MEMORANDUM

Subject:	Groton, NH Noise Report Addendum No. 1 Wind Turbine Location Modifications
From:	Robert O'Neal, Epsilon Associates, Inc.
То:	Kristen Goland, Iberdrola Renewables
Date:	March 4, 2010

I have reviewed the latest wind turbine coordinate layout file for Groton, NH dated January 26, 2010. Wind turbine generator (WTG) E1 has been eliminated, and there have been very minor shifts in WTGs E2 and E3. All other WTGs are in the same locations assumed in the <u>Sound Level</u> <u>Assessment Report</u> prepared by Epsilon Associates, Inc. dated January 14, 2010.

This slight change in the wind turbine layout does not affect the conclusions of the <u>Sound Level</u> <u>Assessment Report</u>. In fact, since E1 was the closest WTG to sound modeling receptors Location 2 (Groton Hollow Road) and Location 3 (Plain Jane's Diner), the predicted sound levels from the wind farm will actually decrease by 0.5 to 1.0 dBA through the removal of E1. The slight shift of E2 and E3 will not make any difference in the sound levels at all sensitive receptors which are over one mile away. The predicted sound levels from the Groton, NH wind farm were well below guideline values under the wind turbine layout assumed in the <u>Sound Level Assessment Report</u>, and will remain well below guideline values under this revised layout.



SOUND LEVEL ASSESSMENT REPORT

Groton Wind Farm Groton, NH



Prepared for:

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Prepared by:

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January 14, 2010

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1.0 INTRODUCTION AND SUMMARY

The Groton Wind Project is a 50 megawatt (MW) wind power generation facility proposed for Grafton County, New Hampshire. The Project will be entirely within the Town of Groton, generally located along the Tenney and Fletcher Ridges south of NH Route 25, and west of NH Route 3A. The wind farm will have twenty-five (25) 2.0 MW Gamesa Model G87 wind turbines using a hub height of 78 meters, and a rotor diameter of 87 meters.

This sound level assessment included a sound-monitoring program to determine existing sound levels in the vicinity of the Project, computer modeling to predict future sound levels when the wind turbines are operational, and a comparison of the worst-case operational sound levels associated with the wind turbines to accepted criteria. There are no federal or existing local noise regulations that apply to this project. However, the results of this sound level impact assessment show that the Project will comply with a recent NH SEC decision on a comparable wind turbine project in Lempster, NH, community noise guidelines published by the World Health Organization, and noise guidelines put out by the US Environmental Protection Agency.

2.0 SOUND METRICS

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

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

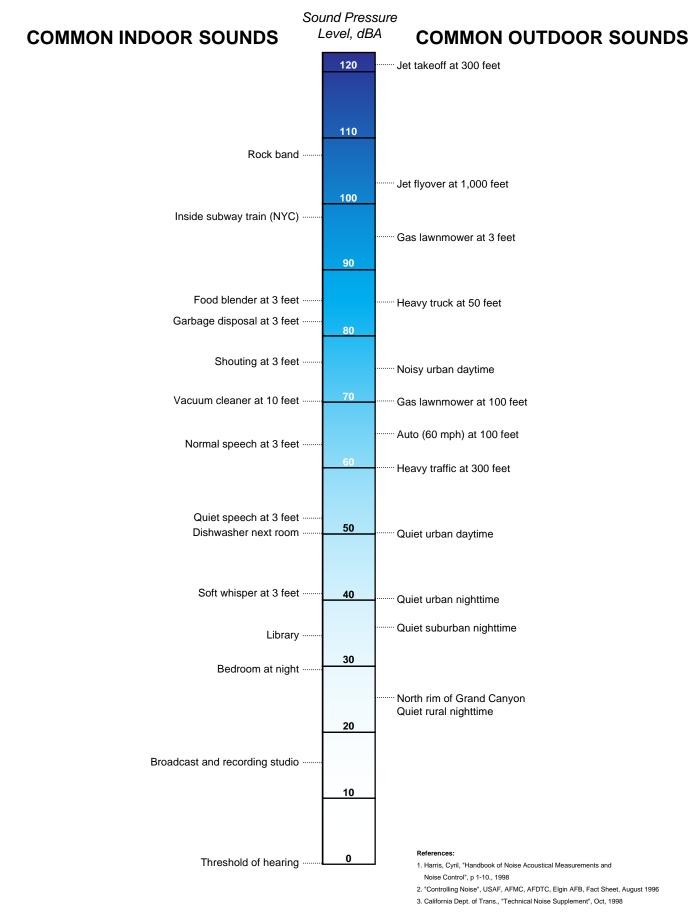
Another property of decibels is that if one source of noise is 10 dB (or more) louder than another source, then the total sound level is simply the sound level of the higher source. For example, a source of sound at 60 dB plus another source of sound at 47 dB is 60 dB.

The sound level meter used to measure noise is a standardized instrument.¹ It contains "weighting networks" to adjust the frequency response of the instrument to approximate that of the human ear under various circumstances. One network is the A-weighting network (there are also B- and C-weighting networks). The A-weighted scale (dBA) most closely approximates how the human ear responds to sound at various frequencies, and is the accepted scale used for community sound level measurements. Sounds are frequently reported as detected with the A-weighting network of the sound level meter. A-weighted sound levels emphasize the middle frequency (*i.e.*, middle pitched – around 1,000 Hertz sounds), and de-emphasize lower and higher frequency sounds. A-weighted sound levels are reported in decibels designated as "dBA." Sound pressure levels for some common indoor and outdoor environments are shown in Figure 2-1.

Because the sounds in our environment vary with time they cannot simply be described with a single number. Two methods are used for describing variable sounds. These are exceedance levels and the equivalent level, both of which are derived from a large number of moment-to-moment A-weighted sound level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n , where n can have a value of 0 to 100 percent. Several sound level metrics that are commonly reported in community noise monitoring are described below.

¹ American National Standard Specification for Sound Level Meters, ANSI S1.4-1983, published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

- L₉₀ is the sound level in dBA exceeded 90 percent of the time during the measurement period. The L₉₀ is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.
- Leq, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.*, the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated Leq and is also A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the Leq is mostly determined by occasional loud noises.







3.0 NOISE REGULATIONS

3.1 Federal Regulations

There are no federal community noise regulations applicable to wind farms.

3.2 New Hampshire State Regulations

There are no State of New Hampshire Community noise regulations applicable to the wind farm. Noise may be reviewed as part of the NH Site Evaluation Committee (SEC) process which applies to any wind energy project over 30 MW. As part of the SEC approval for the Lempster (NH) Wind Farm, several noise conditions were implemented via the Agreement with the Town of Lempster:

- 1. Audible sound from the project shall not exceed 55 dBA measured at 300 feet from any existing occupied building, or at the property line if the property line is less than 300 feet from an existing occupied building for non-participating landowners.
- 2. Sound pressure levels shall not be exceeded for more than 3 minutes in any hour of the day, for non-participating landowners.
- 3. If the existing ambient sound pressure level exceeds 55 dBA, the standard shall be ambient dBA plus 5 dBA.
- 4. Sound from the project immediately outside any residence of a non-participating homeowner shall be limited to the greater of 45 dBA or 5 dBA above the ambient sound level, for non-participating landowners.
- 5. These thresholds implemented via the Town of Lempster were modified by the NH SEC to a level of 45 dBA.

