SOUND LEVEL ASSESSMENT REPORT

Dogtown Wind Project
Ford County, Illinois

Alstom ECO 122 Turbine Option

Prepared for:

Akuo Energy
150 North Michigan Avenue, Suite 2800
Chicago, IL 60601

Prepared by:

Epsilon Associates, Inc.
3 Clock Tower Place, Suite 250
Maynard, MA 01754

December 12, 2012

TABLE OF CONTENTS

1.0 INTRODUCTION AND SUMMARY 1-1

2.0 SOUND METRICS 2-1

3.0 NOISE REGULATIONS 3-1
- 3.1 Federal Regulations 3-1
- 3.2 Illinois State Regulations 3-1
- 3.3 Local Regulations 3-2

4.0 SOUND FROM WIND TURBINES 4-1

5.0 EXISTING SOUND LEVELS 5-1
- 5.1 Overview 5-1
- 5.2 Sound Level Environment 5-1
- 5.3 Sound Level Measurement Locations 5-1
- 5.4 Sound Measurement Methodology 5-3
- 5.5 Sound Level Measurement Equipment 5-4
- 5.6 Measured Sound Levels 5-5
  - 5.6.1 Location 1 – Elliot Property on County Road 300 5-5
  - 5.6.2 Location 2 – Johnson Property on County Road 300 5-6
  - 5.6.3 Location 3 – Cleary Property on County Road 200 5-6
  - 5.6.4 Location 4 – Swan Property on County Road 100 5-6

6.0 WIND SPEED AND EXISTING SOUND LEVELS 6-1
- 6.1 Wind Speed Measurement Equipment and Data 6-1
- 6.2 Existing Sound Levels under Operational Conditions 6-1

7.0 FUTURE CONDITIONS 7-1
- 7.1 Equipment and Operating Conditions 7-1
- 7.2 Modeling Scenarios 7-1
- 7.3 Sound Level Results 7-6

8.0 EVALUATION OF SOUND LEVELS 8-1

9.0 CONCLUSIONS 9-1

LIST OF APPENDICES

Appendix A Continuous Sound Level Measurements

LIST OF FIGURES

Figure 2-1	Common Indoor and Outdoor Sound Levels	2-3
Figure 5-1	Sound Level Measurement Locations	5-2
Figure 7-1	Predicted Project Only Broadband Sound Levels	7-9
Figure 8-1	Predicted Project-Only Sound Levels – 1,000 Hz	8-4

LIST OF TABLES

Table 3-1	Allowable Sound Level Limits (dB)	3-2
Table 5-1	GPS Coordinates -- Sound Level Measurement Locations	5-3
Table 6-1	Existing L_{eq} Sound Levels under Operational Conditions	6-2
Table 6-2	Existing L_{90} Sound Levels under Operational Conditions	6-2
Table 7-1(a)	Alstom ECO 122 – Maximum Octave Band Sound Power Levels	7-3
Table 7-1(b)	Alstom ECO 122 – Sound Power at 10 m/s Hub Height Wind Speed	7-4
Table 7-2	Standard 110 MVA Electrical Transformer	7-4
Table 7-3(a)	Modeled Wind Turbine Coordinates	7-5
Table 7-3(b)	Modeled Transformer Coordinate	7-6
Table 7-4	Cadna/A Prediction Results: Analysis #2 Project Only Sound Levels	7-6
Table 8-1	Project-Only Sound Levels Compared to IPCB Nighttime Limits	8-2

1.0 INTRODUCTION AND SUMMARY

Epsilon Associates, Inc. (Epsilon) is pleased to present this sound level assessment report to Akuo Energy for the proposed Dogtown Wind Project (the Project) consisting of 37 Alstom ECO 122 wind turbines to be located in Ford County, Illinois. This sound level assessment discusses the results of a sound-monitoring program aimed at measuring existing sound levels in the vicinity of the Project, details of the computer modeling used to predict future sound levels when the wind turbines and electrical substation are operational, and a comparison of worst-case operational sound levels with state and local regulations.

The results of this impact assessment show that the Project will be at or below the limits identified in the Illinois Pollution Control Board regulations with respect to Class "C" to Class "A" octave band sound levels at each of the modeled homes as well as at the estimated extents of all Class "A" property. In addition, sound levels from the Alstom wind turbines are not anticipated to cause a violation of the IPCB regulation with respect to prominent discrete tones.

2.0 SOUND METRICS

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

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

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

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

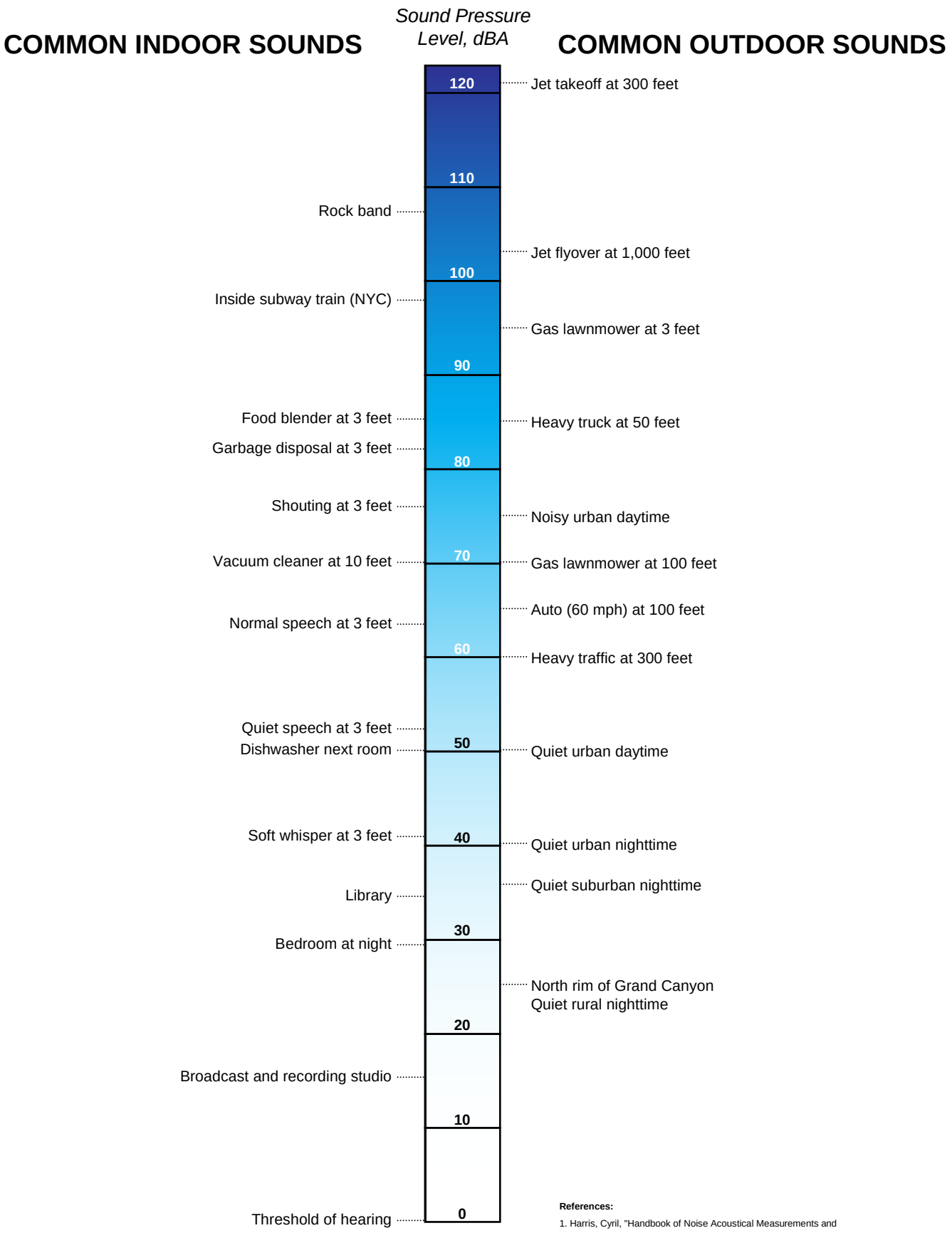
Because the sounds in our environment vary with time they cannot simply be described with a single number. Two methods are used for describing variable sounds. These are exceedance levels and the equivalent level, both of which are derived from a large number of moment-to-moment A-weighted sound level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

---

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

- L_{90} is the sound level in dBA exceeded 90 percent of the time during the measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.

- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is also A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Figure 2-1

Common Indoor and Outdoor Sound Levels

3.0 NOISE REGULATIONS

3.1 Federal Regulations

There are no federal community noise regulations applicable to this Project.

