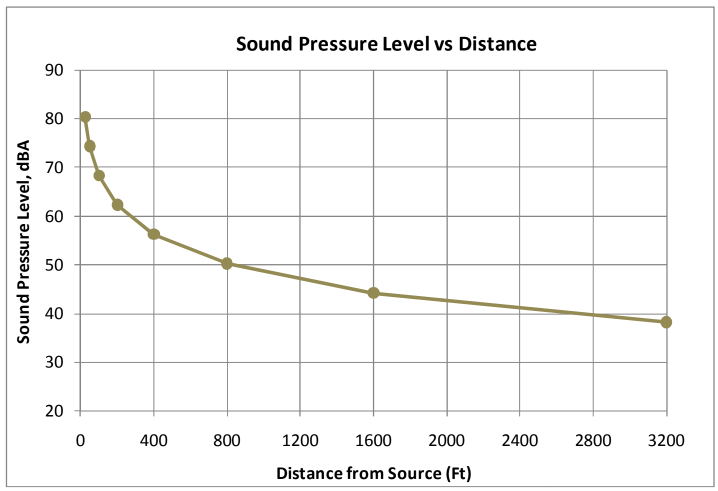


Table 2-2 & Figure 2-3. Attenuation of Sound Levels over Distance

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 Downeast Wind to account for various site and weather conditions can be found in Section 6.2 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 IEC 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 10 to 15 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

[1] Operations Sound Testing, Oakfield Wind, 2016; Stetson II Wind, 201, 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

Downeast Wind is a 30-turbine wind energy project proposed by Apex Clean Energy to be located in Washington County and within the Town of Columbia and unorganized townships of MD T18 and MD T24. A total of 33 potential turbine sites for Downeast Wind are located in southwest Washington County north of US Route 1 and east of State Route 193. The 33 turbines sites are arranged in three groups, with the largest to the north, and will be reduced to 30 installed wind turbines. Figure 3-1 provides a Project Location Map that shows proposed Downeast Wind turbines in relation to surrounding land uses.

The proposed turbines for Downeast Wind will be Vestas V150, which can generate up to 4.2 MW power output. The V150 turbines would have a hub height up to 125 meters and a 150-meter rotor diameter, for a total blade tip height up to 200 meters (656 feet) at the top of the turbine blade rotation. The power generated from each turbine will be collected in approximately 24.5 miles of 34.5-kilovolt (kV) collector lines and will flow to a new substation in the southernmost section of the project area, among the Columbia turbines. Collector lines will be placed underground. The new substation will be located within a fenced area and "step up" the power from Downeast Wind to 115 kV and transmit it directly to an existing 115-kV transmission line with capacity to accept power from the project. The Operations and Maintenance (O&M) building will be sited on a 4.89-acre property at 191 US Route 1 in Columbia. Like other wind projects in the area, Downeast Wind also includes both temporary and permanent meteorological towers.

Downeast Wind, LLC has lease agreements with respective landowners for all potential turbine sites and the proposed substation as currently planned. The proposed O&M Building site in Columbia will be purchased by Downeast Wind. In addition, Downeast Wind has landowner agreements that include a provision that waives potential regulatory sound level limits from being applied within the parcel boundary.