3.3 Local Regulations

There are no applicable noise standards in Groton, NH.

3.4 Other Criteria for Comparison

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, Geneva, 1999). This document states that daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open.

Another useful guideline for comparing sound levels is the "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" (U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, DC, 550/9-74-004, March 1974). This document, often referred to as the "Levels" document, identifies an L_{dn} of 55 dBA outdoors in residential areas as the maximum level below which no effects on public health and welfare occur due to interference with speech or other activities. This level includes a 10 dBA "penalty" for sound levels at night (10 p.m. to 7 a.m.). This level will permit normal speech communication, and would also protect against sleep interference inside a home with the windows open. A constant sound level of 48.6 dBA 24 hours per day would be equal to an L_{dn} of 55 dBA.

4.0 SOUND FROM WIND TURBINES

A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.² A few points are repeated herein. Wind turbine noise can originate from two different sources; mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine noise. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical noise. Aerodynamic noise has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction.

Aerodynamic noise, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

Infrasound (sound at frequencies below about 20 Hz) can be neglected in the assessment of modern upwind turbines such as those at the Groton Wind Farm. Low frequency sound (approximately 10 Hz to 200 Hz) has been reduced to low levels in modern wind turbines and is generally not an issue.³

² Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, <u>Wind Turbine Acoustic Noise</u>, June 2002, amended January 2006.

³ Leventhall, Geoff, "How the 'mythology' of infrasound and low frequency noise related to wind turbines might have developed," First International Meeting on Wind Turbine Noise, Berlin, Germany, 2005.

5.0 EXISTING SOUND LEVELS

5.1 Overview

The wind turbine project is located in the Town of Groton, Grafton County, New Hampshire. The site is generally located along the Tenney and Fletcher Ridges south of NH Route 25, and west of NH Route 3A. The wind farm will have twenty-five (25) 2.0-megawatt (MW) Gamesa Model G87 wind turbines using a hub height of 78 meters. The coordinates for each wind turbine were provided by Iberdrola Renewables.

5.2 Sound Level Environment

An ambient sound level survey was conducted to characterize the current acoustical environment under varying wind conditions at the properties. Current noise sources at the properties include: noise from wind blowing through vegetation, aircraft, running water from brooks, birds, insects, boats on Newfound Lake (near Audubon Society site), and vehicular traffic (for some locations).

5.3 Sound Level Measurement Locations

The selection of the sound monitoring locations was intended to be representative of nearby residences in various directions from the wind farm. Figure 5-1 shows the proposed wind turbine locations overlaid upon an aerial photograph of the surrounding area, as well as the actual measurement locations. Each sound level monitoring location is described below. The coordinates for the sound level measurement locations were obtained by Epsilon staff in the field using a Global Positioning System (GPS) instrument with an accuracy of 3 meters or less. All distances shown are rounded to the nearest 10 feet (under 1,000 feet) or 100 feet (over 1,000 feet).

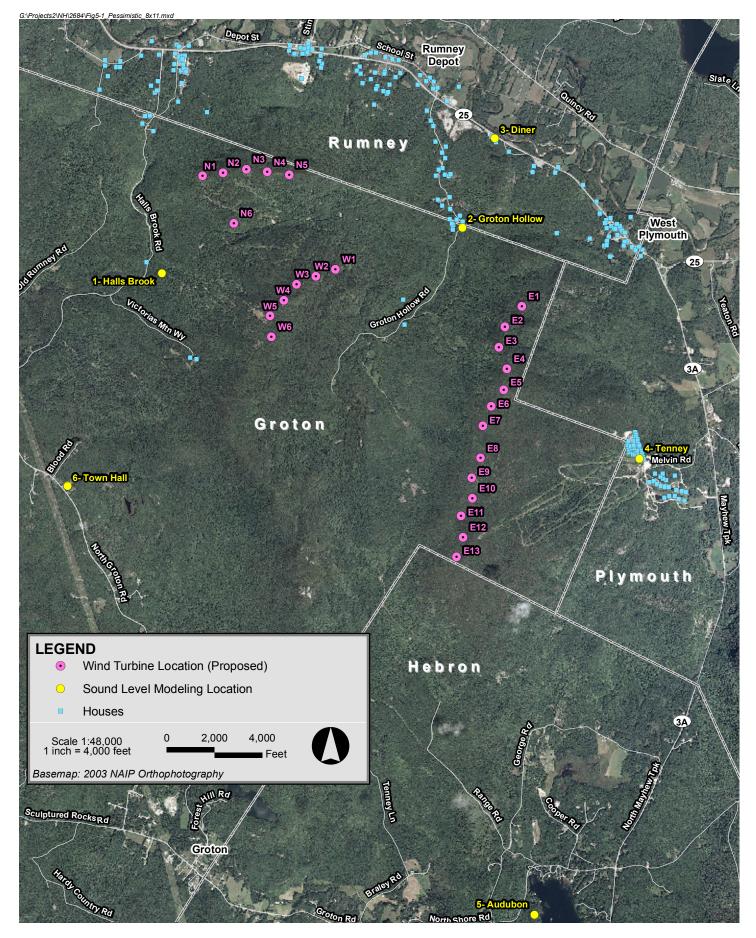
- Location 1 Halls Brook Road, Groton
 - Approximately 3,700 feet to the closest proposed wind turbine (N6). This location is representative of the nearest residents to the west of the wind farm along Halls Brook Road.
- Location 2 Groton Hollow Road, Groton
 - Approximately 4,100 feet to the closest proposed wind turbine (E1). This location is representative of the nearest residents to the north of the wind farm along Groton Hollow Road, but set far back from traffic on Route 25.
- Location 3 Plain Jane's Diner, 897 Route 25, Rumney
 - Approximately 7,200 feet to the closest proposed wind turbine (E1). This location is representative of the nearest residents to the north of the wind farm along Route 25.

- Location 4 Tenney Mountain Ski Area, Plymouth
 - Approximately 6,300 feet to the closest proposed wind turbine (E5). This location is representative of the nearest residents to the east of the wind farm off Route 3A – Tenney Mountain slope side lodging.
- Location 5 NH Audubon Society, North Shore Road, Hebron
 - Approximately 15,200 feet to the closest proposed wind turbine (E13). This location is representative of the residents to the south of the wind farm, and the nature center along Newfound Lake.
- Location 6 Groton Town Hall, 754 North Groton Road, Groton
 - Approximately 10,500 feet to the closest proposed wind turbine (W6). This location is representative of the nearest residents to the southwest of the wind farm along North Groton Road.

Table 5-1 lists the GPS coordinates for the six sound level measurement locations. The 2meter meteorological towers at Locations 2 and 4 were located in the vicinity of these coordinates. All coordinates are in NAD 1983 NH State Plane.

