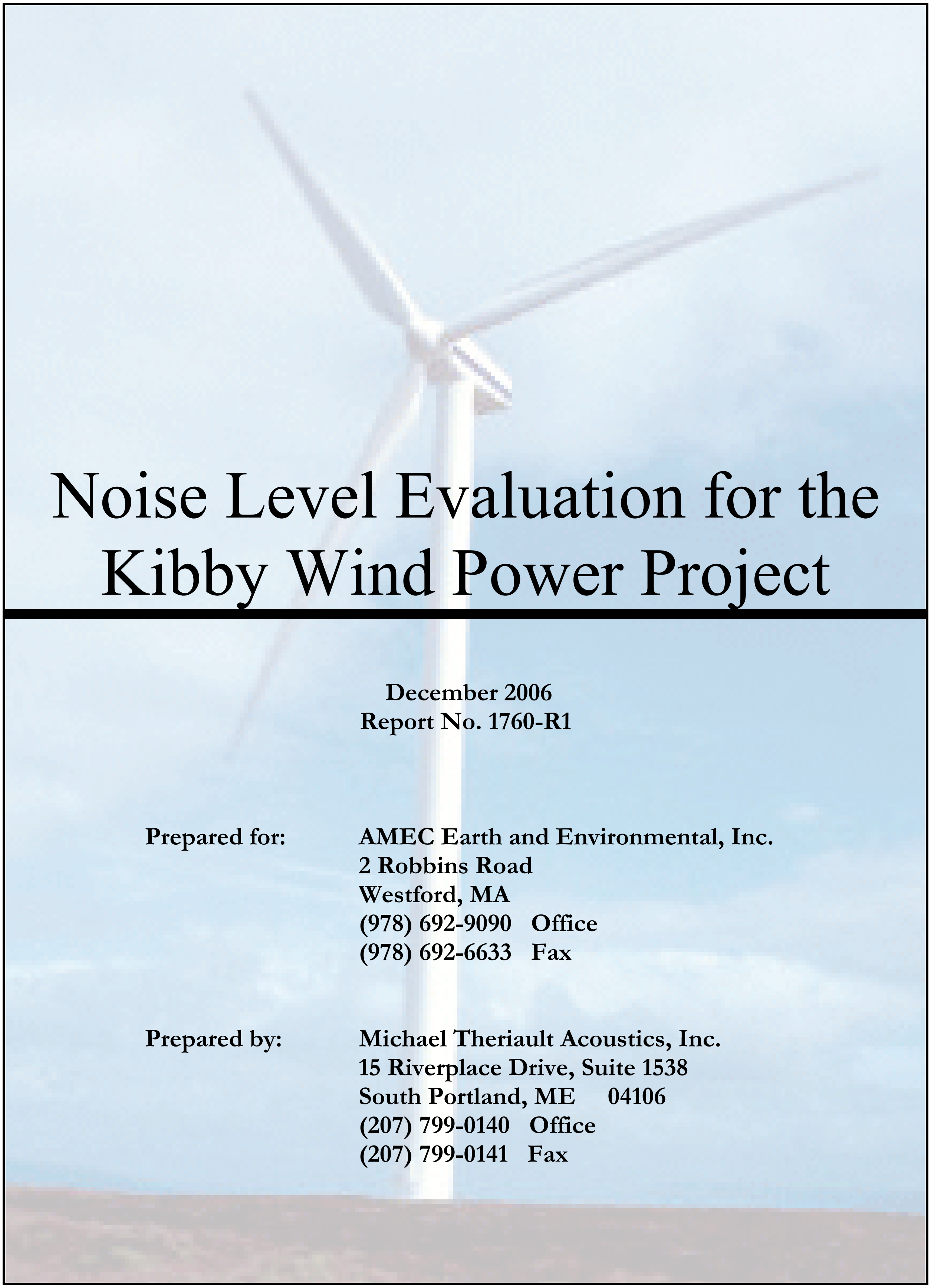

Noise Level Evaluation for the Kibby Wind Power Project

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Report No. 1760-R1

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Michael Theriault ACOUSTICS INC
NOISE CONTROL CONSULTING SERVICES

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1.0 Overview of Analysis Approach and Results

TransCanada Maine Wind Development, Inc. (TransCanada) proposes to construct, own and operate the Kibby Wind Power Project, (the "Facility") an approximately 130-megawatt wind power generating facility located in the Boundary Mountains of western Maine. In support of TransCanada's permit application to construct and operate the Facility, an evaluation was conducted to determine noise impacts potentially created during operation of the Facility. The assessment consisted of: (1) identifying noise-sensitive receivers in the vicinity of the project site potentially affected by noise; (2) predicting Facility noise levels at these receivers using three-dimensional computer modeling techniques; and (3) comparing projected Facility noise levels to various significance criteria (such as laws, ordinances, or regulations for the control of noise; or criteria for hearing damage, speech and sleep interference, low-frequency noise annoyance, etc). In addition to discussion with regard to Land Use Regulation Commission (LURC) standards, Facility noise emissions were compared to guidelines established by federal agencies such as the Department of Housing and Urban Development (HUD) and the U.S. Environmental Protection Agency (EPA).

Results of the analysis showed that given the proposed design of the Facility, noise emissions are well within guidelines established by federal bureaus such as HUD and the EPA, for acceptable levels of environmental noise in residential land uses.. Moreover, the assessment showed that: 1) risk of hearing damage is negligible; 2) interference with sleep and indoor/outdoor speech is not expected; and 3) annoyance due to low-frequency noise is not indicated. Furthermore, levels are consistent with LURC noise standards for General Development subdistricts. Given these findings, noise levels generated during operation of the proposed Kibby Wind Power Project are expected to be insignificant.

2.0 General Information on Noise

To facilitate a review of this evaluation, the following sections briefly discuss how environmental noise levels are measured, described and reported.

Noise is generally defined as loud, unpleasant, unexpected, or undesired sound that interferes with or disrupts normal activities. Although exposure to high noise levels has been demonstrated to cause hearing loss, the principal human response to environmental noise is annoyance. The response of individuals to similar noise events is diverse and influenced by the type of noise, sensitivity of the individual, perceived importance of the noise and its appropriateness in the setting, time of day and type of activity during which the noise occurs.

Sound is generally characterized by several variables, including frequency and intensity. Frequency describes the sound's pitch and is measured in cycles per second, or hertz (Hz), whereas intensity describes the sound's loudness and is measured in decibels (dB). The minimum change detectable by human hearing is about 3 dB and the average person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness.

2.1 Sound Level Meters

Noise is measured using a standardized instrument called the "sound level meter." All sound level meters are equipped with small microphones that detect minute changes in atmospheric pressure caused by the mechanical vibration of air molecules. Healthy human hearing can detect pressures as low as 0.00002 Pascals (threshold of hearing) to as high as 20 Pascals (threshold of pain).[1] Since this represents an enormous dynamic range (one million to one) sound pressures are instead reported using a logarithmic scale, which compresses the numbers to keep them more manageable. Once converted, they are referred to as sound pressure *levels*, followed by "decibels" (abbreviated dB) as the unit of measure. On a logarithmic scale, the threshold of hearing and threshold of pain become 0 decibels and 120 decibels, respectively.

2.2 A-Weighted Levels

Noise can be measured using various "apparent" scales, similar to reporting temperature in terms of wind chill or heat index, or humidity in terms of dew point. The latter are better indicators of perceived cold, warmth, or dampness, respectively. Similarly, sound level measurements are often reported using the "A-weighting" scale of a sound level meter. A-weighting slightly boosts high frequency sound, while reducing low frequency levels (similar to the way stereo bass and treble controls work) providing a better indicator of perceived loudness at relatively modest volumes. These sound level measurements are called A-weighted levels, (abbreviated dBA). Figure 1 illustrates ranges of A-weighted levels for common noise sources.

2.3 Frequency Analysis

To further approximate the response of human hearing, sound level meters are often equipped with octave band filters. As shown in Table 1, octave band filters divide our audible hearing range into nine separate "frequency-bins" much like a prism separates white-light into bands of different color. Imagining a piano with only nine keys to represent the full range of sound is a good analogy. Sound levels are sometimes measured using one-third (1/3rd) octave band filters. As the name implies, one-third octave band filters divide octaves into three additional "bins" for greater resolution. This analogous piano would have twenty-seven "keys" representing the full audible range.

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[1] As pounds are a measure of weight, Pascals are a measure of pressure, equivalent to about 0.02 lbs/ft^2. A single Pascal of pressure will produce a *sound pressure level* of 94 dB.

