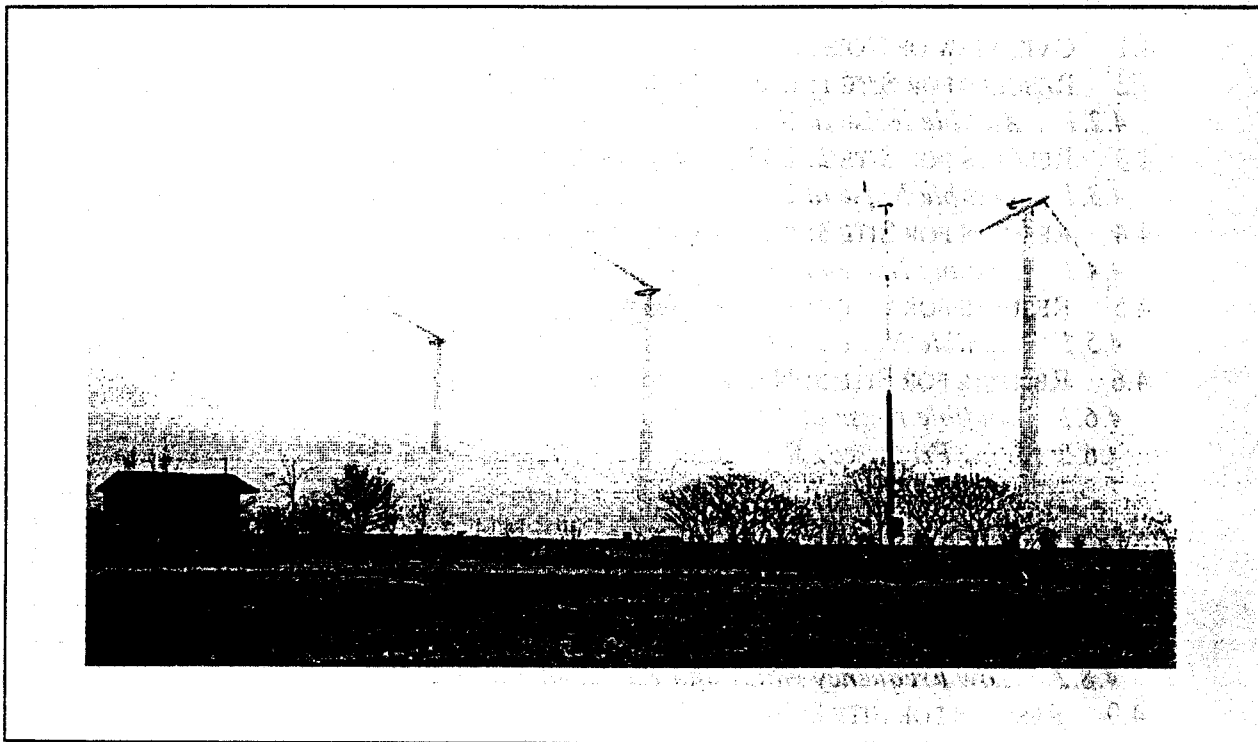


Lincoln Wind Energy Project

Acoustic Sound Measurement Report

Final / Summary Report
March 2001



Prepared For:

Wisconsin Public Service Corporation

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EXECUTIVE SUMMARY

Wisconsin Public Service (WPS) has received several noise complaints due to the operation of the wind turbines in Lincoln Township. In response to community concerns, a noise measurement program was undertaken to document and evaluate noise levels due

In conclusion, the results of both the long-term and short-term noise measurements show that the noise levels due to the turbines are within the limits for audible noise that are contained in the Conditional Use Permit. In addition, the results of the frequency analysis show that low frequency sound levels generated by the turbines are within the limits established by the Conditional Use Permit. Furthermore, the wind turbines were not observed to produce any pure tones, nor were they observed to produce any repetitive or impulsive sounds.

1 INTRODUCTION

Sanchez Industrial Design Inc. (SID) along with Harris Miller Miller & Hanson Inc. (HMMH) measured noise levels due to wind turbines that are owned and operated by Wisconsin Public Service Corporation (WPS). The objective of this study is to evaluate and quantify noise levels created by the wind turbines located in Lincoln Township, and to determine if noise levels due to the wind turbines are within the limits set by the Conditional Use Permit. This permit requires that wind turbine noise levels shall not exceed 50 dBA for any period of time. Furthermore, if noise due to the wind turbines contains a pure tone and/or repetitive impulsive sounds, a 5-dBA penalty will be applied to the standards for audible noise contained within the Conditional Use Permit.

Noise measurements were conducted at eight locations in the vicinity of the Lincoln wind turbines during four different seasons over the course of a year. The purpose of this report is to summarize the results of each set of measurements at each of the eight sites. More detailed information for the eight measurement sites is provided in the Site Reports.

The following report presents a description of the applicable noise metrics and the relevant criteria, a summary of the measurement results on a site-by-site basis, and a summary of conclusions.