Location	X (m)	Y (m)
Location 1 – Halls Brook Road	286022.76886	141038.559462
Location 2 – Groton Hollow Road	289839.985583	141614.647616
Location 3 – Plain Jane's Diner	290249.159932	142750.849655
Location 4 – Tenney Mountain Ski Area	292088.62367	138679.787045
Location 5 – NH Audubon Society	290754.599514	132888.490711
Location 6 – Groton Town Hall	284826.959282	138336.350134

Table 5-1 GPS Coordinates – Sound Level Measurement Locations



Groton Wind Project Groton, New Hampshire



5.4 Sound Measurement Methodology

A comprehensive sound level measurement program was developed to quantify the ambient sound levels around the wind farm. Two weeks of ambient sound level measurements were taken from Thursday, August 6, 2009 through Friday, August 21, 2009. Combinations of continuous and short-term sound level measurements were made at all six locations, and ground-level wind speeds were continuously measured and logged at two locations. A 58-meter-high meteorological tower #3802 located on the Tenney Mountain Ridge also measured and logged wind speeds during the sound level measurement period. Meteorological data from the nearby National Weather Service (NWS) station in Plymouth, NH were also archived for the duration of the measurement period. These data are included as Appendix A.

Sound levels were measured at a height of five feet above the ground at locations where there were no large reflective surfaces to affect the measured levels. Below is a description of the measurement program for each location.

5.4.1 Location 1 – Halls Brook Road

One continuous programmable unattended sound level meter was placed near the dirt access road several hundred feet back from Halls Brook Road. This location is slightly north of Victoria's Mountain Way. This meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics from 6:00 p.m. Thursday August 6 until midnight Friday night August 21 for a total of 366 hours. Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.4.2 Location 2 – Groton Hollow Road

One continuous programmable unattended sound level meter was placed in the woods back from Groton Hollow Road. This location was inside (south) of the locked gate. This meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics from 12:00 p.m. Thursday August 6 until midnight Friday night August 21 for a total of 372 hours. In addition, continuous ground-level wind speed measurements were made at this location, at a height of two meters above ground level (AGL). Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.4.3 Location 3 – Plain Jane's Diner

One continuous programmable unattended sound level meter was placed at the eastern edge of the parking lot of Plain Jane's Diner. This location was approximately the same distance back from Route 25 as the nearest residence just east of the Diner. This meter continuously measured and stored broadband (A-weighted) sound level statistics from 10:00 a.m. Thursday August 6 until midnight Friday night August 21 for a total of 374 hours. Short-term (20-minute) one-third octave band sound level measurements were made once each during both daytime and nighttime periods at this location. Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.4.4 Location 4 – Tenney Mountain Ski Area

One continuous programmable unattended sound level meter was placed near the base of the "Eclipse" triple chairlift at Tenney Mountain. This meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics from 3:00 p.m. Thursday August 6 until midnight Friday night August 21 for a total of 369 hours. In addition, continuous ground-level wind speed measurements were made at this location, at a height of two meters above ground level (AGL). Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.4.5 Location 5 – NH Audubon Society, North Shore Road

One continuous programmable unattended sound level meter was placed just down the hill from the Paradise Point Nature Center, NH Audubon Society, on the northern side of Newfound Lake. This meter continuously measured and stored broadband (A-weighted) sound level statistics from 2:00 p.m. Thursday August 6 until midnight Friday night August 21 for a total of 370 hours. Short-term (20-minute) one-third octave band sound level measurements were made once each during both daytime and nighttime periods at this location. Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.4.6 Location 6 – Groton Town Hall, North Groton Road

One continuous programmable unattended sound level meter was placed at Groton Town Hall. The meter was located near the fence adjoining the cemetery just east of the rear of Town Hall. This meter continuously measured and stored broadband (A-weighted) sound level statistics from 9:00 p.m. Thursday August 6 until midnight Friday night August 21 for a total of 363 hours. Short-term (20-minute) one-third octave band sound level measurements were made once each during both daytime and nighttime periods at this location. Field personnel checked on the integrity of the equipment during the first two days of monitoring, and during an interim field visit on August 13.

5.5 Measurement Equipment

A CEL Instruments Model 593.C1 Precision Sound Level Analyzer, equipped with a CEL-257 Type 1 Preamplifier, a CEL-250 half-inch microphone, and a four-inch foam windscreen were used to collect short-term one-third octave band ambient sound pressure level data at Locations 3, 4, 5, and 6. One daytime and one nighttime sample were collected. The instrumentation meets the "Type 1 - Precision" requirements set forth in American National Standards Institute (ANSI) S1.4 for acoustical measuring devices. The meter was tripod-mounted at a height of five feet above ground. The meter was equipped with an internal one-third octave band filter set along with data logging capabilities. The meter time-weighting was set for the "slow" response (1-second averaging).

Two Larson-Davis (LD) model 831 Sound Level Analyzers, equipped with an LD Type 1 Preamplifier, an LD 377B20 half-inch microphone, and an environmental protection kit were used to collect continuous A-weighted (dBA) and one-third octave band ambient sound pressure level data at Locations 1 and 2. The instrumentation meets the "Type 1 -Precision" requirements set forth in ANSI S1.4 for acoustical measuring devices. The meter was tripod-mounted at a height of five feet above ground. The meter was set to log data every hour along with a one-minute time history. The meter time-weighting was set for the "slow" response.

Three Larson Davis Model 812 sound level meters, and one Rion NL-32 sound level meter were used for the continuous A-weighted (dBA) ambient monitoring at Locations 3, 4, 5, and 6. All meters meet Type 1 ANSI S1.4-1983 standards for sound level meters. The meters were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology. These calibrations were conducted by an independent laboratory within the past 12 months. Each meter has data logging capability and was programmed to log statistical data every hour for the following parameters: L1, L10, L50, L90, Lmax, Lmin, and Leq. All measurement equipment was calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator which meets the standards of IEC 942 Class 1L and ANSI S1.40-1984.

5.6 Measured Sound Levels

A brief summary of the measured sound levels and noise sources from each location is provided below. Several weather events were notable during the 15-day program. These include a period of high ground level winds during the day on August 7 (gusts up to 20 mph), rain on August 9, 11, and 19, and a heavy thunderstorm during the afternoon and evening of August 21. Between 2:00 p.m. and 3:00 p.m. on Wednesday August 12, a loud event was measured at 5 of the 6 measurement locations. This was likely a low-flying airplane. The sound levels at Location 3 (Plain Jane's) are so high during the day, that this event was masked by the existing traffic on Route 25.

5.6.1 Location 1 – Halls Brook Road

Sound levels at the Halls Brook Road monitor were influenced by a distant brook (nighttime), traffic on Halls Brook Road, aircraft, and rustling vegetation. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-2. The steady-state L₉₀ sound level is controlled by the distant running water in the area which decreased gradually over the course of the 15-day program.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 25 to 55 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 27 to 67 dBA.

5.6.2 Location 2 - Groton Hollow Road

Sound levels at the Groton Hollow Road monitor were influenced by a relatively nearby brook, aircraft, and rustling vegetation. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-3. The sound levels at this location are primarily controlled by the running water in the area which decreased gradually over the course of the 15-day program. Some short-term increases in sound levels can be seen immediately following rain events on August 9 and 11.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 38 to 52 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 38 to 65 dBA.