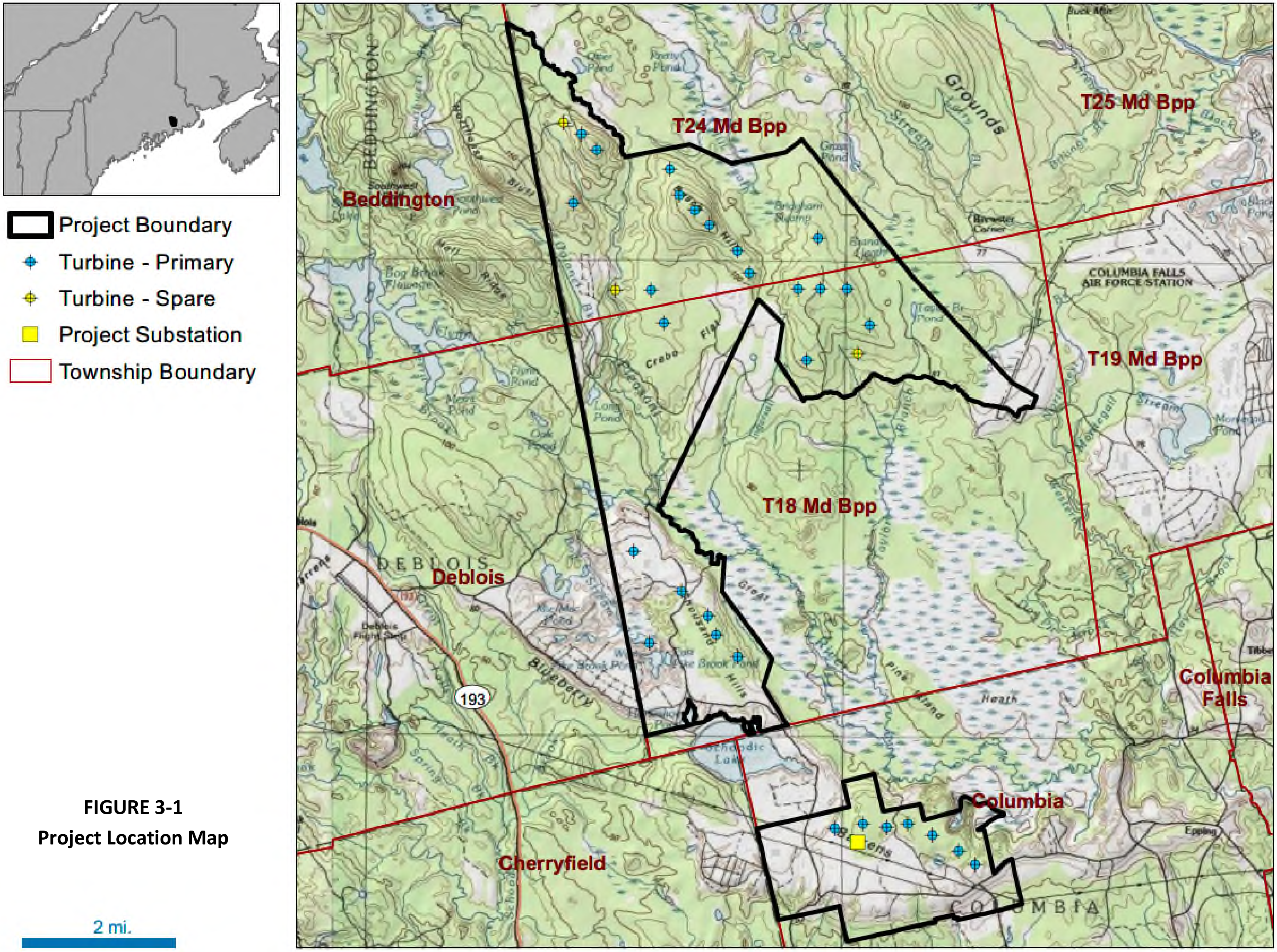


FIGURE 3-1
Project Location Map

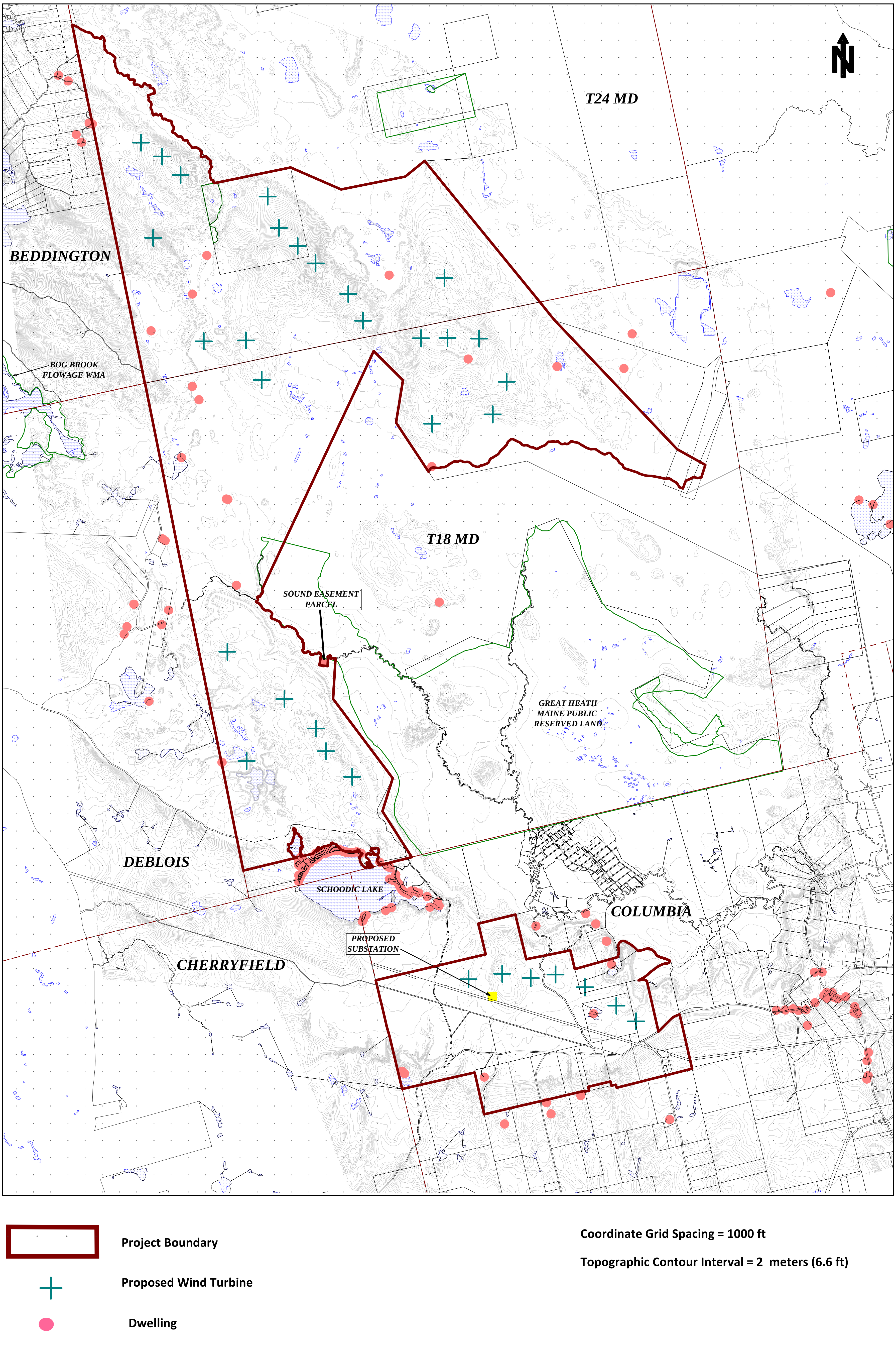
General site topography is relatively flat to gently sloping with narrow valleys between the small hills and low ridges. Within the project area are Beech Hill, Ben Tucker Mountain, several unnamed ridges and numerous small ponds and flowages with ground elevations ranging from about 180 to 550 feet. Schoodic Lake in northwest Columbia is the largest water body in the project area and located between the central and south turbine groups. Large portions of the project area are managed for commercial blueberry production and there are many existing gravel roads providing vehicular access.