2 NOISE METRICS

Environmental noise is made up of a conglomeration of noise sources, both distant and near, which provides a varying background sound called "natural ambient".

Superimposed on the ambient is a succession of transient noisy events that are short or long in duration which cause the noise levels to fluctuate from moment to moment.

Noise metrics have been developed to quantify the complex sound environment in terms of amplitude, pitch and time variation.

Sound is measured using a sound level meter with a microphone that responds accurately to all audible frequencies. However, humans can not hear all frequencies equally. For

sound level" (Leq-1 min) and the "1-second equivalent level" (Leq-1sec) are used respectively.

Statistical noise descriptors provide useful information about the fluctuating sound level during the measurement period, and are denoted with numerical subscripts (e.g. L10, L90). These descriptors represent a noise level that is exceeded a certain percentage of the measurement period. For example, the hourly L10 is the noise level exceeded for 10% of the measurement hour—that is, the fluctuating sound level is louder than this L10 for only 6 minutes out of the hour. Therefore, the L10 is nearly the highest sound level that occurred during the hour. On the other hand, L90 is the sound level exceeded 90% of the time; the sound level is lower than this for only 6 minutes out of the hour. The L90 often represents the "background" or ambient sound level.

3 RELEVANT CRITERIA

Noise levels due to the operation of the WPS wind turbines in Lincoln Township are subject to the noise limits established by the Conditional Use Permit. The relevant criteria for evaluating the measured noise levels due to the turbines are summarized below.

The Conditional Use Permit includes the following limits for measured noise levels at residences, schools, hospitals, churches, or public libraries:

- Audible noise due to the wind turbines shall not exceed 50 dBA for any period of time.
- Low frequency noise shall not exceed the following limits:

1/3 Octave Band Center Frequency (Hz)	Sound Pressure Level (dB)
2 to 1	70 (each band)
20	68
25	67
31.5	65
40	62
50	60
63	57
80	55
100	52
125	50

The Conditional Use Permit also states that if noise due to the wind turbines contains a pure tone and/or repetitive impulsive sounds, a 5-dBA penalty will be applied to the standards for audible noise. The relevant sections of the Conditional Use Permit that are related to noise are reproduced in Appendix A.

4 NOISE MEASUREMENT RESULTS

4.1 Overview of Noise Measurement Program

Long-term (unattended) noise measurements were conducted at four sites (Sites 1 to 4) to obtain the hourly fluctuations in the A-weighted noise levels. Larson Davis Model 870 and 820 Sound Level Meters were used to measure noise levels for 1-hour periods on a continuous basis. Each noise monitor was programmed to sample and store the following noise data for each 1-hour interval; Leq, L10, and L90 (for the equivalent noise level, the noise level exceeded 10 percent of the time, and the noise level exceeded 90 percent of the time, respectively). The noise monitors also were programmed to store continuous 1-sec Leqs for the entire duration of the measurements.

At four additional sites (Sites 5 to 8), short-term (attended) noise measurements were conducted to obtain continuous time histories of the A-weighted noise levels, as well as spectral data. A Larson Davis Model 820 Sound Level Meter was used to sample and store the Leq, L10, and L90 for each 1-minute interval and also 1-sec Leqs. Tape recordings were made with either a Sony Digital Audio Tape recorder or a TEAC 130 Digital Audio Tape Recorder. The recorded signals were processed to obtain several samples of spectral data at each short-term site both with the wind turbines ON and OFF.

The effect of wind on measured noise levels was an important consideration in this study. Wind at sufficient speeds can mask the sounds produced by wind turbines. Two components of wind noise that can adversely affect noise measurements are wind turbulence over the microphone windscreen and pressure fluctuations at the microphone diaphragm. To minimize these unwanted effects of wind noise, special 30-inch two-stage windscreens were used at each of the measurement sites.

Figure 1 shows the locations of the noise measurement sites, as well as the location of the wind monitor. For each of the eight measurement sites, Table 1 provides a summary of the measurement period, the type of data collected, and observed noise sources.