5.6.3 Location 3 – Plain Jane's Diner

Sound levels at the Plain Jane's Diner monitor were influenced by traffic on Route 25. A diurnal range of around 15 dBA is typically seen from daytime to nighttime sound levels. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-4. The sound levels at this location are primarily controlled by the traffic on Route 25, and some distant mechanical HVAC noise from Plain Jane's (nighttime only). On occasion, idling trucks were present in Plain Jane's parking lot around 6:00 a.m.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 31 to 69 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 45 to 80 dBA.

The L₉₀ of 69 dBA was caused by an idling truck near the monitor. More typical L₉₀ values were from about 40 to 55 dBA. The L_{eq} of 80 dBA was caused by an unknown source. More typical L_{eq} values were from about 50 to 65 dBA.

5.6.4 Location 4– Tenney Mountain Ski Area

Sound levels at the Tenney Mountain Ski Area monitor were influenced by a distant stream (nighttime), landscaping activity at the ski area, insects, and rustling vegetation. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-5. The sound levels at this location are a combination of a variety of sources as evidenced by the differences in daily trends in Figure 5-5.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 34 to 51 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 35 to 76 dBA.

The L_{eq} of 76 dBA was caused by an unknown source. More typical L_{eq} values were from about 35 to 50 dBA.

5.6.5 Location 5 – NH Audubon Society, North Shore Road

Sound levels at the NH Audubon Society monitor were influenced by traffic on North shore Road and Route 3A, motorboats on Newfound Lake, and insects. A daily diurnal range of around 20 dBA is typically seen from daytime to nighttime sound levels. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-6.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 20 to 48 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 23 to 59 dBA.

The L₉₀ of 48 dBA was caused by rain. More typical L₉₀ values were from about 20 to 40 dBA. The L_{eq} of 59 dBA was also caused by rain. More typical L_{eq} values were from about 25 to 45 dBA.

5.6.6 Location 6 – Groton Town Hall, North Groton Road

Sound levels at the Groton Town Hall monitor were influenced by traffic on North Groton Road, insects, occasional air conditioner noise from Town Hall, and rustling vegetation. The range of sound levels from the continuous hourly measurements are summarized below, and presented graphically in Figure 5-7. The sound levels at this location are a combination of a variety of sources as evidenced by the differences in daily trends in Figure 5-7.

- The continuous 1-hour steady-state (L₉₀ dBA) measurements ranged from 19 to 48 dBA;
- The continuous 1-hour equivalent level (Leq dBA) measurements ranged from 23 to 73 dBA.

The L₉₀ of 48 dBA was caused by high ground-level winds. More typical L₉₀ values were from about 20 to 40 dBA. The L_{eq} of 73 dBA was caused by an unknown source. More typical L_{eq} values were from about 25 to 45 dBA.

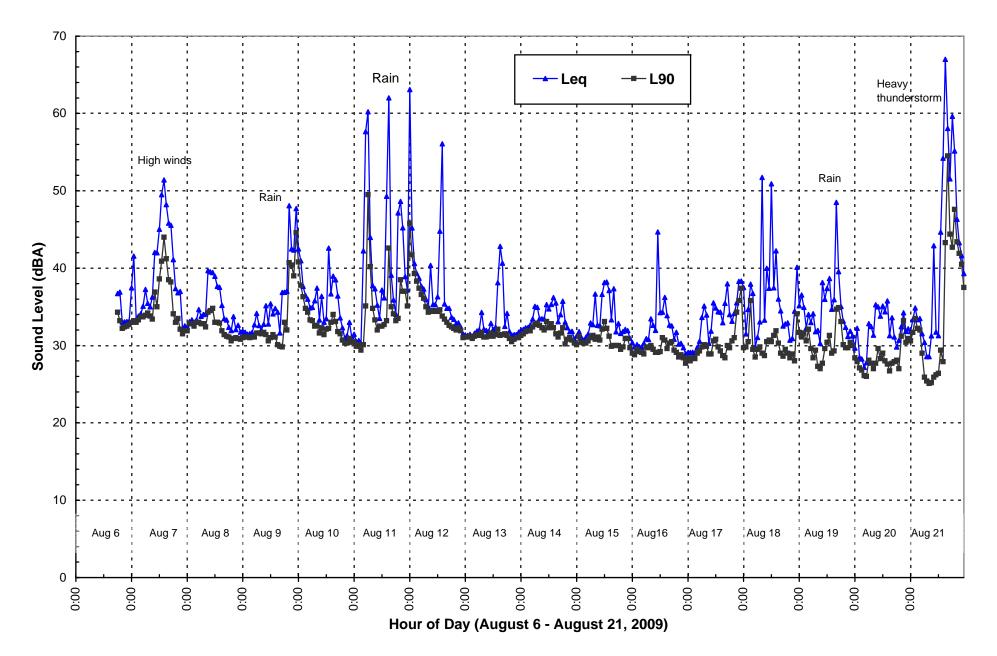


Figure 5-2. Ambient Sound Levels -- Location 1 (Halls Brook Rd)

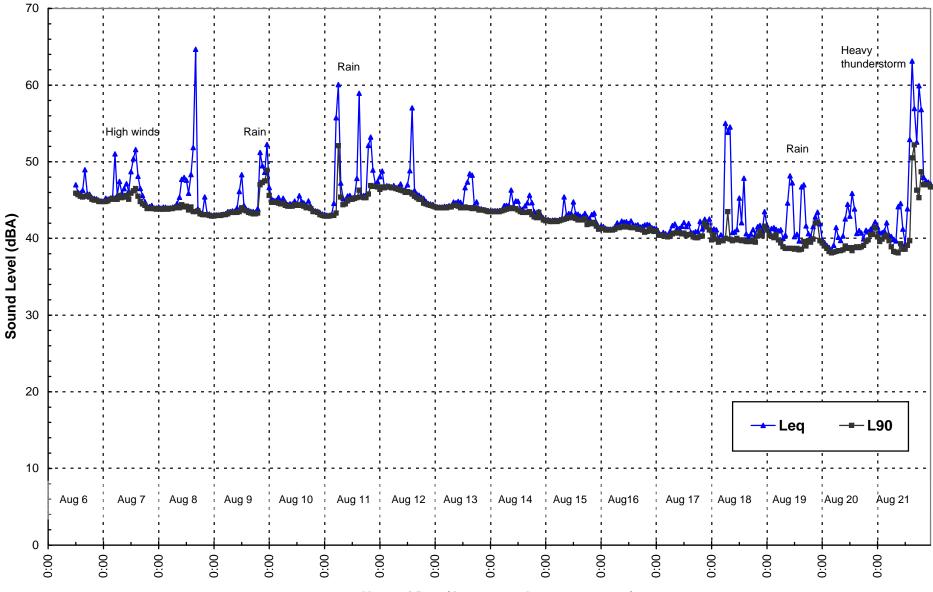


Figure 5-3. Ambient Sound Levels -- Location 2 (Groton Hollow Rd)

Hour of Day (August 6 - August 21, 2009)