Table 1: Octave Band Filter Frequency Ranges	
Octave Band Center Frequency	**Frequency Range**
31.5 Hz	22 Hz – 44 Hz
63 Hz	44 Hz – 88 Hz
125 Hz	88 Hz – 177 Hz
250 Hz	177 Hz - 355 Hz
500 Hz	355 Hz - 710 Hz
1000 Hz	710 Hz - 1420 Hz
2000 Hz	1420 Hz - 2840 Hz
4000 Hz	2840 Hz - 5680 Hz
8000 Hz	5680 Hz - 11360 Hz

2.4 Percentile Levels

Because community noise levels constantly change over time, percentile or "exceedance" measurements are used to quantify them. These measures help describe the "average" noise level as well as the range of highs to lows. Equally important, they allow us to separate loud, short-duration noises from quiet, constant-level background sounds. As shown in Figure 2:

L_{10} ("L-Ten") is the level exceeded 10% of the time, that is, levels are higher than this value only 10% of the measurement time. The L_{10} typically represents the loudest and shortest noise events occurring in the environment, such as car and truck pass-bys or aircraft flyovers.

L_{50} ("L-Fifty") is the sound level exceeded 50% of the time. Levels will be above and below this value exactly one-half of the measurement time, and therefore the L_{50} is sometimes referred to as the "median" sound level.

L_{90} ("L-Ninety") is the sound level exceeded 90% of the time and is often called the "background" sound level. Ninety percent of the time, measured levels are higher than this value, and therefore the L_{90} represents the environment during its quietest periods.

2.5 Equivalent Energy Level

Noise levels may also be reported in terms of "equivalent energy levels" or L_{EQ}. An L_{EQ} is a hypothetical number that is "equivalent" in energy to the actual fluctuating noise for any given measurement period. As shown in Figure 2, a noise level of 50 dBA (L_{EQ}) for a period of 1-minute is equivalent in energy to the fluctuating noise level for the same period, produced by the car and truck passes, which range in level from less than 30 dBA to more than 60 dBA. The L_{EQ} typically falls between the L_{10} and L_{50} and is the "base" metric commonly used to establish other measures of environmental noise, such as the Day-Night level.

2.6 Day-Night Level

Day-Night Levels or L_{DN}, are determined from hourly L_{EQ} measurements and represent a 24-hour assessment of noise within a community. More specifically, the L_{DN} is calculated by adding a 10-decibel "penalty" to hourly L_{EQ} measurements collected between 10 p.m. to 7 a.m., to account for the potential of increased annoyance when people are resting, relaxing or sleeping. L_{DN} is the preferred metric of federal bureaus such as HUD and EPA for the assessment of environmental noise.

2.7 Sound Power and Sound Pressure Levels

Sound power level (PWL) is a single number that describes how much sound energy is radiated by a piece of equipment, independent of the surroundings or environment. Sound power level allows one piece of equipment to be directly compared with another.

Sound power level is analogous to the wattage of a light bulb, whereas sound level is analogous to brightness. Sound power is *independent* of the environment; sound pressure is dependent on the environment. When a 75-watt light bulb is placed in a room painted white or black, it still radiates the same amount of light. However, the apparent brightness of the light bulb changes as the room environment changes. In the room painted white, many reflections are causing the apparent brightness of the bulb to increase, and in the room painted black, much of the light is being absorbed, so the apparent brightness decreases.

For sound, a room painted white is analogous to a contemporary home with sparse furnishings and hardwood floors, i.e., little absorbing material and many reflections. A room painted black is analogous to a colonial home with overstuffed chairs, carpets and paintings on the wall, i.e., many absorbing materials and fewer reflections. A blender or vacuum cleaner would have a higher sound pressure level in the contemporary home versus the colonial one. Similar to light bulb wattage however, the sound power level of the appliance has not changed.

For the most part, no meter "directly" measures sound power. Instead, it is calculated from sound level measurements corrected for reflections, distance to the source, directivity, etc. Sound intensity meters can be used to determine the in-situ sound intensity level of a source (power/unit area). Since these meters measure sound level and the direction that the sound comes from, they inherently account for reflections and other environmental factors. An adjustment for distance or area is then applied to the levels, to derive the sound power level of the equipment.

3.0 Existing Conditions

3.1 Area Description

The project is sited within the Boundary Mountains of western Maine, which border northern New Hampshire and Quebec, Canada and lie within an unincorporated area of Franklin County. Turbine locations are anticipated along two ridgelines within the project area, as shown in Figure 3. The proposed wind turbines and associated substation are located entirely within privately owned commercial forestry lands. The nearest population center is the Town of Eustis/Stratton, located approximately 7 miles from the project. As shown in Figure 4, the nearest noise-sensitive receiver is a single-family residence located approximately 1.25-miles southwest of the closest turbine.

3.2 Acoustical Environment

The acoustical environment of the area can be characterized as rural, with background noise levels typically controlled by natural sources such as vegetation rustle, wildlife (birdcalls) and insects. Noise from logging operations, including extensive truck use, also contributes to background ambient levels within the region. In addition to being used by logging trucks entering and exiting the property, Gold Brook Road and other forestry roads throughout the site are used by individuals traversing the area, thereby contributing to the existing acoustical environment.

4.0 Analysis of Noise Impacts

4.1 Significance Criteria

Noise impact can be classified into one of two categories, namely: 1) the extent to which Facility noise emissions may exceed applicable laws, ordinances, regulations and standards, and 2) the degree that Facility noise emissions may elicit community annoyance or complaint. The following sections discuss each type of impact criteria, and how they have been applied to the proposed Project.

4.1.1 Land Use Regulation Commission

Chapter 10.25 Section F of the Land Use Regulation Commission (LURC) Rules and Standards establishes maximum permissible sound pressure levels at the property line of a site, dependant upon which type of "subdistrict" the site is located in (e.g. industrial, commercial, general). The Facility is sited within a planned development (D-PD) subdistrict. Although noise levels for a planned development (D-PD) subdistrict are "as determined by the Commission," LURC regulations establish noise limits for other subdistricts that provide a useful point of comparison. For example, limits for General Development (D-GN) subdistricts are: 65 dBA daytime and 55 dBA at night. Limits for commercial and industrial subdistricts are higher, and limits for other subdistricts are lower. Since the surrounding land use is for commercial harvesting operations and does not include sensitive noise receptors, the limits for D-GN subdistricts are considered for informational and evaluation purposes in Section 5.1.1

4.1.2 Department of Housing and Urban Development Guidelines

HUD considers sites where Day-Night noise levels do not exceed 65 dBA to be acceptable for housing. As described in Section 2.6, the Day-Night noise level, or L_{DN}, is a hypothetical number that represents a 24-hour assessment of noise within a community. More specifically, the L_{DN} adds a 10-decibel penalty to all noises that occur from 10 p.m. to 7 a.m., to account for the potential of increased annoyance when people are relaxing, resting and sleeping. Note that L_{DN} is a calculated value, and therefore cannot be directly measured by a sound level meter.

4.1.3 Environmental Protection Agency Guidelines

As a result of the Noise Control Act of 1972, the federal EPA published "*Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety,"* (commonly called the "Levels Document"). EPA's criteria, which are mostly stated in terms of Day-Night levels, are shown in Table 2. In summary, EPA indicates that exposure to outdoor sound levels at or below L_{DN} = 55 dBA, or indoor sound levels at or below L_{DN} = 45 dBA, is satisfactory to "*protect the public health and welfare with an adequate margin of safety,*" since it will not produce significant speech interference either indoors or outdoors, and will lead to negligible community reaction, complaint or annoyance in average communities.

Note that HUD and EPA criteria do not constitute enforceable federal regulations or standards. Nevertheless, these criteria represent valid bases for evaluating the potential effects of Facility noise on public health and welfare.

Table 2: Noise Levels Identified as Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety		
Effect	**Level**	**Area**
Hearing loss	$L_{eq(24)} \leq 70$ dB	All areas
Outdoor activity interference	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms, other outdoor areas where people spend widely varying amounts of time, and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas.
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities, such as schools, etc.
Source: Report No. EPA-550/9-74-004, March 1974.		

4.1.4 Additional Criteria

Facility noise levels were also evaluated in terms of their potential for hearing damage and low frequency noise annoyance.

4.2 Operational Noise Prediction

A three-dimensional, computer-generated acoustical model of the proposed Facility was developed using SoundPlan® 6.4, to predict noise levels at the nearest residential receiver.[2] Facility noise levels were estimated using octave band sound power level data from manufacturers and industry-standard prediction algorithms.[3] (Sound power levels provide a convenient means to describe the total amount of noise generated by a piece of equipment.) Conversions from sound power level to sound pressure level are provided in the Appendix, (*see Acoustical Terminology)*. The model conservatively assumed non-stop, simultaneous operation of 48 turbines at maximum power output. Note that only 44 turbines are proposed (four turbines represent optional locations) and therefore predicted noise levels may be overstated in the model.

Equipment power levels were adjusted for the reduction of sound by distance (*geometrical spreading);* the molecular absorption of sound by air (*air absorption*); and the absorption and reflection of sound by the ground (*ground effect)*. Sound power levels were further modified

[2] SoundPlan® 6.4 is an acoustical analysis software package specially designed for estimating noise emissions from industrial facilities.

