Attachment F – 2019 Noise Assessment

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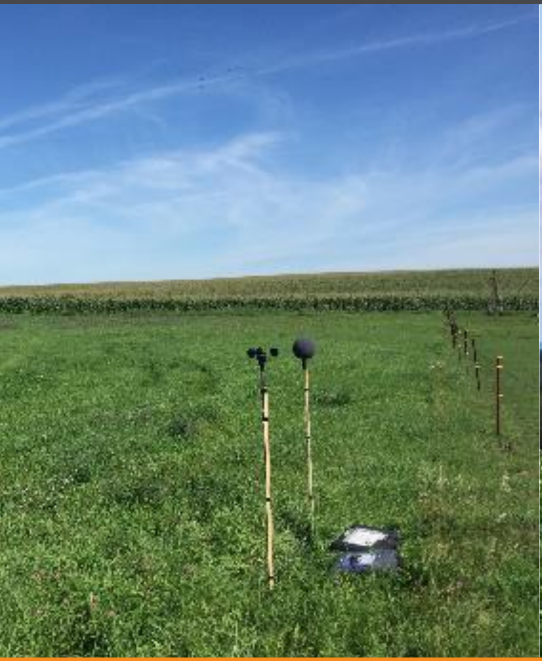
Blazing Star Wind Farm 2, LLC

NOISE COMPLIANCE

Report | June 11, 2019



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PROPRIETARY INFORMATION IN APPENDIX B EXCLUDED

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1.0 INTRODUCTION

Blazing Star Wind Farm, LLC previously applied for and received a permit for phase one (Blazing Star) of a wind power generation facility in Lincoln County, Minnesota. Blazing Star Wind Farm 2, LLC has also received a permit from the Minnesota Public Utilities Commission to build a second phase (Blazing Star 2) adjacent to Blazing Star. Blazing Star 2 will involve the construction of up to 100 wind turbines for a rating of up to 200 MW.

The turbines will be installed in an area south, southwest, and northwest of Ivanhoe and east, southeast, and south of Hendricks. Many of the wind turbines would be along US Route 75 except, but some will be located northwest, north, and south of Lake Shaokatan, up to nine miles west of US Route 75. For the Site Permit Application, RSG preformed a preliminary noise compliance assessment of the project based on the preliminary turbine layout. This noise compliance report is an update version of the preliminary noise assessment with the most recent project information including an updated layout and turbine model selection. Included in this report are:

- A description of the project;
- A discussion of sound level standards;
- A discussion of sound issues that are particular to wind farms;
- Background sound level monitoring procedure and results;
- Sound propagation modeling procedures and results; and
- Conclusions.

Appendix A includes a primer on the science of sound, including descriptions of some of the acoustical terms used in this report.

2.0 PROJECT DESCRIPTION

Blazing Star 2 will be located in Lincoln County, Minnesota. The project area is generally located to the south, southwest, and north of Ivanhoe and east, southeast, and south of Hendricks. The northern extent of the project area is near corner of US Route 75 and County Road 19. On the north and south ends of the project, the project area extends as far east as County Road 5, but in the middle, the project area remains primarily west of US Route 75. Towards the south, the project extends as far west as the South Dakota state line.

Blazing Star 2 is designed to include up to 100 turbines, with a hub height of 80 meters (262 feet. The proposed layout evaluated in this assessment includes ten Vestas V110 STE turbines and 90 Vestas V120 STE turbines. A map of the project area showing the turbine locations for both Blazing Star and Blazing Star 2 is provided in Figure 1.

The area around the project is composed primarily of agricultural land uses (primarily corn, soybean, and dairy) with farm residences. Terrain in the area is mostly flat in the southern part of the project, with more rolling terrain in the northern part of the project. The City of Ivanhoe is located to the east of the project, and the closest proposed turbine location to the city is approximately 1.3 kilometers (4,300 feet) west of North Wallace Street. Land uses within the city are primarily residential and commercial. There is a school on the northwestern edge of the city on North Wallace Street. The City of Hendricks, to the west, is over 5 kilometers (3.1 miles) from any Blazing Star 2 turbines.

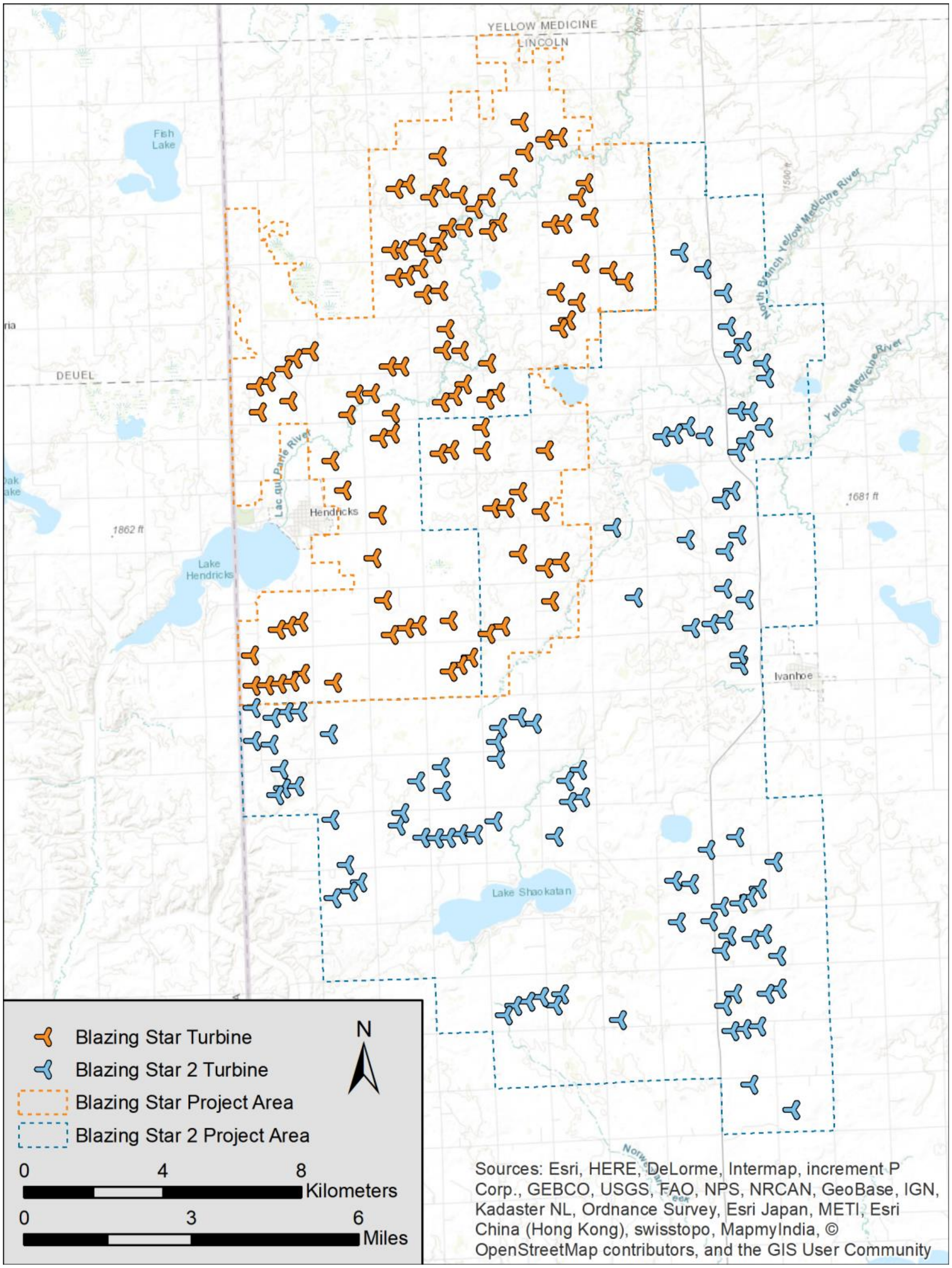

FIGURE 1: BLAZING STAR AND BLAZING STAR 2 AREA MAP

3.0 SOUND LEVEL STANDARDS & GUIDELINES

3.1 LOCAL STANDARD

Locally, Lincoln County Comprehensive Development Ordinance No. 40 regulates noise from wind power in Section 9, Subdivision 700:

> "Noise regulated by Minnesota Pollution Control Agency under Chapter 7030. These rules establish the maximum night and daytime noise levels that effectively limit wind turbine noise to fifty (50) dB (A) at farm residences. However, these standards may not be sufficient for the "preservation of public health and welfare" in relation to impulsive noises. Additional local limits relative to impulsive and pure tone noises may be appropriate."

3.2 STATE STANDARDS

Minnesota Statute §116.07 charges the Pollution Control Agency with adopting noise standards. These standards are set in Minnesota Rules Chapter 7030, for which a wind power project needs to demonstrate it will be in compliance with to receive a site permit from PUC. The Rule provides daytime and nighttime[1] sound level limits (Table 1) for a variety of land uses, which are grouped into three categories identified by a Noise Area Classification. The sensitive land uses around the Blazing Star 2 project area are primarily within Noise Area Classification 1 which includes residences including farm houses, and contain the most restrictive sound limits.

TABLE 1: SOUND LEVEL LIMITS (dBA) FROM MN RULES 7030.0040

Noise Area Classification	Daytime		Nighttime	
	L_{50}	L_{10}	L_{50}	L_{10}
1	60	65	50	55
2	65	70	65	70
3	75	80	75	80

The Rule says that the limits are for the "…preservation of public health and welfare" and that they are "…consistent with speech, sleep, annoyance, and hearing conservation requirements…", but that they "…do not, by themselves, identify the limiting levels of impulsive noise[2] needed for the preservation of public health and welfare."

[1] MN Rules 7030.0020 define daytime as 7:00 a.m. to 10:00 p.m. and nighttime as 10:00 p.m. to 7:00 a.m.
[2] Impulsive noise is defined in Minnesota Rules Chapter 7030.0020. Typical, wind turbine sound at the distance of a residential receiver is not considered impulsive.

4.0 WIND TURBINE ACOUSTICS – SPECIAL CONSIDERATIONS

4.1 SOURCES OF SOUND GENERATION BY WIND TURBINES

Wind turbines generate two principle types of sound: aerodynamic, produced from the flow of air around the blades, and mechanical, produced from mechanical and electrical components within the nacelle.

Aerodynamic sound is the primary source of sound associated with wind turbines. These acoustic emissions can be either tonal or broadband. Tonal sound occurs at discrete frequencies, whereas broadband sound is distributed with little peaking across the frequency spectrum. While unusual, tonal sound can also originate from unstable air flows over holes, slits, or blunt trailing edges on blades. The majority of audible aerodynamic sound from wind turbines is broadband at the middle frequencies, roughly between 200 Hz and 1,000 Hz.

Wind turbines emit aerodynamic broadband sound as the rotating blades interact with atmospheric turbulence and as air flows along their surfaces. This produces a characteristic "whooshing" sound through several mechanisms (Figure 2):

- Inflow turbulence sound occurs when the rotor blades encounter atmospheric turbulence as they pass through the air. Uneven pressure on a rotor blade causes variations in the local angle of attack, which affects the lift and drag forces, causing aerodynamic loading fluctuations. This generates sound that varies across a wide range of frequencies but is most significant at frequencies below 500 Hz.
- Trailing edge sound is produced as boundary-layer turbulence as the air passes into the wake, or trailing edge, of the blade. This sound is distributed across a wide frequency range but is most notable at high frequencies between 700 Hz and 2 kHz.
- Tip vortex sound occurs when tip turbulence interacts with the surface of the blade tip. While this is audible near the turbine, it tends to be a small component of the overall sound further away.
- Stall or separation sound occurs due to the interaction of turbulence with the blade surface.

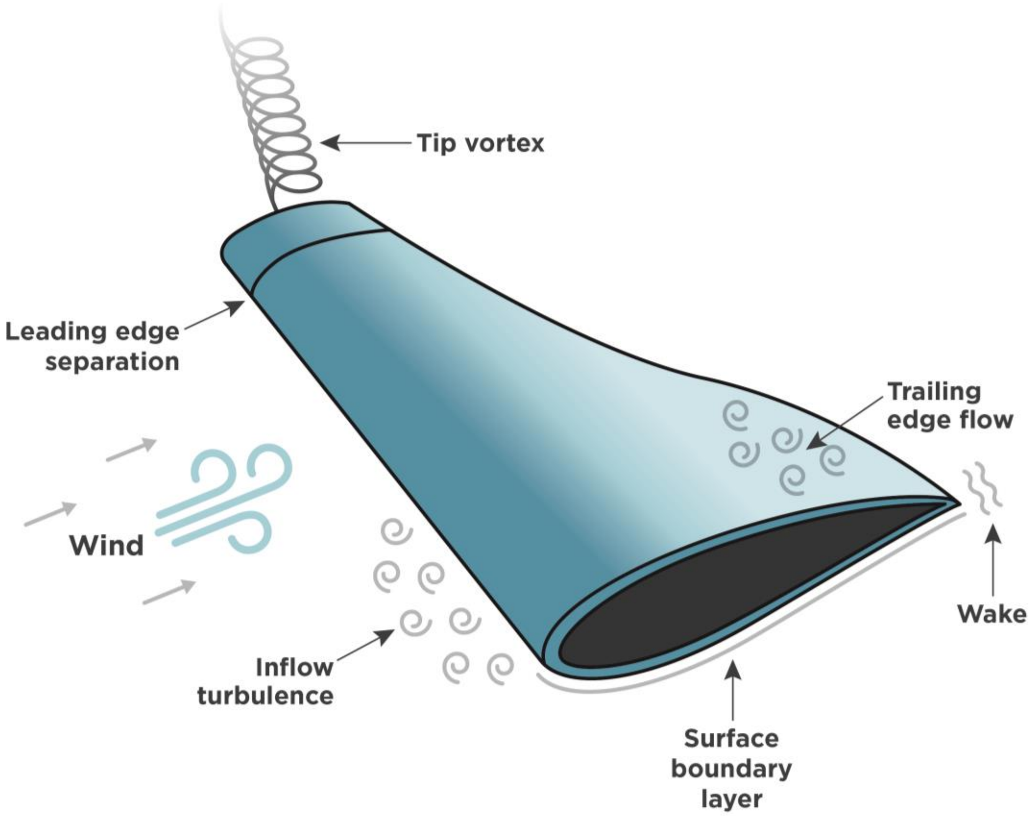

FIGURE 2: AIRFLOW AROUND A ROTOR BLADE

Mechanical sound from machinery inside the nacelle tends to be tonal in nature but can also have a broadband component. Potential sources of mechanical sound include the gearbox, generator, yaw drives, cooling fans, and auxiliary equipment. These components are housed within the nacelle, whose surfaces, if untreated, radiate the resulting sound. However modern wind turbines have nacelles that are designed to reduce the transmission of internal sound, and rarely is this a significant portion of the total wind turbine sound.

4.2 AMPLITUDE MODULATION

Amplitude modulation (AM) is a fluctuation in sound level that occurs at the blade passage frequency. There is no consistent definition how much of a sound level fluctuation is necessary for blade swish to be considered AM. Fluctuations in individual 1/3 octave bands are typically greater. Fluctuations in individual 1/3 octave bands can sometimes synchronize and desynchronize over periods, leading to increases and decreases in magnitude of the A-weighted fluctuations. Similarly, in wind farms with multiple turbines, fluctuations can synchronize and desynchronize, leading to variations in amplitude modulation depth.[3] Most amplitude modulation is in the mid-frequencies and most overall A-weighted AM is less than 4.5 dB in depth.[4]

There are many confirmed and hypothesized causes of amplitude modulation including: blade passage in front of the tower, blade tip sound emission directivity, wind shear, inflow turbulence, and turbine blade yaw error. It has recently been noted that although wind shear can contribute to the extent of amplitude modulation, wind shear does not contribute to the existence of amplitude modulation in and of itself. Instead, there needs to be detachment of airflow from the blades for wind shear to contribute to amplitude modulation.[5] While factors like the blade passing in front of the tower are intrinsic to wind turbine design, other factors vary with turbine design, local meteorology, topography, and turbine layout. Mountainous areas, for example, are more likely to have turbulent airflow, less likely to have high wind shear, and less likely to have turbine layouts that allow for blade passage synchronization for multiple turbines. Amplitude modulation extent varies with the relative location of a receptor to the turbine. Amplitude Modulation is usually experienced most when the receptor is between 45 and 60 degrees from the downwind or upwind position and is experienced least directly with the receptor directly upwind or downwind of the turbines.