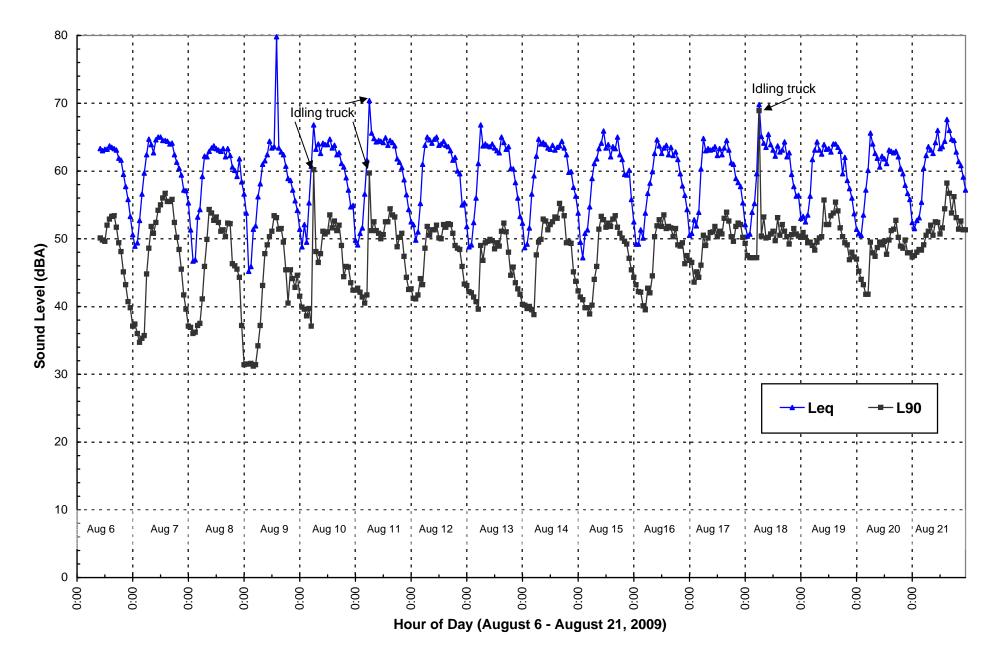


Figure 5-4. Ambient Sound Levels -- Location 3 (Plain Jane's Diner)

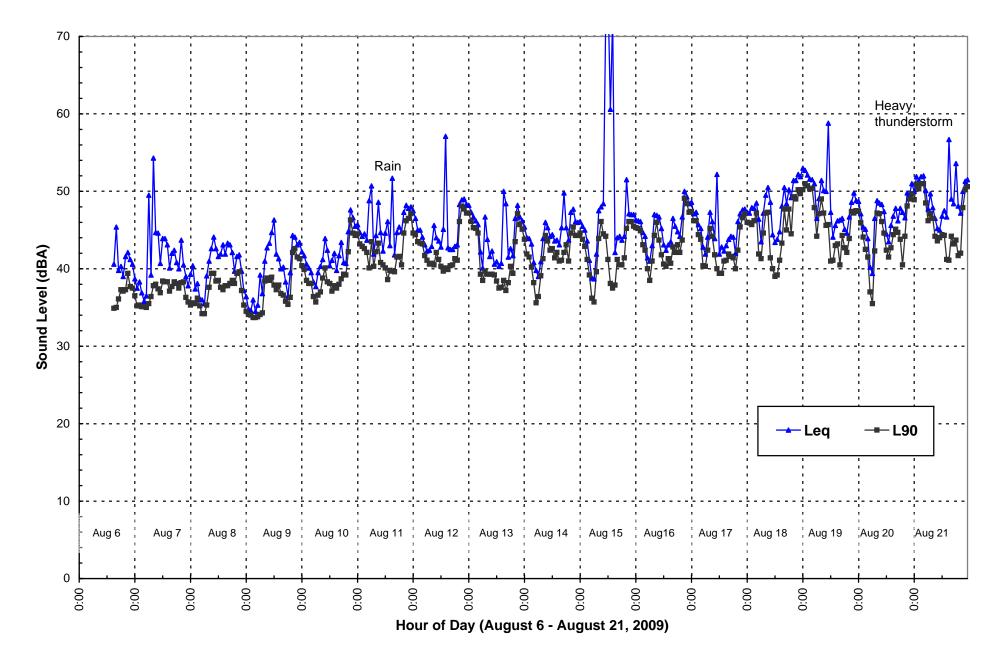


Figure 5-5. Ambient Sound Levels -- Location 4 (Tenney Mtn Ski Area)

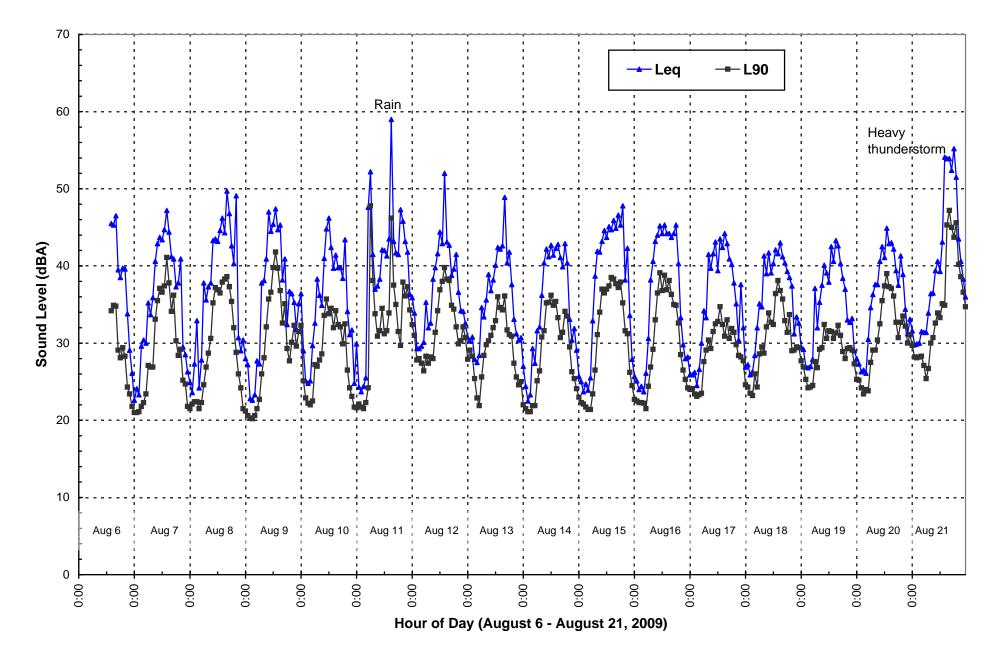


Figure 5-6. Ambient Sound Levels -- Location 5 (NH Audubon Society Nature Center)