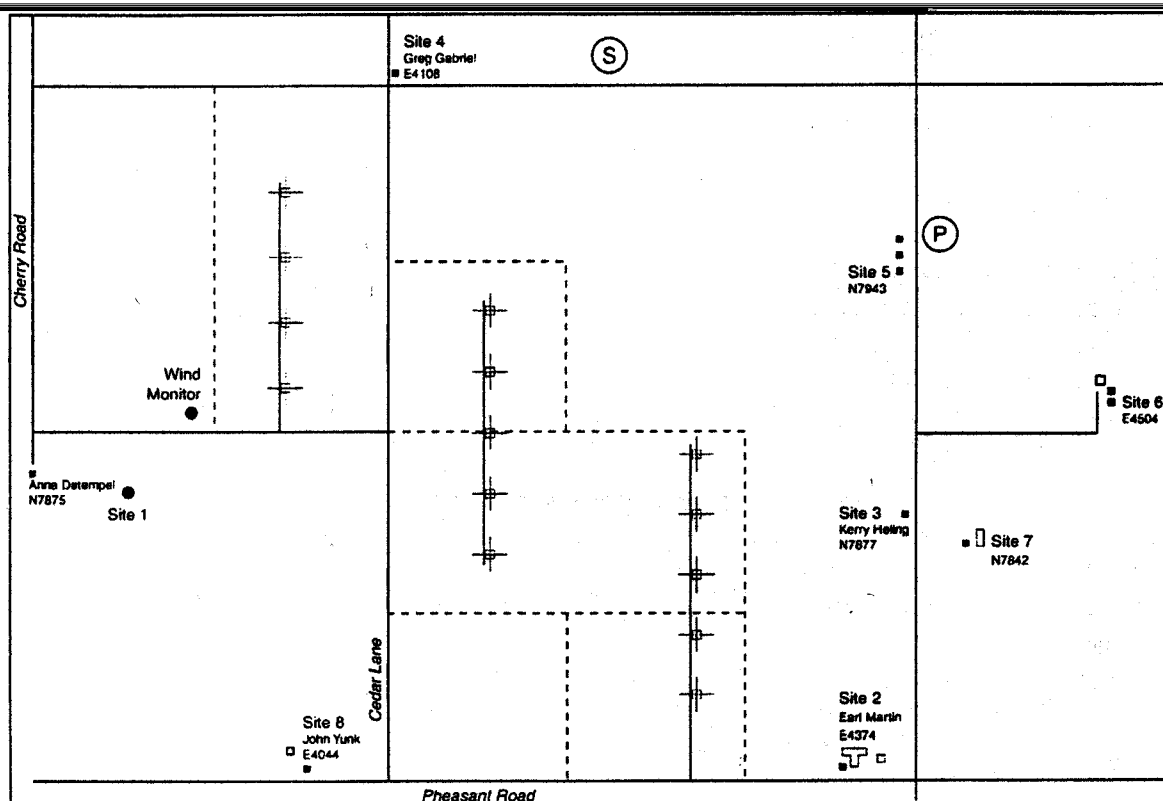


Figure 4.1-1. LOCATIONS OF NOISE MEASUREMENT SITES AND WIND MONITOR

Table 4.1-1. SUMMARY OF NOISE MEASUREMENT SITES

Site No.	Location	Long-term or Short-term	Type of Data
1	675 feet East of N7875 Cherry Road	Long-term	Hourly L10, Leq, L90, 1-sec Leq.
2	E4374 Pheasant Road	Long-term	Hourly L10, Leq, L90, 1-sec Leq.
3	N7877 County P	Long-term	Hourly L10, Leq, L90, 1-sec Leq.
4	E4108 County S	Long-term	Hourly L10, Leq, L90, 1-sec Leq.
5, 5a	N7943 County P	Short-term	1-minute L10, Leq, L90, 1-sec Leq & spectral data
6, 6a	E4504 County P	Short-term	1-minute L10, Leq, L90, 1-sec Leq & spectral data
7, 7a	N7842 County P	Short-term	1-minute L10, Leq, L90, 1-sec Leq & spectral data
8, 8a, 8b	E4044 Pheasant Road	Short-term	1-minute L10, Leq, L90, 1-sec Leq & spectral data

4.2 Results for Site 1: East of Cherry Road

4.2.1 Audible Noise at Site 1

Site 1 was located off a private road in a roughly plowed field with a small stand of trees to the north and a larger stand of trees to the southwest. This site was approximately

Although the measured data from Site 1 contain noise events that exceed 50 dBA, these noise levels were triggered by sources that were not related to the turbines. For example, sustained winds of 34 mph that were recorded during the March measurements caused the measured L90 to reach a maximum value of 59 dBA. At wind speeds approaching 15 to 20 mph, the effectiveness of the dual-stage windscreen is diminished.

Throughout each of the measurement periods, the turbines were observed to meet the limits for audible noise at Site 1.

Table 4.2-3 provides a summary of the wind speeds and directions that were recorded during each of the four seasons.

Table 4.2-2 SUMMARY OF HOURLY A-WEIGHTED NOISE LEVELS: SITE 1

Measurement Period	Range of L10 (dBA)	Range of Leq (dBA)	Range of L90 (dBA)
March 2000	69.8 – 38.5	73.9 – 36.7	59.2 – 28.6
June 2000	71.8 – 37.6	68.9 – 36	61.4 – 29.7
October 2000	58.6 – 24.5	55.2 – 23.0	49.1 – 21.3
January 2001	70.0 – 31.9	67.2 – 29.4	64.0 – 19.9

Table 4.2-3 WIND SPEEDS AND DIRECTIONS AT SITE 1

Measurement Period	Range of Wind Speed (mph)	Range of Wind Direction ¹
March 2000	5 to 34	South to southwest. One day from the north.
June 2000	3 to 33	Southeast to west.
October 2000	1 to 20	South to west.
January 2001	2 to 26	South to west. One day from the east.
Notes:		
1.) Winds from the east constitute a downwind condition for this site.		