Other surrounding land uses consist mostly of undeveloped forestry land, The Great Heath, and rural residential and seasonal properties such as hunting and lakeside camps. The highest density of residential and seasonal properties in the project vicinity is located along the northwest shore of Schoodic Lake primarily within MD T18. The Pleasant River flows through The Great Heath, which is Maine Public Reserved Land to the east of Schoodic Lake and within the Town of Columbia and MD T18. Other conserved lands in the vicinity of the project area include the Bog Brook Flowage Wildlife Management Area in the town of Deblois to the west.

Figure 3-2 provides an area map of the proposed wind turbine sites, along with parcel and land use information, topographic contours and dwellings/protected locations within two miles of a proposed wind turbine. The topographic contours, parcel boundaries and dwelling locations were provided by Apex Clean Energy. Dwelling locations were mapped through use of aerial photography and field verified with the parcel associations confirmed from review of local tax assessor records. Any additional parcels with approved residential building permits or that are part of an approved residential subdivision since were researched by review of state and municipal records.

Figure 3-2 also delineates the project boundary which includes parcels/dwellings subject to lease, and another parcel labeled “Sound Easement Parcel” that is subject to a sound easement with Downeast Wind. Additional discussion concerning leases and sound easements in relation to potentially applicable noise standards can be found in Section 5.0 of this report.

Figure 3-2. Land Uses and Proposed Downeast Wind Turbine Sites



4.0 Wind Turbine Specifications

Downeast Wind proposes to erect thirty Vestas V150 wind turbines (Mode 0) with a rated capacity of 4.2 megawatts (MW) to generate electric power for delivery. The proposed V150 Mode 0 is a pitch-regulated, upwind turbine equipped with Serrated Trailing Edge (STE) turbine blades that provide reduced sound output compared with standard blades. The turbine nacelles are mounted on tubular steel towers and 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 Vestas Wind Systems A/S. 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 V150 turbine and rated sound performance, including 3rd octave band sound levels as provided by Vestas.

4.1 Vestas V150 Wind Turbine Sound Levels

The V150 turbine rotor will be installed at a hub height up to 125 meters above the ground elevation of the turbine base. The turbine cut-in wind speed is 3 meters/sec and the cut-out (pause) wind speed is 24.5 m/s at the turbine hub and the rotational speed of the turbine rotor ranges from 4.9 to 12.0 rpm. The overall sound power level per IEC 61400-11 produced by the V150 Mode 0 ranges from 91.1 dBA at 3 m/s low rpm to 104.9 dBA at hub height wind speeds of 9 m/s or higher. Table 4-1 provides sound levels at various hub height wind speeds ranging from 8 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 V150 Mode 0 (STE blades) in relation to hub height wind speeds are shown graphically in Figure 4-1[3,4].

At full operation, the Vestas V150 Wind Turbine with STE blades (Mode 0) produces an overall rated sound power level of 104.9 dBA.[5] As part of the Turbine Supply Agreement, Vestas will issue a Sound Level Performance Standard that warrants the rated Sound Power Level for the V150 Mode 0, with an expected uncertainty of +2.0 dBA.

[3] Vestas Wind Systems A/S, Performance Specification, V150-4.0/4.2 MW 50/60 Hz, Document no.: 0067-7067 V10, Restricted, August 2019.
[4] Vestas Wind Systems A/S, Third octave noise emission, V150-4.0/4.2 MW, DMS 0067-4767_06, Restricted, December 2019.
[5] Vestas Wind Systems A/S, Performance Specification, V150-4.0/4.2 MW 50/60 Hz, Document no.: 0067-7067 V10, Restricted, August 2019.

Mode 0	Hub Height Wind Speed m/s						
Frequency (Hz)	**8 m/s**	**9 m/s**	**10 m/s**	**11 m/s**	**12 m/s**	**13 m/s**	**14 m/s**
16	57.2	58.9	59.6	60.7	59.5	59.3	59.1
31.5	71.1	72.7	73.1	73.8	73.2	73.0	72.7
63	82.1	83.7	83.9	84.2	84.1	83.9	83.6
125	90.3	91.9	91.9	91.9	92.2	91.9	91.7
250	95.7	97.2	97.1	97.0	97.4	97.2	97.0
500	98.2	99.8	99.7	99.5	99.8	99.7	99.6
1000	97.9	99.5	99.5	99.4	99.4	99.5	99.5
2000	94.7	96.4	96.5	96.7	96.1	96.4	96.6
4000	88.7	90.5	90.9	91.4	90.1	90.6	91.0
8000	79.7	81.7	82.4	83.4	81.1	81.9	82.6
All	**103.3**	**104.9**	**104.9**	**104.9**	**104.9**	**104.9**	**104.9**

Air Density 1.225 kg/m^3
Values in accordance with IEC 61400-11 Ed. 3
Maximum turbulence at hub height: 30%
Inflow angle (vertical): +/- 2 deg

Table 4-1. Sound Power Levels (LwA) for Vestas V150 Wind Turbine (Mode 0 STE Blades)