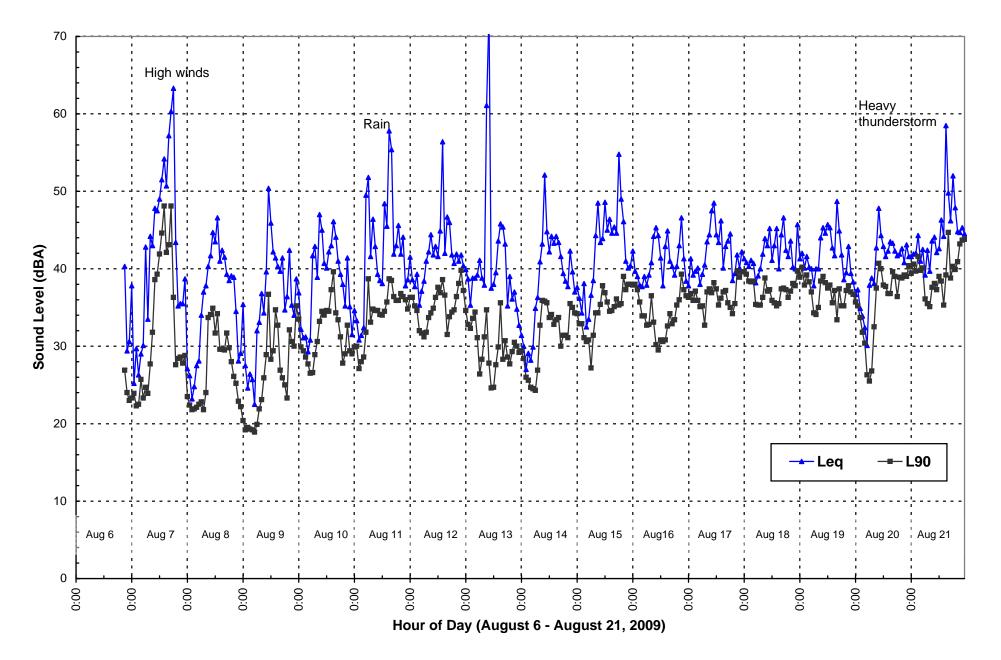


Figure 5-7. Ambient Sound Levels -- Location 6 (Groton Town Hall)

6.0 EXISTING WIND SPEEDS

6.1 Wind Speed Measurement Equipment

Wind speed can have a strong influence on ambient sound levels. In order to understand how the existing sound levels are influenced by wind speed, continuous wind speed and direction data were recorded at two of the sound level monitoring locations. A HOBO H21-002 micro-weather station (manufactured by Onset Computer Corporation) with tripod and data logger was used to continuously measure the wind speed and wind direction. The wind sensors were mounted at a height of 2 meters above ground level, and data were logged every 60 minutes. Figure 6-1 shows the wind speed equipment setup at Location 4 Tenney Mountain Ski Area. This wind instrument has a measurement range of 0 to 44 m/s (99 mph) and an accuracy of +/- 0.5 m/s (1.1 mph). The starting threshold is 0.5 m/s (1.1 mph). The wind direction measurement range is 0 to 358 degrees (2-degree dead band), with an accuracy of +/- 5 degrees. In addition to the HOBO stations, a meteorological tower maintained by Iberdrola Renewables (#3802) measured and logged wind speeds at a height of 58 meters above ground level every 10 minutes. The location of the 58-meter tower is just southeast of proposed wind turbine E3.

6.2 Measured Wind Speeds

The wind speeds measured from August 6 to August 21, 2009 during the ambient program at the two sound level measurement locations and the 58-meter on-site met tower are presented in Figure 6-2. The 10-minute 58-meter wind data have been hourly averaged to be consistent with the sound level data which were collected on an hourly basis. A couple observations from the data are worth noting. In general, ground-level winds were stronger at the more open area (Location 4 – Tenney Mountain) as compared to the woods (Location 2 – Groton Hollow Road). Overall, the winds were generally light during August with only three periods when the 58-meter winds were above 8 m/s.

6.3 Existing Sound Levels under Worst-Case Wind Speeds

International Electrotechnical Commission (IEC) standard IEC 61400-11, Wind Turbine Generator Systems-Part 11; Acoustic Noise Measurement Techniques specifies that a manufacturer provide sound level data as a function of wind speed at a standard reference height of 10 meters above ground level. Wind speeds measured at a height other than 10 meters shall be corrected to 10 meters by assuming wind profiles follow the logarithmic profile in equation (7) from the IEC standard, shown here:

$$V_{s} = V_{z} \left[\frac{\ln\left(\frac{z_{ref}}{r_{0ref}}\right) \ln\left(\frac{H}{z_{0}}\right)}{\ln\left(\frac{H}{z_{0ref}}\right) \ln\left(\frac{z}{z_{0}}\right)} \right]$$

where

- zoref is the reference roughness length of 0.05 m;
- z₀ is the roughness length;
- H is the rotor center height;
- Z_{ref} is the reference height, 10 m;
- z is the anemometer height

Worst-case reference sound data for the Groton Wind turbines (see Section 7 of this report) indicates that hub height wind speeds at 9.7 m/s (22 mph) and above will produce the worst-case sound levels (106.5 dBA sound power level).

A wind speed of 9.7 m/s at hub height (78 meters AGL) using the IEC procedure described above corresponds to a wind speed at the 58-meter height AGL at the meteorological tower of 9.3 m/s. Therefore, a measured 58-meter wind speed of 9.3 m/s would be expected to produce worst-case sound levels from the Gamesa G87 wind turbines. There were 17 hours of 9.3 m/s (or higher) wind speeds at the 58-meter height during the background measurement program. The corresponding L₉₀ and L_{eq} sound levels at the worst-case wind speed (9.3 m/s and above) were then identified for each of the six sound level measurement locations. The average and median background sound levels for each location under the highest wind turbine sound producing conditions are summarized in Table 6-1.

Table 6-1 Ambient Background Sound Levels for 9.7 m/s Wind Speeds at Hub Height

Location	Existing L _{eq} Sound Level Median/Average (dBA)	Existing L ³⁰ Sound Level Median/Average (dBA)		
1 – Halls Brook Rd	37 / 39	33 / 35		
2 – Groton Hollow Rd	44 / 45	44 / 44		
3 – Plain Jane's Diner	60 / 59	50 / 49		
4 – Tenney Mtn Ski Area	42 / 44	38 / 40		
5 – NH Audubon Society	30 / 34	25 / 29		
6 – Groton Town Hall	40 / 44	37 / 35		

Figure 6-1 Wind Measurement Equipment Setup – Location 4 (Tenney Mtn)