4.3 METEOROLOGY

Meteorological conditions can significantly affect sound propagation. The two most important conditions to consider are wind shear and temperature lapse. Wind shear is the difference in wind speeds by elevation and temperature lapse rate is the temperature gradient by elevation. In conditions with high wind shear (large wind speed gradient), sound levels upwind from the source tend to decrease and sound levels downwind tend to increase due to the refraction, or bending, of the sound (Figure 3).

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[3] McCunney, Robert, et al. "Wind Turbines and Health: A Critical Review of the Scientific Literature." *Journal of Occupational and Environmental Medicine.* 56(11) November 2014: pp. e108-e130.
[4] RSG, et al., "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016
[5] "Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect." *RenewableUK.* December 2013.

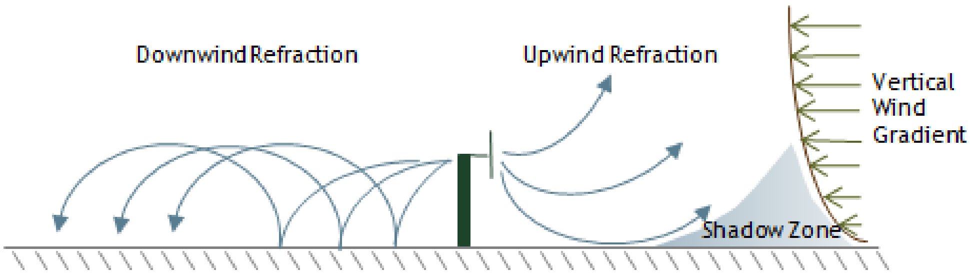

FIGURE 3: SCHEMATIC OF THE REFRACTION OF SOUND DUE TO VERTICAL WIND GRADIENT (WIND SHEAR)

With temperature lapse, when ground surface temperatures are higher than those aloft, sound will tend to refract upwards, leading to lower sound levels near the ground. The opposite is true when ground temperatures are lower than those aloft (an inversion condition).

High winds and/or high solar radiation can create turbulence which tends to break up and dissipate sound energy. Highly stable atmospheres, which tend to occur on clear nights with low ground-level wind speeds, tend to minimize atmospheric turbulence and are generally more favorable to downwind propagation.

In general terms, sound propagates along the ground best under stable conditions with a strong temperature inversion. This tends to occur during the night and is characterized by low ground level winds. As a result, worst-case conditions for wind turbines tend to occur downwind under moderate nighttime temperature inversions. Therefore, this is the default condition for modeling wind turbine sound.

4.4 MASKING

As mentioned above, sound levels from wind turbines are a function of wind speed. Background sound is also a function of wind speed, i.e., the stronger the winds, the louder the resulting background sound. This effect is amplified in areas covered by trees and other vegetation.

The sound from a wind turbine can often be masked by wind sound at downwind receptors because the frequency spectrum from wind is very similar to the frequency spectrum from a wind turbine. Figure 4 compares the shape of the sound spectrum measured during a 5 m/s wind event to that of a Vestas V120 STE wind turbine. As shown, the shapes of the spectra are very similar at lower frequencies. At higher frequencies, the sounds from the masking wind sound are higher than the wind turbine. As a result, the masking of turbine sound occurs at higher wind speeds for some meteorological conditions. Masking will occur most, when ground wind speeds are relatively high, creating wind-caused sound such as wind blowing through the trees and interaction of wind with structures.

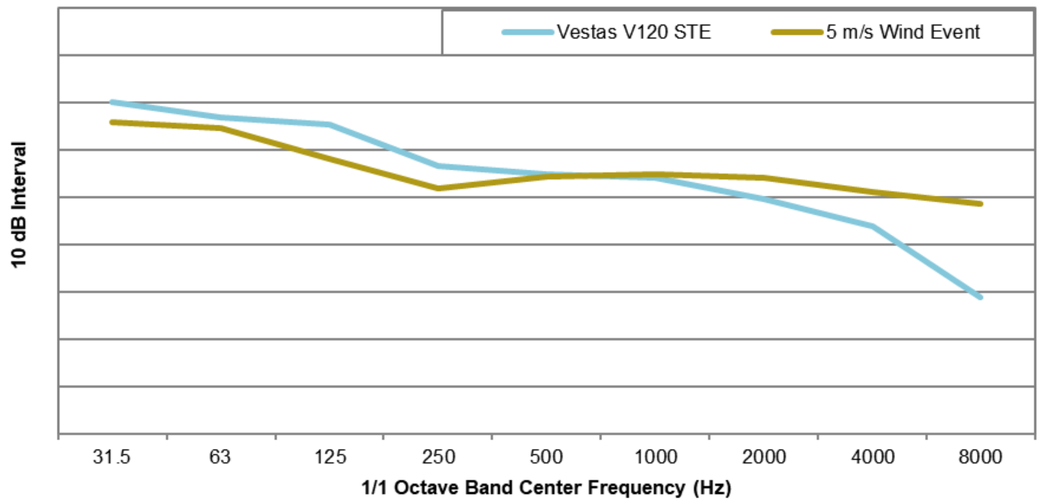

FIGURE 4: COMPARISON OF NORMALIZED FREQUENCY SPECTRA FROM THE WIND AND THE VESTAS V120 STE[6]

It is important to note that while winds may be blowing at turbine height, there may be little to no wind at ground level. This is especially true during strong wind gradients (high wind shear), which mostly occur at night. This can also occur on the leeward side of ridges where the ridge blocks the wind.

4.5 INFRASOUND AND LOW FREQUENCY SOUND

Infrasound is sound pressure fluctuations at frequencies below about 20 Hz. Sound below this frequency is only audible at very high magnitudes. Low frequency sound is in the audible range of human hearing, that is, above 20 Hz, but below 100 to 200 Hz depending on the definition.

Low frequency aerodynamic tonal sound is typically associated with downwind rotors on horizontal axis wind turbines. In this configuration, the rotor plane is behind the tower relative to the oncoming wind. As the turbine blades rotate, each blade crosses behind the tower's aerodynamic wake and experiences brief load fluctuations. This causes short, low-frequency pulses or thumping sounds. Large modern wind turbines are "upwind", where the rotor plane is upwind of the tower. As a result, this type of low frequency sound is at a much lower magnitude with upwind turbines than downwind turbines, well below established infrasonic hearing thresholds.

Figure 5 shows the sound levels 350 meters (1,148 feet) from a wind turbine when the wind turbine was operating (T-on) and shut down (T-off) for wind speeds at hub height greater than 9

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[6] The purpose of this Figure is to show the shapes to two spectra relative to one another and not the actual sound level of the two sources of sound. The level of each source was normalized independently.

m/s. Measurements were made over approximately two weeks.[7] The red 90 dBG line is shown here as the ISO 7196:1995 perceptibility threshold. As shown, the wind turbines generated measurable infrasound, but at least 20 dB below audibility thresholds.

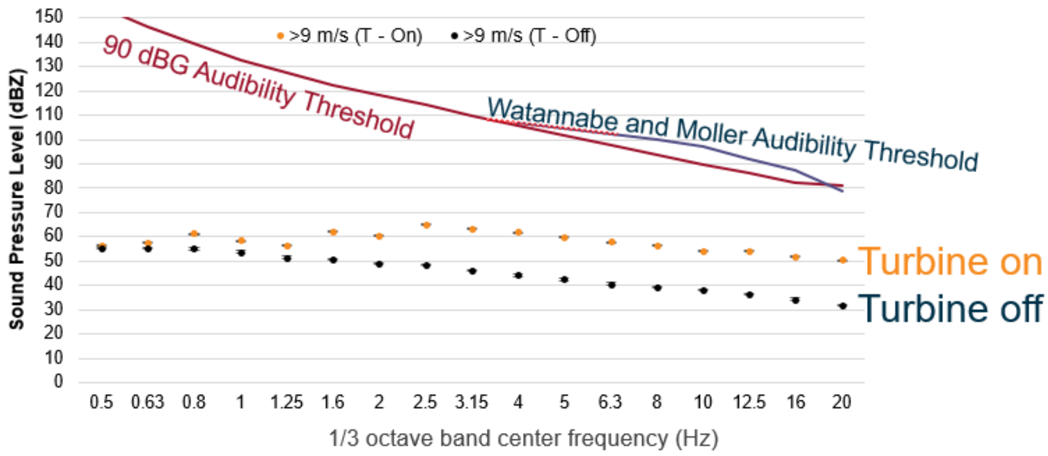

FIGURE 5: INFRASOUND FROM A WIND TURBINE AT 350 METERS (1,148 FEET) COMPARED WITH PERCEPTION THESHOLDS

Low frequency sound is primarily generated by the generator and mechanical components. Much of the mechanical sound has been reduced in modern wind turbines through improved sound insulation at the hub. Low frequency sound can also be generated by the blades at higher wind speeds when the inflow air is very turbulent. However, at these wind speeds, low frequency sound from the wind turbine blades is often masked by wind sound at the downwind receptors.

Finally, low frequency sound is absorbed less by the atmosphere and ground than higher frequency sound. Our modeling takes into account frequency-specific ground attenuation and atmospheric absorption factors that takes this into account.

4.6 USE OF SOUND LEVEL WEIGHTING NETWORKS FOR WIND TURBINE SOUND

The human ear is not equally sensitive to sound pressure levels at all frequencies and magnitudes. Some frequencies, despite being the same decibel level (that is, magnitude), seem louder than others. For example, a 500 Hz tone at 80 dB will sound louder than a 63 Hz tone at the same level. In addition, the relative loudness of these tones will change with magnitude. For

[7] RSG, et al., "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016 – Graphic from RSG presentation to MassDEP WNTAG, March, 2016

example, the perceived difference in loudness between those two tones is less when both are at 110 dB than when they are at 40 dB.

To account for the difference in the perceived loudness of a sound by frequency and magnitude, acousticians apply frequency weightings to sound levels. The most common weighting scale used in environmental noise analysis is the “A-weighting”, which represents the sensitivity of the human ear at lower sound pressure levels. The A-weighting is the most appropriate weighting when overall sound pressure levels are relatively low (up to about 70 dBA). The A-weighting de-emphasizes sounds at lower and very high frequencies, since the human ear is insensitive to sound at these frequencies at low magnitude. The A-weighting is indicated by “dBA” or “dB(A)”.

At higher sound pressure levels (greater than approximately 70 dBA), a different weighting must be used since human hearing sensitivity does not change as much with frequency. The “C-weighting” mimics the sensitivity of the human ear for these moderate to higher sound levels (greater than approximately 70 dBA, which is higher ground-based sound levels produced by wind power projects). C-weighted sound levels are indicated by “dBC” or “dB(C)”.

The “Z-weighting” does not emphasize or de-emphasize sound at any frequency. “Z” weighted sound levels are sometimes labeled as “Flat” or “Linear”. The difference is that the “Z-weighting” is defined as being unweighted in a specific range, whereas “Flat” or “Linear” indicate that no weighting has been used. Z-weighting or unweighted levels are typically used when reporting sound levels at individual octave bands.

The most appropriate weighting for wind turbine sound is the A-weighting, for two reasons. The first is that sound pressure levels due to wind turbine sound are typically in the appropriate range for the A-weighting at typical receiver distances (50 dBA or less). The second is that various studies of wind turbine acoustics have shown that the potential effects of wind turbine noise on people are correlated with A-weighted sound level (i.e. Pedersen et al, 2008[8]) as well as to the perceived loudness of wind turbine sound.[9,10] Other researchers found that 51% of the energy making up a C-weighted measurement of wind turbine sound is not audible. Thus, it is more difficult to relate the level of C-weighted sound to human perception. That is, two sounds may be perceived exactly alike, but there could be significant variations in the C-weighted sound level depending on the content of inaudible sound in each.[4]

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[8] Pedersen, Eja and Waye, Kerstin. “Perception and annoyance due to wind turbine noise - a dose-response relation.” Journal of the Acoustical Society of America. 116(6). pp. 3460-3470.
[9] Yokoyama S., et al. “Perception of low frequency components in wind turbine noise.” Noise Control Engr. J. 62(5) 2014
[10] Yokoyama et al. “Loudness evaluation of general environmental noise containing low frequency components.” Proceedings of InterNoise2013, 2013

5.0 SOUND LEVEL MONITORING PROCEDURES

Background sound level monitoring was conducted throughout the area to quantify the existing sound levels, including the nighttime L50, and to identify existing sources of sound.

In August 2017, four locations were monitored to determine existing background sound levels, including two offsite locations (Offsite C and Offsite D) and two locations within the project area. Also included in this report is monitoring that was conducted at two locations for Blazing Star in July 2016 but are either within or near the Blazing Star 2 project area. The Offsite B Monitor from Blazing Star was located within the Blazing Star 2 project area, and thus, its data is utilized in these analyses. In the context of this report, the Offsite B monitor from Blazing Star is referred to as the West Monitor. The South monitor from Blazing Star is within a mile of the Blazing Star 2 project area, and so its data is also utilized in these analyses. In the context of this report, the South Monitor from Blazing Star is referred to as the Northwest Monitor. A map of the monitor locations within the project area is shown in Figure 6.

Monitoring locations were selected per the guidance provided in the Department of Commerce, Energy Facility Permitting document, “Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report”, October 2012 (LWECS Guidance). The guidance recommends a minimum of three locations within the project area, which were used for this project. The guidance also recommends that one monitoring location be in proximity to the worst-case modeled receptor, and for this project, the South Monitor location was selected as the worst-case modeled area based on the initial turbine layout.

The North Monitor, was located approximately 3.6 kilometers (2.25 miles) west of US Route 75 and was positioned to be representative of the soundscape of the of residences that are further removed from US Route 75. The nearest proposed turbine to the North Monitor is approximately 300 meters (985 feet) to the north. The Northwest Monitor and West Monitor are both locations that were selected for Blazing Star as previously discussed. The Northwest Monitor was selected as one of the worst-case modeled areas for Blazing Star, and it was placed at a location that is approximately 3.3 kilometers meters (2 miles) northeast of a proposed turbine for Blazing Star 2. The West Monitor has proposed turbines to the west, north, and south with the closest located within approximately 470 meters (1,540 feet) to the south.

Two offsite monitors were located to capture background sound levels beyond the extents of the project area. These monitors are expected to have little to no contributions of sound from the wind turbine when the project is built. The Offsite C Monitor was located northeast of the project area while still being located within Lincoln County. The monitor was located 1.1 kilometers (0.7 miles) east of the project boundary and 3.6 kilometers (2.2 miles) northeast of the nearest potential turbine location. The Offsite D monitor was located southeast of the project area, while being removed from Lake Benton to the south, U.S. Route 75 located to the west, and existing wind farms located to the west. The closest potential turbine location is located approximately 3.2 km (2 miles) to the west-northwest.

Further information on the monitoring locations as well as a review of monitoring equipment and procedures is found in the following sections.