3.2 Illinois State Regulations

The Illinois Pollution Control Board (IPCB) has sound emission standards and limitations for property-line-noise-sources as specified in Part 901. Section 901.102 contains the most stringent limits which are for single family residences (Class "A" Land). Class "C" Lands include agricultural use such as crop production and include the class of land on which wind turbines are located. Table 3-1 summarizes the daytime and nighttime IPCB sound level limits for sources located on Class "C" land as measured on Class "A" land. These limits are not to be exceeded when measured at any point within the Class "A" land.

Section 901.106 prohibits the creation of any prominent discrete tones (PDT). A PDT is a sound having a one-third octave band sound pressure level which, when measured in a one-third octave band at the preferred frequencies, exceeds the arithmetic average of the sound pressure levels of the two adjacent one-third octave bands on either side of such one-third octave band by the amount shown below provided that such one-third octave band sound pressure level exceeds the sound pressure level of each adjacent one-third octave band:

- 5 dB for such one-third octave band with a center frequency from 500 Hertz (Hz) to 10,000 Hz inclusive.
- 8 dB for such one-third octave band with a center frequency from 160 Hz to 400 Hz inclusive.
- 15 dB for such one-third octave band with a center frequency from 25 Hz to 125 Hz inclusive.

Section 901.106(b) notes that the PDT prohibition in 901.106(a) does not apply to low sound levels. Low sound levels are defined in Section 901.106(b) as those having a one-third octave band sound pressure level 10 or more dB below the allowable octave band sound pressure level specified in Section 901.102 for the octave band which contains such one-third octave band.

Table 3-1 Allowable Sound Level Limits (dB)

Octave Band Center Frequency (Hz)	Emitted from Class C Land to Class A Land	
	Daytime (7 am – 10 pm)	Nighttime (10 pm – 7 am)
31.5	75	69
63	74	67
125	69	62
250	64	54
500	58	47
1000	52	41
2000	47	36
4000	43	32
8000	40	32

3.3 Local Regulations

Appendix A, Part VIII of the Ford County Zoning Ordinance (Adopted March 13, 2006 and Revised June 2009) specifies noise standards for wind energy conversion systems which reference the aforementioned IPCB regulations. Demonstrated compliance with the state noise limits constitutes compliance with the county zoning ordinance as well. There are no additional noise limits explicitly provided in this document.

4.0 SOUND FROM WIND TURBINES

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

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

---

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

5.0 EXISTING SOUND LEVELS

5.1 Overview

The Dogtown Wind Project will be located in Ford County, Illinois. The Project will consist of 37 Alstom ECO 122 wind turbines with a hub height of 88.5 meters and a rotor diameter of 122 meters. Figure 5-1 shows the extent of the Project.

5.2 Sound Level Environment

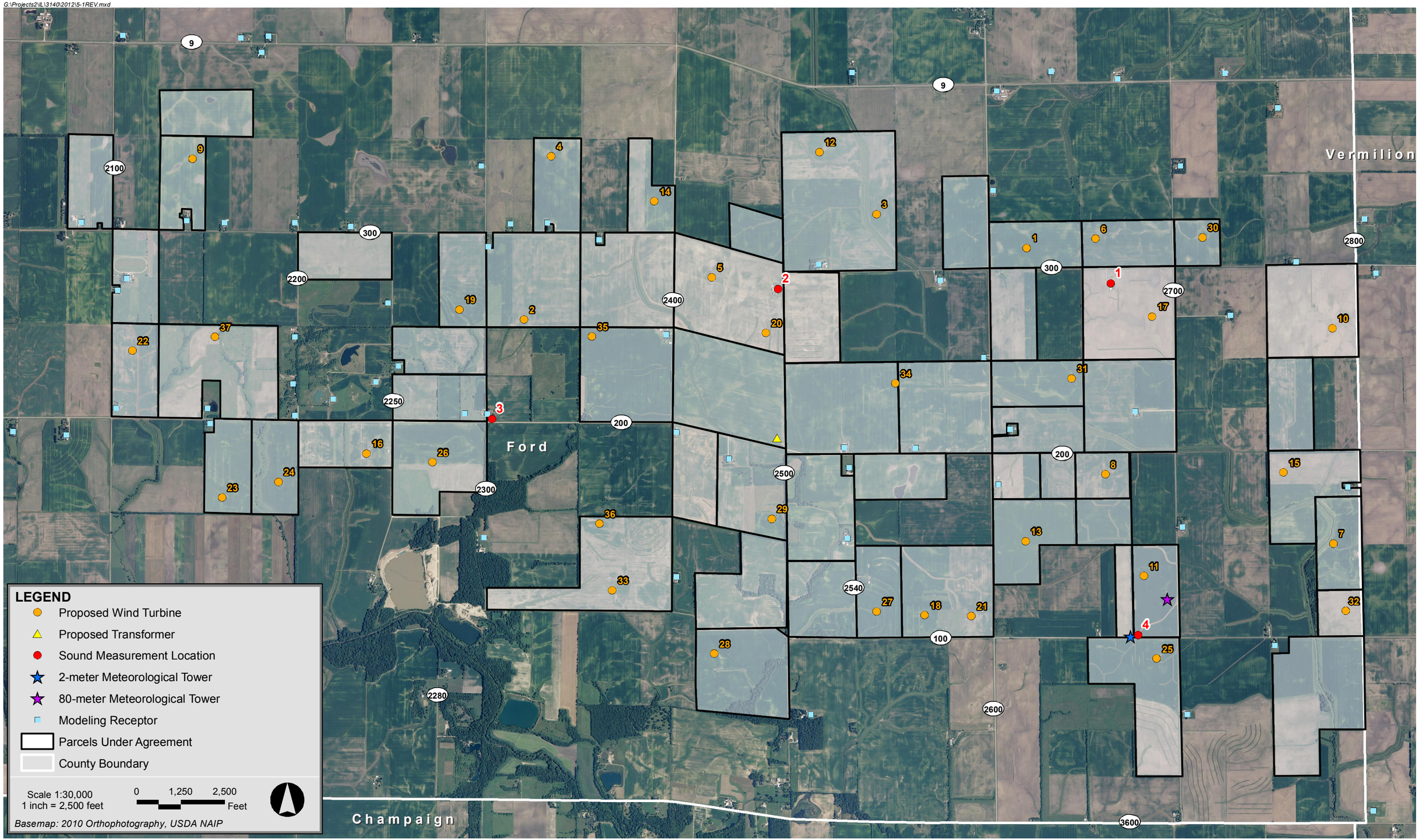
An ambient sound level survey was conducted to characterize the current acoustical environment under varying wind conditions in the vicinity of the Project. Noise sources included: insects, rustling vegetation, wind, birds, traffic on local roads, and nearby construction activity.

5.3 Sound Level Measurement Locations

The selection of the sound monitoring locations was intended to include locations representative of nearby residences in various directions around the wind farm. An aerial photograph of the Project site is shown in Figure 5-1, which shows the county lines, the locations of the proposed wind turbines, nearby residences, and the sound measurement locations. The actual measurement locations are described below. The coordinates for the sound level measurement locations were obtained by Epsilon staff in the field using a Global Positioning System (GPS) instrument with an accuracy of approximately three meters. All distances shown are rounded to the nearest 10 feet.

- Location 1 – Property Owned by Chris Elliot on County Road 300
  - Approximately 1,270 feet to the closest proposed wind turbine (20). Continuous sound level data were collected at this location. This location is representative of residences located near the northeast of the Project.
- Location 2 – Property Owned by T. J. Johnson on County Road 300
  - Approximately 770 feet to the closest proposed wind turbine (7). Continuous sound level data were collected at this location. This location is representative of the residences near the north of the Project.

G:\Projects2\IL\3140\2012\5-1REV.mxd



Akuo Energy - Dogtown Wind Project **Ford County, Illinois**

Epsilon ASSOCIATES INC.

Figure 5-1

Sound Level Measurement Locations

- **Location 3 – Property Owned by Raymond Cleary on County Road 200**
  - Approximately 1,780 feet to the closest proposed wind turbine (3). Continuous sound level data were collected at this location. This location is representative residences near the southwest of the Project.
- **Location 4 – Property Owned by Dean Swan on County Road 100**
  - Approximately 740 feet to the closest proposed wind turbine (13). Continuous sound level data were collected at this location, as well as wind speed and wind direction data. This location is representative of residences near the southeast of the Project

Table 5-1 lists the GPS coordinates for the four sound level measurement locations. All coordinates are in NAD 1983 UTM Zone 16N.

Table 5-1 GPS Coordinates – Sound Level Measurement Locations

Location	X (m)	Y (m)
Location 1 – Elliot Property (Co. Rd. 300)	418734	4477159
Location 2 – Johnson Property (Co. Rd. 300)	415862	4477110
Location 3 – Cleary Property (Co. Rd. 200)	413394	4475989
Location 4 – Swan Property (Co. Rd. 100)	418971	4474124

5.4 Sound Measurement Methodology

A comprehensive sound level measurement program was developed to quantify the existing ambient sound levels around the Project. Approximately one week of ambient sound level measurements was taken from Wednesday, August 31, 2011 to Thursday, September 8, 2011. Continuous broadband and one-third octave band sound level measurements were made at all four locations. Ground-level wind speeds were continuously measured and logged at one of the sound level measurement locations and an 80-meter-high meteorological tower measured and logged wind speeds near hub height during the sound level measurement period. Meteorological data from the closest National Weather Service (NWS) station in Rantoul, IL were also archived for the duration of the measurement period.