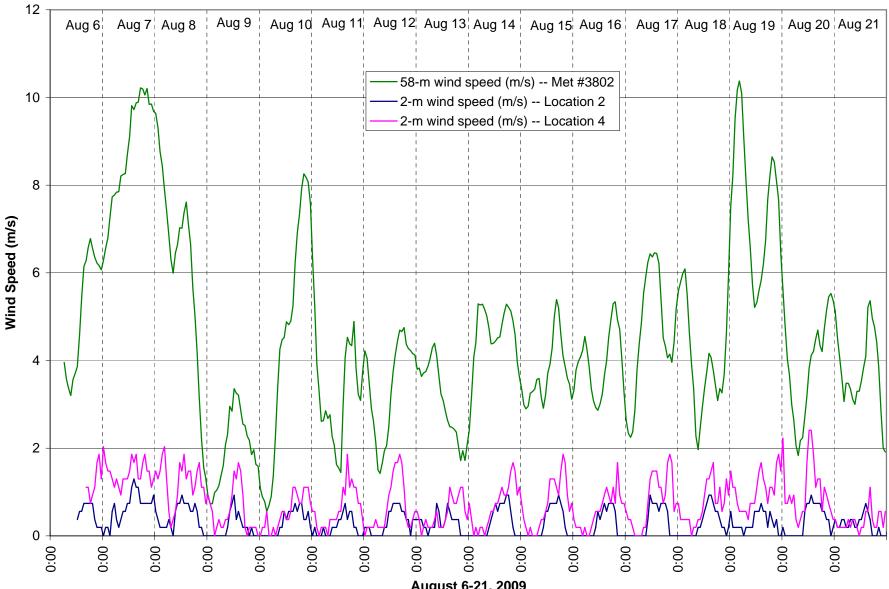


Figure 6-2. Measured Wind Speeds During Ambient Sound Level Measurement Program

August 6-21, 2009

7.0 FUTURE CONDITIONS

7.1 Equipment and Operating Conditions

The twenty-five (25) wind turbines modeled for this project are Gamesa G87 2.0 MW wind generators. Each wind turbine will have three blades and will be placed on a 78-meter-high tower, with a rotor diameter of 87 meters. Under operational conditions, the blades will rotate at speeds between 9 and 19 rpm. In general, the turbines will be operational when the wind is blowing at speeds between 4 and 25 meters per second (approximately 9 - 56 mph). Table 7-1 shows the A-weighted sound power level with respect to wind speed.

Wind Speed at 10- meter-height (m/s)	3	4	5	6	7	8	9	10
Wind Speed at 78- meter hub height (m/s)	4.2	5.6	6.9	8.3	9.7	11.1	12.5	13.9
Sound Power Level (dBA re 1 pW)	92.8	97.3	102.1	106.0	106.4	106.4	106.4	106.4

 Table 7-1
 Gamesa Model G87 Sound Power Levels vs. Wind Speed

Under peak relative noise producing operating conditions (hub height wind speed of 9.7 m/s) each turbine has an A-weighted sound power level of 106.4 dBA (based on power pressure emitted from the turbine in the nacelle). At cut-in wind speed (around 4 m/s) the A-weighted sound power level is 92.8 dBA or about 13.6 dBA quieter than at maximum production. At hub height wind speeds above 9.7 m/s, the sound power level is constant and no longer increases as wind speeds increase.

Gamesa provides one-third octave band sound power level data for three scenarios:

- Optimistic model: more energy at high frequencies,
- Pessimistic model: more energy at low frequencies, and
- Average model: this model contains 50% of each of the optimistic and pessimistic models.

When the octave band data are converted to A-weighted and combined on an energy basis, the "optimistic" model equals 106.4 dBA and the "pessimistic" model equals 106.5 dBA. Epsilon ran both the "optimistic" and "pessimistic" models and found the results from the "pessimistic" scenario were slightly higher. Therefore, the "pessimistic" model is the one carried forth in this analysis.

The sound power levels for the Gamesa G87 were determined according to international standard IEC 61400-11, Wind Turbine Generator Systems-Part 11; Acoustic Noise Measurement Techniques. That is, the sound power levels are reflective of wind speeds measured at the 10-meter IEC reference height.

7.2 Modeling Scenarios

The noise impacts associated with the proposed wind turbine generators were predicted using the Cadna/A noise calculation software (DataKustik Corporation, 2005). This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. Cadna/A differs with noise predictions that are based on spreadsheet calculations. Spreadsheet methods offer more of a screening-level approach, since they do not typically include the effects of topography, various ground attenuations, and multiple building reflections.

The Cadna/A software allows for octave band calculation of noise from multiple noise sources, as well as computation of diffraction around building edges, and multiple reflections off parallel buildings and solid ground areas. The turbine locations and terrain height contour elevations in the surrounding area were directly imported into Cadna/A. Elevations in the surrounding area were obtained from data provided by Geographic Information System (GIS) data sets. This allowed for consideration of terrain shielding where appropriate. In this manner, all significant noise sources and geometric propagation effects are accounted for in the noise predictions. The maximum order of reflection was set to two (2). The software was run with meteorology conditions of 10 degrees C (50 degrees F), and 70% relative humidity. The modeled results, especially at the closest receptors, are not very sensitive to the relative humidity or temperature settings, varying only a few tenths of a decibel. For this analysis the "Alternative Method" of calculation for A-weighted sound pressure levels was used, which corresponds to "Not Spectral" ground attenuation within the Cadna/A configuration settings. This method yields more conservative results (i.e., higher sound levels). The octave band sound power levels for the "pessimistic" model at 106.5 dBA were input into Cadna/A to model turbine-generated sound levels at worst-case sound levels (9.7 m/s or higher).

Sound levels due to operation of all twenty-five wind turbines were modeled at the six background measurement locations. In addition to these specific locations, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart. The grid covered an area approximately 9 km by 14 km for a total of over 300,000 grid points. This made it possible to create sound level "contours" for the wind farm as a whole. Sound levels were computed assuming that the receptors are always located directly downwind from all turbines simultaneously. This is a physical impossibility but provides conservative results.

7-2

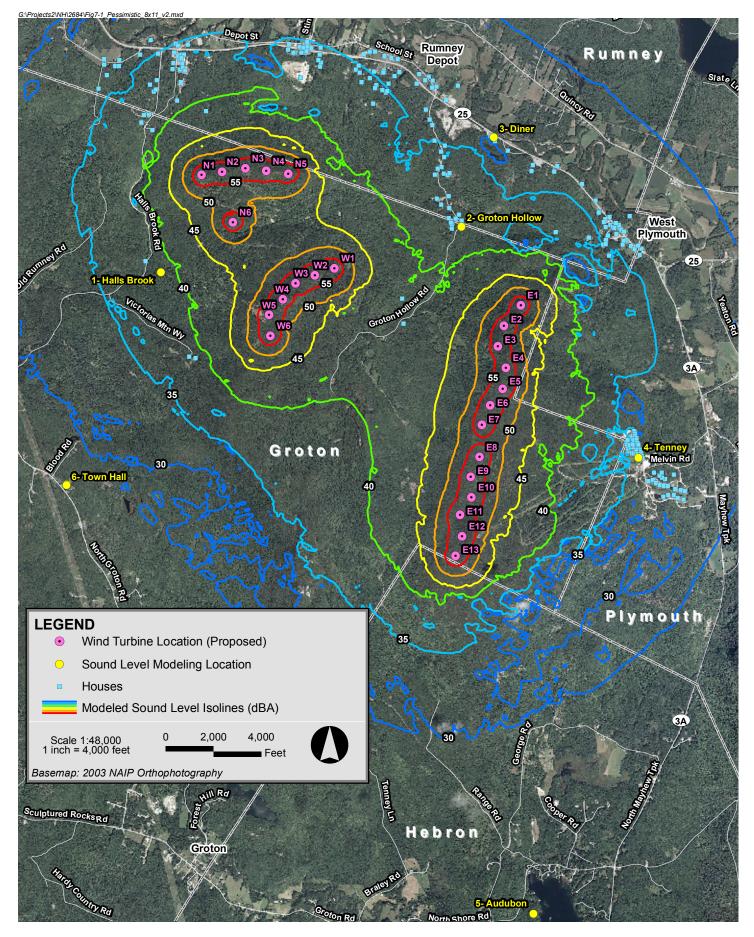
7.3 Sound Level Results

Table 7-2 shows the predicted sound levels due to full wind turbine operations, as modeled by the Cadna/A program. The table shows the turbine sound levels at the six background monitoring locations for worst-case operational conditions.