4.3 Results for Site 2: E4374 Pheasant Road

4.3.1 Audible Noise at Site 2

Site 2 was located north of the house and barn at E4374 Pheasant Road with direct lines of sight to the closest turbines that were at a distance of approximately 990 feet from the microphone. Dominant noise sources at this site included the wind turbines and traffic on Pheasant Road and County P. Table 4.3-1 provides a summary of the major noise sources that were observed during each measurement period.

Table 4.3-1 NOISE SOURCES AT SITE 2

Measurement Period	Noise Sources ¹
March 2000	Wind turbines, cattle, thunderstorm, traffic on Pheasant Road and County P.
June 2000	Wind turbines, cattle, rain, road construction on County P and traffic on Pheasant Road and County P.

March 2000	5 to 34	South to southwest. One day from the north.
June 2000	3 to 33	Southeast to west.
October 2000	1 to 20	South to west.
January 2001	2 to 26	South to west. One day from the east.
<u>Notes:</u> 1.) Winds from the northwest constitute a downwind condition at this site.		

4.4 Results for Site 3: N7877 County P

4.4.1 Audible Noise at Site 3

Site 3 was located southwest of the house at N7877 County P with direct lines of sight to the closest turbines. The terrain along the western boundary of the backyard shielded the microphone from the farthest turbines. Dominant noise sources at this site included the wind turbines and traffic on County P. Table 4.4-1 provides a summary of the major noise sources that were observed during each measurement period.

Table 4.4-1 NOISE SOURCES AT SITE 3

Measurement Period	Noise Sources ¹
March 2000	Wind turbines, thunderstorm, activities at the house, other distant human-related activities and traffic on County P.
June 2000	Wind turbines, activities at the house, other distant human-related activities, road construction equipment and traffic on County P.
October 2000	Wind turbines, activities at the house, other distant human-related activities and traffic on County P.
January 2001	Wind turbines and traffic on County P.
<u>Notes:</u> 1.) Wind noise at the microphone windscreen was present whenever wind speeds exceeded 15 mph.	

Long-term (unattended) noise measurements were conducted at this site during each of the four seasons. Table 4.4-2 provides a summary of the hourly A-weighted noise levels that were measured at this site including, the L10, the Leq, and the L90.

Although the measured data from Site 3 contain noise events that exceed 50 dBA, these noise levels were triggered by sources that were not related to the turbines. For example, heavy rain that accompanied a thunderstorm on June 18th generated noise levels that exceeded 50 dBA due to the raindrops that struck the plywood base of the dual-stage windscreen. During periods without any other intrusive noise sources, the turbines were observed to meet the limit for audible noise in the Conditional Use Permit.

At the request of the homeowner, the microphone was placed in the backyard about 12

Table 4.4-3 provides a summary of the wind conditions that were recorded during each of the four seasons.

Table 4.4-2 SUMMARY OF HOURLY A-WEIGHTED NOISE LEVELS: SITE 3

Measurement Period	Range of L10 (dBA)	Range of Leq (dBA)	Range of L90 (dBA)
March 2000	72.5 - 30.4	67.9 - 28.5	46.2 - 23.4

Long-term (unattended) noise measurements were conducted at this site during each of the four seasons. Table 4.5-2 provides a summary of the hourly A-weighted noise levels that were measured at this site including, the L10, the Leq, and the L90.

Although the measured data from Site 4 contain noise events that exceed 50 dBA, these events were not related to the turbines. During periods without any other intrusive noise sources, the turbines were observed to meet the limit for audible noise in the Conditional Use Permit.

At the request of the homeowner, the microphone was placed in the backyard about 45 feet east of the house and 30 feet from the road for the October measurements (Site 4a). The purpose of these measurements was compare the sound levels at Site 4a with simultaneous noise measurements at Site 4 to determine whether there would be a difference in the measured noise levels on different sides of the house. The results of the comparison indicated that noise levels at Site 4a were approximately 3 dBA lower than

Site 5 was located to the south of the residence at N7943 County P, and was partially shielded from the northernmost turbines by other buildings on the property. This site also was partially shielded from the southern turbines by the intervening terrain. Short-term (attended) noise measurements were conducted at this site during each of the four seasons. During each measurement program, a time-log was kept of individual noise events and noise sources.

Because this site was approximately 1,970 feet from the closest turbine, measured noise levels were affected by other sources, such as wind in the trees and traffic on County P. Table 4.6-1 provides a summary of the different noise sources that were observed during each of the measurement periods. As shown in the table, many additional noise sources were observed during the March 2000 measurements because these measurements were conducted during normal daytime hours (between 10 AM and 11 AM). During the other two measurement periods (October 2000 and January 2001), the noise measurements were conducted during nighttime hours when there was less overall activity.

Table 4.6-1 NOISE SOURCES AT SITE 5

Measurement Period	Noise Sources
March 2000	Wind turbines, traffic on County P, wind in the trees, wind in the ear, birds and a dog.
June 2000	N/A
October 2000	Wind turbines, traffic on County P and dogs.
January 2001	Wind turbines.
Note: Wind noise at the microphone windscreen was present whenever wind speeds exceeded 15 mph.	