Sound levels were measured at a height of approximately four feet ten inches above the ground at locations where there were no large reflective surfaces to affect the measured levels. Field personnel checked on the integrity of the equipment during the first day, first night, second day, and last day of monitoring.

During these checks, hand-held wind speed measurements were made with a Davis Instruments TurboMeter electronic wind speed indicator, and temperature and humidity measurements were made using a hand-held digital psychrometer.

At Location 1, Elliot Property on County Road 300, one continuous programmable unattended sound level meter was placed near a barn on the property, adjacent to corn fields on all sides. The sound level meter was located approximately 430 feet from the road. Data were collected and analyzed from this location from 11:20 a.m. Wednesday August 31 until 9:50 p.m. Monday September 5, at which time the sound level meter stopped logging data due to an internal logging error.

At Location 2, Johnson Property on County Road 300, one continuous programmable unattended sound level meter was placed in the cleared field adjacent to corn fields on all sides as well as various farm equipment and barns. The sound level meter was located approximately 510 feet from the road. Data were collected and analyzed from this location from 12:00 p.m. Wednesday August 31 until 10:10 a.m. Thursday September 8.

At Location 3, Cleary Property on County Road 200, one continuous programmable unattended sound level meter was placed on the front lawn of the residence. The property currently consists of a residence with several barns as well as soy bean fields, with a wooded area and a soy bean field across the road. The sound level meter was located approximately 80 feet from the road and approximately 80 feet south the nearest residence. Data were collected and analyzed from this location from 12:50 p.m. Wednesday August 31 until 10:40 a.m. Thursday September 8.

At Location 4, Swan Property on County Road 100, one continuous programmable unattended sound level meter was placed in a cleared area near the road. The property currently consists of soy bean fields to the north, east and south, and a corn crop to the west. The sound level meter was located approximately 70 feet from the road. Data were collected and analyzed from this location from 10:30 a.m. Wednesday August 31 until 12:00 p.m. Thursday September 8. Continuous wind speed and direction measurements were also logged at this location, at a comparable height to the sound level meter.

5.5 Sound Level Measurement Equipment

Three Larson Davis model 831 integrating sound level meters (Locations 2, 3, & 4) and one Norsonic model NOR140 integrating sound level meter (Location 1) were used during the field program. All instrumentation met the "Type 1 - Precision" requirements set forth in American National Standards Institute (ANSI) S1.4-1983 (sound level meter standard). All instrumentation also met ANSI S1.11-2004 (octave filter standard) for acoustical measuring devices. The microphones were tripod-mounted at a height of approximately four feet ten inches above ground. The meters were connected to the microphone by a five meter cable, and the meters were housed in a protective weatherproof suitcase. An environmental windscreen was used on all microphones.

The measurement equipment was calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator which meets the standards of IEC 942 Class 1L and ANSI S1.40-1984. All calibrations were within $\pm$ 0.5 dB from the most recent calibration. The meters were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology by an independent laboratory within the past 12 months. The Larson Davis 831 and the Norsonic NOR140 measure broadband A-weighted sound levels and one-third octave band sound levels. All instruments have data logging capability and were programmed to log statistical data every 10 minutes for the following parameters: L_1, L_{10}, L_{50}, L_{90}, L_{max}, and L_{eq}.

5.6 Measured Sound Levels

During the sound level measurement program there were several periods of precipitation. These periods were identified through a review of the observations from the closest National Weather Service station in Rantoul, IL. Sound level data from the following periods listed were excluded from the analysis due to precipitation although they are shown in the continuous sound level measurement figures.

- From 6:50 p.m. on Saturday, September 3 to 7:30 p.m. on Saturday, September 3
- From 8:30 p.m. on Saturday, September 3 to 9:10 p.m. on Saturday, September 3
- From 5:50 a.m. on Sunday, September 4 to 6:30 a.m. on Sunday, September 4
- From 6:50 a.m. on Sunday, September 4 to 7:30 a.m. on Sunday, September 4
- From 8:50 a.m. on Sunday, September 4 to 10:30 a.m. on Sunday, September 4

A brief summary of the measured sound levels and noise sources from each location is provided below. During one time period, a spike in the sound levels occurred at all four locations and was likely due to a weather event. Elevated sound levels occurred at each location during different time periods throughout the program and were most likely due to local sound sources such as wind noise, construction, etc.

5.6.1 Location 1 – Elliot Property on County Road 300

Sound levels at the monitor at the Elliot Property were dominated by insects, rustling vegetation, and wind noise but were also influenced by birds, vehicles on local roads, and aircraft. The sound levels from the continuous measurements are presented in Figure A-1 in Appendix A. The continuous 10-minute steady-state (L_{90}) measurements ranged from 28 to 51 dBA, while the continuous 10-minute equivalent (L_{eq}) measurements ranged from 29 to 60 dBA.

5.6.2 Location 2 – Johnson Property on County Road 300

Sound levels at the monitor at the Johnson Property were dominated by insects, rustling vegetation, and wind noise but were also influenced by birds, vehicles on local roads, and aircraft. The sound levels from the continuous measurements are presented in Figure A-2 in Appendix A. The continuous 10-minute steady-state (L_{90}) measurements ranged from 22 to 56 dBA, while the continuous 10-minute equivalent (L_{eq}) measurements ranged from 24 to 63 dBA.

5.6.3 Location 3 – Cleary Property on County Road 200

Sound levels at the monitor at the Cleary Property were dominated by local traffic on CR 1000 during the day and insect noise at night. Sound levels were also influenced by birds, wind, local human activity, and aircraft. The sound levels from the continuous measurements are presented in Figure A-3 in Appendix A. The continuous 10-minute steady-state (L_{90}) measurements ranged from 31 to 53 dBA, while the continuous 10-minute equivalent (L_{eq}) measurements ranged from 33 to 67 dBA.

5.6.4 Location 4 – Swan Property on County Road 100

Sound levels at the monitor at the Swan Property were dominated by insects, rustling vegetation, and wind noise but were also influenced by birds, vehicles on local roads, and aircraft. The sound levels from the continuous measurements are presented in Figure A-4 in Appendix A. The continuous 10-minute steady-state (L_{90}) measurements ranged from 22 to 58 dBA, while the continuous 10-minute equivalent (L_{eq}) measurements ranged from 25 to 60 dBA.

6.0 WIND SPEED AND EXISTING SOUND LEVELS

6.1 Wind Speed Measurement Equipment and Data

Wind speed can have a strong influence on ambient sound levels. In order to understand how the existing sound levels are influenced by wind speed, continuous wind speed and direction data were recorded at one of the sound level monitoring locations. A HOBO H21-002 micro-weather station (manufactured by Onset Computer Corporation) with tripod and data logger was used to continuously measure the wind speed and wind direction. The wind sensors were mounted at an approximate height of 4 feet 10 inches above ground level and data were logged every 10 minutes. This wind instrument has a measurement range of 0 to 44 m/s (99 mph) and an accuracy of +/- 0.5 m/s (1.1 mph). The starting threshold is 0.5 m/s (1.1 mph). The wind direction measurement range is 0 to 358 degrees (2-degree dead band), with an accuracy of +/- 5 degrees. In addition to the HOBO station, an onsite meteorological tower logged wind speeds at a height of 80 meters above ground level every 10 minutes. The location of this meteorological tower is shown in Figure 5-1. The continuous ground level wind speeds and the 80-meter wind speeds from the onsite meteorological tower are presented in Figures A-1 through A-4 (see Appendix A).

6.2 Existing Sound Levels under Operational Conditions

Cut-in and cut-out wind speed for the proposed wind turbines are 3.0 m/s (6.7 mph) and 25 m/s (56 mph), respectively, at a hub-height of 88.5 meters. Wind speeds from the onsite meteorological tower were scaled from 80 meters to 88.5 meters (hub-height) using the power-law extrapolation and a wind shear coefficient of $\alpha = 0.23$ in order to determine which periods during the measurement program were representative of operational conditions. The wind shear value was calculated by a third party wind analyst, Hatch™, in the wind resource assessment report[3] provided by Akuo Energy.

According to the IPCB's procedures outlined in Part 910, "To minimize wind effects on the microphone, sound measurements must not be taken when the wind velocity is greater than 12 miles per hour (5.4 m/second) at the microphone position."