[3] *Electric Power Plant Environmental Noise Guide,* Edison Electric Institute, NY, NY, 1978.

by the effects of shielding, (i.e., via topography) to estimate receiver noise levels. A complete set of modeling calculations can be found in the Appendix.

4.2.1 Acoustical Modeling Parameters

Acoustical modeling was based on ISO 9613-2, *"Attenuation of Sound during Propagation Outdoors,"* adopted by the International Standards Organization (ISO) in 1996. This standard provides a widely accepted engineering method for the calculation of outdoor environmental noise levels from sources of known sound emission. The following sections briefly discuss under which conditions the predictions are considered valid.

4.2.2 Meteorology

ISO 9613 is designed to estimate far-field noise levels under favorable sound-propagation conditions, that is, when wind is blowing from the Facility towards receivers, up to a speed of 11 mph, when measured at a height of 10 feet above the ground. (These near-grade conditions, when translated to wind speeds at turbine hub height, correspond to wind speeds for maximum turbine noise emissions.) For other conditions, such as during crosswind or upwind weather patterns, or for temperature lapses, observed noise levels would generally be equal to or less than predicted. Note that noises indirectly produced by wind effects, such as tree rustle, are not considered in this analysis, which under some circumstances are significant, and can mask audibility of turbine operations.

4.2.3 Air Absorption

Absorption/attenuation of sound by air is strongly dependent on the frequency of sound, as well as on temperature and relative humidity. In general, low temperature and humidity increase high-frequency sound absorption, which in turn reduces far-field noise levels. For this evaluation, site-specific mean annual temperature, relative humidity (RH) and barometric pressure conditions were obtained from the National Climatic Data Center (NCDC) for the period of record from 1961 through 1990. Specifically, 36 °F, 71% RH, and 1016 millibars were used in the analysis.

4.2.4 Ground Effect

Absorption/attenuation of sound by the ground is largely dependant on both the type and extent of "ground" condition assumed for the site and receiver areas. Ground areas near the receiver were assumed to be moderately porous, characterized as covered by grass or other vegetation. Areas of ground at each turbine site and at the substation were modeled as "hard" which includes ground that is tamped, paved or covered with concrete, all of which are commonly found at industrial sites. This approach generally results in a conservative, worse-case estimate of turbine noise levels. However, given the relatively large distance between the turbine nacelle and the ground, ground conditions at the source have little effect on receiver noise levels.

4.2.5 Model Accuracy

ISO 9613 predictions are expected to agree with field measurements within a ± 3 dBA range out to a distance of 1000 meters, for the meteorological and environmental conditions described above. This implies that actual levels observed in the field might be up to 3 decibels lower than predicted, or 3 decibels higher. As such, noise levels presented in this analysis represent a "best estimate" of Facility emissions, as they would be measured in the field.

4.2.6 Operational Noise Modeling Results

Facility noise levels at the nearest receiver during favorable sound propagation conditions are expected to be approximately 35 dBA or less (L_{EQ}). Figure 5 presents the analysis results as a series of noise level contours. Complete modeling calculations can be found in the Appendix.

5.0 Impacts

5.1 Operational

This section provides a comparison of Facility noise levels to various impact criteria, including criteria for hearing damage, sleep and speech interference, and low frequency noise annoyance.

5.1.1 LURC

As discussed in Section 4.1.1, maximum permissible sound pressure levels produced at the property or boundary line of planned developments are "as determined by the Commission." However, since the surrounding land use is for commercial harvesting activities, the General Development subdistrict limits (65 dBA daytime and 55 dBA at night) are considered here for informational and comparative purposes only. Figure 6 illustrates the 55 dBA contour produced during worse-case operation of the Facility, in contrast to property boundaries. As shown, the contour falls within the property lines, with the exception of a few small regions. Given this, worse-case turbine noise levels are consistent with and mostly lower than LURC noise standards for General Development subdistricts, and are less than the limits for other development subdistricts.

5.1.2 Hearing Damage

It is generally accepted that exposure to levels of continuous noise less than 75 dBA presents insignificant risk for hearing damage. Since the highest predicted Facility noise level at the nearest residence is 35 dBA, or 40 decibels lower than the 75 dBA threshold, and since the Facility operates intermittently and therefore does not produce a continuous level of noise, the Facility poses negligible risk of hearing damage. Moreover, no area within the project region exhibits noise levels above 75 dBA, including those at turbines bases.

5.1.3 Sleep Interference

In order to avoid negative effects on sleep, indoor noise levels (L_{EQ}) should not exceed 30 to 35 dBA.[4] Given an estimated Facility noise level of 35 dBA at the nearest residence, and a fifteen (15) decibel noise reduction for a typical home with partially open windows,[5] interior noise levels would be no more than 20 dBA, (35 dBA – 15 dBA = 20 dBA) and therefore significantly below recommended criteria.

5.1.4 Indoor and Outdoor Speech Interference

Speech spoken in relaxed conversation is intelligible when background (i.e., Facility) noise levels are at or below 55 dBA (L_{EQ}).[6] Since the highest Facility noise level at the nearest residence is 35 dBA, no interference with outdoor speech is anticipated. To be able to hear and understand spoken messages indoors, it is recommended that sound levels do not exceed 35 dBA (L_{EQ}). As discussed in Section 5.1.2, noise levels will conform to this recommended criterion, and therefore no interference with indoor speech is anticipated.

Outdoor speech interference for forest users was also considered. Assuming maximum noise generation from the Facility, areas within 300 to 750 feet of turbine bases may exhibit noise levels of 55 dBA or greater. As depicted in Figure 6, these constitute relatively small regions within the overall project area.

5.1.5 Low Frequency Noise Annoyance

Low frequency noise is sometimes characterized as "pulsating" when indoor sound pressure levels are 26 to 36 dBA in the 31.5-Hertz octave band. As discussed in Section 2.3, octave

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[4] *Community Noise,* Archives of the Center for Sensory Research, Berglund, B., & Lindvall, T (Eds.), 1995.

[5] *US EPA, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety,* USEPA Report 550/9-74-004 (March 1974).

[6] *Community Noise,* Archives of the Center for Sensory Research, Berglund, B., & Lindvall, T (Eds.), 1995.

band filters divide our audible hearing range into nine separate "frequency-bins" much like a prism separates white-light into bands of different color. Imagining a piano with only nine keys to represent the full range of sound is a good analogy. Bass keys would best represent noise levels in the low frequency octave bands. Since the maximum *outdoor* noise level at the nearest residence is predicted to be about 13 dBA in the 31.5-Hertz octave band, low-frequency noise annoyance is not expected.

5.1.6 HUD Guidelines

HUD considers sites where Day-Night noise levels (L_{DN}) do not exceed 65 dBA to be acceptable for housing. As discussed in Section 2.6, L_{DN} is the preferred metric of federal agencies and represents a 24-hour assessment of noise within a community. Assuming a facility produces a constant level of noise and operates 24-hours per day, 65 L_{DN} translates to an hourly L_{EQ} of 58 dBA, (which is the metric predicted by the acoustical model). As presented in Section 4.2.6, Facility noise levels at the nearest receiver during favorable sound propagation conditions are expected to be approximately 35 dBA or less (L_{EQ}). As a result, Facility noise levels will be more than 20 decibels lower than HUD guidelines for acceptable levels of environmental noise (58 dBA – 35 dBA = 23 dBA).

5.1.7 EPA Guidelines

The Federal EPA indicates that exposure to outdoor sound levels at or below L_{DN} = 55 dBA is satisfactory to "*protect the public health and welfare with an adequate margin of safety,*" since it will not produce significant speech interference either indoors or outdoors, nor lead to substantial community reaction, complaint or annoyance in average communities. As discussed in Section 2.6, L_{DN} is the preferred metric of federal agencies and represents a 24-hour assessment of noise within a community. Assuming a facility produces a constant level of noise and operates 24-hours per day, 55 L_{DN} translates to an hourly L_{EQ} of 48 dBA, (which is the metric predicted by the acoustical model). As presented in Section 4.2.6, worse-case Facility noise levels at the nearest receiver during favorable sound propagation conditions are expected to be approximately 35 dBA or less (L_{EQ}). As a result, Facility noise levels will be significantly lower than EPA guidelines for acceptable levels of environmental noise (48 dBA – 35 dBA = 13 dBA). (Note that for purposes of evaluation studies, the Facility was assumed to produce maximum noise output 24-hours per day, 7-days per week. However, since the Facility operates intermittently, the allowable hourly L_{EQ} derived from the 55 L_{DN} standard may actually be higher than 48 dBA. As such, the difference between allowable and predicted noise levels may be greater than conservatively stated here.)