Table 4.6-2 provides a summary of the measured one-minute Leq, L10 and L90 at Site 5 during each of the measurement periods. While measured sound levels are shown to exceed 50 dBA during the March 2000 measurements, these sound levels were caused by sources other than the turbines. During the March 2000 measurements, one-second Leqs due to the turbines ranged from 36 to 47 dBA, while car passbys on County P generated noise levels that ranged from 54 to 63 dBA (refer to the appropriate Site Reports for details).

Table 4.6-2 SUMMARY OF ONE-MINUTE A-WEIGHTED NOISE LEVELS: SITES 5 & 5a

Measurement Site / Period	Range of L10 (dBA)		Range of Leq (dBA)		Range of L90 (dBA)	
	Turbines ON	Turbines OFF	Turbines ON	Turbines OFF	Turbines ON	Turbines OFF
March 2000	56.3 - 37.8	43.2 - 32.7	51.7 - 36.2	41.0 - 31.7	43.5 - 33.8	39.7 - 30.3
June 2000	N/A	N/A	N/A	N/A	N/A	N/A
October 2000	-	50.8 - 21.8	-	46.4 - 21.3	-	29.2 - 20.7

October 2000	41.5 - 37.6	48.1 - 28.8	40.5 - 37.5	43.9 - 27.3	39.4 - 34.7	30.0 - 24.9
January 2001	37.1 - 34.5	25.4 - 22.0	36.4 - 34.0	23.5 - 21.9	35.3 - 33.6	22.2 - 21.6

The measured one-minute sound levels in Table 4.3-2 indicate some seasonal variation. In general, noise levels with the turbines ON were highest during the March measurements, and lowest during the January 2001 measurements. This variation in measured sound levels was primarily due to the different wind speeds and directions that were observed during each measurement period. In March 2000, the winds were from the west at speeds from 13 to 16 mph, representing a *strong* downwind condition for this site. In comparison, the wind speeds were only 5 to 6 mph out of the southwest during the January 2001 measurements, representing less of a downwind condition than was observed in March 2000. Table 4.6-3 provides a summary of the observed wind speeds and directions at Site 5.

Table 4.3-3 WIND SPEEDS AND DIRECTIONS AT SITE 5

Measurement Period	Range of Wind Speed (mph)	Range of Wind Direction ¹
March 2000	13 to 16	West
June 2000	N/A	N/A
October 2000	2 to 3	Southwest
October 2000	8 to 11	Southwest
January 2001	5 to 6	Southwest
Notes: 1.) Winds from the west and southwest constitute a downwind condition for this site.		

4.6.2 Low Frequency Noise and Pure Tones at Site 5

Spectral data were analyzed for five different one-minute periods with the turbines both ON and OFF; tape recordings at Site 5 were made in March and October 2000, and in January 2001. One-minute periods with little or no intrusion from non-turbine events were selected for the spectral analysis. For each one-minute interval, spectral data were analyzed for the 1/3-octave bands from 16 Hz to 10 kHz. These spectra were evaluated with respect to the limits for low frequency noise, and then for the presence of pure tones.

Fifteen samples of spectral data obtained at Site 5 (over three seasons) were found to meet the limits for low frequency noise as contained in the Conditional Use Permit (subsection 6, subparagraph b).

The spectral data obtained during each of the three measurement periods at Site 5 did not contain any pure tones with the turbines ON (as defined in subsection 6, subparagraph c of the Conditional Use Permit). However, during the March 2000 measurements, a pure tone in the 1/3-octave band centered at 3.15 kHz was observed during a one-minute interval starting at 10:30 with the turbines OFF. During this one-minute interval, wind in the trees was the dominant source.

Appendix B provides plots of the spectral data for Site 5 with the turbines ON.