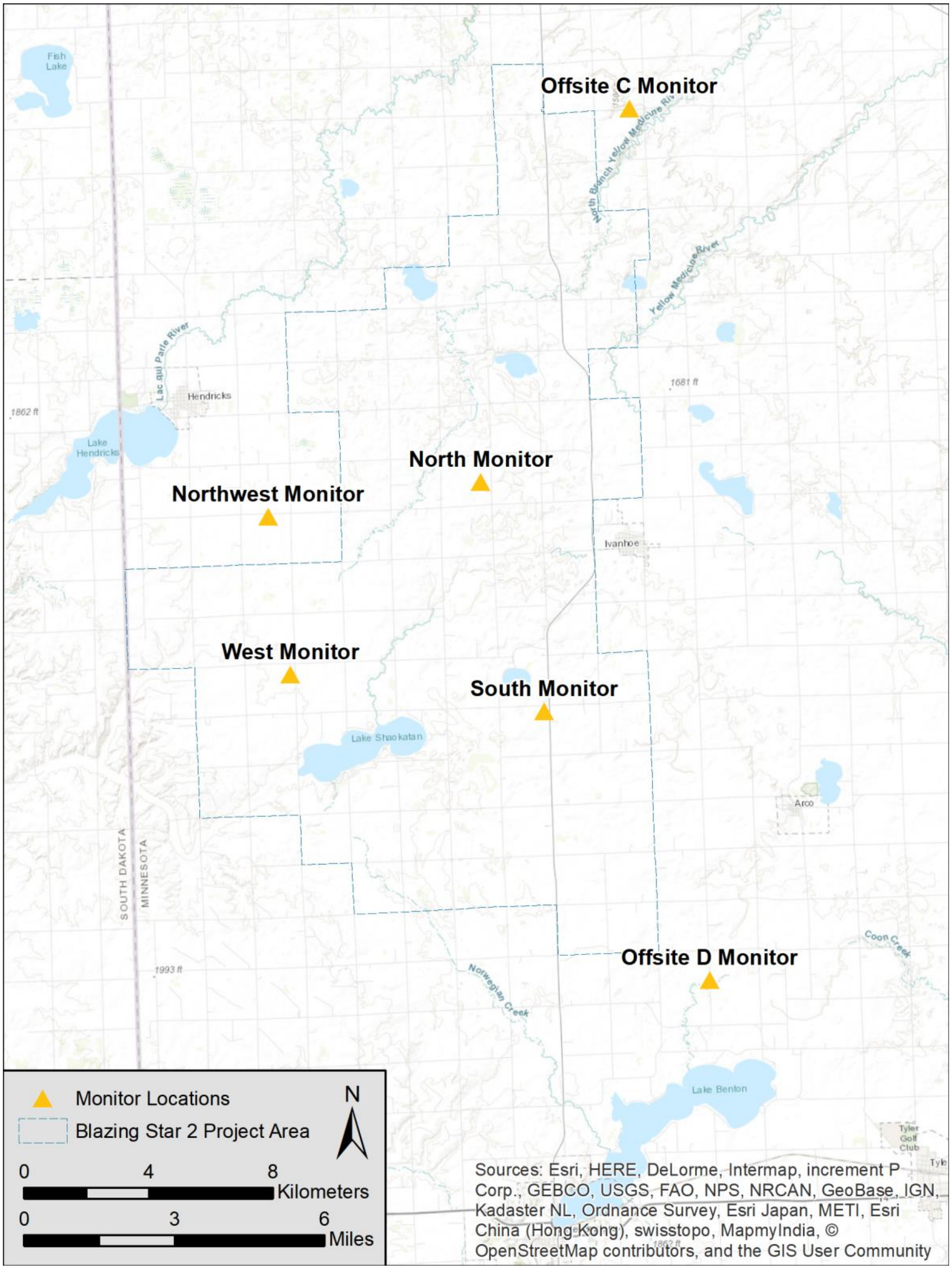

FIGURE 6: SOUND MONITOR MAP

5.1 EQUIPMENT

Background sound level monitoring was performed with ANSI/IEC Type 1 Cesva SC310 and Svantek SV979 sound level meters with a minimum frequency range of 20 Hz to 10 kHz. Meters were set to log, at a minimum, 1/3 octave band sound levels once each second for the entire measurement period. Sound level meter microphones were mounted on wooden stakes at a height of approximately 1.5 meters (5 feet) and covered with 180 mm (7 inch) windscreens to minimize the impact of wind distortion on measurements. The Cesva SC 310 meters were connected to Edirol audio recorders, recording audio data at a minimum resolution of 96 kbps in the .mp3 format. Svantek SV979 sound level meters record audio internally; resolution for audio files was set to 288 kbps in .wav format. Before and after the measurement periods, the meters were calibrated with a Cesva CB-5 calibrator. The monitoring equipment meets LWECS Guidance.

A list of the equipment used at each monitor is shown in Table 2. At each site, an ONSET anemometer was located at microphone height. At the Offsite C and Offsite D locations, a wind direction sensor was also included in the setup. Wind data was logged at a rate of once each minute. Precipitation and temperature data were obtained from the KCNB National Weather Service weather station located at the airport in Canby, MN.

TABLE 2: SOUND MONITOR SPECIFICATIONS BY SITE

Monitor Location	Sound Level Meter[11]	1/3 Octave Band Frequency Range	Audio Recorder	Weather Station
North	Cesva SC310	20 Hz - 10 kHz	Edirol R-09HR	ONSET HOBO Wind Speed Sensor
South	Svantek SV979	3.15 Hz - 20 kHz	Internal	ONSET HOBO Wind Speed Sensor
Northwest[12]	Cesva SC310	10 Hz – 20 kHz	Edirol R-05	ONSET HOBO Wind Speed Sensor
West[13]	Svantek SV979	3.15 Hz – 20 kHz	Internal	ONSET HOBO Wind Speed and Direction Sensor
Offsite C (North)	Svantek SV979	3.15 Hz - 20 kHz	Internal	ONSET HOBO Wind Speed and Direction Sensors
Offsite D (South)	Svantek SV979	3.15 Hz - 20 kHz	Internal	ONSET HOBO Wind Speed and Direction Sensor

5.2 DATA PROCESSING

After data collection, data was downloaded, processed, and summarized into 1-hour periods. For each period A-, C-, and Z-weighted equivalent average sound levels (L_{EQ}) were calculated.

[11] The frequency range for the Cesva SC-310 sound level meters is limited by the instrument and the range for the Svantek SV979 sound level meters is limited by the microphone.
[12] The Northwest Monitor collected data as part of the pre-construction background monitoring for Blazing Star conducted in July 2016 and was referred to as the South Monitor for Blazing Star.
[13] The West Monitor collected data as part of the preconstruction background monitoring for Blazing Star conducted in July 2016 and was referred to as the Offsite B Monitor for Blazing Star.

For A- and C-weighted sound levels, the L10, L50, and L90 statistical sound levels were also calculated.

A second set of data was also generated with periods removed from the data that either contained anomalous sound events or periods with conditions that could lead to false sound level readings.

Periods that were removed from the sound level data included:

- Wind speeds above 11 mph (5 m/s),
- Precipitation and thunderstorm events,
- Low flying aircraft near the monitor (presumably crop dusters),
- Personnel and animal interaction with equipment.

5.3 MONITOR LOCATION DESCRIPTIONS

North Monitor

The North Monitor was located in an open field in the northern half of the proposed project area. The monitor was placed approximately 340 meters (1,110 feet) west of 180th Avenue on a fence line between a cow pasture, a hayfield, and cornfields. An abandoned homestead, about 250 meters (820 feet) southeast of the monitoring location, is still used for agricultural operations, including the pastured cattle. The surrounding area is predominantly under agricultural control. A picture of the monitoring setup is shown in Figure 7, and a map of the monitoring location is shown in Figure 8.

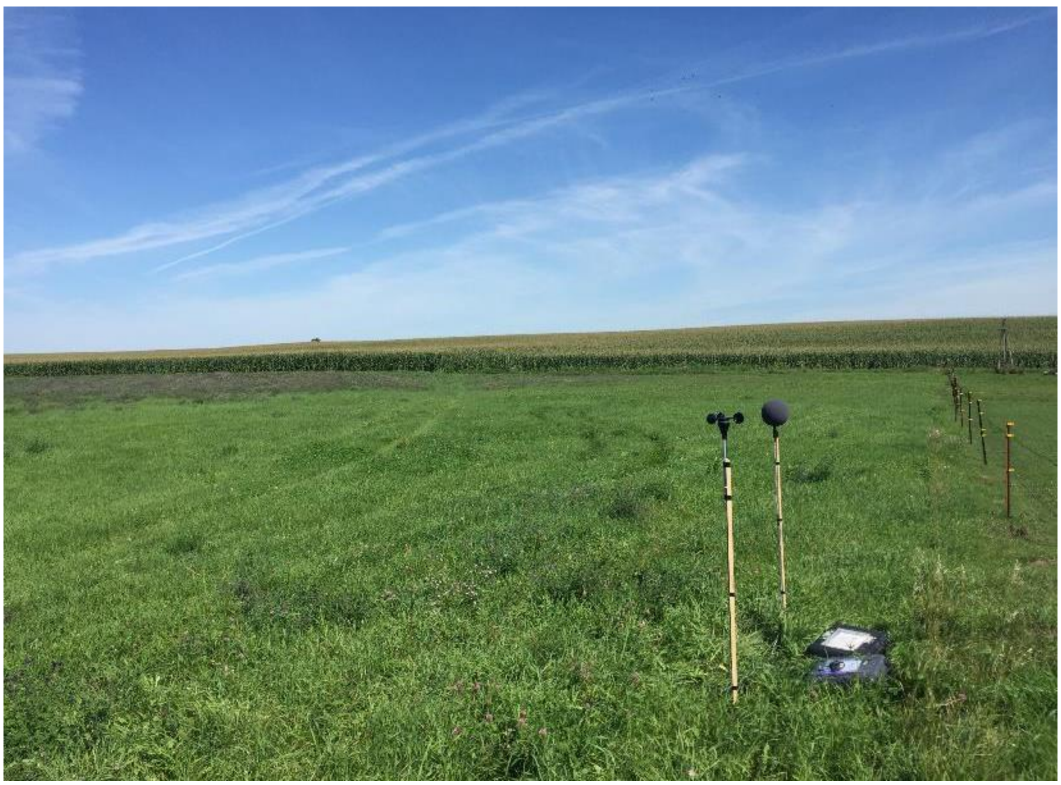

FIGURE 7: PHOTOGRAPH OF THE NORTH MONITOR LOOKING NORTHWARD

FIGURE 8: NORTH MONITOR LOCATION AERIAL VIEW

South Monitor

The South Monitor was located approximately 180 meters (590 feet) south of CSAH-16, and 165 meters (540 feet) from US-75. This position was about 325 meters southeast of Ash Lake. The monitor was located in a sheltered area on the outskirts of a homestead, between a grove of planted trees and active soybean field. The homestead was approximately 100 meters (330 feet) to the southeast and uphill of the sound level meter. A picture of the monitor setup is shown in Figure 9, and a map of the monitoring location is shown in Figure 10.

FIGURE 9: PHOTOGRAPH OF THE SOUTH MONITOR LOOKING NORTHWARD

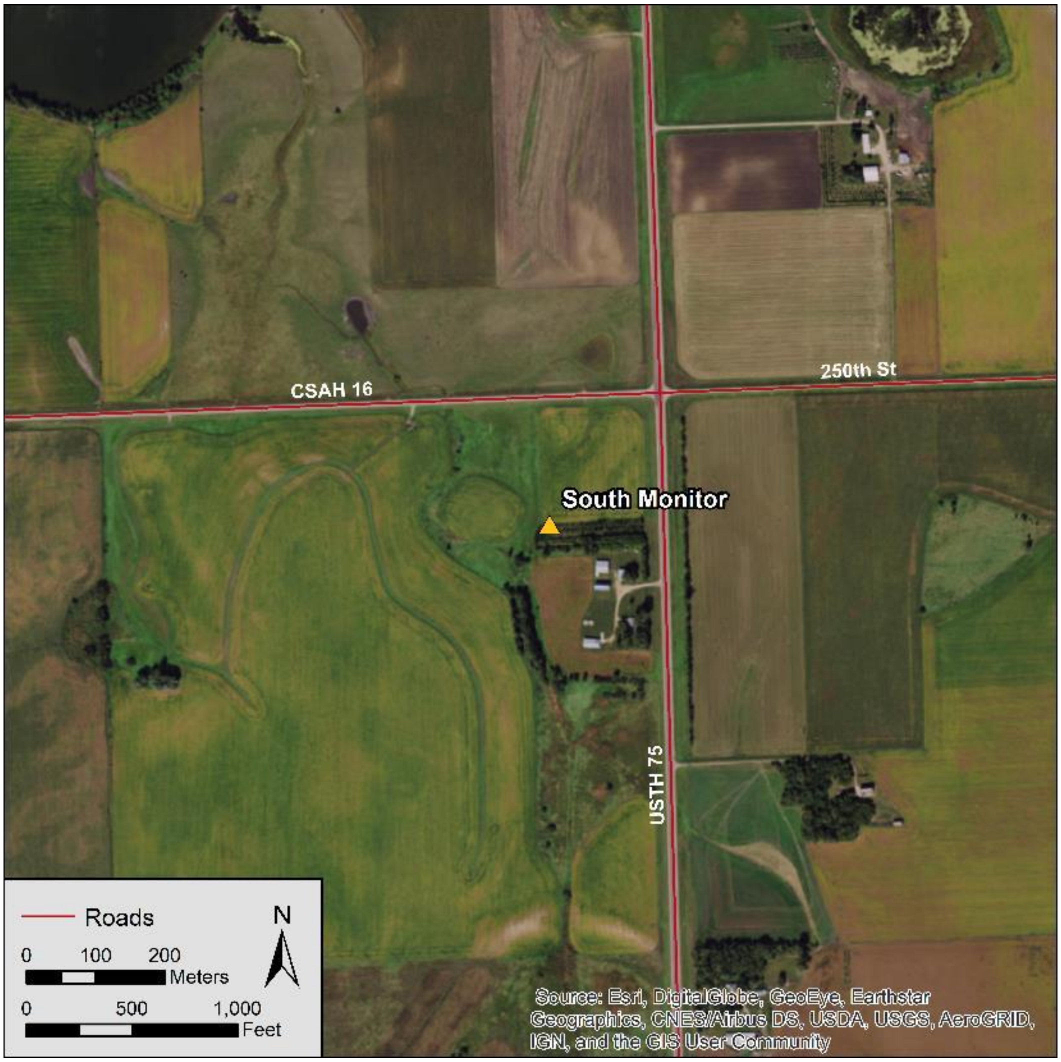

FIGURE 10: SOUTH MONITOR LOCATION AERIAL VIEW

Northwest Monitor

The Northwest Monitor was located along a row a trees that divided a homestead from the adjoining farm field to the east.

The monitor was located approximately 76 meters (250 feet) south of 290th Street, and approximately 720 meters (2,360 feet) west of County Road 101 (CR-101). A residence was located approximately 50 meters (164 feet) to the west and a larger group of trees was located approximately 65 meters (213 feet) to the west.

Farm fields surrounded the homestead and monitor location. Terrain in this part of the project is relatively flatter than to the north.

A picture of the monitoring setup is shown in Figure 11, and a map of the monitor location is shown in Figure 12.

FIGURE 11: PHOTOGRAPH OF THE NORTHWEST MONITOR LOOKING EASTWARD

FIGURE 12: NORTHWEST MONITOR LOCATION AERIAL VIEW

West Monitor

The West Monitor was located in the western portion of the project area approximately 2.4 kilometers (1.5 miles) north of Lake Shaokatan, to represent rural-residential soundscapes in this area.

The monitor was located at a homestead, approximately 145 meters (475 feet) west of CR-101 and approximately 350 meters (1,150 feet) southwest of the intersection between CR-101 and 260th Street.

The area immediately surrounding the homestead was wooded and surrounding fields were planted with corn. Terrain in this area is flat, and like the rest of the project area, is predominantly agricultural.

A picture of the monitoring setup is shown in Figure 13, and a map of the monitoring location is shown in Figure 14.