5.1.8 Summary of Operational Noise Impacts

Results of the acoustical analysis showed that given the proposed design of the Facility, 1) hearing damage risk is negligible; 2) interference with sleep and indoor/outdoor speech is not expected; and 3) annoyance due to low-frequency noise is not indicated. Finally, the assessment showed that Facility noise levels are well within guidelines established by federal bureaus such as HUD and the EPA, for acceptable levels of environmental noise within residential land uses. Given these findings, noise levels generated during operation of the proposed Kibby Wind Power Project are expected to be insignificant.

5.2 Construction Noise Impacts

Like most projects, construction of the proposed Facility will result in temporary increases to ambient noise levels. The magnitude of the increases will depend on the type of construction activity; the noise levels generated by various pieces of construction equipment; the duration of the construction phase; and the distance between the noise sources and receiver. Table 3 shows average noise levels generated by individual pieces of construction equipment. Note that much of this construction equipment is similar to the logging machinery in common use at the site. Since a detailed construction plan identifying construction sequences, phases and specific equipment has not been developed, specific projection of sound levels cannot be made.

TABLE 3
TYPICAL NOISE EMISSION LEVELS FOR CONSTRUCTION EQUIPMENT

Equipment Item	Noise Level at 50 Feet (dBA)	Equipment Item	Noise Level at 50 Feet (dBA)
Air Compressors	76 – 89	Generators (Portable)	71 – 87
Backhoes	81 – 90	Jackhammers	69 – 85
Concrete Pumps	74 – 84	Pile Drivers	81 – 107
Concrete Vibrators	68 – 81	Pumps	68 – 80
Cranes (Derrick)	79 – 86	Steel Rollers	75 – 82
Cranes (Mobile)	80 – 85	Shovels	77 – 90
Dozers	77 – 90	Trucks	81 – 87
Front-End Loaders	77 – 90	Vibratory Conveyors	70 – 80
Graders	79 – 89	Welders	66 – 75

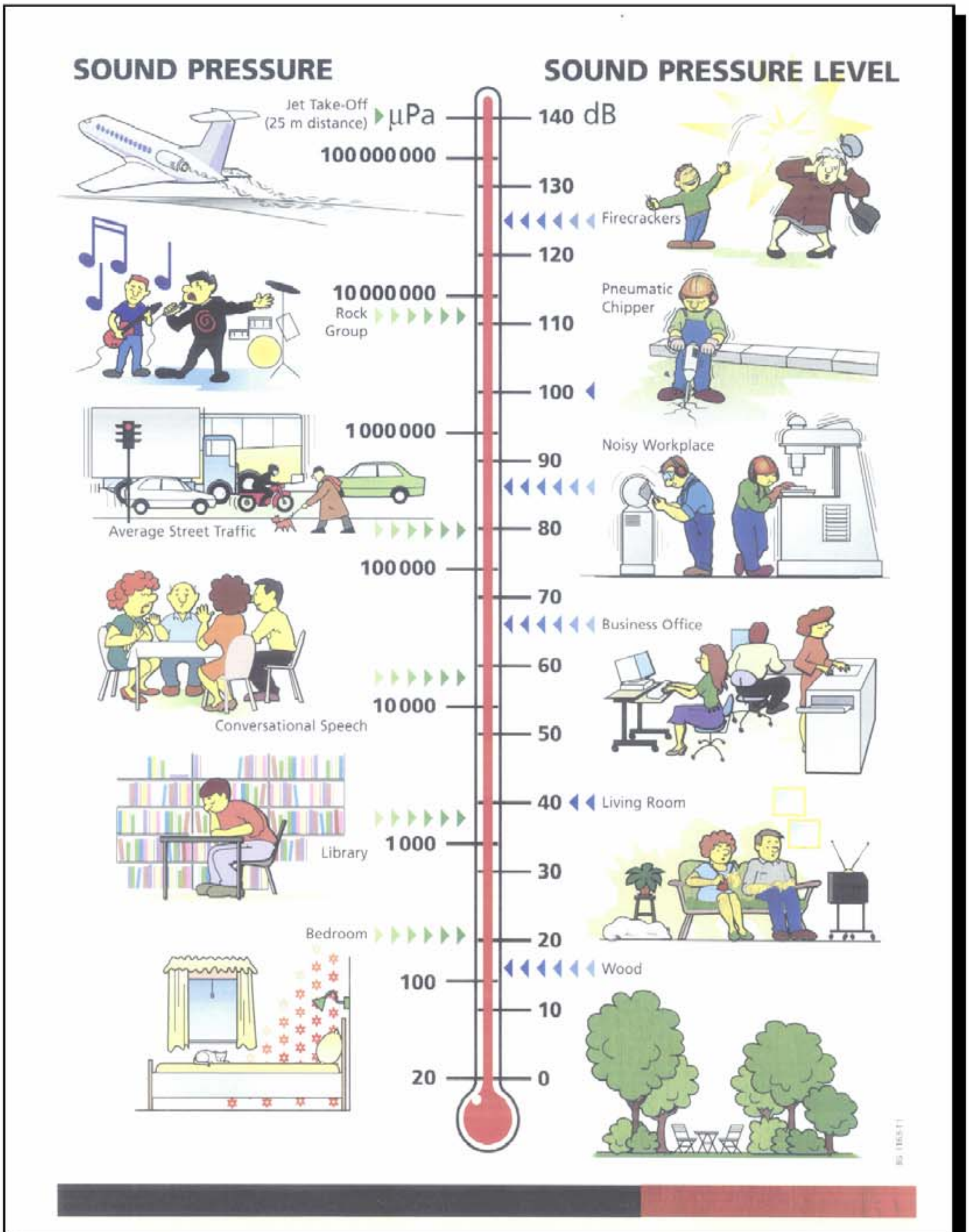
Source*: Power Plant Construction Noise Guide, Bolt Beranek and Newman, Inc., May 1997.*

In general, it is anticipated that construction noise levels will be near or below current ambient noise levels (L_{EQ}). Also, while construction noise will be discernable at some locations, it is not expected to increase ambient noise levels significantly for any appreciable period of time.

The average individual is likely to tolerate noise associated with construction, given its temporary nature, and that the majority of construction will take place during daytime hours, (i.e., when acceptance towards noise is higher, and the risk of sleep disturbance and interference with relaxation activities is low). As a result, noise impacts associated with construction operations are expected to insignificant.

6.0 Mitigation

In order to achieve levels presented, no equipment-specific mitigation requirements are indicted by the analysis, other than those already incorporated in the standard manufacturer's design.



Levels Shown are Equivalent to A-Weighted Levels At 1,000 Hertz

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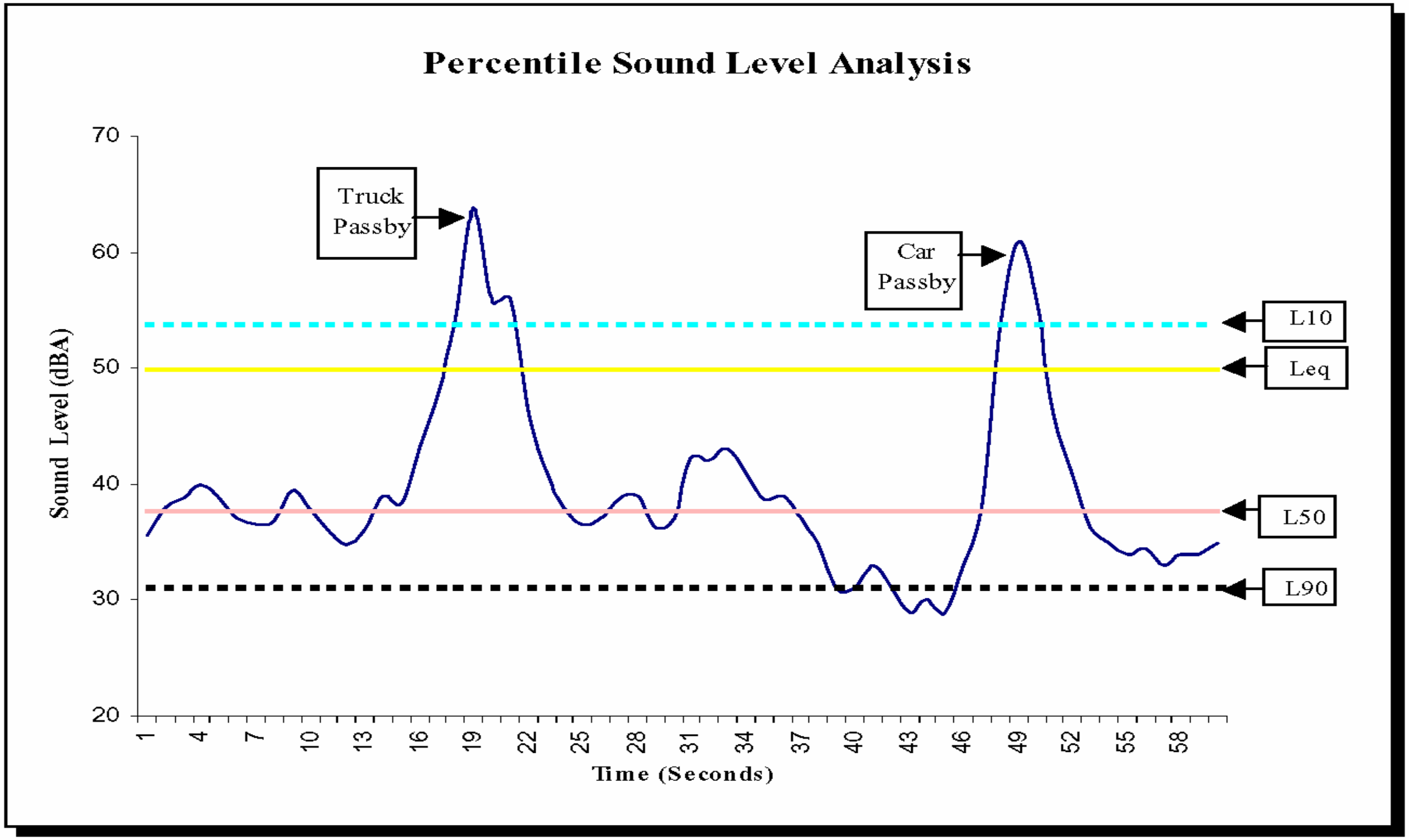
SOURCE: BRÜEL & KJÆR, DENMARK