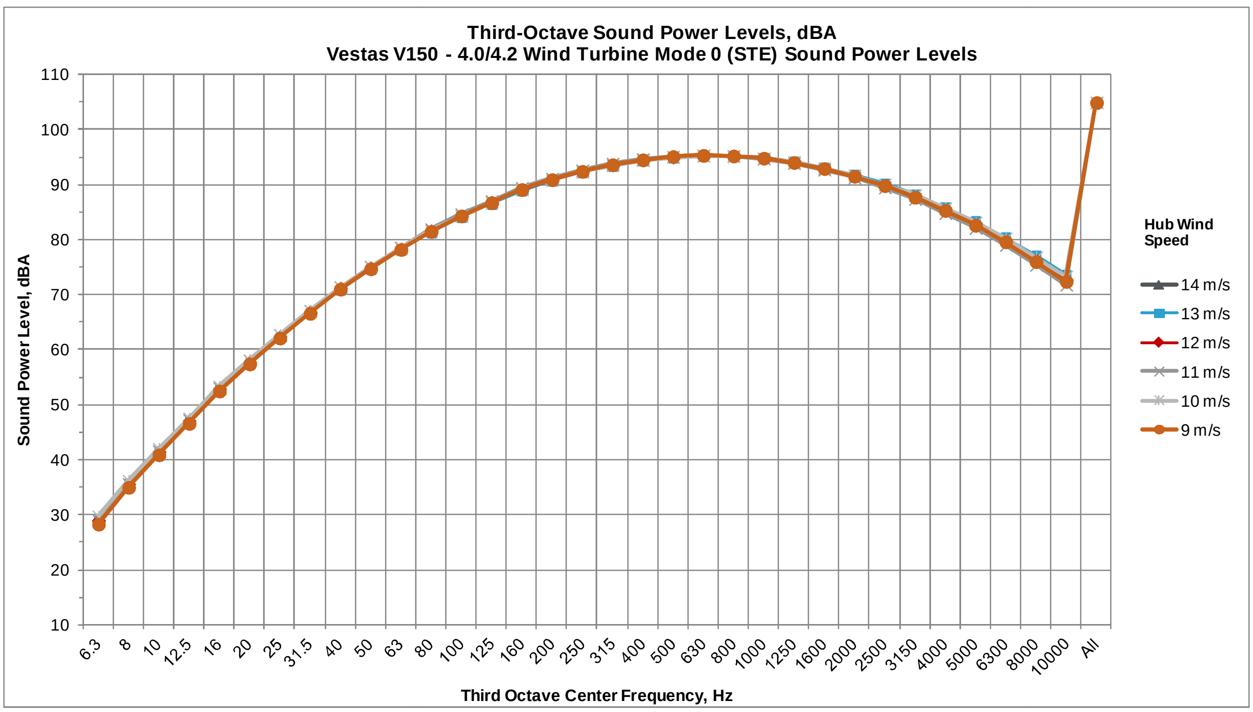


Figure 4-2. Sound Power Levels for Vestas V150 Wind Turbine (Mode 0 STE Blades) for Hub Height Wind Speeds of 9 to 14 meters/second

4.3 Meteorological Conditions

Meteorological conditions have the potential to affect overall turbine sound levels and the 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 wind projects in northeast 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.

Available studies of wind 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 Downeast Wind.[6] Within this premise, this Sound Level Assessment applies a widely recognized International Standard for outdoor sound propagation (ISO 9613-2) combined with model assumptions demonstrated by testing 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. Sound level increases that can result from turbine icing conditions are addressed in Section 6.5 of this report.

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 Columbia 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).

Downeast Wind 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

[6] Operations Sound Testing at Hancock, Bingham, Bull Hill, Stetson, and Oakfield Wind Projects, R.S. Bodwell, P.E., 2009 to 2019. Town of Oakfield Wind Energy Review Committee, 2011 Review of Evergreen Wind Power II, LLC's Proposed Wind Energy Facility, Final Report, October 2011.
Stetson II Operations Sound Testing Peer Review, Warren L. Brown, EnRad Consulting, June 2011.

(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 and 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 Downeast Wind 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 Downeast Wind 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 when determining compliance with hourly sound level limits. Further details and an assessment of these types of sound for Downeast Wind are presented in Section 6.4 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 sound level 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 1.7 seconds for the V150 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 atmospheric and site 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 Downeast Wind are located in the unorganized townships of MD T18 and MD T24, and the incorporated Town of Columbia. Unorganized townships have no local land use ordinances and therefore no duly enacted municipal noise control ordinance for the purposes of Maine DEP Chapter 375.10 noise rules.

On October 8, 2014, the Town of Columbia enacted the Wind Turbine Ordinance establishing noise standards that apply to wind energy facilities located within the Town. The main components of the Columbia Wind Turbine Ordinance addressing noise are as follows:

> **SOUND LEVEL LIMITS**
>
> The sound level resulting from routine operation of a Wind Energy System measured in accordance with DEP described standards shall not exceed the following limits:
>
> a.) 75 dBA at any time of day at any property line of the WES development or contiguous property owned or controlled by the WES developer, whichever is farther from the proposed WES development's regulated sound
>
> b.) 55 dBA between 7:00 a.m. and 7:00 p.m. ("daylight limit"), and 42 dBA between 7:00 p.m. and 7:00 a.m. ("night time limit") within 500 (five hundred) feet of any protected location (i.e. residence with living and sleeping quarters), per Maine DEP Rule 06-096, Chapter 375, Section 10(I) (updated 2014).
>
> **SETBACKS**
>
> a.) Minimum property line setbacks shall be the Manufacturer's Recommended Safety Setback (MRSS) for the WES turbine used. In addition, small wind systems (Type 2 and 3 -See Appendix A) shall be setback from a property line a distance of 1.5 times the height of the tower with blade extended. Additional setback due to ice throw, if not included in the MRSS, must also be considered. The greater setback shall prevail.
>
> b.) Commercial WES shall be set back 2500 feet from a residence of a non-participating landowner. This may be waived by a Mitigation Waiver.