FIGURE 13: PHOTOGRAPH OF THE WEST MONITOR LOOKING NORTHWARD

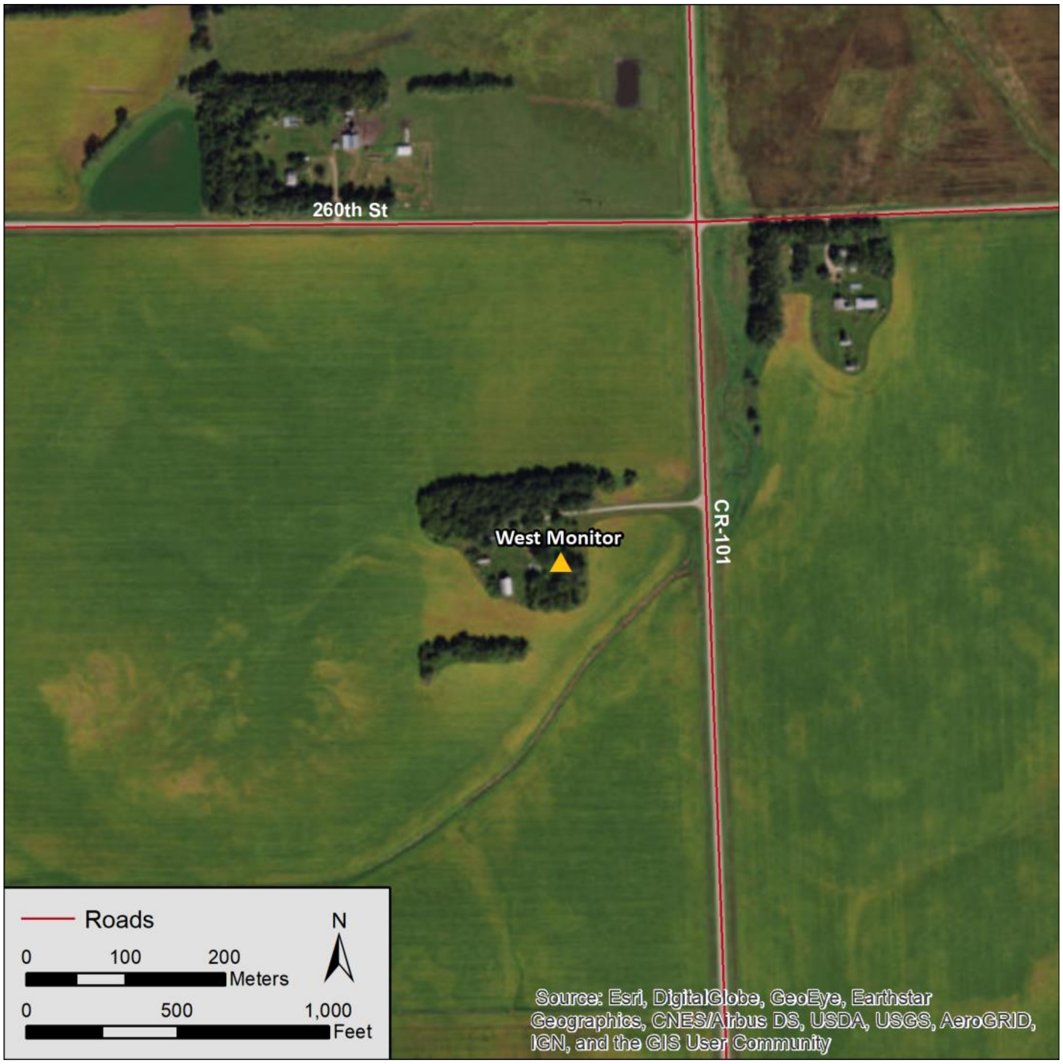

FIGURE 14: WEST MONITOR LOCATION AERIAL VIEW

Offsite C Monitor

The Offsite C Monitor was located along 370th Street (CSAH-19) adjacent to a wild and riparian area, approximately 465 meters (1525 feet) west of Country Road 109. The monitor did not have direct line of sight to the creek that ran well below its elevation to the north. The monitor was placed approximately 30 meters (100 feet) north of the road in a clearing. The nearest homestead was 750 meters (2460 feet) west on Route 19 and the surrounding land use primarily agricultural. A picture of the monitoring setup is shown in Figure 15, and a map of the monitor location is shown in Figure 16.

FIGURE 15: PHOTOGRAPH OF THE OFFSITE C MONITOR LOOKING EASTWARD

FIGURE 16: OFFSITE C MONITOR LOCATION AERIAL VIEW

Offsite D Monitor

The Offsite D Monitor was located in a power line right-of-way, approximately 5 meters (16 feet) east of County Road 110 and approximately 1.5 km (0.95 miles) north of the intersection with County Road 13. The field to the east of the monitor was in active corn production. Most other land in the surrounding area was used for farming. Terrain in this area was rolling and the monitor was located in an area with a higher elevation than nearby terrain, surrounded by tall grass and tall corn, and attached to a utility pole. The closest residence to this monitor was located approximately 135 meters (440 feet) to the south, which also appeared to be used for agricultural operations. A picture of the monitoring setup is shown in Figure 17, and a map of this location is shown in Figure 18.

FIGURE 17: PHOTOGRAPH OF THE OFFSITE A MONITOR LOOKING NORTHWARD

FIGURE 18: OFFSITE D MONITOR LOCATION AERIAL VIEW

6.0 SOUND LEVEL MONITORING RESULTS

For each monitor site, sound level monitoring results are presented in a single chart in this report section. Each chart contains hourly sound levels, gust wind speed measured adjacent to each microphone, "hub height" average wind speed, precipitation events, and indications of data exclusions in conformance with LWECS Guidance. Points on the sound level graph represent data summarized for a single one-hour interval. The top portion of the chart displays A-weighted sound levels, the middle portion presents C-weighted levels, and the bottom portion shows wind speeds and times when there were data exclusions. All portions of the chart exhibit day/night shading: night is defined as 22:00 to 07:00 and shaded in grey.

The specific sound level metrics reported are L_{EQ}, L_{90}, L_{50}, and L_{10}. Equivalent continuous sound levels (L_{EQ}) are the energy-average level over one hour. Tenth-percentile sound levels (L_{90}) are the statistical value above which 90% of the sound levels occurred during one hour. Fiftieth-percentile sound levels (L_{50}) represent the median sound level of that one-hour period. Ninetieth-percentile sound levels (L_{10}) are the statistical value above which 10% of the sound levels occurred during one hour. Data that were excluded from processing (e.g., due to high wind and rain periods) are included in the graphs but shown in lighter colors. Furthermore, square markers on the lower portion of the chart indicate periods for which data was excluded and designate if the period was eliminated as a result of rain, wind gusts over 11 mph, or anomalous events.

Sound level data and wind gust data presented in the charts are those measured at each corresponding site. Wind data from the monitoring location, measured at the microphone height of 1.5 meters (5 feet), are presented as the maximum gust speed occurring at any time over a 10-minute interval; they are not averaged. The average 10-minute wind speed measured at the project met-tower closest to the monitoring location is also displayed on the chart. Lastly, one-hour precipitation totals are plotted with respect to the secondary axis on the right-hand side of the chart.

6.1 RESULTS SUMMARY

Exclusion Periods

Periods were excluded at each monitor through both manual identification and automated processing. Manual processing included the review of spectrograms created from the measured one-second one-third octave band data, accompanied by audio recordings made through the sound level meter's microphone. In this way, typical sources and anomalous events were identified.

Exact rain periods were manually identified from the spectrogram to ensure that data during rain events at each monitor were excluded. Automated processing of wind speed permitted the identification of gusts above 11 mph on a one-minute basis. That is, if a gust within a specific one-minute period was measured above 11 mph, then that whole minute was eliminated.

A summary of each monitor's total runtime and the amount of time excluded from the reported sound levels for rain, wind, and anomalous events are shown in Table 3.

TABLE 3. SUMMARY OF EXCLUSION PERIODS AT EACH MONITOR

LOCATION	RUN-TIME[14]	EXCLUSION STATISTICS							
		RAIN		WIND		ANOMALIES		TOTAL	
	(hr)	(hr)	(%)	(hr)	(%)	(hr)	(%)	(hr)	(%)
North Monitor	144	9.1	6.3%	16.0	11.1%	1.5	1.1%	26.6	18.5%
South Monitor	144	9.0	6.3%	0.6	0.4%	1.1	0.8%	10.7	7.4%
Northwest Monitor	224	3.9	1.7%	1.1	0.5%	0.4	0.2%	5.3	2.4%
West Monitor	285	3.2	1.1%	3.9	1.4%	0.5	0.2%	7.6	2.7%
Offsite C	198	16.2	8.2%	12.5	6.3%	0.2	0.1%	28.8	14.5%
Offsite D	144	8.1	5.6%	0.0	0.0%	1.2	0.8%	9.3	6.4%

Sound Levels

The A-weighted sound levels are listed for all seven sites in Table 4 and the C-weighted sound levels are listed Table 5. The reported levels represent all valid periods, that is, all periods that were not excluded due to weather or anomalous activity, as discussed in Section 5.2. In both tables, the equivalent continuous levels (L_{EQ}) at night are less than (or equal to) daytime levels at all sites, which is typical and indicate the influence of human activity on the measured sound levels during the day. For some locations, the large difference between L_{EQ} and 10th-percentile levels (L_{90}) indicate that the soundscapes are often dominated by transient or intermittent sounds (such as aircraft overflights or passing automobiles).

The average background L50 across the project site is 37 dBA during the day and 35 dBA at night.

[14] Due to firmware upgrades from Svantek immediately prior to the August 2017 monitoring period, the Svantek 979's memory became full after 144 hours of data collection.

TABLE 4. PRECONSTRUCTION MONITORING SUMMARY (A-WEIGHTED RESULTS)[15]

Location	Sound Level (dBA)											
	Overall				Day				Night			
	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}
North Monitor	36	26	34	38	38	30	35	39	32	23	31	35
South Monitor	43	30	39	47	42	30	37	45	44	30	42	48
Northwest Monitor	49	27	34	41	51	29	35	41	36	24	32	39
West Monitor	51	35	40	47	53	36	41	47	42	31	37	45
Offsite C	46	25	32	43	47	27	33	44	40	23	30	42
Offsite D	44	30	39	45	45	32	39	45	41	29	38	44
Average of Onsite Monitors	*45*	*29*	*37*	*43*	*46*	*31*	***37***	*43*	*39*	*27*	***35**[16]*	*42*

TABLE 5. PRECONSTRUCTION MONITORING SUMMARY (C-WEIGHTED RESULTS)[17]

Location	Sound Level (dBC)											
	Overall				Day				Night			
	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}
North Monitor	47	34	41	48	49	37	42	50	41	32	38	43
South Monitor	51	37	44	52	52	39	46	54	47	34	41	47
Northwest Monitor	57	36	44	52	59	40	45	54	47	33	41	50
West Monitor	61	41	47	54	63	42	47	55	49	38	45	53
Offsite C	55	36	42	49	57	37	43	51	46	35	40	44
Offsite D	53	45	47	52	54	44	48	54	49	45	47	50
Average of Onsite Monitors	*54*	*37*	*44*	*51*	*56*	*40*	*45*	*53*	*46*	*34*	*41*	*48*

Meteorology

Local meteorological data was collected from anemometers alongside the monitors, project met-towers, and the Canby Airport (station KCNB). According to the airport, local temperatures

[15] The results for the North, South, Offsite C, and Offsite D Monitors are from the Blazing Star 2 monitoring period of August 8-16, 2017, while the results from the Northwest and West Monitors are from the Blazing Star monitoring period of July 20 – August 1, 2016.

[16] The values presented in Table 4 are rounded to the nearest decibel. This is common practice in acoustics given that the average human listener cannot perceive a difference in sound level of less than 3 dB. The unrounded nighttime L50 values for the onsite monitors are: North Monitor – 30.7 dBA, South Monitor – 41.8 dBA, Northwest Monitor – 32.0 dBA, and West Monitor – 37.0 dBA. These values result in an average nighttime L50 of 35.4 dBA across the site.

[17] The results for the North, South, Offsite C, and Offsite D Monitors are from the Blazing Star 2 monitoring period of August 8-16, 2017, while the results from the Northwest and West Monitors are from the Blazing Star monitoring period of July 20 – August 1, 2016.

ranged from 12.0°C to 27.8°C during the August 2017 monitoring period and from 12.5°C to 33.6°C during the July 2016 monitoring period.

According to KCNB, the only significant precipitation events during the August 2017 monitoring period took place the morning of August 9 and the evening of August 9. The evening of August 9 involved a strong thunderstorm system that moved through the area between 7 and 9 pm. During the July 2016 monitoring period, the only registered precipitation event from KCNB was on July 23. This too was a strong thunderstorm system that moved through the area. Additional short duration rain was observed at some of the monitors on July 26. Thunder, which was observed in the spectrograms, occurred on the morning of July 27th and was excluded from data processing as an anomaly.

A summary of the 1.5-meter (5-foot) wind speeds measured at each monitoring location over the deployment period at each site is provided in Table 6.

TABLE 6. SUMMARY OF MEASURED 10-MINUTE 1.5-METER (5-FOOT) WIND SPEEDS

Location	Measured 1.5-meter Height (mph)			
	10-min Wind Speed		10-min Gust Speed	
	Average	Maximum	Average	Maximum
North Monitor	2.8	17.1	6.5	27.0
South Monitor	0.5	6.9	2.9	21.4
Northwest Monitor	1.7	8.6	4.4	15.2
West Monitor	1.9	10.3	5.0	24.8
Offsite C	2.3	11.8	6.1	23.6
Offsite D[18]	1.5	6.0	5.1	11.3

6.2 MONITORING RESULTS - NORTH MONITOR

Monitoring results for the North Monitor are presented in Figure 19.

The North Monitor was the most exposed monitor and therefore registered the highest wind speeds. It had the most periods of wind greater than 5 meters per second which merited removal from the analysis due to wind-cause pseudo-noise on the microphone.

The North Monitor was one of the quietest locations monitored. It was not near any major roadways and was set back a few hundred meters from local roadways, so the North Monitor was less influenced by traffic noise than other monitors. Primary sources of sound were wind rustling grass, biogenic sounds (both wildlife and agricultural), and occasional aircraft overflights. The sound levels displayed a clear diurnal pattern. That is, sound levels rose during

[18] The anemometer data logger for the Offsite D Monitor had a memory failure after 1.5 days. The data in Table 6 for the Offsite D Monitor only represent the 1.5 days of collected data.

the day and fell at night. This is often attributable to human activity, and in this case, it was primary caused by aircraft overflights and biogenic sounds, which both occurred less at night.

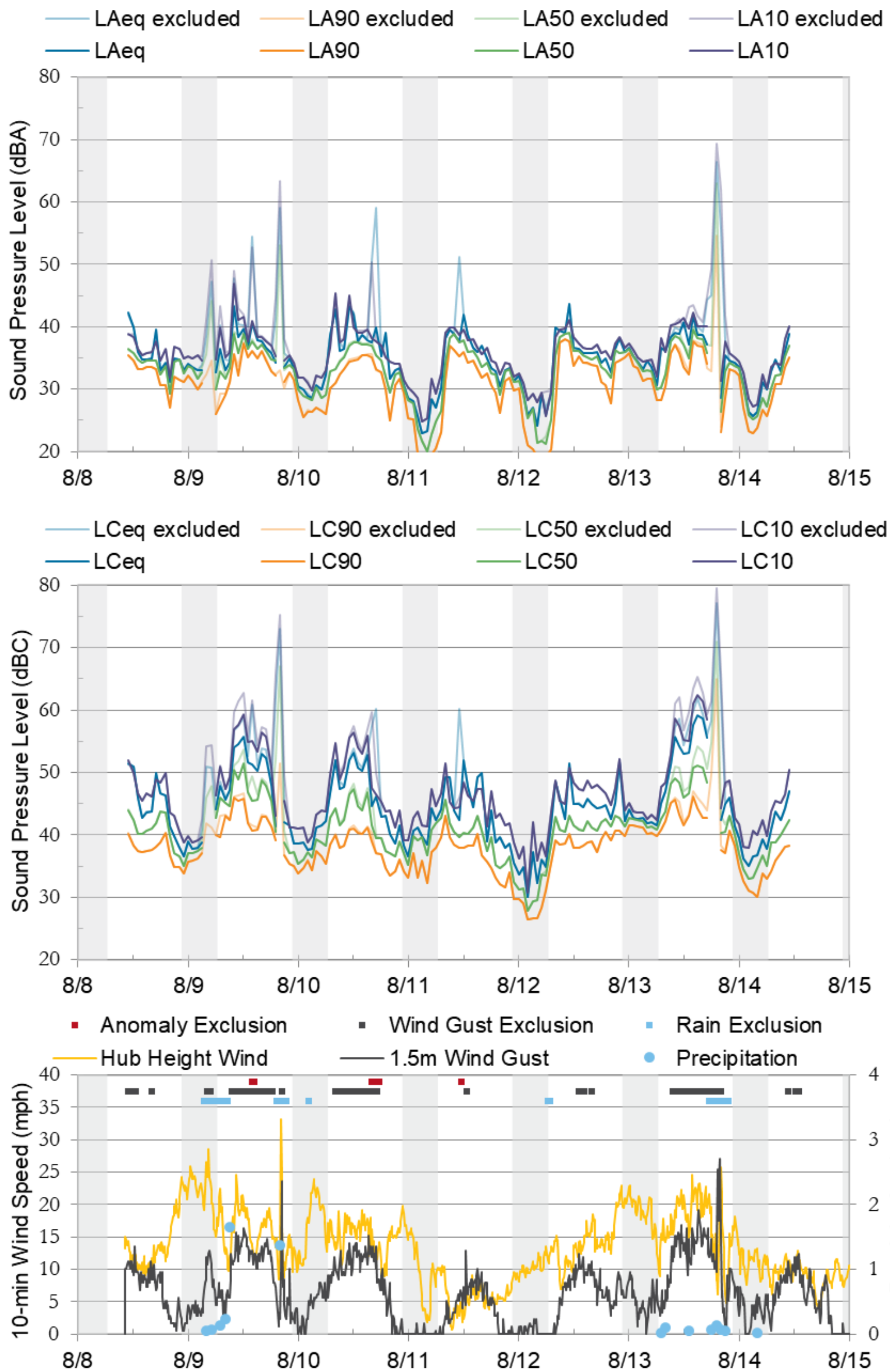

FIGURE 19. PRE-CONSTRUCTION MONITORING RESULTS AT THE NORTH MONITOR

6.3 MONITORING RESULTS - SOUTH MONITOR

Monitoring results for the South Monitor are presented in Figure 20.