4.7 Results for Site 6: E4504 County P

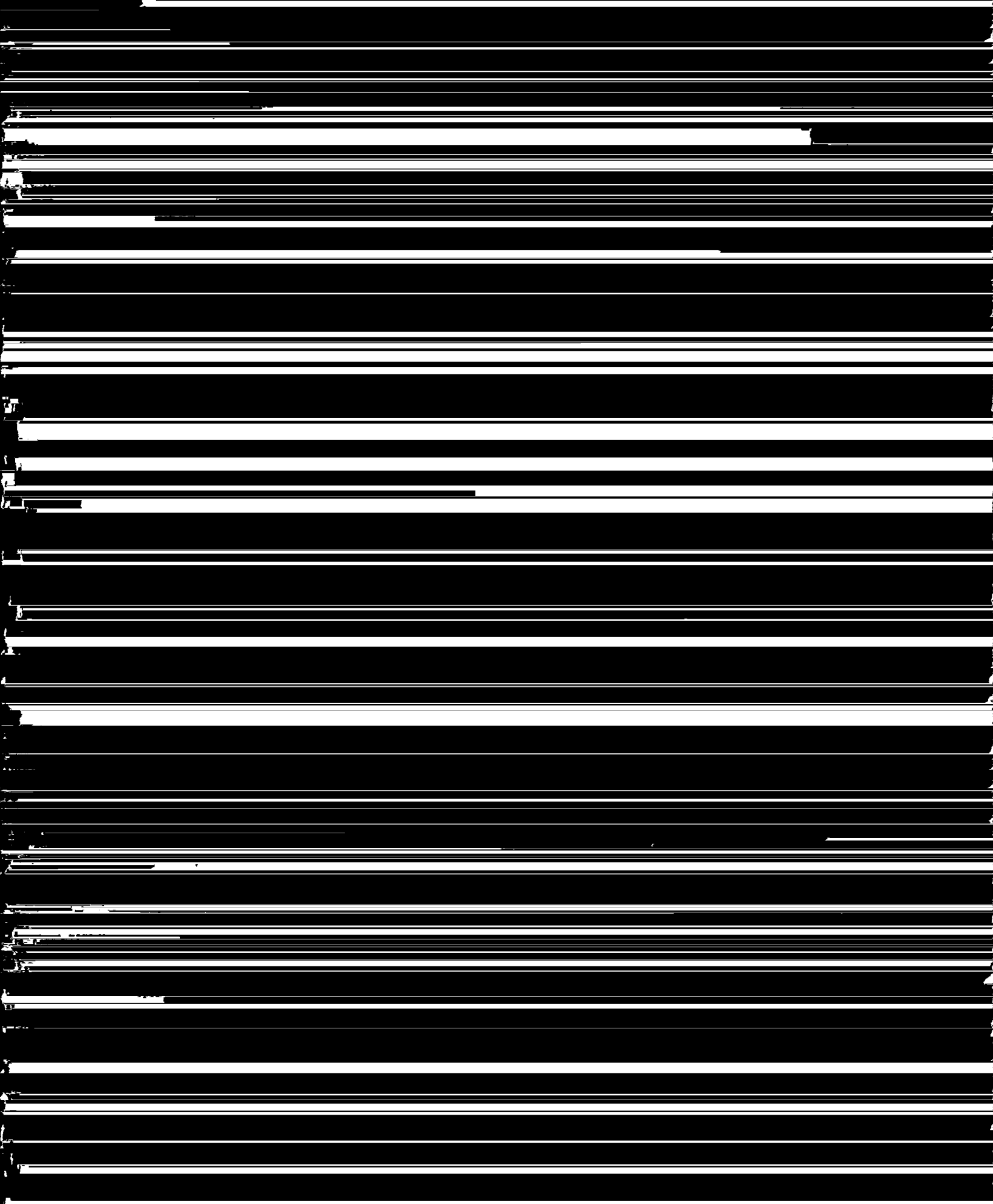
4.7.1 Audible Noise at Site 6

Site 6 was located to the west of the residence at E4504 County P, and was shielded from the wind turbines by trees and the intervening terrain. Short-term (attended) noise measurements were conducted at this site during each of the four seasons. During each measurement program, a time log was kept of individual noise events and noise sources

Because this site is approximately 2830 feet from the closest turbine, measured noise levels were affected by other sources, such as wind in the trees and traffic on County P. Table 4.7-1 provides a summary of the different noise sources that were observed during each of the measurement periods. As shown in the table, many additional noise sources were observed during the March 2000 measurements because these measurements were

For example, in January 2001, the measured L90 with the turbines OFF ranged from 21

each of the four seasons. One-minute periods with little or no intrusion from non-turbine events were selected for the spectral analysis. For each one-minute interval, spectral data



Measurement Site & Period	Noise Sources ¹
Site 7; Mar-00	Wind turbines, traffic on County P, wind in the trees, wind in the ear, birds, dogs, squirrels and gun shots.
Site 7a; Mar-00	Wind turbines, and a single car passby.
Site 7a; Jun-00	Wind turbines and cars.
Site 7a; Oct-00	Wind turbines, wind in the trees and car traffic.
Site 7a; Jan-01	Wind turbines.
<u>Note:</u> 1.) Wind noise at the microphone windscreen was present whenever wind speeds exceeded 15 mph.	

Table 4.8-2 provides a summary of the measured one-minute Leq, L10 and L90 at Sites 7 and 7a during each of the measurement periods. Although the one-minute A-weighted noise levels for March and June were shown to exceed 50 dB during periods with the

Measurement Site & Period	Range of Wind Speed (mph)	Range of Wind Direction ¹
Site 7; Mar-00	4 to 14	West
Site 7a; Mar-00	13 to 21	West
Site 7a; Jun-00	4 to 9	Southeast
Site 7a; Oct-00	9 to 11	West
Site 7a; Jan-01	5 to 8	Southwest
<u>Notes:</u> 1.) Downwind conditions for this site would be winds from the west.		