The Columbia ordinance does not specifically regulate tonal or SDR sounds although this could be implied by reference to Maine DEP Chapter 375 Section 10(I). Further, the sound limits apply within 500 feet of any "protected location", which is specified to mean a "residence with living and sleeping quarters". The Maine DEP definition of a protected location is the entire parcel of land upon which a residence exists and also includes other types of land uses (e.g. conservation areas, approved residential subdivisions) which do not appear to be included in the Columbia Wind Ordinance.

As set forth in Maine DEP 375.10, the local quantifiable noise standards of a town where sound emissions will be received are also to be taken into consideration and shall apply for the types of sound regulated provided the limits do need exceed Maine DEP sound limits by more than 5 dBA.

For Downeast Wind, seven of the proposed turbine sites are located within the Town of Columbia. For these turbine sites, the Columbia sound level limits apply within the Columbia town boundary within 500 feet of any residence as set forth in the Columbia Wind Ordinance. As required by the setback provision for Commercial Wind Energy Systems (WES), there are no "non-participating landowner" residences within 2,500 feet of the proposed turbines sites in Columbia. The remainder of the turbine sites are located outside the Town of Columbia where Maine DEP sound limits apply and are generally equivalent to the Columbia ordinance with additional provisions regarding tonal and short duration repetitive sounds. Provisions for these types of sounds as regulated by Maine DEP would also apply in Columbia.

5.5 Sound Model Factors and Uncertainty

Maine DEP 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)):

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, 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 Downeast Wind.

6.1 Construction Sound Levels

Construction of Downeast Wind 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.

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 Columbia Wind Ordinance does not specifically regulate sound from construction activities, so the Maine DEP noise rule applies. Per Maine DEP, 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.

Construction activity is expected to occur between the hours of 7 a.m. and 6 p.m. Construction activity during nighttime, non-daylight hours must comply with the nighttime limits applicable to routine facility operation.

6.2 Wind Turbine Sound Power Levels

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

The Vestas turbine specification indicates that the full-rated sound power level for operation of the V150 Mode 0 with STE blades is 104.9 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 106.9 dBA for the proposed V150 turbine type and mode. At a hub height of 125 meters (410 feet) above the ground, the resulting elevations of the turbine hubs (modeled point sources) range from approximately 600 to 848 feet above msl, with base elevations ranging from approximately 233 to 481 feet.

Vestas 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 12 m/s, yielding the highest sound level predictions, were used in the sound model for the V150 Mode 0 turbines. An adjustment of +2 dBA was applied for the specified sound level plus stated uncertainty for the overall sound power level of 106.9 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 level prediction model was prepared to calculate the sound levels from daytime and nighttime operation of Downeast Wind. 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 area terrain for calculating sound attenuation from multiple sound sources such as wind turbines. Mapping of proposed turbine locations, topography, roads, parcels, land uses, and water bodies was provided by Apex Clean Energy and imported to Cadna/A in order to calculate the resulting sound levels at points within the study area. The surface model was derived from topographic contours at 2-meter (6.6 ft) intervals as provided by Apex and used to determine approximate turbine base elevations.

Although substation equipment, such as the step-up transformer, emits sound, this equipment is not considered to be a significant sound source due to its relatively low sound output, low source height and large distances from regulated protected locations. Project met towers are also not expected to be significant sound sources.

Sound level predictions are calculated in accordance with ISO 9613-2, an international standard for calculating outdoor sound propagation. This method calculates sound levels as though all receiver points were 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 ±3 dBA for a source and receiver mean height of 5 to 30 meters and a distance of 100 to 1000 m. Although the mean source height between wind turbine hubs (up to 125 meters) and receivers (1.5 meters) is closer to 63 meters, use of Cadna/A and ISO 9613-2 has been found to be accurate for prediction of wind turbine sound levels at distances of the regulated protected locations.[7]

Cadna/A allows flexibility in defining model settings and adjustments related to calculation methods, ground absorption and other factors. Additionally, as discussed above, conservative assumptions are utilized with respect to each of these factors. Sound measurements of turbine operations at numerous projects in Maine have been evaluated to ensure that the model is "calibrated" to actual sound levels for reliable model predictions. As the following describes, model settings have been applied to predict the high range of wind turbine sound levels as measured under a wide variety of site and weather conditions at other projects.

Other model settings were 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 as mapped were assigned a ground absorption factor of 0.0, similar to hard

[7] 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 Years 1, 2, and 3, Oakfield Wind, Bingham Wind, Hancock Wind

ground, for an acoustically reflective surface. Attenuation resulting from intervening terrain and atmospheric absorption using standard day conditions (temperature 10°C, relative humidity 70%) was also calculated. No attenuation was calculated due to trees or other foliage that could act to reduce sound levels at protected locations and surrounding area.

Results from other wind energy facilities in Maine where wind 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 accuracy of ISO 9613-2 in accordance with Section I of Maine DEP 375.10. For Downeast Wind, that equates to a total 3 dBA added to the rated turbine sound power levels for model calculations.

6.4 Tonal and Short Duration Repetitive (SDR) Sounds

The Maine DEP noise rule requires that 5 dBA be added to the measured 10-minute equivalent sound level at a protected location if sound from a development generates either 1) a tonal sound and 2) more than five SDR sound events over a ten-minute measurement interval.