Operational conditions with respect to a sound level evaluation would consist of no precipitation, wind speeds of at least 3.0 m/s (6.7 mph) but no greater than 25 m/s (56 mph) at a height of 88.5 meters, and wind speeds at the height of the microphone no greater than 5.4 m/s (12 mph).

There were 705-1068 10-minute periods per location under the operational conditions described above during the background measurement program. The corresponding L_{eq} and L_{90} sound levels under these conditions were then identified for each of the four sound level

---

[3] Hatch, Wind Resource Assessment for Dogtown, IL, Site No. 4303, January 5, 2012.

measurement locations. The existing L_{eq} sound levels for each location during no precipitation and under adequate wind speeds are summarized in Table 6-1. The existing L_{90} sound levels for each location during no precipitation and under adequate wind speeds are summarized in Table 6-2. The measured sound levels are in the expected range of what one would expect to find for this type of land-use during this season, although construction noise may have influenced the sound levels at different periods throughout the measurement program.

Table 6-1 Existing L_{eq} Sound Levels under Operational Conditions

Location	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)	Median L_{eq} (dBA)	Average L_{eq} (dBA)
1 – Elliot Property (Co. Rd. 300)	29	60	47	45
2 – Johnson Property (Co. Rd. 300)	24	59	44	44
3 – Cleary Property (Co. Rd. 200)	33	65	47	47
4 – Swan Property (Co. Rd. 100)	24	60	45	44

Table 6-2 Existing L_{90} Sound Levels under Operational Conditions

Location	Minimum L_{90} (dBA)	Maximum L_{90} (dBA)	Median L_{90} (dBA)	Average L_{90} (dBA)
1 – Elliot Property (Co. Rd. 300)	28	51	45	43
2 – Johnson Property (Co. Rd. 300)	22	53	41	40
3 – Cleary Property (Co. Rd. 200)	31	53	40	40
4 – Swan Property (Co. Rd. 100)	22	58	40	40

7.0 FUTURE CONDITIONS

7.1 Equipment and Operating Conditions

The 37 proposed wind turbines modeled for the Project are Alstom ECO 122 units. Each 2.7 megawatt (MW) wind turbine will have three blades with a rotor diameter of 122 meters and will be installed on an 88.5-meter tower. A report from Alstom Wind, s.l.u.[4] was provided by Akuo Energy which documented the expected sound power levels associated with the Alstom wind turbine. This document included overall, octave, and 1/3 octave band A-weighted sound power levels for various wind speeds. According to the technical document the maximum sound power level of 106 dBA occurs at a wind speed of 10 m/s at hub height.

There will be a single electrical substation serving the wind turbines which is expected to include a 110 MVA transformer. No equipment-specific sound level data are currently available for the unit so reference sound levels for the transformer were calculated using the procedures found in section 4.2.5 of the Electric Power Plant Environmental Noise Guide (Edison Electric Institute, Washington, DC, 1984). A broadband sound power level of 99 dBA was calculated using the provided "supplementary data approximation" equations while octave-band levels were calculated using "Estimation Method 1."

7.2 Modeling Scenarios

The noise impacts associated with the proposed wind turbine generators and electrical substation were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. Cadna/A differs with noise predictions that are based on spreadsheet calculations which offer more of a screening-level approach, since they do not typically include the effects of topography, various ground attenuations, and multiple building reflections. The Cadna/A software allows for octave band calculation of noise from multiple noise sources, as well as computation of diffraction around building edges, and multiple reflections off parallel buildings and solid ground areas.

Since one wind speed did not result in maximum sound power levels in all octave bands, two analyses were conducted for the sound level impact assessment. Instead of evaluating the sound levels under each possible wind speed, the maximum sound power presented in the Alstom technical document for each octave band was modeled (Analysis #1). This allowed for comparison with the IPCB limits with one model run but resulted in a

---

4 Alstom Wind, s.l.u., Acoustic Noise Emission of the ECO 122, July 13, 2012.

broadband sound power level which was above the maximum broadband sound power presented by Alstom since these maximum octave band levels were not representative of a particular wind speed condition. Therefore, a second analysis was conducted to calculate the broadband sound pressure levels in the community for the wind speed with the highest broadband sound power level, 10 m/s at hub height.

The sound power levels for Analysis #1 prior to any correction for uncertainty are presented in Table 7-1(a). These values correspond to the maximum sound power levels presented in the Alstom technical document for each octave band. The sound power levels in the Alstom technical document are identified as "estimated theoretically". Since these were not guaranteed values an uncertainty factor of 2 dB was applied to 35 of the 37 modeled wind turbines. Initial analyses of the layout indicated that the sound levels presented in the technical document for wind turbines #7 and #37 would need to be guaranteed in order for the project to meet the IPCB limits. Therefore, the sound power levels for these two wind turbines do not include an uncertainty factor. It is assumed that Akuo Energy will reach an agreement with Alstom to provide wind turbines with guaranteed maximum sound power levels at or below the values modeled in this analysis.

The sound power levels for Analysis #2 prior to any correction for uncertainty are presented in Table 7-1(b). These values correspond to the sound power levels presented in the Alstom technical document for the 10 m/s hub height wind speed case. Since data was not provided for the 31.5 Hz octave band, the sound power level was extrapolated from the best-fit sound power level curve between 63Hz and 8k Hz. These sound power levels were assigned to 35 of the 37 wind turbines plus an uncertainty factor of 2 dB since these values were "estimated theoretically". For wind turbines #7 and #37 the guaranteed sound power levels used in Analysis #1 were also used in Analysis #2.

One transformer at the proposed substation was modeled in each analysis. The modeled octave band sound power levels for the transformer are presented in Table 7-2.

Each analysis evaluated the same wind turbine layout provided by Akuo Energy on November 9, 2012. The coordinates for the proposed wind turbines are presented in Table 7-3(a) and are shown graphically in Figure 7-1. The location of the transformer was estimated based on the substation footprint provided by Akuo Energy on October 30, 2012. Its location is presented in Table 7-3(b) and in Figure 7-1.

The locations of 64 residences in the vicinity of the Project were provided by Akuo Energy on October 29, 2012 and are shown in Figure 7-1. Sound levels were computed assuming that the receptors are always located directly downwind from all turbines simultaneously. This is a physical impossibility but provides conservative results and is required by the ISO 9613-2 standard. In addition, Figure 7-1 shows the properties participating in the Project. This information was provided by Akuo Energy on October 30, 2012.

The terrain height contour elevations for the modeling domain were derived from a Digital Elevation Model (DEM) created by the US Geological Survey. This allowed for consideration of terrain shielding where appropriate. The modeling software was run with meteorological conditions of 10 degrees C (50 degrees F), and 70% relative humidity.

Table 7-1(a) Alstom ECO 122 – Maximum Octave Band Sound Power Levels

Frequency (Hz)	Sound Power (dBA)*
31.5	79.5**
63	85.4
125	91.4
250	99.3
500	102.1
1000	100.6
2000	98.9
4000	95.0
8000	87.9

* Does not include 2 dB uncertainty factor

** Data not provided by manufacturer. Extrapolated from best-fit sound power level curve between 63Hz and 8kHz for the 10 m/s wind speed case.

Table 7-1(b) Alstom ECO 122 – Sound Power at 10 m/s Hub Height Wind Speed

Frequency (Hz)	Sound Power (dBA)*
31.5	79.5**
63	83.0
125	89.3
250	95.5
500	101.8
1000	100.6
2000	97.5
4000	94.4
8000	87.4
Total	106.0

* Does not include 2 dB uncertainty factor

** Data not provided by manufacturer. Extrapolated from best-fit sound power level curve between 63Hz and 8kHz

Table 7-2 Standard 110 MVA Electrical Transformer

Frequency (Hz)	Sound Power* (dB)
31.5	95.6
63	101.6
125	103.6
250	98.6
500	98.6
1000	92.6
2000	87.6
4000	82.6
8000	75.6
Total (dBA)	99.0

* Calculated from Estimation Method 1 of §4.2.5 of the Electric Power Plant Environmental Noise Guide (Edison Electric Institute, Washington, DC, 1984) using the supplementary data approximation.