4.8.2 Low Frequency Noise and Pure Tones at Site 7

Spectral data were analyzed for five different one-minute periods with the turbines both ON and OFF; tape recordings at Site 7 were made in March and October 2000, and in January 2001. One-minute periods with little or no intrusion from non-turbine events were selected for the spectral analysis. For each one-minute interval, spectral data were analyzed for the 1/3-octave bands from 16 Hz to 10 kHz. These spectra were evaluated with respect to the limits for low frequency noise, and then for the presence of pure tones.

Fifteen samples of spectral data obtained at Site 7 (over three seasons) were found to meet the limits for low frequency noise as contained in the Conditional Use Permit (subsection 6, subparagraph b).

The spectral data obtained during each of the three measurement periods at Site 7 did not contain any pure tones with the turbines ON (as defined in subsection 6, subparagraph c of the Conditional Use Permit).

Appendix B provides plots of the spectral data for Site 7 with the turbines ON.

4.9 Results for Site 8: E4044 Pheasant Road

4.9.1 Audible Noise at Site 8

Site 8 was located to the northeast of the house at E4044 Pheasant Road, whereas Site 8b was located to the northwest of the house. Short-term (attended) noise measurements were conducted at these sites during each of the four seasons. During each measurement program, a time-log was kept of individual noise events and noise sources.

Both sites had unobstructed views of the turbines and were 1,980 feet or more from the closest wind turbine, and only 100 to 200 feet from Pheasant Road. At these distances, measured noise levels were affected by sources other than the turbines, such as traffic on Pheasant Road and farm equipment. Table 4.9-1 provides a summary of the different noise sources that were observed during each of the measurement periods.

Table 4.9-1 NOISE SOURCES AT SITES 8 & 8b

Measurement Period	Noise Sources
March 2000	Wind turbines, traffic on Pheasant Road, wind in the trees, thunder, heavy rain, birds, cattle and farm equipment.
June 2000	N/A
October 2000	Wind turbines and traffic on Pheasant Road.
January 2001	Wind turbines and furnace.

As shown in Table 4.9-1, many additional noise sources were observed during the March measurements at Site 8 because these measurements were conducted during normal daytime hours (between 2:00 PM and 5:00 PM). Because the wind turbines were only somewhat audible due to an upwind condition, when other noise sources were present they tended to mask the noise from the wind turbines. During the other measurement periods, the noise measurements were conducted during nighttime hours when there were fewer occurrences of intrusive noise sources that were unrelated to the turbines.

Table 4.9-2 provides a summary of the measured one-minute Leq, L10 and L90 at Sites 8 and 8b during each of the measurement periods. Although the one-minute A-weighted noise levels for March were shown to exceed 50 dB during periods with the turbines ON, these noise levels were due to events that were unrelated to the turbines. For example, a thunderstorm triggered noise events with one-minute Leqs that exceeded 50 dBA, 60 dBA, and then 70 dBA, as this fast-moving storm approached the microphone. Prior to the passing thunderstorm, noise levels due to the turbines were generally less than 40 dBA with winds from the west (an upwind condition for this site).

Table 4.9-2 SUMMARY OF ONE-MINUTE A-WEIGHTED NOISE LEVELS: SITES 8 & 8b

Measurement Period	Range of L10 (dBA)		Range of Leq (dBA)		Range of L90 (dBA)	
	Turbines ON	Turbines OFF	Turbines ON	Turbines OFF	Turbines ON	Turbines OFF
March 2000	88.0 - 36.7	66.4 - 38.4	85.8 - 35.8	62.8 - 37.5	50.2 - 33.1	56.9 - 35.2
March 2000	51.4 - 33.1	61.4 - 28.9	46.8 - 32.3	56.2 - 27.9	33.6 - 30.7	32.6 - 24.3
June 2000	N/A	N/A	N/A	N/A	N/A	N/A
October 2000	45.0 - 33.9	52.8 - 27.7	40.9 - 33.1	49.0 - 26.8	34.1 - 32.1	27.8 - 25.7
January 2001	35.3 - 33.0	33.8 - 22.9	34.2 - 32.7	33.1 - 22.2	33.1 - 32.1	32.2 - 22.0

Table 4.9-3 WIND SPEEDS AND DIRECTIONS AT SITES 8 & 8b

Measurement Site & Period	Range of Wind Speed (mph)	Range of Wind Direction ¹
Site 8; Mar-00	13 to 18	West
Site 8; Mar-00	11 to 14	North
Site 8; Jun-00	N/A	N/A
Site 8; Oct-00	6 to 8	West
Site 8; Jan-01	5 to 7	Southwest
Notes:		
1.) Winds from the north constitute a downwind condition for this site.		

4.9.2 Low Frequency Noise and Pure Tones at Site 8

Spectral data were analyzed for five different one-minute periods with the turbines both ON and OFF; tape recordings at Site 8 were made in March and October 2000, and in January 2001. One-minute periods with little or no intrusion from non-turbine events were selected for the spectral analysis. For each one-minute interval, spectral data were analyzed for the 1/3-octave bands from 16 Hz to 10 kHz. These spectra were evaluated with respect to the limits for low frequency noise, and then for the presence of pure tones.