6.4.1 Tonal Sounds

The Vestas V150 Turbine Supply Agreement (pending) is expected to warrant the overall sound power level of the proposed turbines and further warrant that the V150 Mode 0 turbine will not produce tonal sounds as defined by Maine DEP 375.10. Sound testing reports for other Vestas turbines per IEC and Maine DEP methods indicate potential for tonality in some frequencies but at levels well below the Maine DEP criteria for regulated tonal sounds.[8] From the available turbine testing data and third-octave sound data from Vestas, the proposed V150 wind turbines are not expected to generate regulated tonal sounds during routine operation.[9]

6.4.2 Short Duration Repetitive (SDR) Sounds

For wind turbines, short duration changes in sound levels occur with the 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 sound performance data provided for the Vestas V150 Mode 0 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, sound testing at operational wind projects including Stetson II, Rollins, Bull Hill, and Oakfield Wind, indicates that SDR sound events are relatively uncommon even under stable atmospheric conditions, high wind shear and other factors identified in technical

[8] DNV-GL, Results of acoustic noise measurements according to IEC 61400-11 Edition 3, Vestas V126-3.3MW IEC3A, mode 0, V201503, November 2014.
[9] Vestas Wind Systems A/S, Third octave noise emission, V150-4.0/4.2 MW, DMS 0067-4767_06, Restricted, December 2019.

studies as having the potential to increase amplitude modulation.[10] Operational sound testing of Downeast Wind will evaluate the potential presence of SDR sound events and, if present to a sufficient degree, apply the required penalty for determining compliance.

6.5 Predicted Sound Levels

From the project sound model, wind turbine sound levels during full operations were 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 were calculated and presented specifically for selected community receptor points. “Receptor points” are the locations in each direction from Downeast Wind with the greatest potential to exceed the Maine DEP or Town of Columbia sound level limits. In addition, sound level contours were calculated to provide model predictions at all locations within the study area. A grid spacing of 20 meters by 20 meters and height of 5 feet were used to calculate the sound level contours.

Sound level predictions for Downeast Wind were calculated with all proposed wind turbines operating at full-rated sound power output, and the addition of 3 dBA for modeling the V150 Mode 0 turbines based on a turbine manufacturer uncertainty of +2 dBA and model accuracy of +1 dBA. Sound level isopleths at 1 dBA intervals were calculated for the 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, public lands, and water bodies. Parcels within the study area that are within the project boundary, either owned or leased by Downeast Wind are indicated by hatching. Some of these parcels contain seasonal camps located on land leased from Cherryfield Foods. An additional parcel is labeled as a “Sound Easement Parcel”, which is subject to a sound easement. Maine DEP and local sound limits do not apply at parcels within the project boundary or that are under a landowner agreement that includes a sound easement.

A summary of predicted sound levels at the receptor points for daytime and nighttime operation of the proposed Vestas V150 turbines is provided in Table 6-1. This table also provides the distance from each receptor point to the nearest turbine and the applicable nighttime sound level limit.

Receptor points represent the nearest protected locations to Downeast Wind and are positioned up to 500 feet from the associated dwelling where the lower nighttime sound limit applies. With discretionary settings and uncertainty included in the Downeast predictive model (i.e. 3 dBA added to the full-rated turbine sound power level), the resulting sound levels are below the Maine DEP and Columbia daytime limit of 55 dBA at all receptor points. The predicted sound levels are also below the Maine DEP 42 dBA nighttime limit applicable within 500 feet of sleeping quarters within a protected location within Beddington, T18MD, and Deblois and also below the Columbia 42 dBA nighttime limit that applies within 500 feet of a dwelling at protected locations in Columbia. Consequently, the modeling results indicate

---

[10] R.S. Bodwell, Operations Sound Testing: Rollins Wind, Stetson II Wind, Oakfield Wind.
Lee, Seunghoon, Lee, Seungmin, & Lee, Soogab, Time domain modeling of aerodynamic noise from wind turbines, 2011.
Oerlemans, S. & Schepers, G., Prediction of wind turbine noise directivity and swish, 2009.
Palmer, K.G.,A New Explanation for Wind Turbine Whoosh – Wind Shear, 2009.
Richarz, W. & Richarz, H., Wind Turbine Noise Diagnostics, 2009.
Siponen, D., The assessment of low frequency noise and amplitude modulation of wind turbines, 2011.