TYPICAL SOUND PRESSURE LEVELS

KIBBY WIND POWER PROJECT
FRANKIN COUNTY, MAINE

FIGURE 1	**PROJ. NO. 1760**



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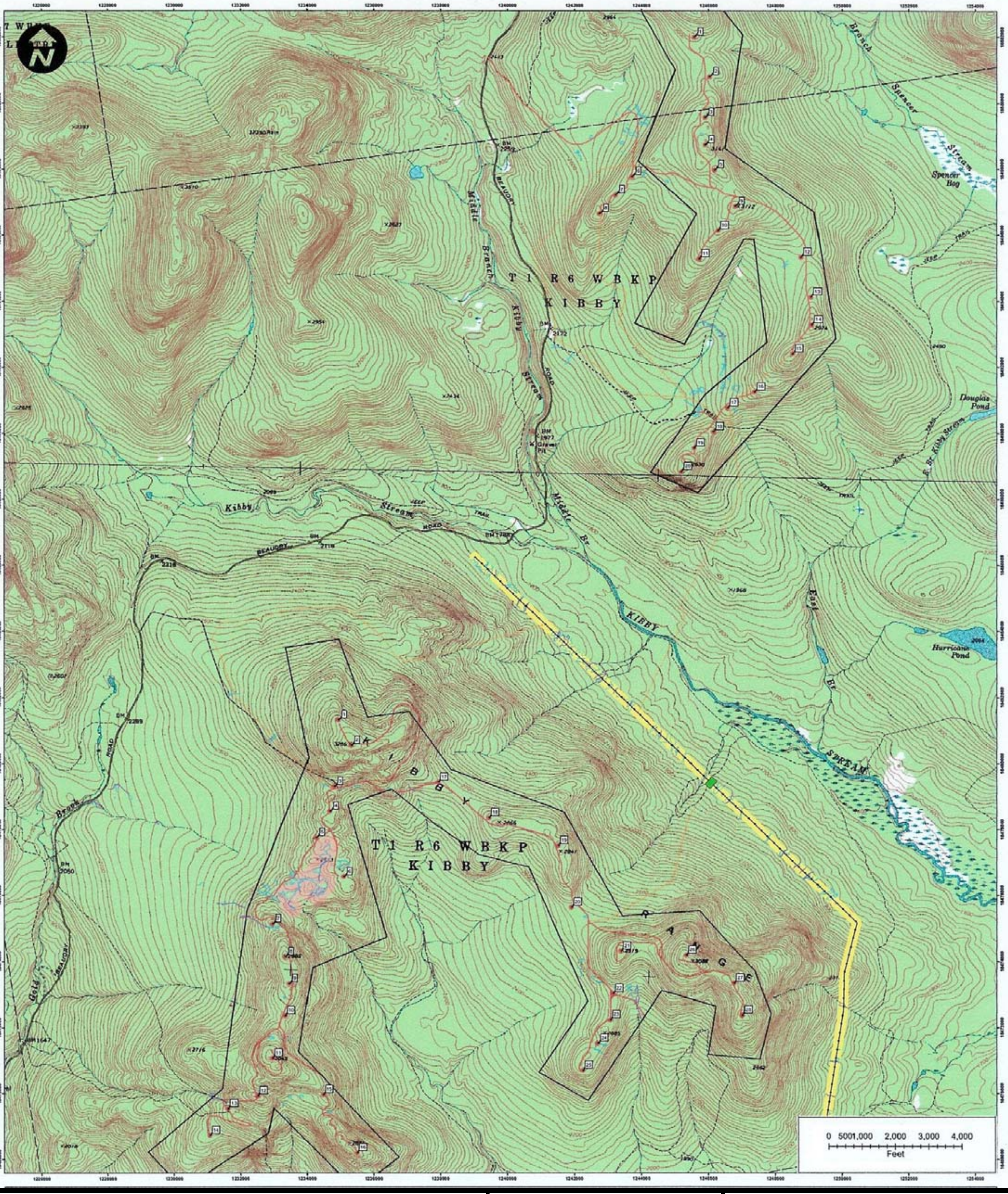
EXAMPLE PERCENTILE ANALYSIS

KIBBY WIND POWER PROJECT
FRANKLIN COUNTY, MAINE

FIGURE 2	**PROJ. NO. 1760**



LEGEND

- Turbines
- Proposed Collector Line
- Bigelow T-Line
- Access Road
- Turbine Road Alignment
- Goldbrook Road
- Delineated Stream
- Delineated Wetland
- Project Boundary
- Vernal Pool
- 250' Buffer of Critical Habitat
- Transmission Line Corridor (300 ft wide)
- Proposed Substation

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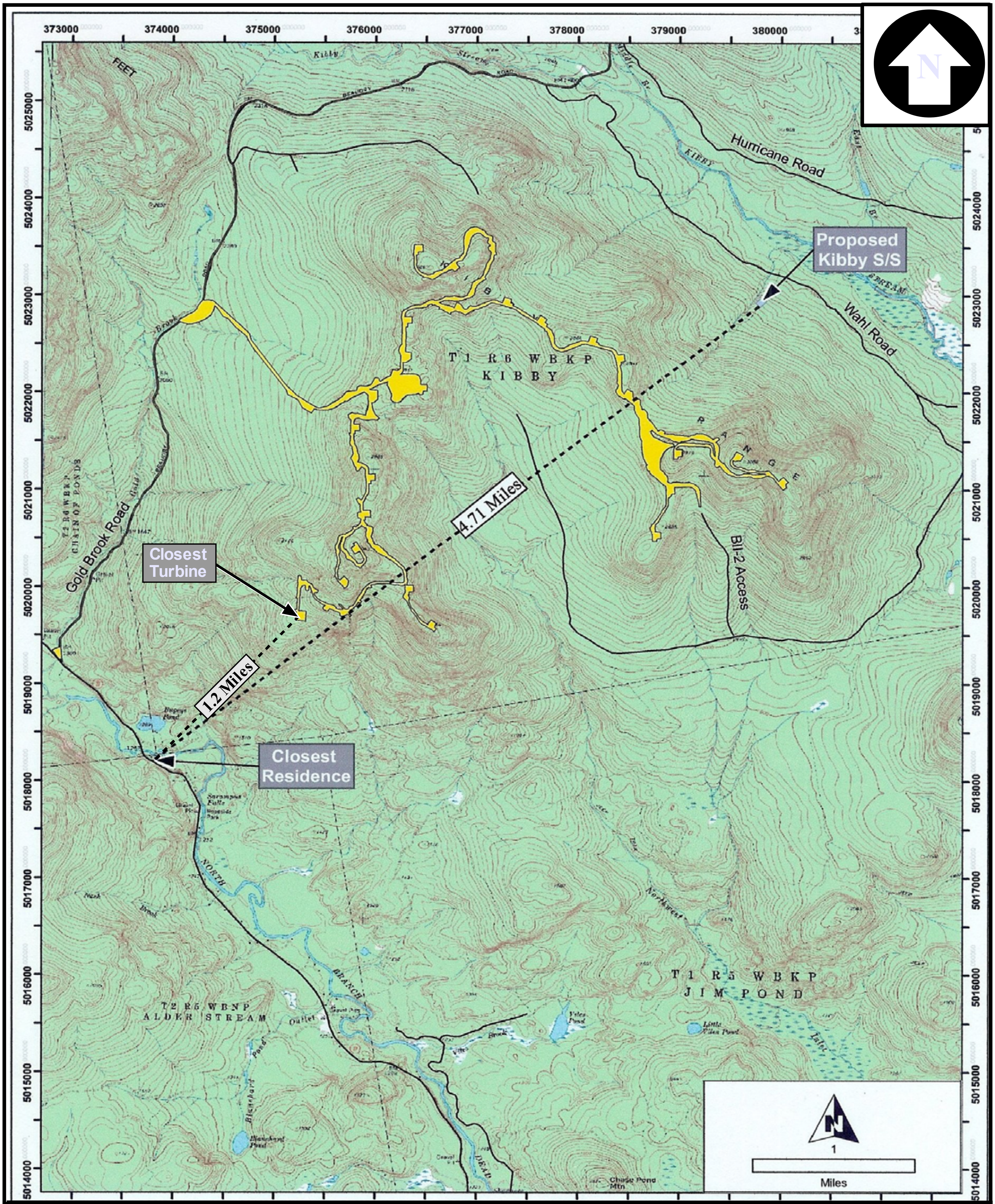
PROPOSED TURBINE LOCATIONS