Being located near the US Route 75 corridor, the South Monitor was more influenced by periodic traffic noise than the other monitors. This resulted in the South Monitor having the some of the highest background sound levels of all the monitoring locations. The overall nighttime L50 was 42 dBA, 4 dB higher than the next highest monitor location (Offsite D). The sound levels displayed a slightly diurnal pattern; less so than the North Monitor.

Primary sources of sound at the South monitor included vehicle passbys, aircraft flyover, wind in foliage, and at night, insects.

The South Monitor was placed in the proximity of the worst-case receptors, as identified in preliminary modeling of the project wind turbines.

Figure 21 presents the 1/3 octave band statistical sound levels for a representative wind speed at the South Monitor. A wind speed of 9 m/s, applied at a representative hub height of 85 meters (279 feet), was selected because it is typically the speed at which turbines begin producing maximum sound power. Only periods with this representative wind speed were used for the unweighted statistical metrics in the figure, providing a baseline for direct comparison with post-construction measurements. The large difference between the upper and lower 10th percentiles in the 10,000 Hz octave band is indicative of occasional insect sounds at night.

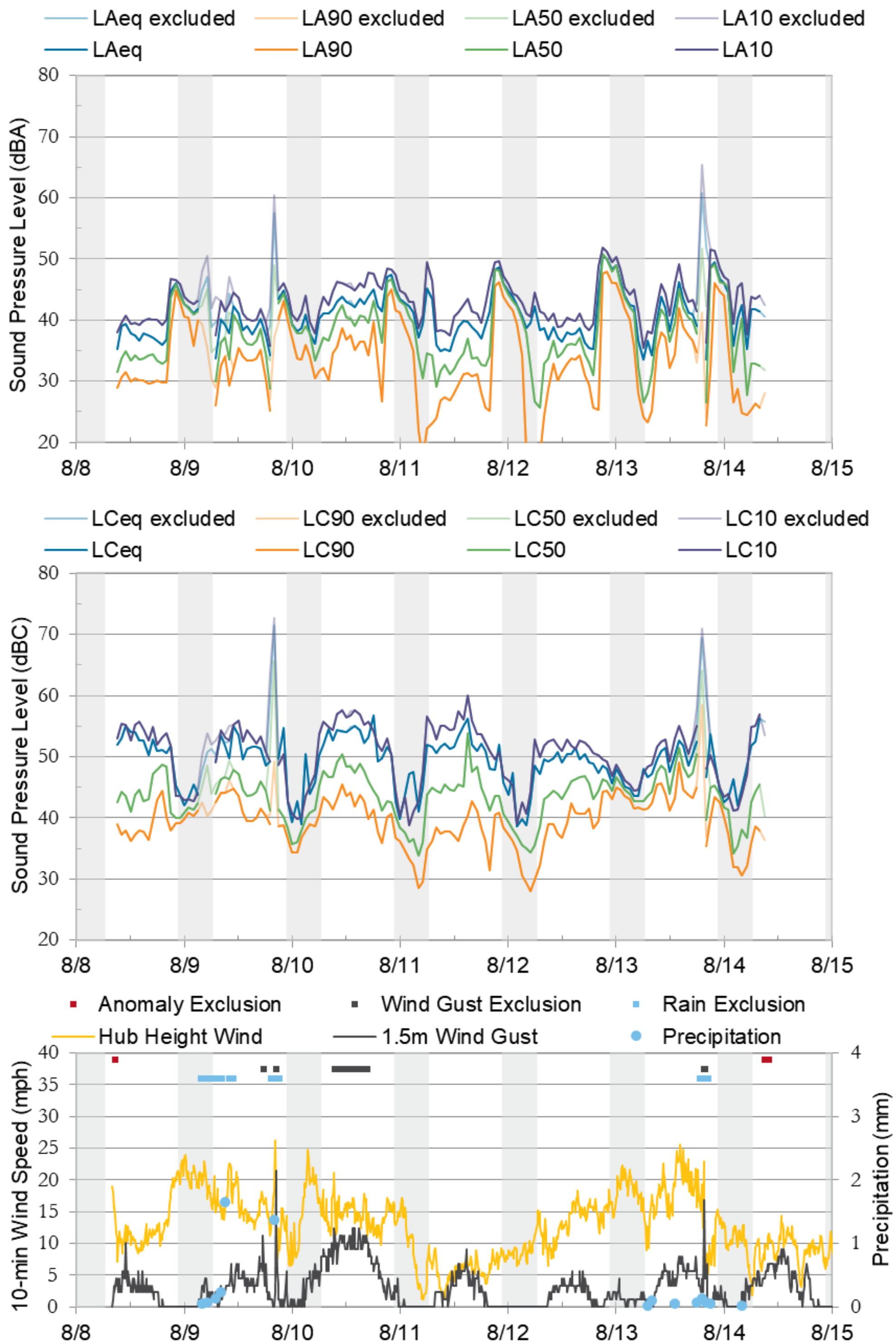

FIGURE 20. PRECONSTRUCTION MONITORING RESULTS AT THE SOUTH MONITOR

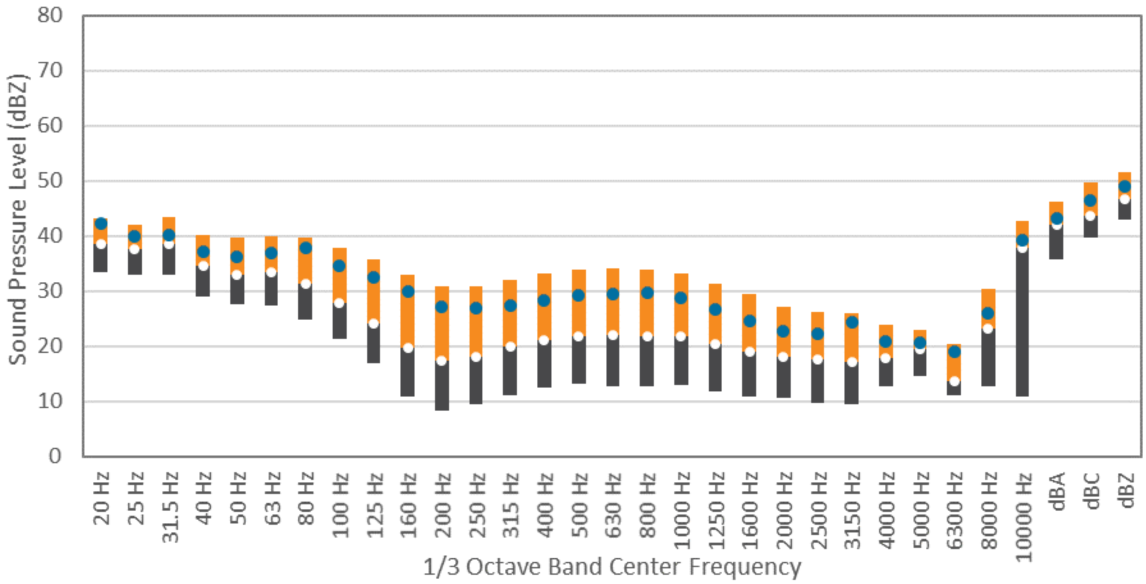

FIGURE 21: SOUTH MONITOR - 1/3 OCTAVE BAND AND OVERALL STATISTICAL SOUND LEVELS[19] AT 9 M/S 85-METER (279-FOOT) HEIGHT WIND SPEED

6.4 MONITORING RESULTS - NORTHWEST MONITOR

Monitoring results at the Northwest Monitor are presented in Figure 22.

Although the wind's behavior generated what appears to be a diurnal pattern, distant human activity was also a contributing factor. Two Hundred Ninetieth Street, located to the north, had a relatively low traffic volume, leading to noticeable soundscape contribution from vehicle traffic during the day yet minimal impact at night. Most of the sound sources at night were commercial aircraft flyovers at cruising altitude and barking dogs. Farm equipment was relatively infrequent during the monitoring period, even with farm fields surrounding the homestead. Dog barking was common due to two dogs inhabiting the site. Other sound sources that were present included birds, insects, aircraft, residents coming and going, and yard maintenance equipment.

The louder period in the middle of the day on July 25th was a result of the property, on which the monitor was placed, being mowed.

[19] Each vertical orange and grey bar shows the Lower 10th, median, and Upper 10th percentile L_{90}, L_{50}, and L_{10}) sound level for a single 1/3 octave band. The top of the orange bar is the Upper 10th percentile sound pressure level, the white dot is the median, and the bottom of the grey bar is the lower 10th percentile sound level. The entire length of the bar indicates the middle 80th percentile of sound pressure levels. The blue dots indicate the equivalent average sound pressure level (L_{EQ}) for that 1/3 octave band. At the far right of the chart are the A-, C-, and Z-weighted overall levels. Data shown was measured during periods where the estimated 85-meter (279-foot) wind speed was at 9 meters per second, the speed where most turbine models begin producing maximum sound emissions.

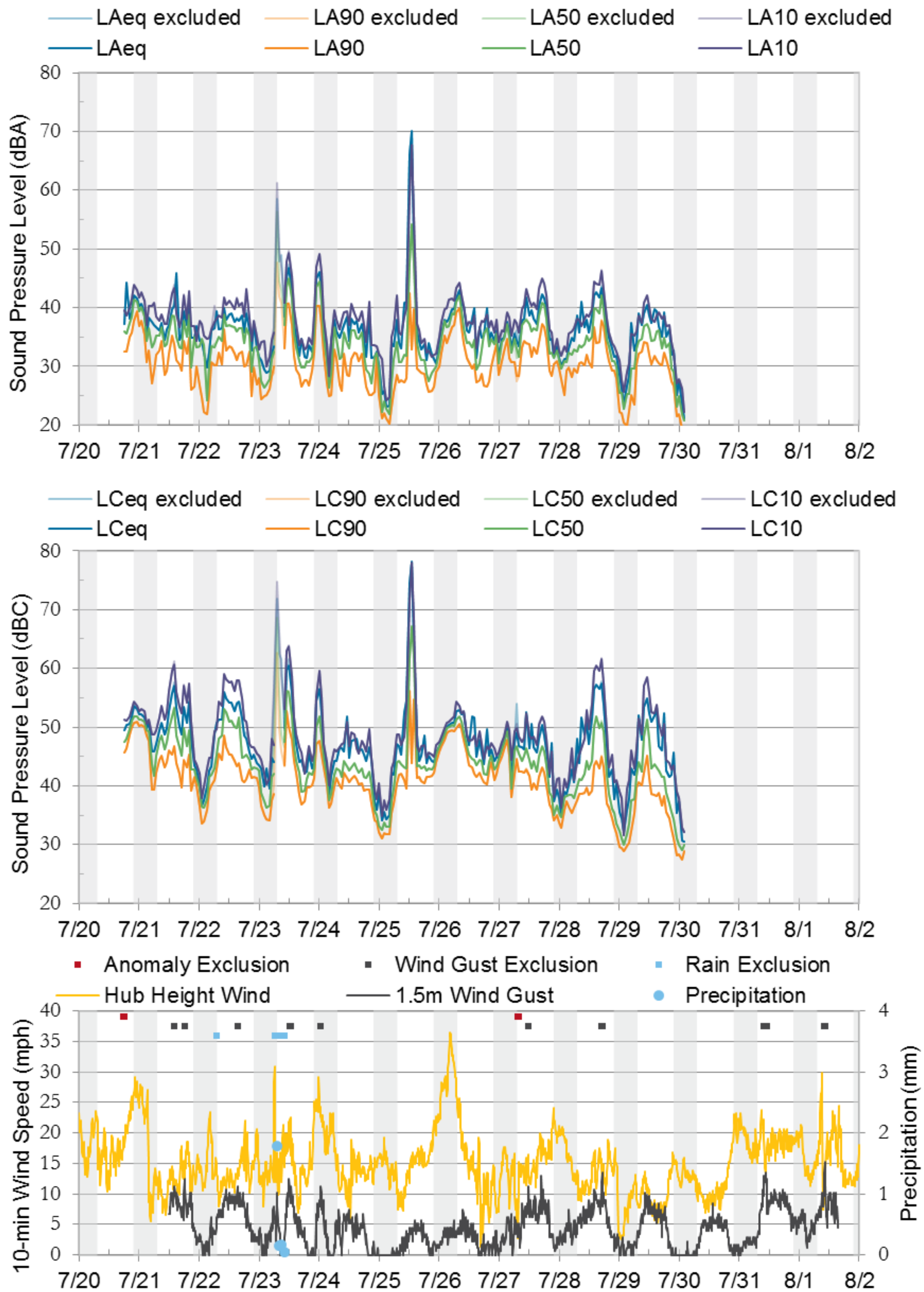

FIGURE 22. PRE-CONSTRUCTION MONITORING RESULTS FOR THE NORTHWEST MONITOR

6.5 MONITORING RESULTS – WEST MONITOR

Results for the monitoring period at the West monitor are presented in Figure 26.

The soundscape at this location was often dominated by wind-caused sound, mostly resulting from the wind's interaction with nearby trees and crops. The C-weighted L_{10} very closely followed the trend of 10-minute gust speed. Nearby vegetation also housed birds and insects that were responsible for the biogenic sound observed during monitoring. During quieter periods, a fan located at the nearby residence was audible, as was a television or radio. The early morning hours of July 29th was observed to be the quietest period at this monitor as a result of the calm winds, with all A-weighted metrics dropping below 30 dBA.

Yard maintenance activities and farm equipment were occasionally audible. Due to low overall traffic volume and distance to the roads, vehicle noise was infrequent and lower in magnitude. Airplane overflights were often masked by the fan and a railroad was occasionally audible. Lawn care of the property on which the monitor was installed took place on July 27th and July 29th.

Figure 27 displays the summary of overall and statistical levels for the representative hub height wind speed of 9 m/s. The relatively small difference between the upper 10th-precentile level and the lower 10th-percentile level means that there are few transient sounds that occurred at the monitoring location.