Fifteen samples of spectral data obtained at Site 8 (over three seasons) were found to meet the limits for low frequency noise as contained in the Conditional Use Permit (subsection 6, subparagraph b).

The spectral data obtained in March 2000 contained a pure tone in the 1/3-octave band centered at 4 kHz during a single one-minute interval; this tone was due to wind in the trees.

The spectral data obtained in January 2001 contained a pure tone in the 1/3-octave band centered at 400 Hz during several one-minute intervals; this tone was due to the operation of the homeowner's furnace, and was present when the turbines were OFF.

During each of the other measurement periods at Site 8, the measured spectra did not contain any pure tones with the turbines ON (as defined in subsection 6, subparagraph c of the Conditional Use Permit).

Appendix B provides plots of the spectral data for Site 8 with the turbines ON.

5 CONCLUSION

The results of both the long-term and short-term noise measurements show that the noise levels due to the turbines are within the limits for audible noise that are contained in the Conditional Use Permit. In addition, the results of the frequency analysis show that low frequency sound levels generated by the turbines are within the limits established by the Conditional Use Permit. Furthermore, the wind turbines were not observed to produce any pure tones, nor were they observed to produce any repetitive or impulsive sounds.

Appendix A – Conditional Use Permit: Noise Limits

6. Noise.

- a. Audible noise due to wind turbine operations shall not exceed fifty (50) dBA for any period of time, when measured at any residence, school, hospital, church, or public library existing on the date of approval of this Permit.
- b. Low frequency noise or infrasound from wind turbine operations shall not exceed the following limits when measured at any residence, school, hospital, church, or public library existing on the date of approval of this Permit.

One-third Octave Band Center Frequency (Hz)	Sound Pressure Level (dB)
2 to 1	70 (each band)
20	68
25	67
31.5	65
40	62
50	60
63	57
80	55
100	52
125	50

- c. In the event audible noise due to wind turbine operations contains a steady pure tone, such as a whine, screech, or hum, the standards for audible noise set forth in Subparagraph a of this subsection shall be reduced by five (5) dBA. A pure tone is defined to exist if the one-third (1/3) octave band sound pressure level in the band, including the tone, exceeds the arithmetic average of the sound pressure levels of the two (2) contiguous one-third (1/3) octave

bands by five (5) dBA for center frequencies of five hundred (500) Hz and above, by eight (8) dBA for center frequencies between one hundred and sixty (160) Hz and four hundred (400) Hz, or by fifteen (15) dBA for center frequencies less than or equal to one hundred and twenty-five (125) Hz.

- d. In the event the audible noise due to wind turbine operations contains repetitive impulsive sounds, the standards for audible noise set forth in

Subparagraph a of this subsection shall be reduced by five (5) dBA. "Repetitive impulsive sounds", as used in this Section shall refer to mechanical sounds, such as clanking, jarring, hammering, pounding or whistling

- e. In the event the audible noise due to wind turbine operations contains both a pure tone and repetitive impulsive sounds, the standards for audible noise set forth in Subparagraph a of this subsection shall be reduced by a total of five (5) dBA.
- f. In the event the ambient noise level (exclusive of the development in question) exceeds one (1) of the standards given above, the applicable standard shall be adjusted so as to equal ft ambient noise level. For audible noise, the ambient noise level shall be expressed in terms of the highest whole number sound pressure level in dBA which is exceeded for more than five (5) minutes per hour. For low frequency noise or infrasound, the ambient noise level shall be expressed in terms of the equivalent level (Leq) for the one-third (1/3) octave band in question, rounded to the nearest whole decibel. Ambient noise levels shall be at the exterior of potentially affected existing residences, schools, hospitals, church", or public libraries, Ambient noise level measurement techniques shall employ all practical means of reducing the effect of wind-generated noise at the microphone. Ambient noise level measurements may be performed when wind velocities at the proposed project site are sufficient to allow wind turbine operation, provided that the wind velocity does not exceed thirty (30) mph at the ambient noise measurement location.
- g. Any noise level failing between two (2) whole decibels shall be the lower of the two (2).
- h. In the event the noise levels, resulting from the Project, exceed the criteria listed above, a waiver to said levels may be granted by the Town Zoning Administrator provided that the following has been accomplished:
 - i. Written consent from the affected property owners has been obtained stating that they are aware of the Project and the noise limitations imposed by this Permit, and that consent is granted to allow noise levels to exceed the maximum limits allowed.
 - ii. If WPS wishes the waiver to apply to succeeding owners of the Property, a permanent noise impact easement has been recorded in the Office of the Kewaunee County Register of Deeds which describes the benefited and burdened properties and which advises all subsequent owners of the burdened property that noise levels in

APPENDIX B – PLOTS OF SPECTRAL DATA WITH TURBINES “ON”

excess of those permitted by this Permit may exist on or at the
burdened property,