Table 7-3(a) Modeled Wind Turbine Coordinates

Wind Turbine ID	UTM NAD83 Zone 16N	
	Easting (meters)	Northing (meters)
1	418009	4477466
2	413669	4476849
3	416712	4477759
4	413904	4478258
5	415289	4477214
6	418604	4477546
7	420656	4474914
8	418687	4475514
9	410805	4478237
10	420647	4476775
11	419020	4474636
12	416219	4478296
13	417998	4474935
14	414794	4477870
15	420225	4475528
16	412309	4475693
17	419091	4476874
18	417129	4474297
19	413111	4476936
20	415756	4476733
21	417531	4474288
22	410286	4476580
23	411061	4475313
24	411549	4475449
25	419131	4473923
26	412878	4475617
27	416714	4474329
28	415311	4473966
29	415806	4475129
30	419526	4477557
31	418397	4476341
32	420763	4474334
33	414431	4474513
34	416873	4476297
35	414254	4476703
36	414319	4475087
37	411001	4476699

Table 7-3(b) Modeled Transformer Coordinate

Transformer ID	UTM NAD83 Zone 16N	
	Easting (meters)	Northing (meters)
1	415853	4475827

7.3 Sound Level Results

Table 7-4 shows the predicted "Project-only" broadband (dBA) sound levels for Analysis #2 at the 64 modeling locations due to wind turbine operations under wind speeds resulting in the highest broadband sound power (10m/s @ hub height). These levels do not include any contribution from the existing noise sources in the area. The predicted sound levels due to wind turbine operation at the 64 modeling locations range from 34 to 46 dBA. The predicted Project Only broadband sound levels for the Analysis #2 are shown as isolines in Figure 7-1. Included in this figure is a 47 dBA isoline. Akuo Energy has an internal guideline of 47 dBA for all existing homes. All modeling locations are predicted to have sound levels due to the wind turbines below 47 dBA. The broadband sound levels are not regulated by the IPCB, but are provided for informational purposes.

Table 7-4 Cadna/A Prediction Results: Analysis #2 Project Only Sound Levels

Modeling Location	UTM NAD83 Zone 16N		Broadband Sound Level (dBA)
	Easting (meters)	Northing (meters)	
1	416217	4477321	45
2	417258	4477190	44
3	414899	4476722	46
4	414986	4475877	43
5	416462	4474957	45
6	416430	4475747	44
7	417051	4475741	45
8	415438	4475649	45
9	417764	4475425	46
10	413352	4476035	45
11	412584	4476444	44
12	412497	4476994	44
13	413548	4477675	44
14	413303	4478176	43
15	412176	4477653	40
16	418946	4476057	46

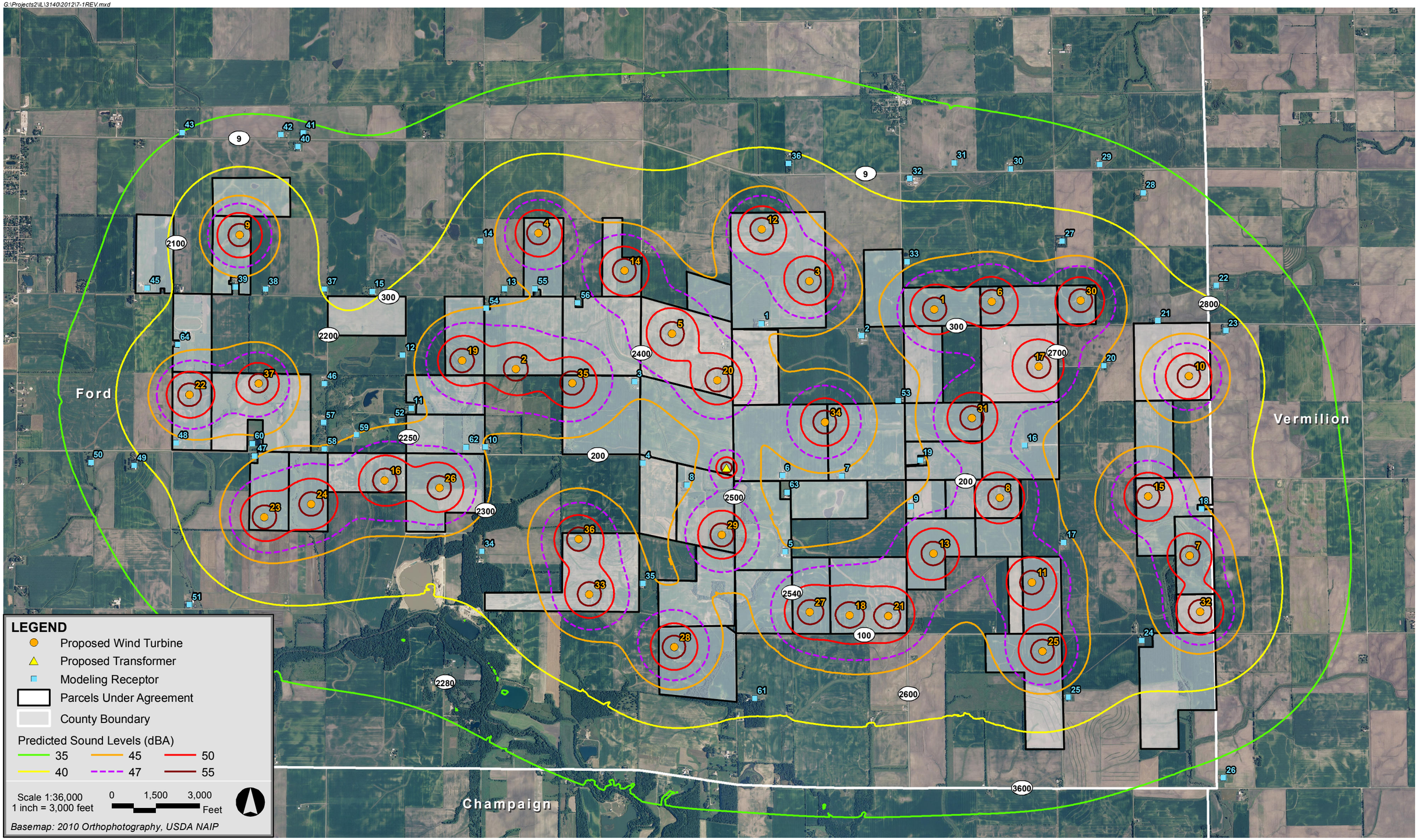
Table 7-4 Cadna/A Prediction Results: Analysis #2 Project Only Sound Levels (Continued)

Modeling Location	UTM NAD83 Zone 16N		Broadband Sound Level (dBA)
	Easting (meters)	Northing (meters)	
17	419355	4475055	46
18	420778	4475400	46
19	417862	4475905	45
20	419763	4476885	45
21	420330	4477348	43
22	420929	4477713	39
23	421027	4477245	42
24	420155	4474036	43
25	419398	4473443	43
26	421005	4472609	34
27	419333	4478176	43
28	420172	4478677	37
29	419720	4478971	36
30	418799	4478928	38
31	418216	4478988	38
32	417753	4478819	39
33	417721	4477964	44
34	413320	4474962	43
35	414986	4474630	46
36	416501	4478982	41
37	411685	4477680	40
38	411081	4477680	43
39	410760	4477702	44
40	411408	4479156	37
41	411468	4479298	36
42	411228	4479282	36
43	410209	4479304	35
44	410237	4477206	43
45	409850	4477691	39
46	411685	4476700	43
47	410961	4475948	45
48	410144	4476084	44
49	409714	4475850	39
50	409262	4475883	36
51	410287	4474409	37

Table 7-4 Cadna/A Prediction Results: Analysis #2 Project Only Sound Levels (Continued)

Modeling Location	UTM NAD83 Zone 16N		Broadband Sound Level (dBA)
	Easting (meters)	Northing (meters)	
52	412388	4476314	45
53	417637	4476522	44
54	413364	4477480	45
55	413870	4477683	45
56	414313	4477538	46
57	411672	4476295	44
58	411686	4476024	45
59	412020	4476163	45
60	410933	4476079	45
61	416145	4473435	41
62	413158	4476040	46
63	416477	4475571	44
64	410162	4477104	44

G:\Projects2\IL\3140\2012\7-1REV.mxd



Akuo Energy - Dogtown Wind Project **Ford County, Illinois**

Epsilon ASSOCIATES INC.

Figure 7-1

Predicted Project-Only Broadband Sound Levels

8.0 EVALUATION OF SOUND LEVELS

The Illinois Pollution Control Board (IPCB) has limits for the sound levels measured on residential land (Class "A" Land) which are specified in Section 901.102 of the regulations. These limits are on an octave band basis and are not to be exceeded when measured at any point within the Class "A" land. Table 8-1 shows the predicted "Project-only" sound levels for Analysis #1 at each of the modeled receptor locations as compared to the most stringent nighttime IPCB limit. All modeling locations (homes) meet each of the octave band limits.

As illustrated in Table 8-1, the modeled sound levels are closest to the 1,000 Hz octave band limit as compared to the other octave bands. Not only do these limits apply to the home but also to all of the Class "A" land on which the home is situated. To evaluate compliance with this portion of the regulation, the predicted Project-only 1,000 Hz sound level of 41.4 dB for Analysis #1 was overlaid onto an aerial photograph in Figure 8-1. Areas within the 41.4 dB isoline would be above the 41 dB nighttime limit at 1,000 Hz. Areas outside the isoline would round down to the 41 dB limit or be below the limit, i.e. in compliance. In general, areas within this isoline are agricultural land where the limit does not apply and therefore not exceeded. All Class A land in the vicinity of the Project is anticipated to meet the IPCB sound level limits. This evaluation is based on the assignment of land use designations based on the review of the aerial imagery in the immediate area surrounding modeling locations. In situations where land use was questionable based on the aerial imagery, Epsilon relied upon Akuo Energy for the designation of land use.