Location	Turbine Sound Level (9.7 m/s Worst-Case Hub Height Wind Speed) (dBA)				
1 – Halls Brook Rd	39.0				
2 – Groton Hollow Rd	38.3				
3 – Plain Jane's Diner	31.7				
4 – Tenney Mtn Ski Area	34.6				
5 – NH Audubon Society	23.4				
6 – Groton Town Hall	28.8				

Table 7-2 Cadna/A Prediction Results: Sound Levels Due to Turbine Operation (dBA)

The turbine-only sound level modeling results are also shown as color contour plots in Figure 7-1. The contour lines shown in Figure 7-1 shows the sound level contours for worst-case wind turbine operational sound levels.



Groton Wind Project Groton, New Hampshire



8.0 EVALUATION OF SOUND LEVELS

8.1 Previous NH SEC Criteria

As discussed in section 3, there are no State of New Hampshire community noise regulations applicable to the wind farm. Noise may be reviewed as part of the NH SEC process which applies to any wind energy project over 30 MW. As part of the SEC approval for the Lempster (NH) Wind Farm, several noise conditions were implemented via the Agreement with the Town of Lempster:

- 1. Audible sound from the project shall not exceed 55 dBA measured at 300 feet from any existing occupied building, or at the property line if the property line is less than 300 feet from an existing occupied building for non-participating landowners.
- 2. Sound pressure levels shall not be exceeded for more than 3 minutes in any hour of the day, for non-participating landowners.
- 3. If the existing ambient sound pressure level exceeds 55 dBA, the standard shall be ambient dBA plus 5 dBA.
- 4. Sound from the project immediately outside any residence of a non-participating homeowner shall be limited to the greater of 45 dBA or 5 dBA above the ambient sound level, for non-participating landowners.
- 5. These thresholds implemented via the Town of Lempster were modified by the NH SEC to a level of 45 dBA.

The predicted worst-case sound levels from the Groton Wind Project will be below 45 dBA at all occupied buildings. A review of Figure 7-1 shows that the two closest structures within the site along Groton Hollow Road will be approximately 41 dBA. These receptors are not residences but seasonal camps, one of which is in disrepair and not used. These locations are southeast of wind turbine W1. The closest non-participating residence is located due north of turbines N1 and N2. Worst-case sound levels at this location are predicted to be 41 dBA. All other residences will be less than 40 dBA under worst-case operating conditions. Therefore, the Groton Wind Project would easily meet the noise criteria applied to the Lempster, NH wind project.

Although not required since the Project-only sound levels are all well below 45 dBA, a summary comparison of expected future sound levels from the Project to existing background is shown in Table 8-1 for the six ambient measurement locations described in Section 5. Generally speaking, changes of 3 dBA or less are difficult for the human ear to perceive. What the results in Table 8-1 suggest is that with the wind turbines running at full power, and contemporaneous quietest L₉₀ background conditions, the wind farm may be audible at a few of the closest locations at Halls Brook Road and Tenney Mountain Ski

Area. At other more distant locations, such as along Groton Hollow Road, Route 25, around Newfound Lake, and along North Groton Road, the wind turbines may be inaudible, or barely audible. In all cases, sound levels from the wind farm at all locations are well below all community noise guideline criteria.

In reviewing Table 8-1, it is important to note that some of the lowest background sound levels are near or above 45 dBA (Location 2 – Groton Hollow Road; Location 3 – Plain Jane's Diner). This has nothing to do with the proposed wind farm but is due to existing sources of sound in the community.

Receptor	Table 7-2 Wind Farm Only (All Turbines) (dBA)	Table 6-1 Lowest L90 Background (dBA)	Total: Wind Farm + Lowest L‰ (dBA)	Increase Over Background (dBA)
1 – Halls Brook Rd	39.0	33	40	7
2 – Groton Hollow Rd	38.3	44	45	1
3 – Plain Jane's Diner	31.7	49	49	0
4 – Tenney Mtn Ski Area	34.6	38	40	5
5 – NH Audubon Society	23.4	25	27	2

28.8

Table 8-1Evaluation of Sound Levels – Wind Farm plus Background, Worst-case Wind Speed
(9.7 m/s)

8.2 World Health Organization Guidelines

6 – Groton Town Hall

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, Geneva, 1999). Daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. This translates to an indoor guideline value for bedrooms of 30 dBA L_{eq} for a continuous noise. All participating and non-participating residences will be below 45 dBA for exterior sound from the Groton wind Project.

35

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8.3 Pure-Tone Considerations

Epsilon's experience with wind turbines of similar capacity indicates that it is unlikely that there will be a "pure tone." This is based on the following reasons:

- Modern wind turbines with upwind blades do not have prominent discrete tones from aerodynamic sources. [Pedersen and Persson Waye, JASA 2004 ⁴]
- Mechanical equipment associated with the wind turbine may emit prominent discrete tones; however, tones due to mechanical equipment can be reduced "efficiently". [Pedersen and Persson Waye, JASA 2004 ⁴]
- For larger wind turbines, the aerodynamic noise dominates (blade/wind interaction). Even if there were mechanical tones, they would be masked by aerodynamic noise resulting in no prominent discrete tones.
- There have been no prominent discrete tones from any of the recent wind turbine sound level data received from manufacturers, which Epsilon Associates has used in other wind turbine projects. These new wind turbines ranged in size from 1.5 to 2.3 MW.

There have been no prominent discrete tones in any of the recent Epsilon field testing of utility-scale wind turbines. As noted in section 4, low frequency sound from modern upwind wind turbines has been studied and is not an issue.

 ⁴ Eja Pedersen and Kerstin Persson Waye, Dept of Environmental Medicine, Goteborg University, Sweden,
 "Perception and annoyance due to wind turbine noise-a dose-relationship," published by the Journal of the Acoustical Society of America, Melville, NY. JASA 116(6), December 2004, pgs 3460-3470.

9.0 CONCLUSIONS

A comprehensive sound level assessment was conducted for the Groton Wind Project. Baseline sound levels were measured to characterize the existing background sound levels within the area. Turbine-only sound levels were then predicted throughout the entire wind farm, and off-site, so as to determine the future sound levels expected under worst-case operations.

Sound levels due to wind turbine operation are expected to be less than 45 dBA at all participating and non-participating residences. These sound levels are expected to meet previously approved noise conditions from the NH SEC, the World Health Organization's 45-dBA nighttime guideline for residential locations, and the US EPA guideline of 48.6 dBA which is equal to an L_{dn} of 55 dBA.

The analysis was based on extremely conservative assumptions. The increases-abovebackground presented in this report should be considered in this context. Also, the results are worst case. If comparisons were made using the background equivalent sound level (L_{eq}), any changes would be even smaller. The largest increases-above-background will likely occur infrequently. Actual sound levels and actual increases-above background will probably be much lower than the values presented in this report. Also, the background sound level measurement program at Tenney Mountain Ski Area occurred during a period when the area was virtually shutdown for the summer (August). During the winter, background sound levels would be higher due to ski activity thus making changes over background even smaller.

9-1

Appendix A NWS Meteorological Data – Plymouth, NH

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