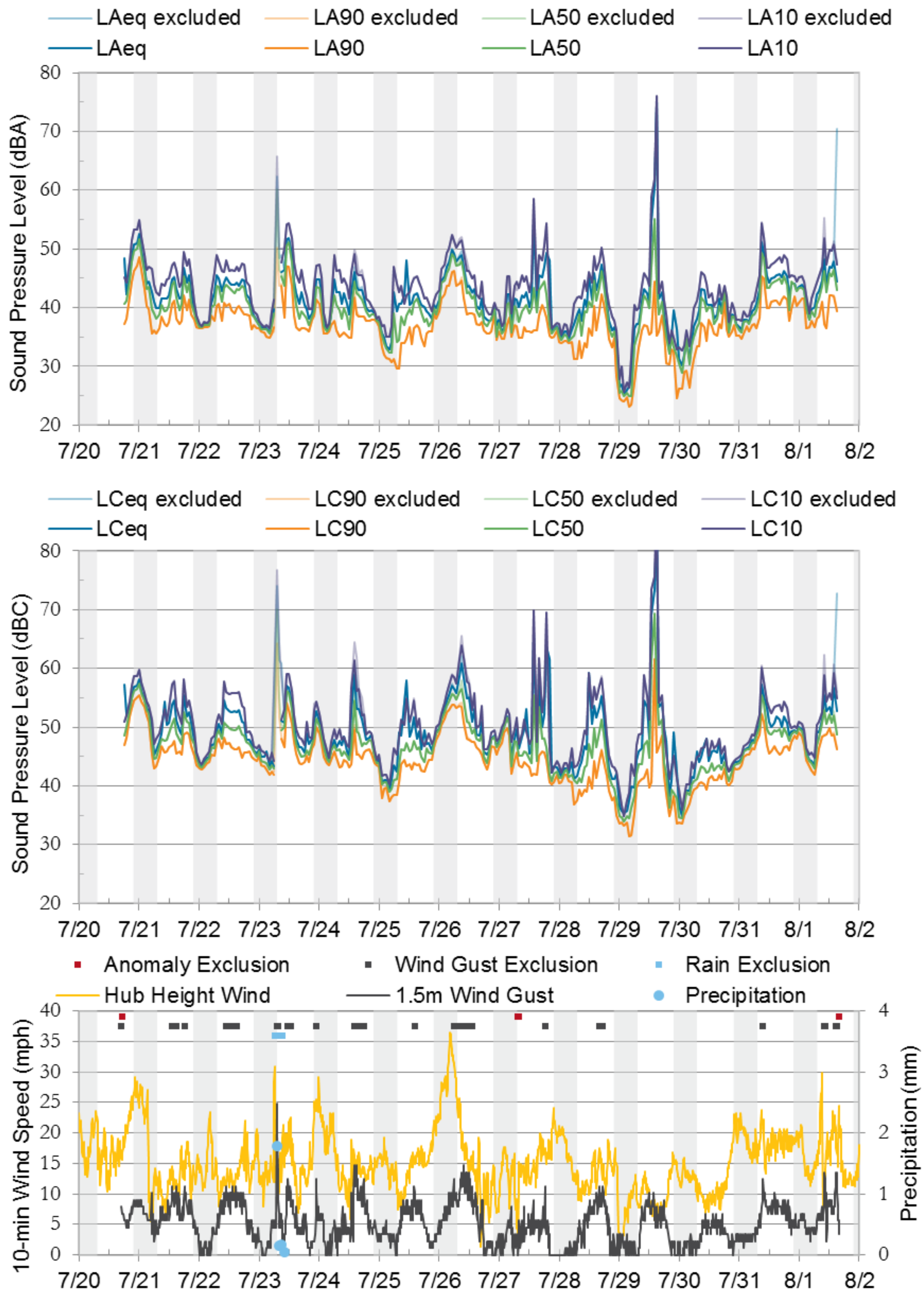

FIGURE 23. PRECONSTRUCTION RESULTS FOR THE WEST MONITOR

6.6 MONITORING RESULTS – OFFSITE C MONITOR

The monitoring results for the Offsite C monitor are presented in Figure 24.

The soundscape at the Offsite C Monitor was dominated by wind-caused sound in nearby foliage and biogenic sounds, mostly bird calls. There were also occasional vehicle passbys on 370th Street. The sound levels displayed a diurnal pattern which was due to both bird calls and vehicle passbys. Aircraft flyovers were also present at this monitor, but appeared slightly less frequent than at other monitoring locations.

The L50 at this monitor location closely matches the pattern of wind speed at the site while the equivalent sound level is more influenced by vehicle passybs. This is evident in Figure 24. For example, August 10 and 14 were days with lower wind speeds and corresponding lower median sound levels, but the equivalent sound levels are similar to days with higher wind speeds indicating that they are driven more by occasional vehicle passbys. This would be due to the monitor's proximity to 370th Street.

Figure 25 displays the summary of overall and statistical levels for the representative hub height wind speed of 9 m/s. The relatively small difference between the upper 10th-percentile and lower 10th-percentile level means that there are few transient sounds that occurred at this monitor location. The large difference between the upper and lower 10th percentiles in the 2,000 and 10,000 Hz octave bands is indicative of occasional insect sounds at night.

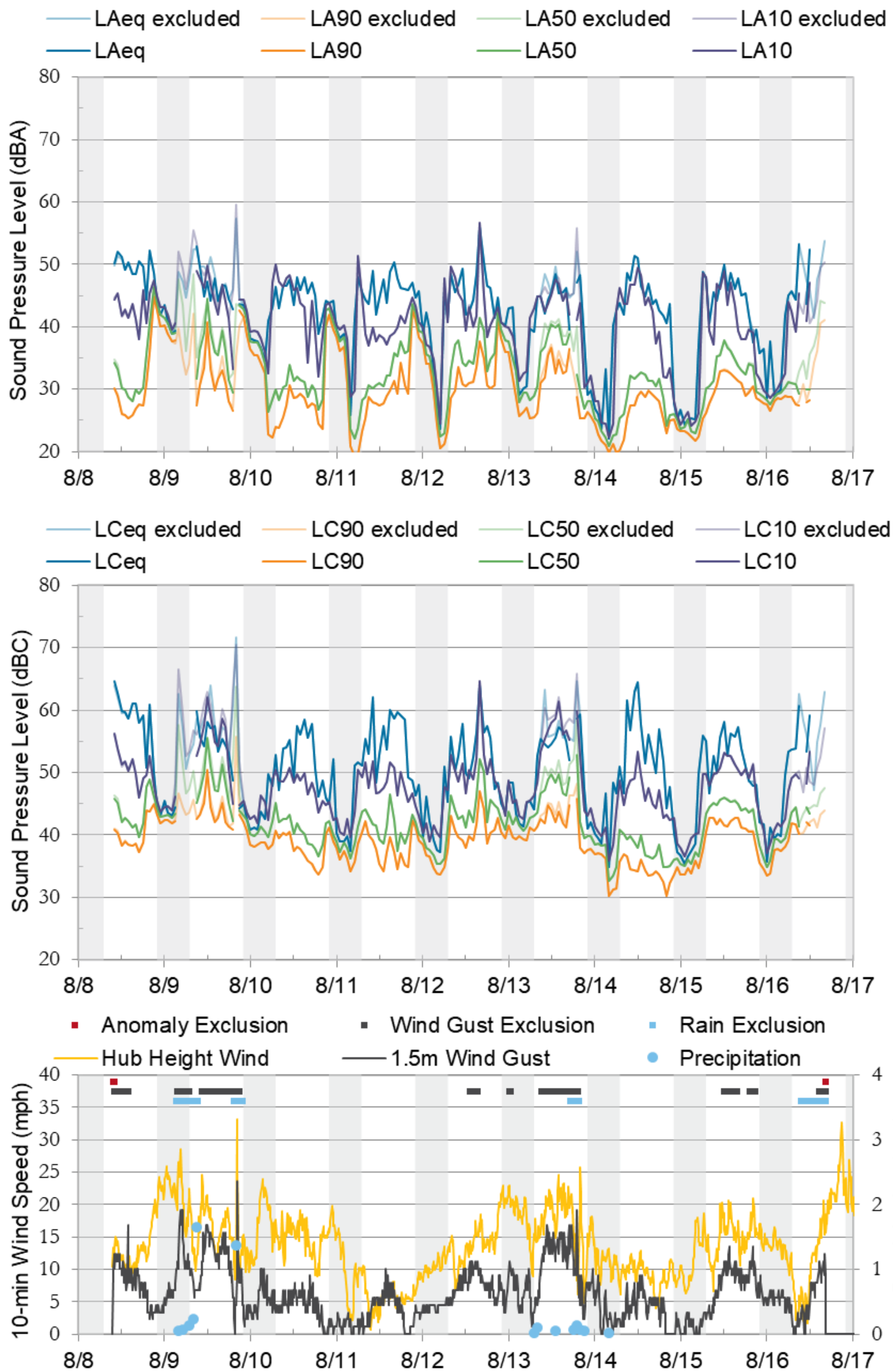

FIGURE 24. PRE-CONSTRUCTION RESULTS FOR THE OFFSITE C MONITOR

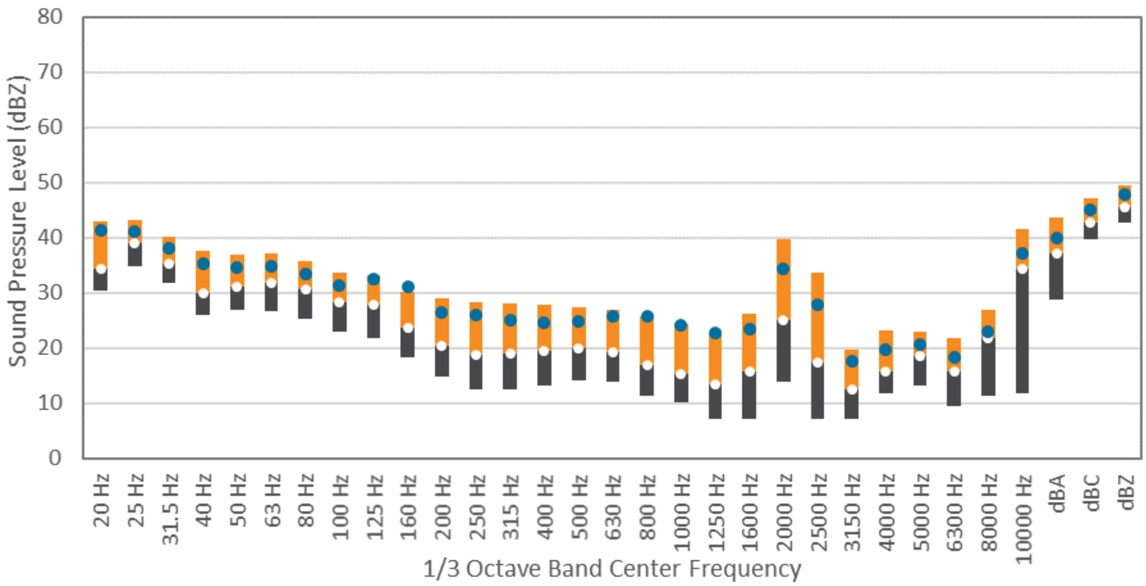

FIGURE 25: OFFSITE C - 1/3 OCTAVE BAND AND OVERALL STATISTICAL SOUND LEVELS AT 9 M/S 85-METER (279-FOOT) HEIGHT WIND SPEED

6.7 MONITORING RESULTS – OFFSITE D MONITOR

Results for the monitoring period at the Offsite D monitor are presented in Figure 26.

The soundscape at the Offsite D Monitor was dominated by wind-caused sound in nearby foliage, biogenic sounds including insects at night and occasional birds and dogs, and sound from agricultural activities at nearby farms. There were also occasional vehicle passbys on County Road 110. The A-weighted sound levels displayed a diurnal pattern, but the C-weighted sound levels did not. This is due to consistently present low frequency sound from agricultural operations at nearby farms. The spike in sound levels on August 12 which was removed from the data analysis as an anomaly was caused by a low-flying aircraft, presumably a crop duster.

Figure 27 displays the summary of overall and statistical levels for the representative hub height wind speed of 9 m/s. The large difference between the upper and lower 10th percentiles in the 10,000 Hz octave band is indicative of occasional insect sounds at night. The consistent low frequency sound from nearby agricultural operations is also apparent in Figure 27.

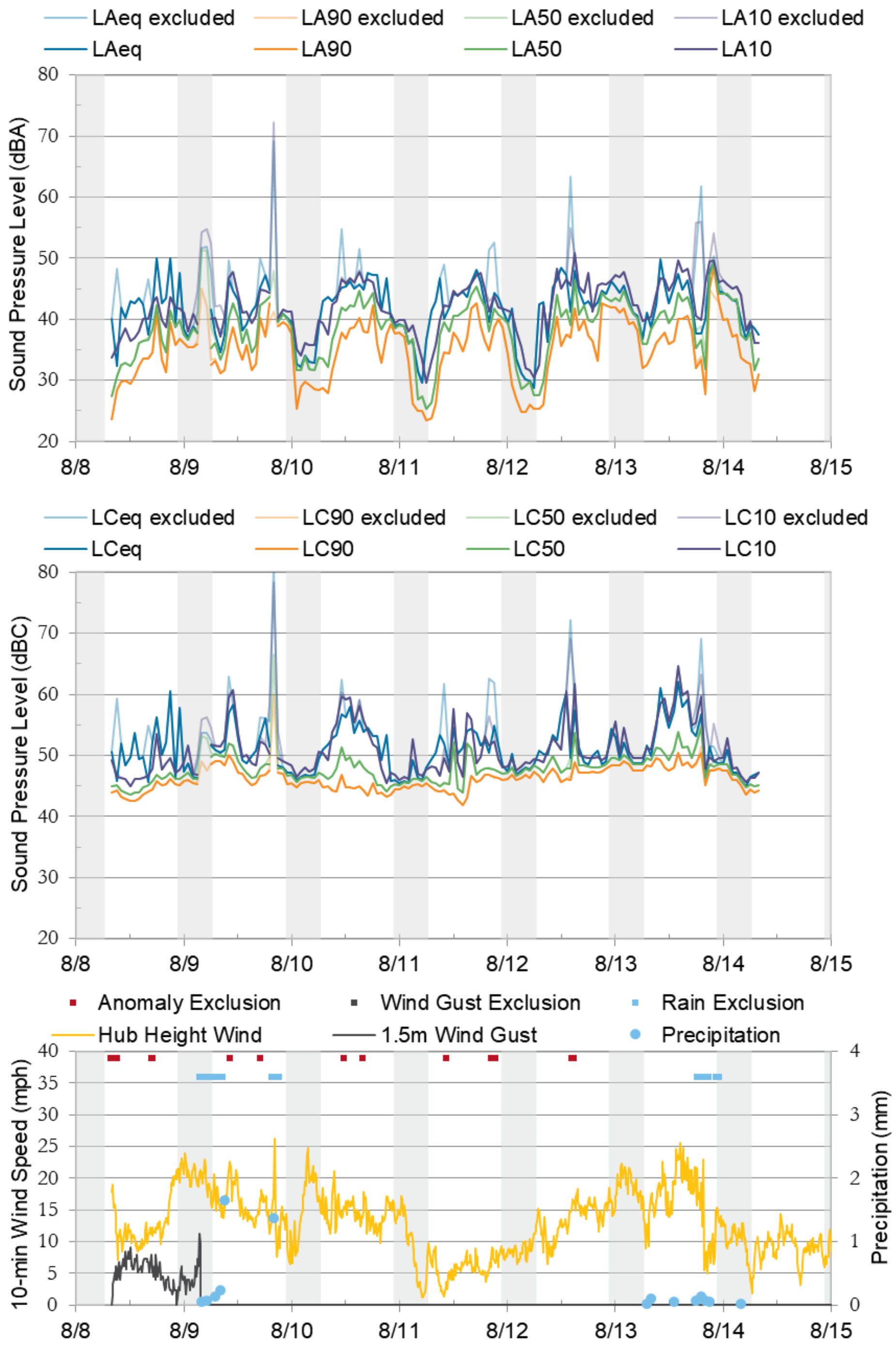

FIGURE 26. PRECONSTRUCTION RESULTS FOR THE OFFSITE D MONITOR[20]

[20] The anemometer data logger for the Offsite D Monitor had a memory failure after 1.5 days. The 1.5-meter wind data in Figure 26 shows the data that was collected over the first 1.5 days.