Section 901.106 of the IPCB regulations prohibits the creation of any prominent discrete tones (PDT). A PDT is a sound having a one-third octave band sound pressure level which, when measured in a one-third octave band at the preferred frequencies, exceeds the arithmetic average of the sound pressure levels of the two adjacent one-third octave bands on either side of such one-third octave band by the amount shown in Section 3.2 of this report provided that such one-third octave band sound pressure level exceeds the sound pressure level of each adjacent one-third octave band. Sound pressure level calculations using the Cadna/A modeling software and the ISO 9613-2 standard it incorporates are limited to octave band sound levels; therefore, one-third octave band sound levels in the community were not calculated and a quantitative evaluation of this portion of the regulation was not conducted. One-third octave band sound power levels were provided by the manufacturer and do not exhibit a PDT. A paper by Pedersen and Persson Waye states that modern wind turbines with upwind blades do not have prominent discrete tones from aerodynamic sources and that mechanical equipment associated with the wind turbine may emit prominent discrete tones; however, tones due to mechanical equipment can be reduced "efficiently".[5] In addition, Epsilon has not measured sound levels at residences

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

near existing wind farms in Illinois which would have violated the IPCB regulation with respect to prominent discrete tones. **It is unlikely that there will be a PDT in the community resulting from the operation of the proposed wind turbines.**

Table 8-1 Project-Only Sound Levels Compared to IPCB Nighttime Limits

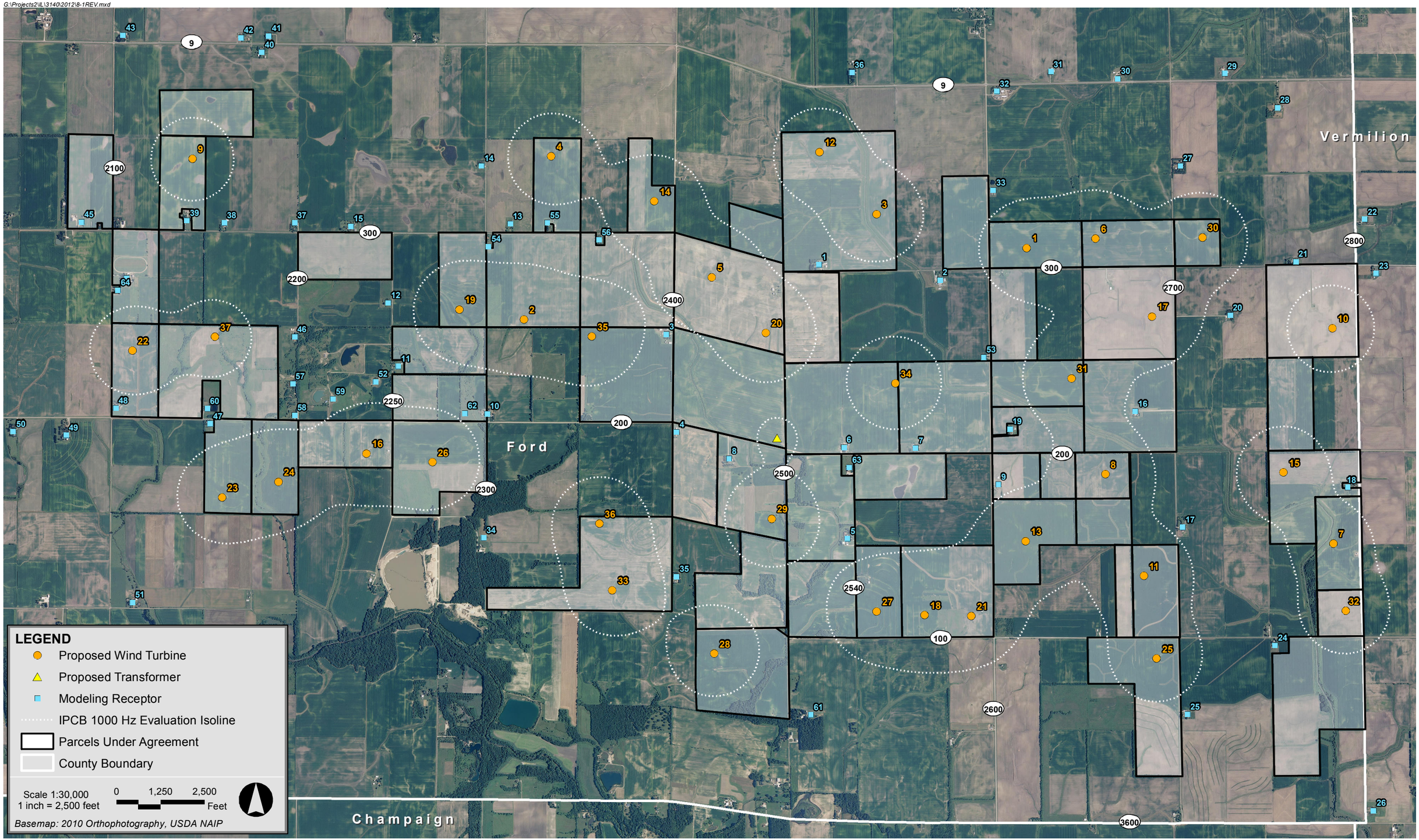
Modeling Location	Sound Level [dB] per Octave-Band Center Frequency [Hz]*								
	31.5	63	125	250	500	1k	2k	4k	8k
	dB	dB	dB	dB	dB	dB	dB	dB	dB
1	63	56	50	49	45	40	32	11	0
2	63	55	49	48	45	39	30	7	0
3	64	56	50	49	46	40	33	13	0
4	62	55	48	47	44	37	27	0	0
5	63	56	50	49	46	40	32	12	0
6	63	55	49	48	45	39	30	9	0
7	63	55	49	48	45	39	31	13	0
8	62	55	50	48	45	39	31	12	0
9	63	56	50	49	46	40	32	15	0
10	63	56	49	48	45	40	32	11	0
11	62	55	49	48	45	39	31	9	0
12	62	54	48	47	44	38	30	11	0
13	62	55	49	48	45	39	31	10	0
14	61	54	48	47	43	38	30	12	0
15	60	52	45	44	40	33	21	0	0
16	64	56	50	49	46	41	33	15	0
17	63	56	50	49	46	40	33	15	0
18	63	55	49	48	45	40	34	17	0
19	63	56	49	48	45	39	30	9	0
20	63	55	49	48	45	39	32	11	0
21	61	54	48	47	43	38	30	10	0
22	59	51	45	43	39	33	23	0	0
23	60	53	47	46	42	37	30	12	0
24	61	54	48	47	43	38	29	9	0
25	61	54	48	47	44	38	31	14	0
26	56	48	41	39	34	26	11	0	0
27	61	54	48	47	43	38	30	10	0
28	58	50	43	42	37	30	18	0	0
29	58	50	43	41	37	29	16	0	0
30	58	51	44	43	38	31	18	0	0
31	59	51	44	43	38	31	17	0	0

Table 8-1 Project-Only Sound Levels Compared to IPCB Nighttime Limits (Continued)

Modeling Location	Sound Level [dB] per Octave-Band Center Frequency [Hz]*								
	31.5	63	125	250	500	1k	2k	4k	8k
	dB	dB	dB	dB	dB	dB	dB	dB	dB
32	59	52	45	43	39	32	20	0	0
33	62	55	49	48	45	39	31	13	0
34	61	54	48	47	43	37	28	4	0
35	63	56	50	49	46	40	33	14	0
36	60	53	46	45	42	35	27	6	0
37	59	52	45	44	40	34	23	0	0
38	61	53	47	46	43	37	30	11	0
39	61	54	48	47	44	38	32	15	0
40	57	50	43	41	37	30	20	0	0
41	57	49	42	40	36	29	17	0	0
42	57	49	43	41	37	30	19	0	0
43	56	48	42	40	35	28	18	0	0
44	61	53	47	46	43	37	30	11	0
45	58	50	44	43	39	32	22	0	0
46	61	54	47	46	43	37	28	6	0
47	62	55	49	48	45	40	32	12	0
48	61	54	48	47	44	39	32	16	0
49	58	51	44	43	39	33	24	0	0
50	56	49	42	41	37	30	18	0	0
51	57	50	43	41	37	30	19	0	0
52	63	55	49	48	45	39	31	11	0
53	63	55	49	48	45	39	30	7	0
54	63	55	49	48	45	40	32	13	0
55	63	56	50	49	45	40	32	13	0
56	63	56	50	49	46	40	33	13	0
57	61	54	48	47	44	38	29	6	0
58	63	55	49	49	45	40	33	14	0
59	63	55	49	48	45	40	32	14	0
60	62	55	49	48	45	39	32	11	0
61	60	53	47	45	42	35	25	0	0
62	63	56	50	49	46	41	33	17	0
63	62	55	49	48	45	38	29	6	0
64	61	54	48	47	44	38	32	15	0
IPCB Nighttime Limits	**69**	**67**	**62**	**54**	**47**	**41**	**36**	**32**	**32**

* Octave-band sound levels are rounded to the nearest whole number decibel

G:\Projects2\IL\3140\2012\8-1REV.mxd



Akuo Energy - Dogtown Wind Project **Ford County, Illinois**

Epsilon Associates Inc.