KIBBY WIND POWER PROJECT
FRANKLIN COUNTY, MAINE

FIGURE 3	**PROJ. NO. 1760**



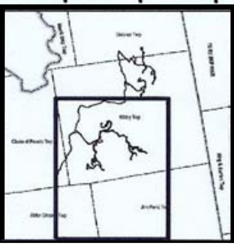
Legend

Proposed Wind Turbine and Road Construction Area

Road

Notes: Base map: USGS 24k Topographic Map. Coordinate Grid: NAD83 UTM Zone 19N, Meters

SOURCE: E-PRO



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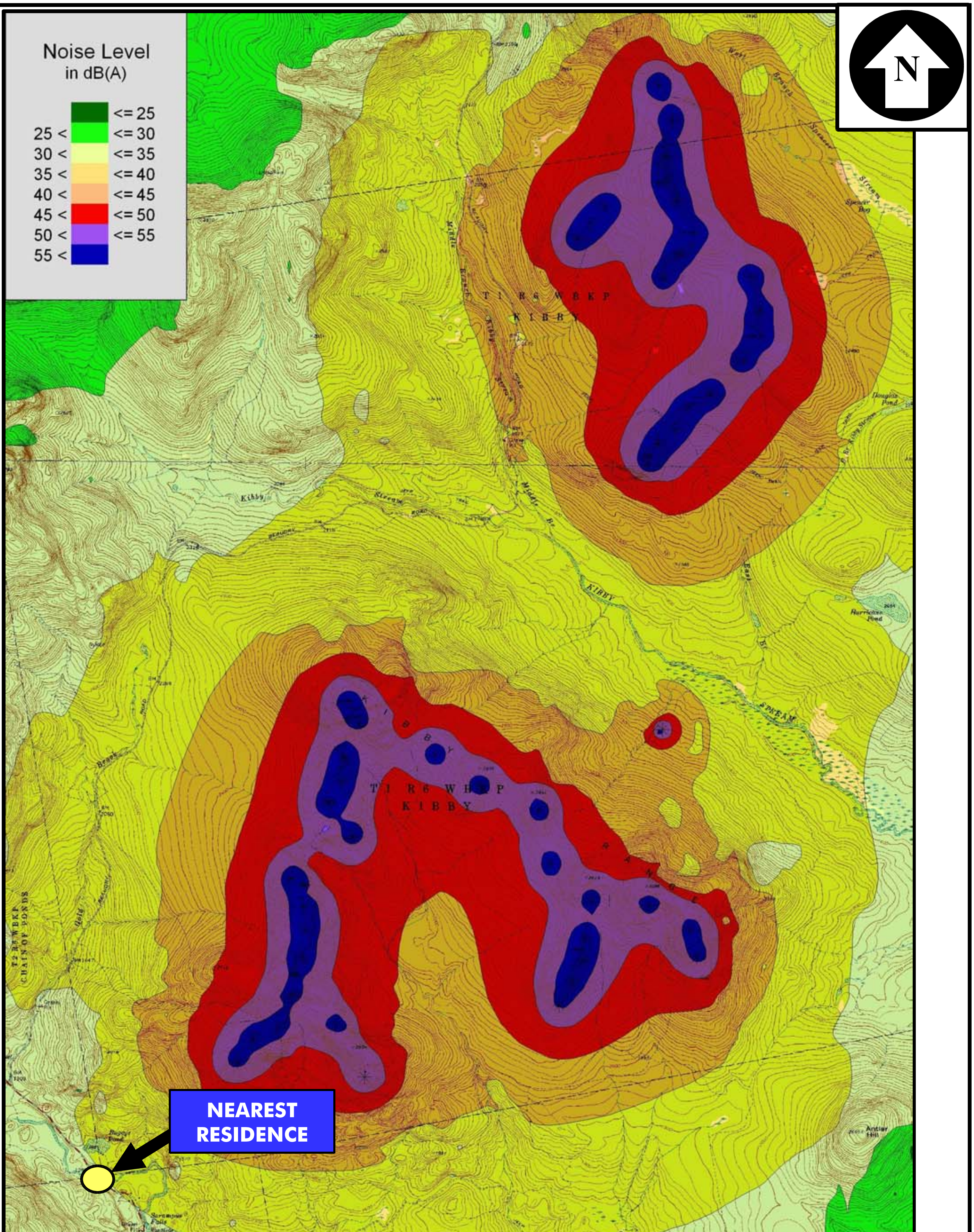
SITE AREA MAP

KIBBY WIND POWER PROJECT
FRANKLIN COUNTY, MAINE

FIGURE 4	**PROJ. NO. 1760**



0 4000 8000 12000

Scale in Feet

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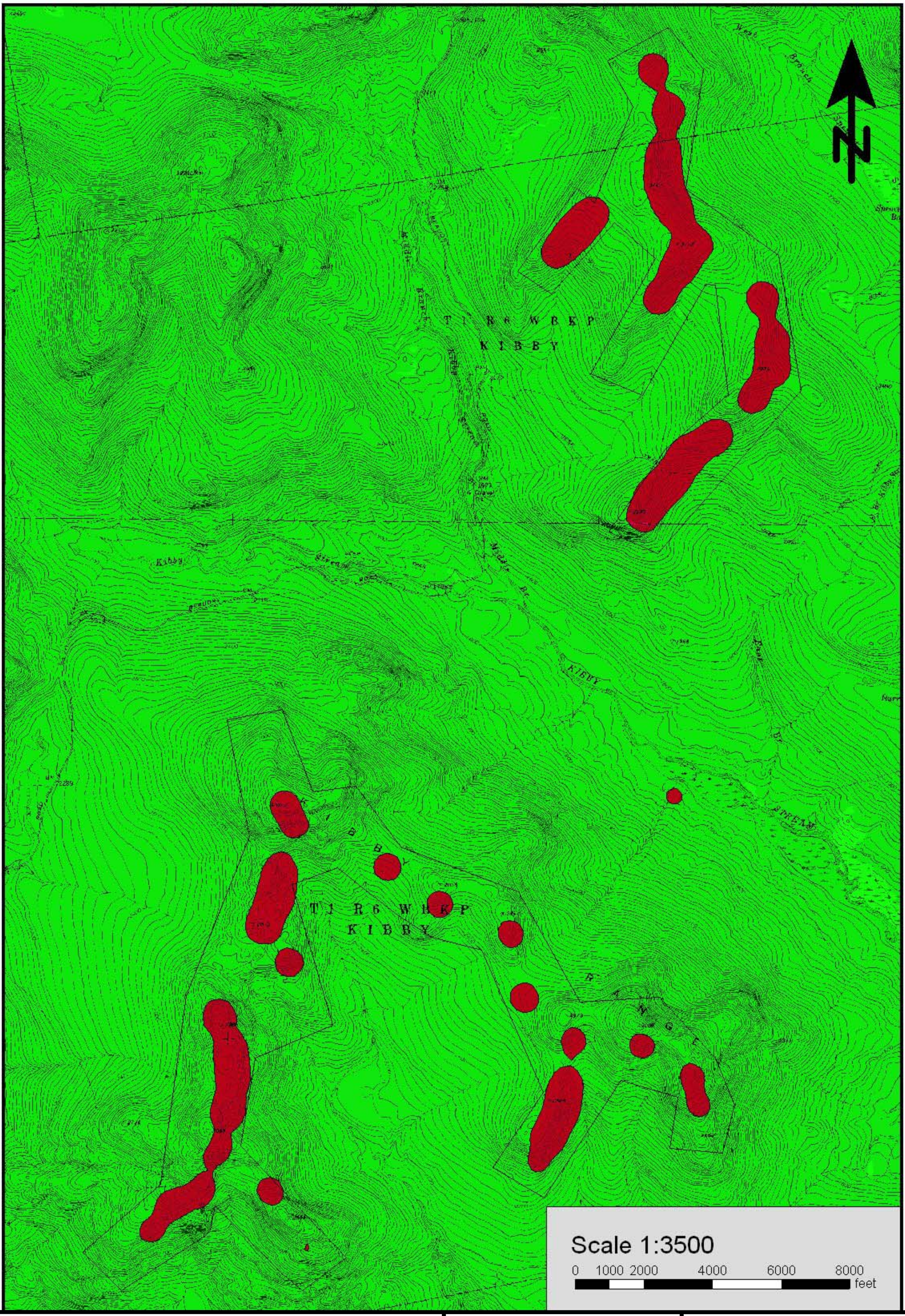
PREDICTED NOISE LEVEL CONTOURS