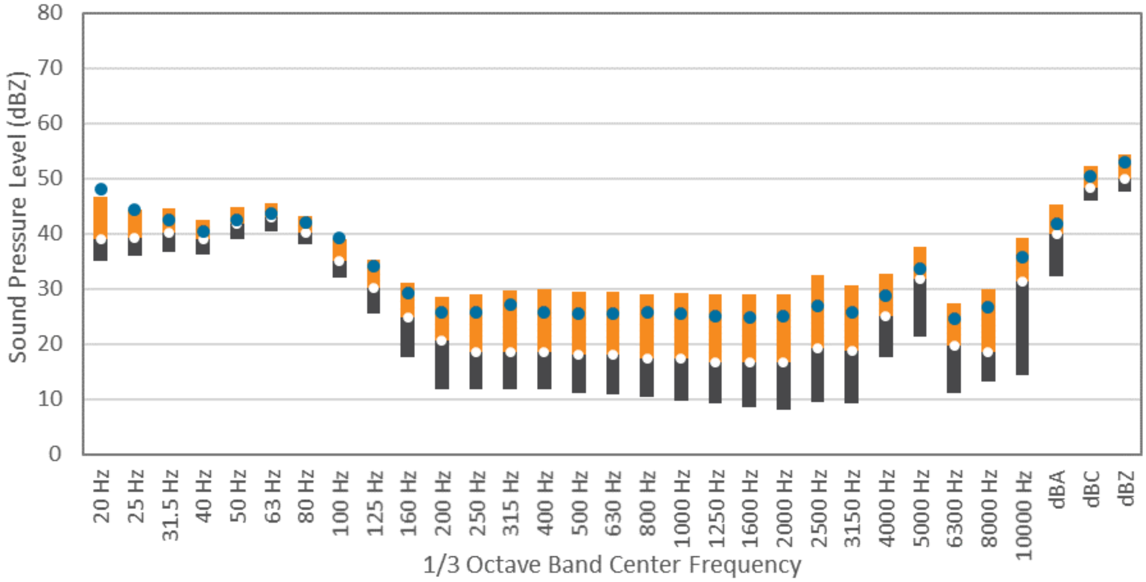

FIGURE 27: OFFSITE D - 1/3 OCTAVE BAND AND OVERALL STATISTICAL SOUND LEVELS AT 9 M/S 85-METER (279-FOOT) HEIGHT WIND SPEED

7.0 SOUND PROPAGATION MODELING PROCEDURES

Modeling for the project was in accordance with the standard ISO 9613-2, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation." The ISO standard states,

> This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level … under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation … or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. The acoustical modeling software used here was CadnaA, from Datakustik GmbH. CadnaA is a widely accepted acoustical propagation modeling tool, used by many noise control professionals in the United States and internationally.

ISO 9613-2 also assumes downwind sound propagation between every source and every receiver, consequently, all wind directions, including the prevailing wind directions, are taken into account.

Model input parameters are listed in Appendix B including the modeled sound power spectra for each turbine model.

For this analysis, we utilized a ground absorption factor of G = 0.7, which is appropriate for comparing modeled results to the L_{50} metric used in the state standard, particularly when summing model results with the monitored L_{50} levels[21]. A 2 dB uncertainty factor was still added to the turbine sound power per IEC 61400-14.

Two distinct receiver heights are included in the analysis; different receiver heights result in different sound levels as a result of source proximity and relative exposure. Residences are modeled as discrete receivers at 4 meters (13 feet) above ground level. The 4-meter (13-foot) receiver height mimics the height of a second story window. A total of 397 residences located within 1.6 kilometers (1 mile) of the Blazing Star 2 project area. The grid, represented in the

[21] Generally accepted wind turbine modeling procedure calls for a ground absorption factor of G = 0.5, with a 2 dB uncertainty factor added to the manufacturer's guaranteed levels, to predict a maximum $L_{EQ(1-hr)}$. In this case, the state limit utilizes an L50 metric instead of maximum $L_{EQ(1-hr)}$, which means a ground factor of G=0.7 is more appropriate.

results map by sound pressure level contours, is calculated at a height of 1.5 meters (5 feet), to represent one's average listening height.

A search distance up to 10,000 meters (6.2 miles) allows for the contributions of distant turbines to be considered at receivers. The contribution of distant turbines will depend on the geometry and geography of the project.

The model included the turbines from Blazing Star and Blazing Star 2 to account for the combined potential impact of both projects together.

8.0 SOUND PROPAGATION MODELING RESULTS

8.1 OVERALL A-WEIGHTED MODEL RESULTS

Modeling results are shown in Figure 28. Results are presented as contour lines representing 5-dB increments of calculated A-weighted sound pressure levels. Appendix C provides a list of the calculated sound pressure levels at each receiver in tabular format and a map showing all receiver identification numbers for reference in the appendix table.

A summary of the sound propagation model results is presented in Table 7. All modeled receivers are predicted to experience sound levels at or below 50 dBA. The highest sound level (L50) at a non-participating residence is 45 dBA, and the average sound level (L50) across all non-participating residences is 39 dBA.

TABLE 7: MODEL RESULTS SUMMARY

RESIDENCE CLASSIFICATION	AVERAGE L50	MAXIMUM L50	MINIMUM L50
All	41	50	31
Participating	45	50	32
Non-Participating	39	45	31

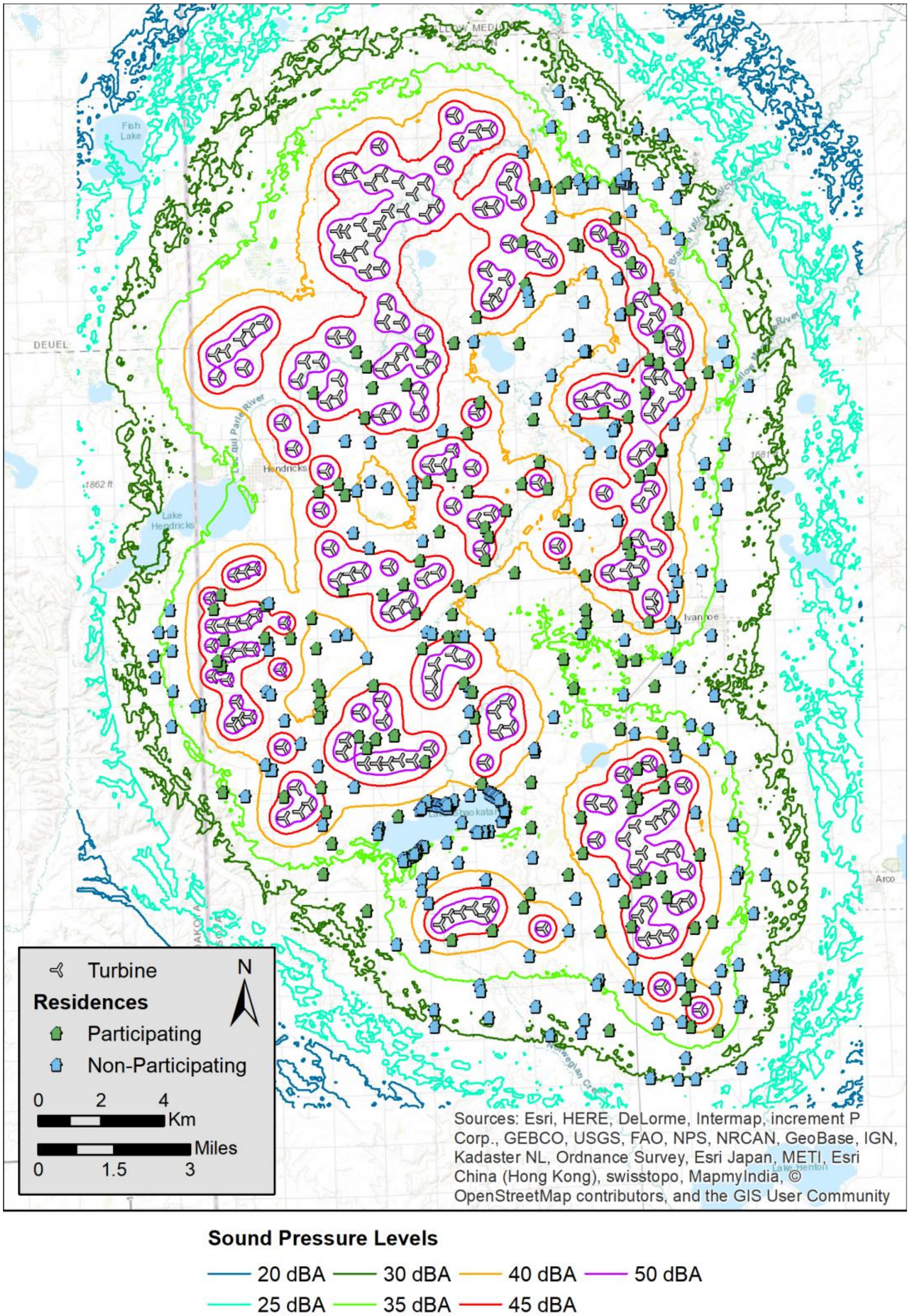

FIGURE 28: SOUND PROPAGATION MODEL RESULTS

8.2 MODEL RESULTS ADDED TO BACKGROUND L50

To assess potential for compliance with state noise regulations, the model results must be summed (logarithmically)[22] with the monitored overall nighttime L50 results to determine possible L50 levels that could occur when the project is operating. This analysis is presented in Table 8. As shown in the Table, the model results summed with the overall nighttime L50 for each monitoring location are less than 50 dBA.

TABLE 8: MODEL RESULTS (dBA) SUMMED WITH MONITORED BACKROUND SOUND LEVELS (L50, dBA)

SCENARIO	METRIC	MONITOR LOCATION			
		North Monitor	Northwest Monitor	West Monitor	South Monitor
Background Monitor Results	Overall Nighttime L50	31	32	37	42
	Maximum 1-hr Nighttime L50	37	45	52	50
	Minimum 1-hr Nighttime L50	20	21	36	27
Blazing Star & Blazing Star 2	Modeled Sound Level	49	48	48	48
	Summed with Overall Nighttime L50	49	48	49	49

The background L50 does and will vary from hour to hour, as shown in the monitor results in Section 6. Thus, in Appendix C, the model results are summed with a range of potential background L50 values ranging from 35 dBA to 55 dBA in 5 dB increments. As previously discussed in Section 5, only periods with high wind (above 5 m/s), precipitation, thunder, low flying aircraft near the monitor, and personnel and animal interaction with equipment were excluded from the monitored data. For post-construction compliance monitoring, LWECS Guidance allows for elimination of sporadic noise such as vehicle passbys, dogs barking, and other non-turbine related extraneous sound. With all of those sources removed, the background L50s are likely lower than those reported here and in Section 6.

[22] $L_{p1,2} = 10 \times \log_{10}\left(10^{L_{p1}/10} + 10^{L_{p2}/10}\right)$

9.0 CONCLUSIONS

Blazing Star 2 is a permitted wind power generation facility in Lincoln County, Minnesota. The facility will include up to 100 wind turbines for a rating of up to 200 MW. For the Site Permit Application, RSG performed a preliminary noise compliance assessment of the project based on the preliminary turbine layout and turbine models under consideration. This noise compliance assessment is an updated version of the preliminary noise compliance assessment with the most recent project information.

Conclusions of the assessment are as follows:

1. Background sound level monitoring periods with high wind (above 5 m/s), precipitation, thunder, low-flying aircraft near the monitors, and personnel and animal interaction with equipment were excluded from the monitored data.
2. Background sound levels vary some around the project site with the quietest areas on the north and northwest side of the project area where the overall nighttime L50 was 31 to 32 dBA over the course of the entire monitoring periods. At other on-site locations, the overall nighttime L50 was 37 to 42 dBA over the course of the entire monitoring periods. The average background L50 across the project site is 37 dBA during the day and 35 dBA at night.
3. Minimum 1-hour nighttime L50s were between 21 and 36 dBA across the project area, while maximum 1-hour nighttime L50s were between 37 and 52 dBA.
4. With non-turbine extraneous sound sources such as, vehicle passbys and dogs barking, background sound levels may be lower than those reported here.
5. State noise regulations require that wind power generation facilities show compliance with a nighttime limit of 50 dBA (L50) and a daytime limit of 60 dBA (L50) at residences.
6. Sound propagation modeling was performed in accordance with ISO 9613-2 at 397 discrete receivers within 1 mile of the project area with spectral ground attenuation and a ground factor of G=0.7. These modeling parameters are meant to represent the L50 of the proposed facility.
7. Modeling was completed for the selected turbine models: 90 Vestas V120 STE & 10 Vestas V110 STE.
8. Projected sound levels from the project in combination with projected sound levels from Blazing Star are 50 dBA or less at all residences with the highest projected sound level (L50) at a non-participating residence of 45 dBA. The average sound level (L50) across all non-participating residences is 39 dBA.

9. When added to the overall nighttime L50 from monitored locations, sound levels remain below 50 dBA, but the background L50 does and will vary from hour to hour, as shown in the monitor results.

APPENDIX A. ACOUSTICS PRIMER

Expressing Sound in Decibel Levels

The varying air pressure that constitutes sound can be characterized in many different ways. The human ear is the basis for the metrics that are used in acoustics. Normal human hearing is sensitive to sound fluctuations over an enormous range of pressures, from about 20 micropascals (the "threshold of audibility") to about 20 pascals (the "threshold of pain").[23] This factor of one million in sound pressure difference is challenging to convey in engineering units. Instead, sound pressure is converted to sound "levels" in units of "decibels" (dB, named after Alexander Graham Bell). Once a measured sound is converted to dB, it is denoted as a level with the letter "L".

The conversion from sound pressure in pascals to sound level in dB is a four-step process. First, the sound wave's measured amplitude is squared and the mean is taken. Second, a ratio is taken between the mean square sound pressure and the square of the threshold of audibility (20 micropascals). Third, using the logarithm function, the ratio is converted to factors of 10. The final result is multiplied by 10 to give the decibel level. By this decibel scale, sound levels range from 0 dB at the threshold of audibility to 120 dB at the threshold of pain.

Typical sound sources, and their sound pressure levels, are listed on the scale in Figure 29.

Human Response to Sound Levels: Apparent Loudness

For every 20 dB increase in sound level, the sound pressure increases by a *factor* of 10; the sound *level* range from 0 dB to 120 dB covers 6 factors of 10, or one million, in sound *pressure*. However, for an increase of 10 dB in sound *level* as measured by a meter, humans perceive an approximate doubling of apparent loudness: to the human ear, a sound level of 70 dB sounds about "twice as loud" as a sound level of 60 dB. Smaller changes in sound level, less than 3 dB up or down, are generally not perceptible.

[23] The pascal is a measure of pressure in the metric system. In Imperial units, they are themselves very small: one pascal is only 145 millionths of a pound per square inch (psi). The sound pressure at the threshold of audibility is only 3 one-billionths of one psi: at the threshold of pain, it is about 3 one-thousandths of one psi.