Figure 8-1

Predicted Project-Only Sound Levels - 1 kHz

9.0 CONCLUSIONS

A comprehensive sound level assessment was conducted for the proposed Dogtown Wind Project. Baseline sound levels were measured to characterize the existing background sound levels in and around the Project in Ford County, Illinois. Project-only sound levels were then predicted for nearby homes, so as to determine the future sound levels expected under wind speed conditions with the highest sound power (10 m/s wind at hub height) and evaluate compliance with the IPCB regulations.

The measurement program included a wide range of wind conditions and included periods during identified in the Alstom technical document as having the maximum broadband sound power level. **The predicted sound levels at each of the modeled homes do not exceed the limits identified in the IPCB regulations with respect to the Class "C" to Class "A" octave band sound levels.** Sound levels were also evaluated at the estimated extents of Class "A" lands and these areas will also meet the limits. **In addition, sound levels from the Alstom wind turbines are not anticipated to cause a violation of the IPCB regulation with respect to prominent discrete tones.**

Appendix A

Continuous Sound Level Measurements

Figure A-1

A-Weighted Sound Pressure Levels & Wind Speeds - Location 1 (Elliot Property)

Wednesday, August 31, 2011 through Thursday, September 8, 2011

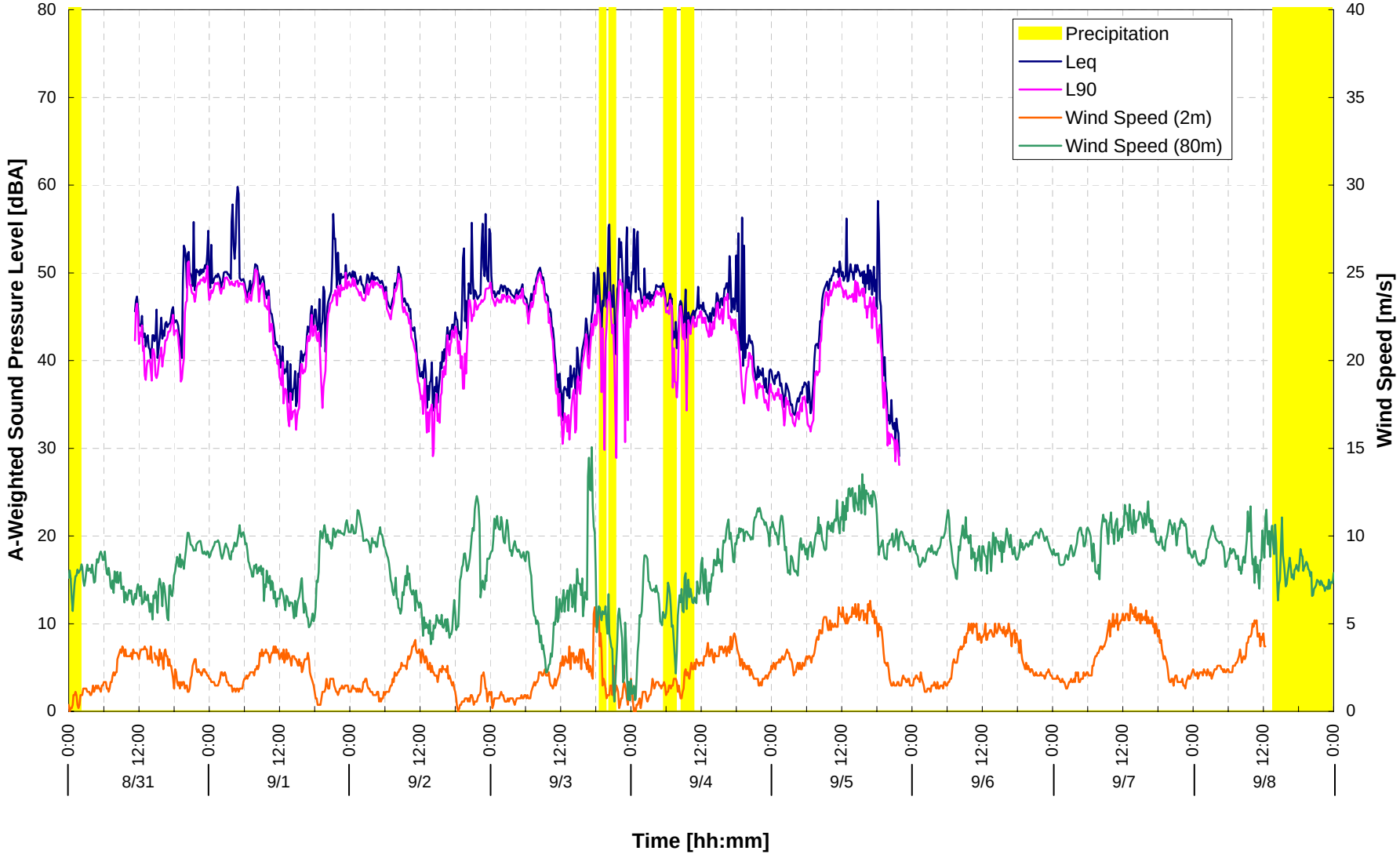


Figure A-2

A-Weighted Sound Pressure Levels & Wind Speeds - Location 2 (Johnson Property)

Wednesday, August 31, 2011 through Thursday, September 8, 2011

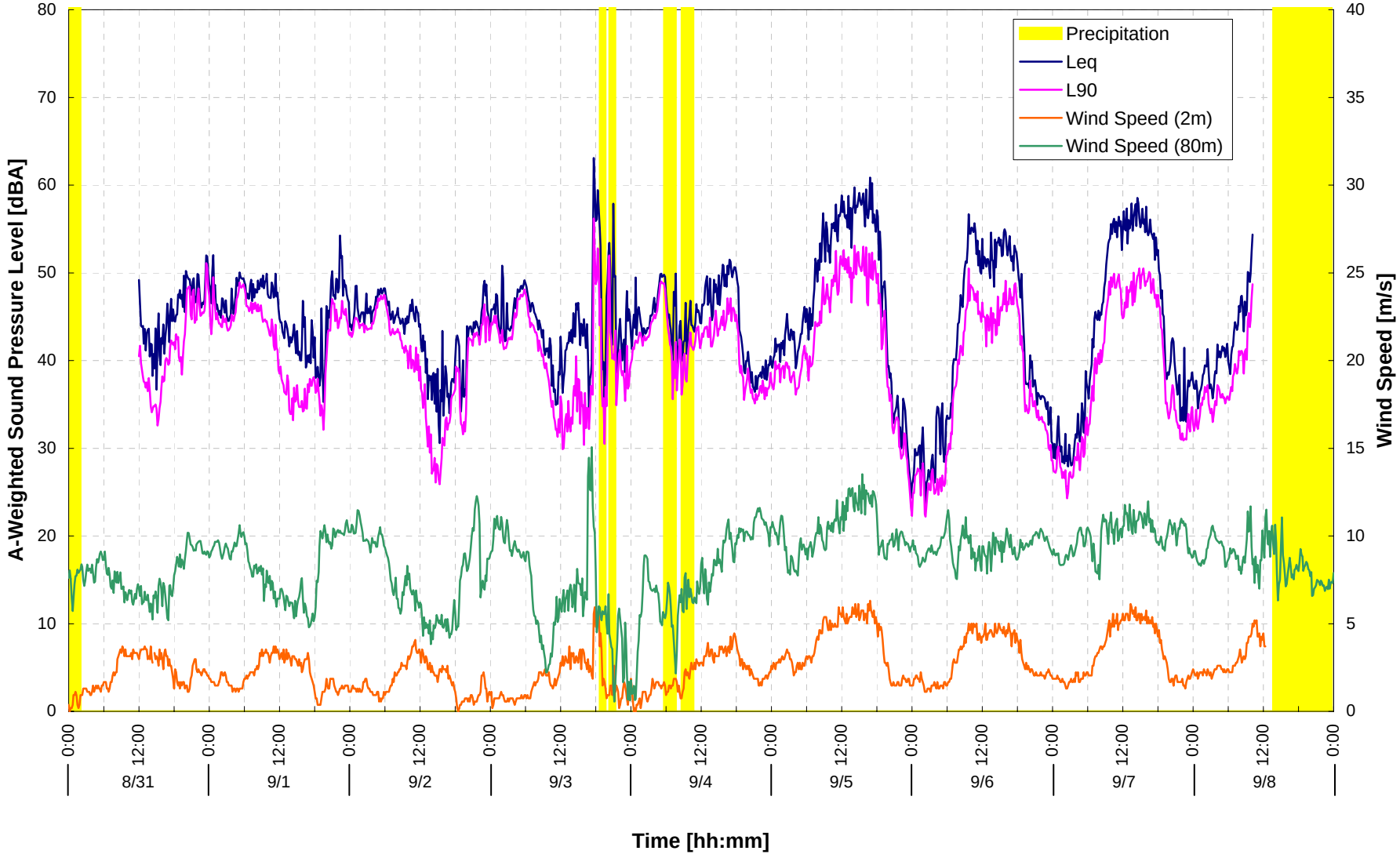


Figure A-3

A-Weighted Sound Pressure Levels & Wind Speeds - Location 3 (Cleary Property)