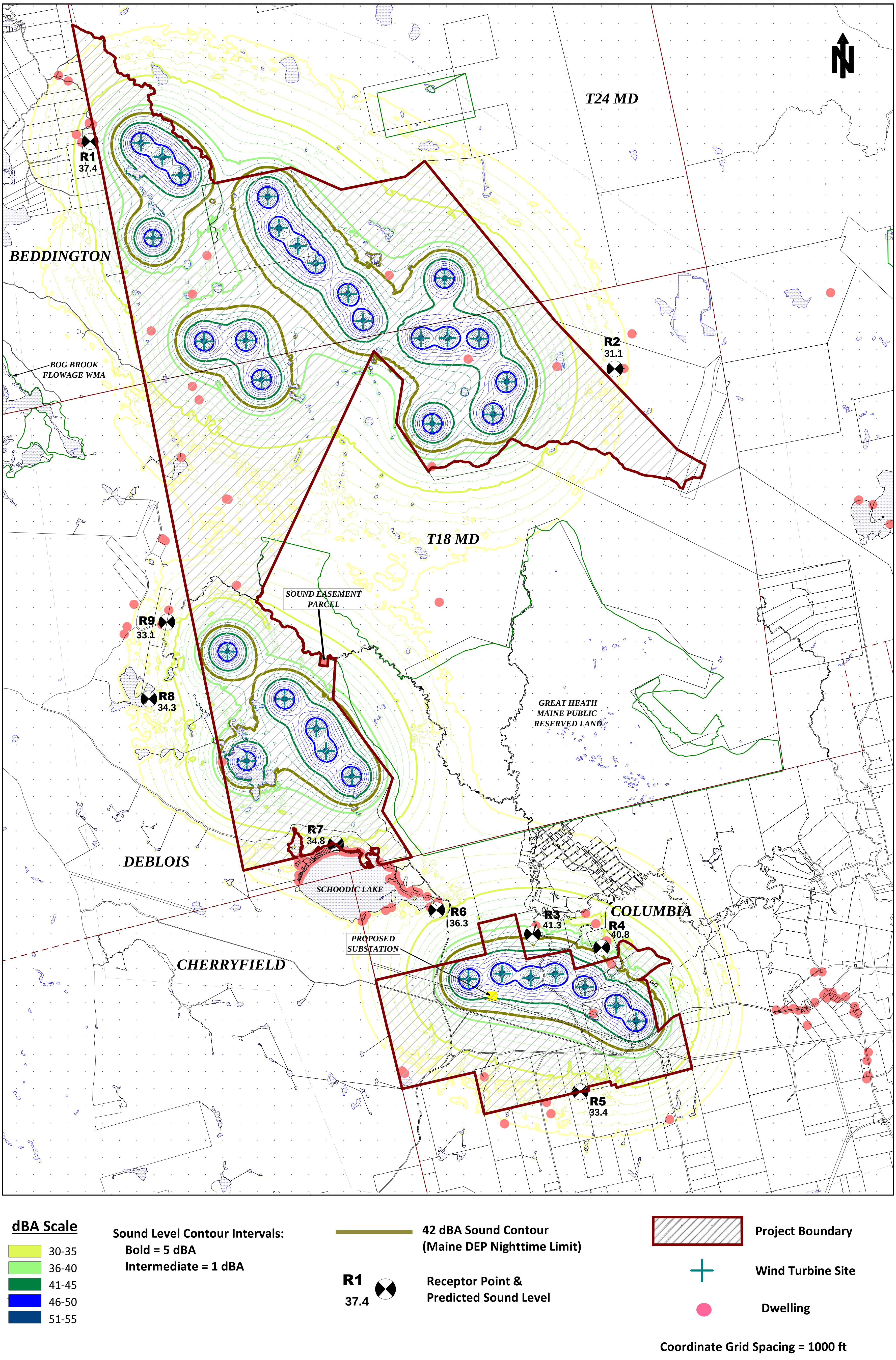
that with all turbines operating at full-rated sound output, Downeast Wind will comply with all applicable Maine DEP and Columbia sound level limits.

Receptor Point	Description and Approximate Distance to Nearest Downeast Wind Turbine		Predicted Hourly Sound Level and Nighttime Sound Limit, dBA	
	Description	**Distance (ft)**	**V150 Turbines**	**Sound Level Limit[a]**
R1	Beddington – 500' from Dwelling	2950	37.4	42
R2	T18MD – 500' from Dwelling	6,290	31.1	42
R3	Columbia – 500' from Dwelling	2,540	41.3	42
R4	Columbia – 500' from Dwelling	2,470	40.8	42
R5	Columbia – 500' from Dwelling	5,230	33.4	42
R6	Columbia – Shoreline near Dwelling	4,400	36.3	42
R7	T18 MD – Residential Lot Line	4,030	34.8	42
R8	Deblois – Shoreline near Dwelling	5,330	34.3	42
R9	Deblois – Residential Lot Line	3,900	33.1	42

[a] Town of Columbia nighttime sound limits apply at 500 feet from a dwelling regardless of the distance to the associated property line

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

Figure 6-1. Predicted Sound Levels from Full Routine Operation of Downeast Wind



Operations sound testing of wind turbines during winter periods has demonstrated that turbine sound output can increase under conditions when turbine blade icing occurs. Detailed analysis of turbine performance in relation to sound output has shown a consistent relationship between turbine power degradation (TPD) and sound level increases. These results indicate that a moderate to heavy icing condition with a TPD of approximately 40% may increase sound levels by 5 dBA.

From the Project sound model for predictable worst-case operating conditions without icing, the sound buffers for compliance at the nearest residential receptor points to Downeast Wind turbines are 1 to 12 dBA during nighttime operations and 14 to 25 dBA during daytime periods. Consequently, even with moderate icing, the project will comply with the nighttime limit of 42 dBA at most protected locations. The potential exists, however, for nighttime operations under heavy icing conditions to exceed the nighttime sound limits at all residential receptor points for Downeast Wind.[11] To ensure compliance during heavy icing conditions, Downeast Wind will implement one of the following measures:

1. Programming specific turbines to pause when the TPD reaches 25% or greater for three consecutive 10-minute operating periods.

2. Programming specific turbines to implement noise-reduced operating (NRO) modes to offset the increase in turbine sound levels during icing conditions.

Following construction, a winter operating plan for detecting and responding to turbine icing will be developed to ensure sound compliance at all protected locations during icing conditions.

7.0 Sound Level Testing

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

7.1 Project Construction

Construction of Downeast Wind is planned to primarily occur during daytime hours when sound levels generated by construction activity are exempt from the Maine DEP sound level limits by Maine statute and the Town of Columbia does not specify construction sound limits. Therefore, 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.

[11] Winter Operations Sound Testing, Oakfield Wind Project, BEA, September 2017.