KIBBY WIND POWER PROJECT
FRANKLIN COUNTY, MAINE

FIGURE 5	**PROJ. NO. 1760**



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55 dBA NOISE LEVEL CONTOUR VERSUS PROPERTY BOUNDARY

KIBBY WIND POWER PROJECT
FRANKLIN COUNTY, MAINE

FIGURE 6 | **PROJ. NO. 1760**

Acoustical Modeling Results

Kibby Wind Energy Project - Receiver Sound Levels
Kibby - Base Analysis - A Weighted

Name	Design Goal dB(A)	Sound Pressure Level dB(A)	
Nearest Residence	59	34.8	

Kibby Wind Energy Project - Receiver Sound Levels
Kibby - Base Analysis - C Weighted

Name	Sound Pressure Level dB(C)	
Nearest Residence	52.4	

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Kibby Wind Energy Project - Receiver Spectra
Kibby - Base Analysis - Linear

Time Slice	31 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Nearest Residence SPL 54.4 dB( )									
LrD	52.2	48.8	43.9	38.3	33.2	24.7	4.3		
LrN	52.2	48.8	43.9	38.3	33.2	24.7	4.3		

Kibby Wind Energy Project - Source List
Kibby - Base Analysis - A Weighted

Source	Lw	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1,25 kHz	1,6 kHz	2 kHz	2,5 kHz	3,15 kHz	4 kHz	5 kHz	6,3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz
Substation	101.4		58.6			77.8			89.9			92.4			97.8			95.0			91.2			86.0			76.9				
Turbine 01A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 01B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 02A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 02B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 03A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 03B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 04A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 04B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 05A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 05B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 06A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 06B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 07A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 07B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 08A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 08B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 09A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 09B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 10A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 10B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 11A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 11B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 12A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 12B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 13A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 13B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 14A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 14B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 15A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 15B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 16A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 16B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5

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Kibby Wind Energy Project - Source List
Kibby - Base Analysis - A Weighted

Source	Lw	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1,25 kHz	1,6 kHz	2 kHz	2,5 kHz	3,15 kHz	4 kHz	5 kHz	6,3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz
Turbine 17A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 17B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 18A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 18B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 19A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 19B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 20A	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 20B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 21B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 22B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 23B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 24B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 25B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 26B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 27B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5
Turbine 28B	109.4	70.5	76.1	77.8	81.7	85.6	88.2	90.8	93.0	99.5	96.7	98.1	99.6	99.0	98.6	98.5	98.8	98.1	97.4	96.3	94.6	92.2	90.2	88.7	86.0	84.3	79.4	80.6	85.6	75.6	64.5

Kibby Wind Energy Project - Source List
Kibby - Base Analysis - Linear

Source	Lw	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1,25 kHz	1,6 kHz	2 kHz	2,5 kHz	3,15 kHz	4 kHz	5 kHz	6,3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz
Substation	110.0		98.0			104.			106.			101.			101.			95.0			90.0			85.0			78.0				
Turbine 01A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 01B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 02A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 02B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 03A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 03B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 04A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 04B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 05A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 05B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 06A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 06B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 07A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 07B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 08A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 08B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 09A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 09B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 10A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 10B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 11A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 11B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 12A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 12B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 13A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 13B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 14A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 14B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 15A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 15B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 16A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 16B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8

Kibby Wind Energy Project - Source List
Kibby - Base Analysis - Linear

Source	Lw	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1,25 kHz	1,6 kHz	2 kHz	2,5 kHz	3,15 kHz	4 kHz	5 kHz	6,3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz
Turbine 17A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 17B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 18A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 18B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 19A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 19B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 20A	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 20B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 21B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 22B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 23B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 24B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 25B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 26B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 27B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8
Turbine 28B	122.7	115.	115.	112.	111.	111.	110.	109.	109.	112.	107.	106.	106.	103.	101.	100.	99.6	98.1	96.8	95.3	93.4	90.9	89.0	87.7	85.5	84.4	80.5	83.1	89.9	82.2	73.8

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Kibby Wind Energy Project - Mean Propogation
Kibby - Base Analysis - A Weighted

Source	PWL dB(A)	PWL/unit dB(A)	Non-Sphere dB	Distance m	Spreading dB	Ground Effct. dB	Ins. Loss dB	Air dB	Directivity dB	Reflection dB(A)	SPL dB(A)	Awind dB
Nearest Residence LrD 34.8 dB(A)												
Turbine 01A	109.4	109.4	0.0	13050.75	93.3	-1.6	6.4	11.9	0.0		-0.6	
Turbine 02A	109.4	109.4	0.0	12794.66	93.1	-1.6	6.4	11.8	0.0		-0.3	
Turbine 03A	109.4	109.4	0.0	12446.18	92.9	-1.6	6.4	11.6	0.0		0.2	
Turbine 04A	109.4	109.4	0.0	12226.04	92.7	-1.6	6.4	11.4	0.0		0.4	
Turbine 05A	109.4	109.4	0.0	12070.51	92.6	-1.6	6.4	11.4	0.0		0.6	
Turbine 06A	109.4	109.4	0.0	11650.94	92.3	-1.6	6.3	11.1	0.0		1.2	
Turbine 07A	109.4	109.4	0.0	11430.83	92.2	-1.6	6.3	11.0	0.0		1.5	
Turbine 08A	109.4	109.4	0.0	11208.64	92.0	-1.6	6.3	10.8	0.0		1.8	
Turbine 09A	109.4	109.4	0.0	11882.74	92.5	-1.6	6.4	11.2	0.0		0.9	
Turbine 10A	109.4	109.4	0.0	11605.96	92.3	-1.6	6.3	11.1	0.0		1.3	
Turbine 11A	109.4	109.4	0.0	11292.83	92.0	-1.6	6.3	10.9	0.0		1.7	
Turbine 12A	109.4	109.4	0.0	11822.50	92.4	-1.6	6.4	11.2	0.0		1.0	
Turbine 13A	109.4	109.4	0.0	11583.45	92.3	-1.6	6.3	11.1	0.0		1.3	
Turbine 14A	109.4	109.4	0.0	11385.84	92.1	-1.6	6.3	10.9	0.0		1.6	
Turbine 15A	109.4	109.4	0.0	11068.44	91.9	-1.6	6.3	10.8	0.0		2.0	
Turbine 16A	109.4	109.4	0.0	10569.43	91.5	-1.5	6.3	10.5	0.0		2.7	
Turbine 17A	109.4	109.4	0.0	10302.26	91.3	-1.5	6.3	10.3	0.0		3.1	
Turbine 18A	109.4	109.4	0.0	10048.13	91.0	-1.5	6.3	10.1	0.0		3.5	
Turbine 19A	109.4	109.4	0.0	9822.85	90.8	-1.5	6.3	10.0	0.0		3.8	
Turbine 20A	109.4	109.4	0.0	9578.22	90.6	-1.5	6.3	9.8	0.0		4.2	
Turbine 01B	109.4	109.4	0.0	5770.40	86.2	-1.2	6.0	7.1	0.0		11.3	
Turbine 02B	109.4	109.4	0.0	5623.57	86.0	-1.2	6.0	7.0	0.0		11.7	
Turbine 03B	109.4	109.4	0.0	5207.75	85.3	-1.2	5.9	6.6	0.0		12.7	
Turbine 04B	109.4	109.4	0.0	4991.00	85.0	-1.1	5.9	6.5	0.0		13.2	
Turbine 05B	109.4	109.4	0.0	4715.66	84.5	-1.1	5.9	6.2	0.0		13.9	
Turbine 06B	109.4	109.4	0.0	4558.35	84.2	-1.1	5.8	6.1	0.0		14.4	
Turbine 07B	109.4	109.4	0.0	3837.28	82.7	-0.9	5.7	5.5	0.0		16.5	
Turbine 08B	109.4	109.4	0.0	3664.22	82.3	-0.9	5.6	5.3	0.0		17.1	
Turbine 09B	109.4	109.4	0.0	3491.64	81.9	-0.8	0.0	5.9	0.0		22.5	
Turbine 10B	109.4	109.4	0.0	3245.38	81.2	-0.7	5.5	4.9	0.0		18.5	
Turbine 11B	109.4	109.4	0.0	2900.32	80.2	-0.6	0.0	5.3	0.0		24.5	