Wednesday, August 31, 2011 through Thursday, September 8, 2011

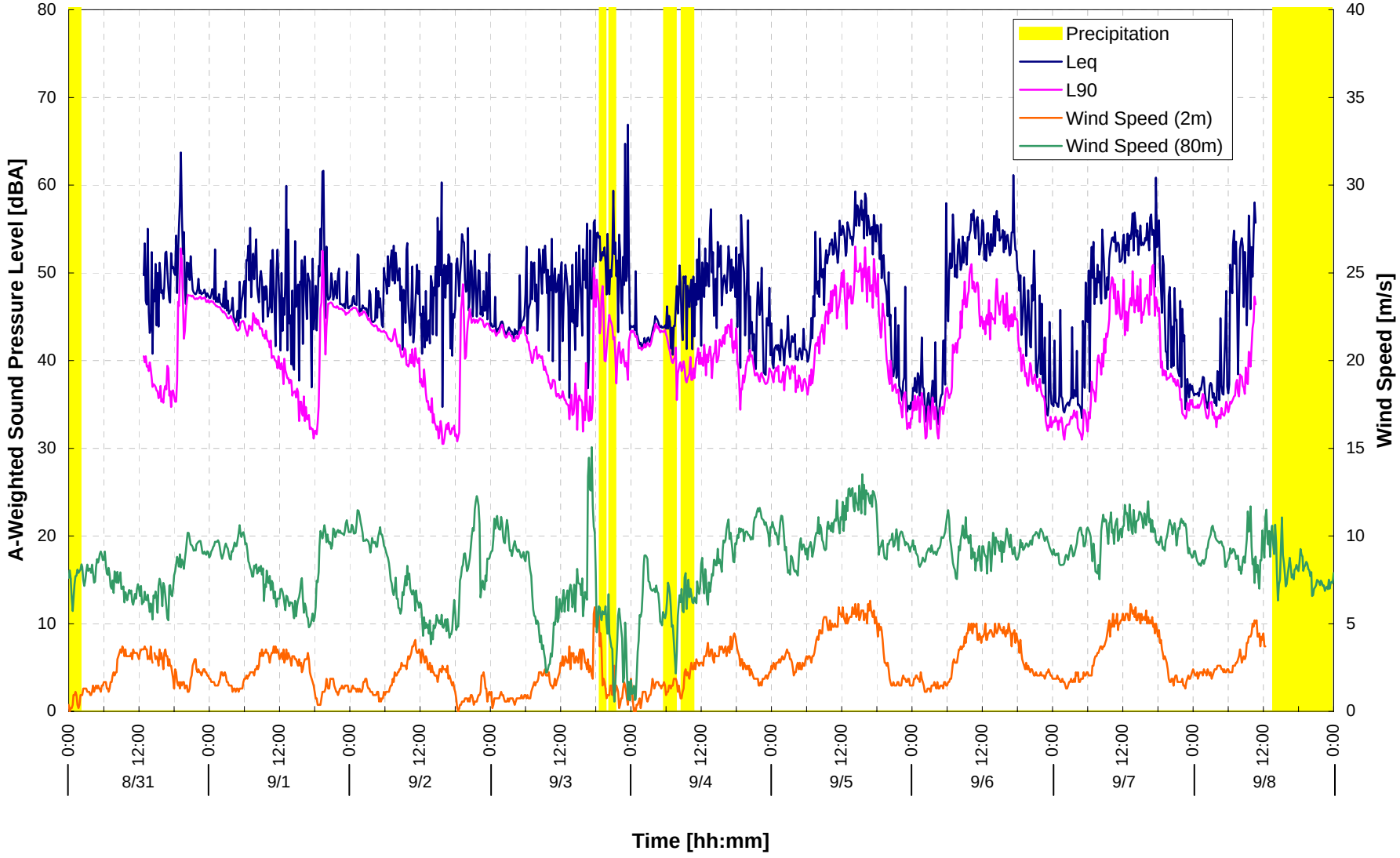
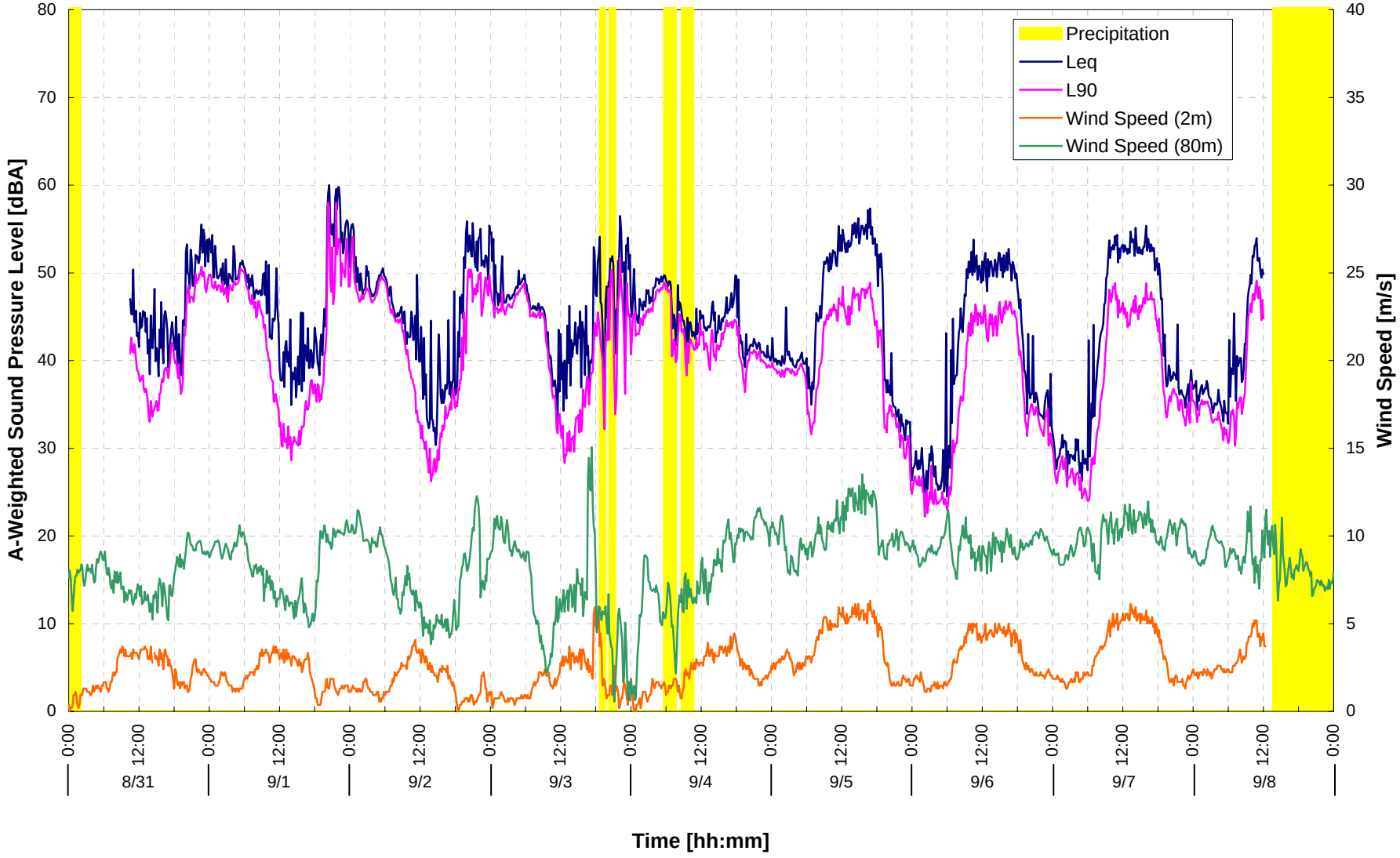


Figure A-4

A-Weighted Sound Pressure Levels & Wind Speeds - Location 4 (Swan Property)

Wednesday, August 31, 2011 through Thursday, September 8, 2011