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 significant wind speed 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 the wind project.

However, during nighttime periods, the winds aloft along the project ridges 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 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 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 for the presence of SDR sounds.

BEA worked closely with the Maine DEP and EnRad Consulting, former acoustical consultant to Maine DEP, to develop a specific and detailed testing protocol for measuring sound levels from wind turbines in Maine. This testing protocol was refined 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 Downeast Wind, an Operations Sound Testing Plan will be prepared to identify sound test locations and other test details. These test locations will be selected based on post-construction site conditions and accessibility to represent receptors R3 and R4 as the nearest protected locations where Maine DEP or Columbia nighttime sound level limits apply. 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 ($Leq_{A\ 10\text{-}min}$). Compliance will be demonstrated based on the arithmetic average of the sound levels for a minimum of twelve, 10-minute measurement intervals in a given compliance measurement period. In the unlikely event that tonal or SDR sounds occur more frequently than anticipated, operating adjustments could be made to ensure that turbines are operating within the applicable sound limits, including any penalties for SDR sound events.

The Maine DEP requires 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

Downeast Wind 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, Downeast Wind 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 the Downeast Wind Project and provides sound level predictions for full daytime and nighttime turbine operations using a terrain-based computer model. Model settings reflect Section I of Maine DEP 375.10 and the Columbia Wind Ordinance as well as the results of turbine sound level testing of similar grid-scale wind energy facilities in Maine.

The Maine DEP hourly sound level limits of 55 dBA daytime and 42 dBA nighttime apply at residential protected locations and the Town of Columbia applies the same daytime and nighttime limits within 500 feet of a protected dwelling/location. Sound level predictions indicate that with all wind turbines operating simultaneously at full capacity, Downeast Wind will meet Maine DEP and Columbia daytime sound level limit of 55 dBA at all protected locations, and the Maine DEP and Columbia 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. Formal protocols for detection and response to icing conditions, and for receiving and resolving sound complaints, will be established to reduce the potential for noise problems associated with long-term operation of Downeast Wind.

10.0 References

B. Sondegaard, Noise and Low frequency noise from Wind Turbines, Inter Noise, 2014.

Bodwell EnviroAcoustics LLC, Bingham Wind Project, Year 1 Operations Sound Testing – April, 2017.

Bodwell EnviroAcoustics LLC, Bull Hill Wind Project, Operations Sound Testing, Years 1, 2 and 3, May, 2013 to 2015.

Bodwell EnviroAcoustics LLC, Hancock Wind Project, Year 1 Operations Sound Testing – January, 2018.

Bodwell EnviroAcoustics LLC, Oakfield Wind Project, Winter Operations Sound Testing – September, 2017.

Bodwell EnviroAcoustics, LLC, Rollins Wind Project, Operations Sound Testing, July 2012.

Bodwell EnviroAcoustics, LLC, Stetson II Wind Project, Operations Sound Testing, March 2011.

Bodwell, R. S, Pre-Filed Direct Testimony of R. Scott Bodwell, P.E., In the Matter of Petition to Amend Chapter 375(10), Noise Rules, July 2011.

Danish Electronics, Light and Acoustics (DELTA), Low Frequency Noise from Large Wind Turbines, 2008.

DNV-GL, Results of acoustic noise measurements according to IEC 61400-11 Edition 3, Vestas V126-3.3MW IEC3A, mode 0, V201503, November 2014.

EnRad Consulting, Warren L. Brown, Stetson II Operations Sound Testing, Peer Review, June 2011.

EnRad Consulting, Warren Brown, Bull Hill Wind Project Sound Level Assessment – Peer Review, 2011.

IEC 61400-11 Wind turbine generator systems – Part 11: Acoustic noise measurement techniques, Edition 3.0, November 2012.

ISO 9613-2 Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation, 1996.

K. Kaliski and E. Duncan, Propagation Modeling Parameters for Wind Power Projects, Sound & Vibration, December 2008.

Lee, Seunghoon, Lee, Seungmin, & Lee, Soogab, Time domain modeling of aerodynamic noise from wind turbines, 2011.

Maine Department of Environmental Protection (DEP) Site Location of Development Regulations for Control of Noise (06-096 CMR c. 375.10), 1989 and 2012.

Maine DEP, Site Location of Development Act Order, Oakfield Wind Project, January 2010.

Maine Revised Statutes Annotated, Standards for Development, 38 MRSA 484, Subsection 3, 1993.

Mills, D.A., MD, MPH, Wind Turbine Neuro-Acoustical Issues, Maine CDC/DHHS, June 2009.

Oerlemans, S. & Schepers, G., Prediction of wind turbine noise directivity and swish, 2009.

Palmer, K.G., A New Explanation for Wind Turbine Whoosh – Wind Shear, 2009.

Richarz, W. & Richarz, H., Wind Turbine Noise Diagnostics, 2009.

Siponen, D., The assessment of low frequency noise and amplitude modulation of wind turbines, 2011.

Town of Columbia, Wind Energy Facility Ordinance, Adopted January 19, 2011.

Town of Oakfield, Wind Energy Review Committee, Final Report, October 19, 2011.

Van den Berg, G. P., The Sounds of High Winds, the effect of atmospheric stability on wind turbine sound and microphone noise, University of Groningen, 2006.

Vestas Wind Systems A/S, Performance Specification, V150-4.0/4.2 MW 50/60 Hz, Document no.: 0067-7067 V10, Restricted, August 2019.

Vestas Wind Systems A/S, Third octave noise emission, V150-4.0/4.2 MW, DMS 0067-4767_06, Restricted, December 2019.