Kibby Wind Energy Project - Mean Propogation
Kibby - Base Analysis - A Weighted

Source	PWL dB(A)	PWL/unit dB(A)	Non-Sphere dB	Distance m	Spreading dB	Ground Effct. dB	Ins. Loss dB	Air dB	Directivity dB	Reflection dB(A)	SPL dB(A)	Awind dB
Turbine 12B	109.4	109.4	0.0	2559.71	79.2	-0.4	0.0	4.9	0.0		25.8	
Turbine 13B	109.4	109.4	0.0	2273.58	78.1	-0.4	0.0	4.5	0.0		27.1	
Turbine 14B	109.4	109.4	0.0	1983.33	76.9	-0.4	0.0	4.2	0.0		28.6	
Turbine 15B	109.4	109.4	0.0	3036.32	80.6	-0.6	0.0	5.4	0.0		24.0	
Turbine 16B	109.4	109.4	0.0	3072.27	80.7	-0.7	0.0	5.5	0.0		23.9	
Turbine 17B	109.4	109.4	0.0	5771.33	86.2	-1.2	6.0	7.1	0.0		11.3	
Turbine 18B	109.4	109.4	0.0	5829.36	86.3	-1.2	6.0	7.1	0.0		11.2	
Turbine 19B	109.4	109.4	0.0	6112.45	86.7	-1.3	6.1	7.4	0.0		10.5	
Turbine 20B	109.4	109.4	0.0	5857.52	86.3	-1.3	6.0	7.2	0.0		11.1	
Turbine 21B	109.4	109.4	0.0	6028.05	86.6	-1.3	6.0	7.3	0.0		10.7	
Turbine 22B	109.4	109.4	0.0	5774.17	86.2	-1.2	6.0	7.1	0.0		11.3	
Turbine 23B	109.4	109.4	0.0	5648.82	86.0	-1.2	6.0	7.0	0.0		11.6	
Turbine 24B	109.4	109.4	0.0	5459.61	85.7	-1.2	6.0	6.9	0.0		12.0	
Turbine 25B	109.4	109.4	0.0	5239.94	85.4	-1.2	5.9	6.7	0.0		12.6	
Turbine 26B	109.4	109.4	0.0	6537.87	87.3	-1.3	6.1	7.7	0.0		9.6	
Turbine 27B	109.4	109.4	0.0	6823.59	87.7	-1.3	6.1	7.9	0.0		9.0	
Turbine 28B	109.4	109.4	0.0	6781.49	87.6	-1.3	6.1	7.9	0.0		9.1	
Substation	101.4	101.4	0.0	7645.35	88.7	-1.9	12.8	7.7	0.0		-5.9	

Kibby Wind Energy Project - Source Contribution
Kibby - Base Analysis - A Weighted

Source	SPL dB(_)	A dB(A)
Nearest Residence LrD 34.8 dB(A)		
Turbine 14B	28.6	0.0
Turbine 13B	27.1	0.0
Turbine 12B	25.8	0.0
Turbine 11B	24.5	0.0
Turbine 15B	24.0	0.0
Turbine 16B	23.9	0.0
Turbine 09B	22.5	0.0
Turbine 10B	18.5	0.0
Turbine 08B	17.1	0.0
Turbine 07B	16.5	0.0
Turbine 06B	14.4	0.0
Turbine 05B	13.9	0.0
Turbine 04B	13.2	0.0
Turbine 03B	12.7	0.0
Turbine 25B	12.6	0.0
Turbine 24B	12.0	0.0
Turbine 02B	11.7	0.0
Turbine 23B	11.6	0.0
Turbine 01B	11.3	0.0
Turbine 17B	11.3	0.0
Turbine 22B	11.3	0.0
Turbine 18B	11.2	0.0
Turbine 20B	11.1	0.0
Turbine 21B	10.7	0.0
Turbine 19B	10.5	0.0
Turbine 26B	9.6	0.0
Turbine 28B	9.1	0.0
Turbine 27B	9.0	0.0
Turbine 20A	4.2	0.0
Turbine 19A	3.8	0.0
Turbine 18A	3.5	0.0

Kibby Wind Energy Project - Source Contribution
Kibby - Base Analysis - A Weighted

Source	SPL dB(_)	A dB(A)
Turbine 17A	3.1	0.0
Turbine 16A	2.7	0.0
Turbine 15A	2.0	0.0
Turbine 08A	1.8	0.0
Turbine 11A	1.7	0.0
Turbine 14A	1.6	0.0
Turbine 07A	1.5	0.0
Turbine 13A	1.3	0.0
Turbine 10A	1.3	0.0
Turbine 06A	1.2	0.0
Turbine 12A	1.0	0.0
Turbine 09A	0.9	0.0
Turbine 05A	0.6	0.0
Turbine 04A	0.4	0.0
Turbine 03A	0.2	0.0
Turbine 02A	-0.3	0.0
Turbine 01A	-0.6	0.0
Substation	-5.9	0.0

Acoustical Terminology

Sound Power Levels & Sound Pressure Levels

Sound power level (PWL) is a single number that describes how much sound energy is radiated by a piece of equipment, independent of the surroundings or environment. Sound power level allows one piece of equipment to be directly compared with another, and then source-ranked to determine which should be attenuated first.

Sound power level is analogous to the wattage of a light bulb, whereas sound level is analogous to brightness. Sound power is *independent* of the environment, sound pressure is *dependant* on the environment. When a 75-watt light bulb is placed in a room painted white or black, it still radiates the same amount of energy. However, the apparent brightness of the light bulb does not remain the same; it changes as the environment changes. In the room painted white, many reflections are causing the apparent brightness of the bulb to increase, and in the room painted black, much of the light is being absorbed, so the apparent brightness decreases.

For sound, a room painted white is analogous to a contemporary home with sparse furnishings and hardwood floors, i.e., little absorbing material and many reflections. A room painted black is analogous to a colonial home with overstuffed chairs, carpets and paintings on the wall, i.e, many absorbing materials and fewer reflections. A blender or vacuum cleaner would have a higher sound level in the contemporary home versus the colonial one. Similar to the light bulb wattage however, the sound power level of the source would remain the same.

For the most part, no meter "directly" measures sound power. Instead, it is calculated from sound level measurements corrected for reflections, distance to the source, directivity, etc. Sound intensity meters can be used to determine the in-situ sound intensity level of a source, (power/unit area). Since these meters measure sound level and the direction that the sound comes from, they inherently account for reflections and other environmental factors. An adjustment for distance or area is then applied to the levels, to derive the sound power level of the equipment.

With respect to the relationship between sound power levels and sound pressure levels, the conversions are provided below. Note that the technique does not include air absorption effects, which can be significant at large distances. Moreover, the calculations are valid for free-field conditions only, (i.e., outdoors).

$$PWL = SPL + 20 \log (R) - 2$$

or

$$SPL = PWL - 20 \log (R) + 2$$

Where R is the distance in feet from the source to the receiving point.

Examples:

A small power plant is reported to have a sound power level of 114 dBA. What is the sound level at 250 feet?

$$SPL = 114 \text{ dBA} - 20 \text{ Log } (250) + 2$$

$$SPL = 68 \text{ dBA}$$

The sound level of a diesel pay loader is 85 dBA at 50 feet. What is the sound power level?

$$PWL = 85 + 20 \log (50) - 2$$

$$PWL = 117 \text{ dBA}$$

If instead, one has a sound pressure level (SPL_1) at a given distance (R_1) and wants to know what the sound pressure level (SPL_2) will be at another distance (R_2), then the formula becomes:

$$SPL_2 = SPL_1 - 20 \log (R_2/R_1)$$

The sound level of a transformer is given as 80 dBA at 50 feet. What is the sound level at 300 feet?

$$SPL_{300} = SPL_{50} - 20 \log (300/50)$$

$$SPL_{300} = 80 - 16$$

$$SPL_{300} = 64 \text{ dBA}$$

Note: Do no use these formulas to convert 3-foot sound levels from equipment manufacturers, to levels at further distances. The equations are only valid when both locations are significantly removed from the source, i.e., R_1 & R_2 $ 5x to 10x the largest dimension of the equipment.

Logarithmic Operations

"Rule of Thumb" Decibel Addition

Difference Between Two Sound Levels	Decibel(s) to Add to Higher Level
0 to 1	3
2 to 3	2
4 to 9	1
10 or more	0

Decibel Addition Example 1

- Two pieces of equipment each produce 53 dBA at 400 feet. The total sound level is:

  - Step 1 53 dBA - 53 dBA = 0

  - Step 2 53 dBA + 3 dBA = 56

Decibel Addition Example 2

- A third piece of equipment is added, which also produces 53 dBA at 400 feet. The total sound level becomes:

  - Step 1 56 dBA - 53 dBA = 3 dBA

  - Step 2 56 dBA + 2 dBA = 58 dBA

Decibel Addition Example 3

- Finally, a fourth unit is added. The total becomes:
  - Step 1 58 dBA - 53 dBA = 5 dBA
  - Step 2 58 dBA + 1 dBA = 59 dBA