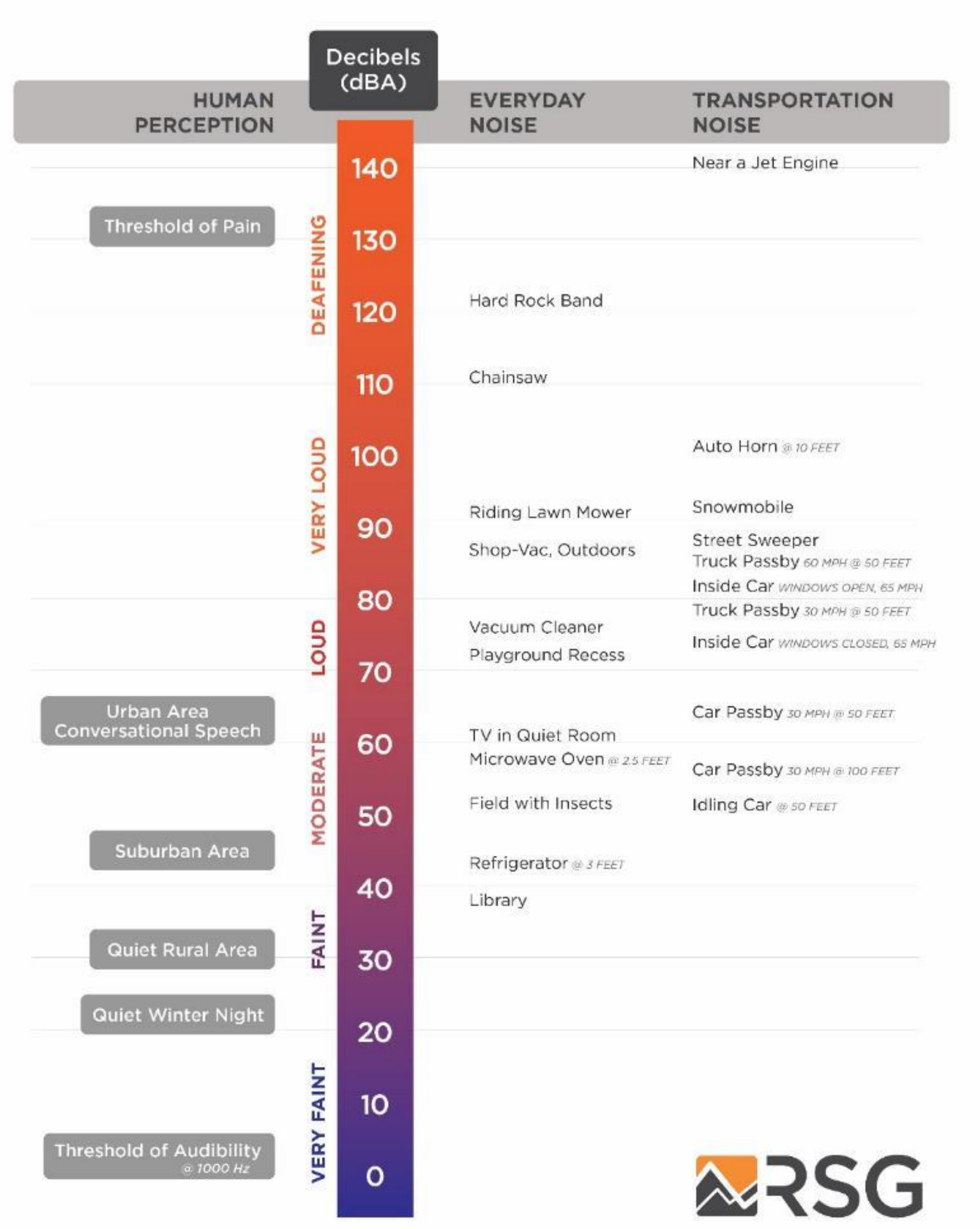

FIGURE 29: A SCALE OF SOUND PRESSURE LEVELS FOR TYPICAL SOUND SOURCES

Frequency Spectrum of Sound

The “frequency” of a sound is the rate at which it fluctuates in time, expressed in Hertz (Hz), or cycles per second. Very few sounds occur at only one frequency: most sound contains energy at many different frequencies, and it can be broken down into different frequency divisions, or bands. These bands are similar to musical pitches, from low tones to high tones. The most common division is the standard octave band. An octave is the range of frequencies whose upper frequency limit is twice its lower frequency limit, exactly like an octave in music. An octave band is identified by its center frequency: each successive band’s center frequency is twice as high (one octave) as the previous band. For example, the 500 Hz octave band includes all sound whose frequencies range between 354 Hz (Hertz, or cycles per second) and 707 Hz. The next band is centered at 1,000 Hz with a range between 707 Hz and 1,414 Hz. The range of human hearing is divided into 10 standard octave bands: 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1,000 Hz, 2,000 Hz, 4,000 Hz, 8,000 Hz, and 16,000 Hz. For analyses that require finer frequency detail, each octave-band can be subdivided. A commonly-used subdivision creates three smaller bands within each octave band, or so-called 1/3-octave bands.

Human Response to Frequency: Weighting of Sound Levels

The human ear is not equally sensitive to sounds of all frequencies. Sounds at some frequencies seem louder than others, despite having the same decibel level as measured by a sound level meter. In particular, human hearing is much more sensitive to medium pitches (from about 500 Hz to about 4,000 Hz) than to very low or very high pitches. For example, a tone measuring 80 dB at 500 Hz (a medium pitch) sounds quite a bit louder than a tone measuring 80 dB at 60 Hz (a very low pitch). The frequency response of normal human hearing ranges from 20 Hz to 20,000 Hz. Below 20 Hz, sound pressure fluctuations are not “heard”, but sometimes can be “felt”. This is known as “infrasound”. Likewise, above 20,000 Hz, sound can no longer be heard by humans; this is known as “ultrasound”. As humans age, they tend to lose the ability to hear higher frequencies first; many adults do not hear very well above about 16,000 Hz. Most natural and man-made sound occurs in the range from about 40 Hz to about 4,000 Hz. Some insects and birdsongs reach to about 8,000 Hz.

To adjust measured sound pressure levels so that they mimic human hearing response, sound level meters apply filters, known as “frequency weightings”, to the signals. There are several defined weighting scales, including “A”, “B”, “C”, “D”, “G”, and “Z”. The most common weighting scale used in environmental noise analysis and regulation is A-weighting. This weighting represents the sensitivity of the human ear to sounds of low to moderate level. It attenuates sounds with frequencies below 1000 Hz and above 4000 Hz; it amplifies very slightly sounds between 1000 Hz and 4000 Hz, where the human ear is particularly sensitive. The C-weighting scale is sometimes used to describe louder sounds. The B- and D- scales are seldom used. All of these frequency weighting scales are normalized to the average human hearing response at

1000 Hz: at this frequency, the filters neither attenuate nor amplify. When a reported sound level has been filtered using a frequency weighting, the letter is appended to “dB”. For example, sound with A-weighting is usually denoted “dBA”. When no filtering is applied, the level is denoted “dB” or “dBZ”. The letter is also appended as a subscript to the level indicator “L”, for example “L_A” for A-weighted levels.

Time Response of Sound Level Meters

Because sound levels can vary greatly from one moment to the next, the time over which sound is measured can influence the value of the levels reported. Often, sound is measured in real time, as it fluctuates. In this case, acousticians apply a so-called “time response” to the sound level meter, and this time response is often part of regulations for measuring sound. If the sound level is varying slowly, over a few seconds, “Slow” time response is applied, with a time constant of one second. If the sound level is varying quickly (for example, if brief events are mixed into the overall sound), “Fast” time response can be applied, with a time constant of one-eighth of a second.[24] The time response setting for a sound level measurement is indicated with the subscript “S” for Slow and “F” for Fast: L_S or L_F. A sound level meter set to Fast time response will indicate higher sound levels than one set to Slow time response when brief events are mixed into the overall sound, because it can respond more quickly.

In some cases, the maximum sound level that can be generated by a source is of concern. Likewise, the minimum sound level occurring during a monitoring period may be required. To measure these, the sound level meter can be set to capture and hold the highest and lowest levels measured during a given monitoring period. This is represented by the subscript “max”, denoted as “L_{max}”. One can define a “max” level with Fast response L_{Fmax} (1/8-second time constant), Slow time response L_{Smax} (1-second time constant), or Continuous Equivalent level over a specified time period L_{EQmax}.

Accounting for Changes in Sound Over Time

A sound level meter’s time response settings are useful for continuous monitoring. However, they are less useful in summarizing sound levels over longer periods. To do so, acousticians apply simple statistics to the measured sound levels, resulting in a set of defined types of sound level related to averages over time. An example is shown in Figure 30. The sound level at each instant of time is the grey trace going from left to right. Over the total time it was measured (1 hour in the figure), the sound energy spends certain fractions of time near various levels, ranging from the minimum (about 27 dB in the figure) to the maximum (about 65 dB in the figure). The simplest descriptor is the average sound level, known as the Equivalent Continuous

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[24] There is a third time response defined by standards, the “Impulse” response. This response was defined to enable use of older, analog meters when measuring very brief sounds; it is no longer in common use.

Sound Level. Statistical levels are used to determine for what percentage of time the sound is louder than any given level. These levels are described in the following sections.

Equivalent Continuous Sound Level - Leq

One straightforward, common way of describing sound levels is in terms of the Continuous Equivalent Sound Level, or L_{EQ}. The L_{EQ} is the average sound pressure level over a defined period of time, such as one hour or one day. L_{EQ} is the most commonly used descriptor in noise standards and regulations. L_{EQ} is representative of the overall sound to which a person is exposed. Because of the logarithmic calculation of decibels, L_{EQ} tends to favor higher sound levels: loud and infrequent sources have a larger impact on the resulting average sound level than quieter but more frequent sounds. For example, in Figure 30, even though the sound levels spends most of the time near about 34 dBA, the L_{EQ} is 41 dBA, having been “inflated” by the maximum level of 65 dBA and other occasional spikes over the course of the hour.

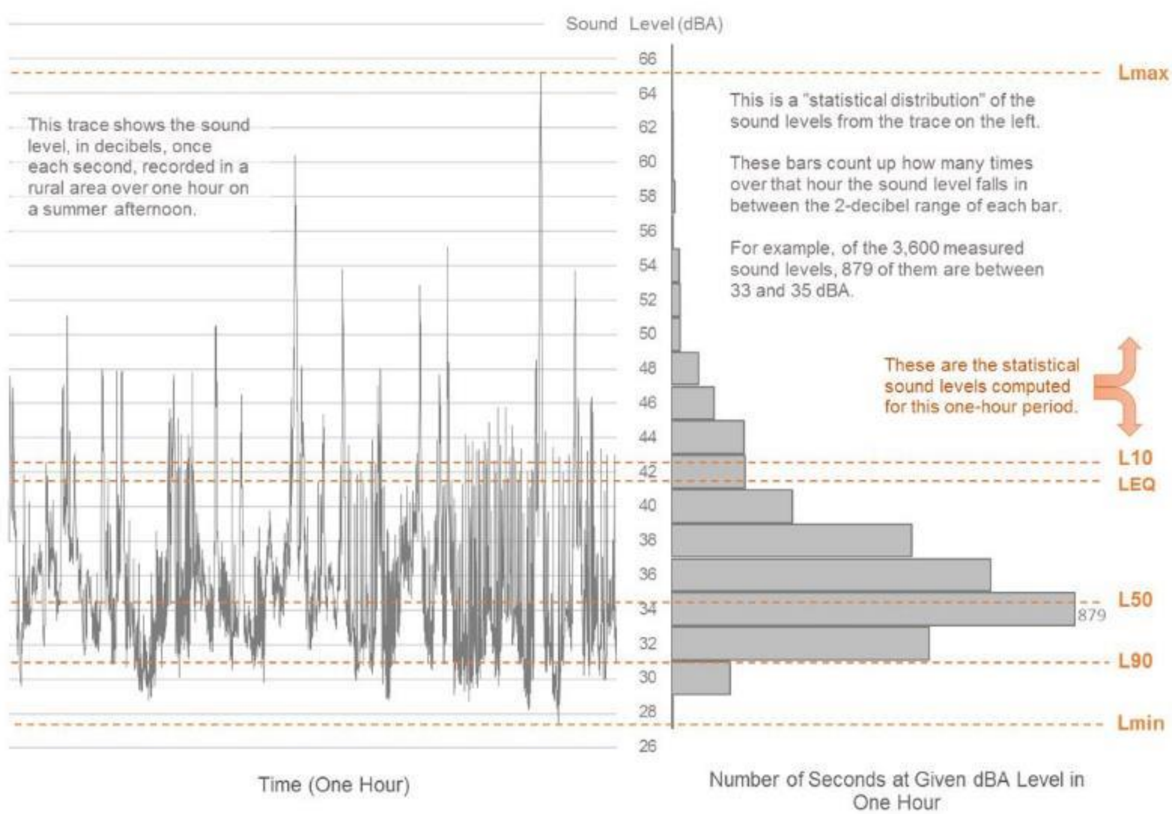

FIGURE 30: EXAMPLE OF DESCRIPTIVE TERMS OF SOUND MEASUREMENT OVER TIME

Percentile Sound Levels – Ln

Percentile sound levels describe the statistical distribution of sound levels over time. “L_N” is the level above which the sound spends “N” percent of the time. For example, L_{90} (sometimes called the “residual base level”) is the sound level exceeded 90% of the time: the sound is louder than L_{90} most of the time. L_{10} is the sound level that is exceeded only 10% of the time. L_{50} (the “median level”) is exceeded 50% of the time: half of the time the sound is louder than L_{50}, and half the time it is quieter than L_{50}. Note that L_{50} (median) and L_{EQ} (mean) are not always the same, for reasons described in the previous section.

L_{90} is often a good representation of the “ambient sound” in an area. This is the sound that persists for longer periods, and below which the overall sound level seldom falls. It tends to filter out other short-term environmental sounds that aren’t part of the source being investigated. L_{10} represents the higher, but less frequent, sound levels. These could include such events as barking dogs, vehicles driving by and aircraft flying overhead, gusts of wind, and work operations. L_{90} represents the background sound that is present when these event sounds are excluded.

Note that if one sound source is very constant and dominates the soundscape in an area, all of the descriptive sound levels mentioned here tend toward the same value. It is when the sound is varying widely from one moment to the next that the statistical descriptors are useful.

APPENDIX B. SOURCE INFORMATION

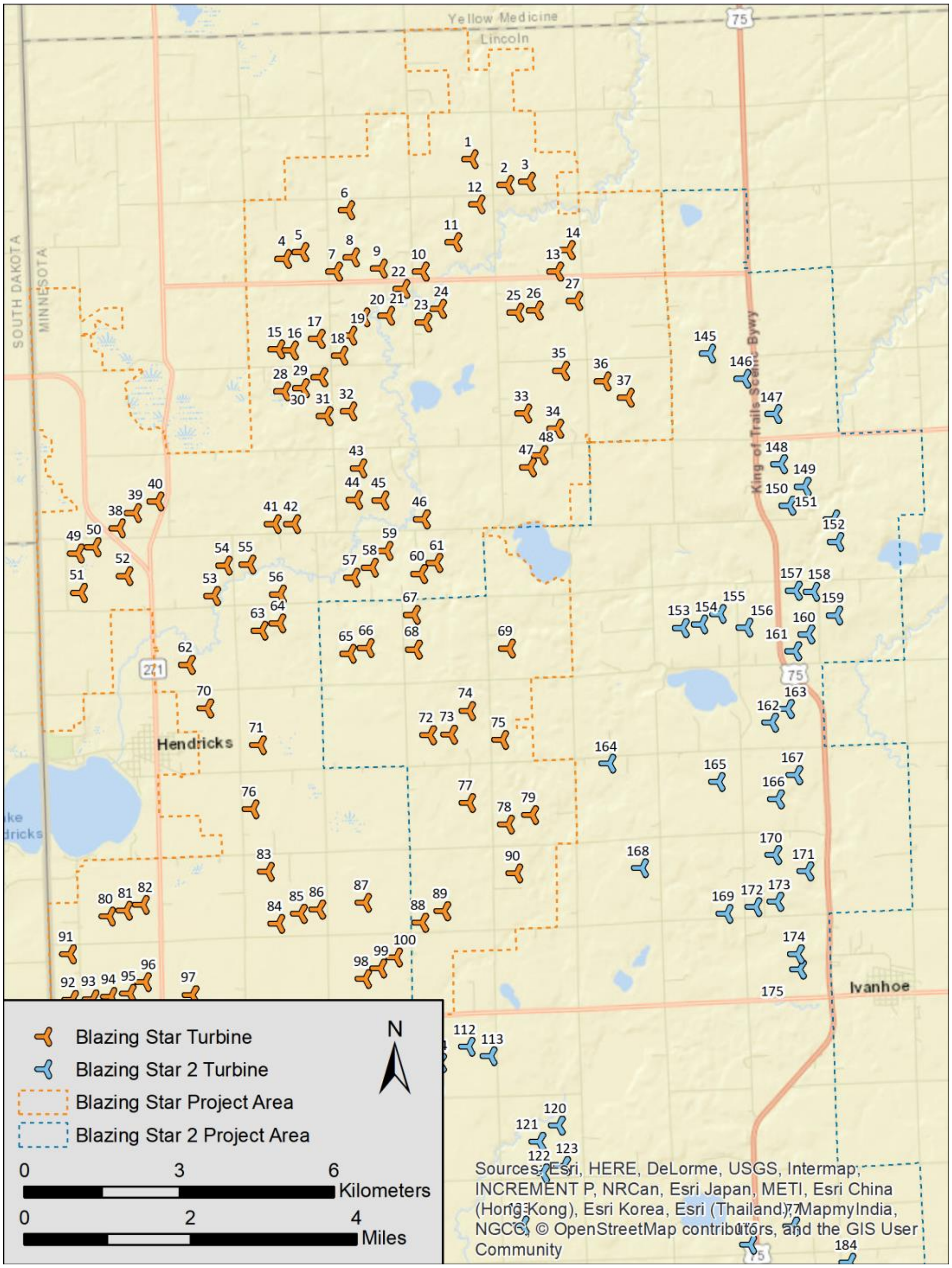

FIGURE 31: SOURCE LOCATIONS NORTHERN HALF

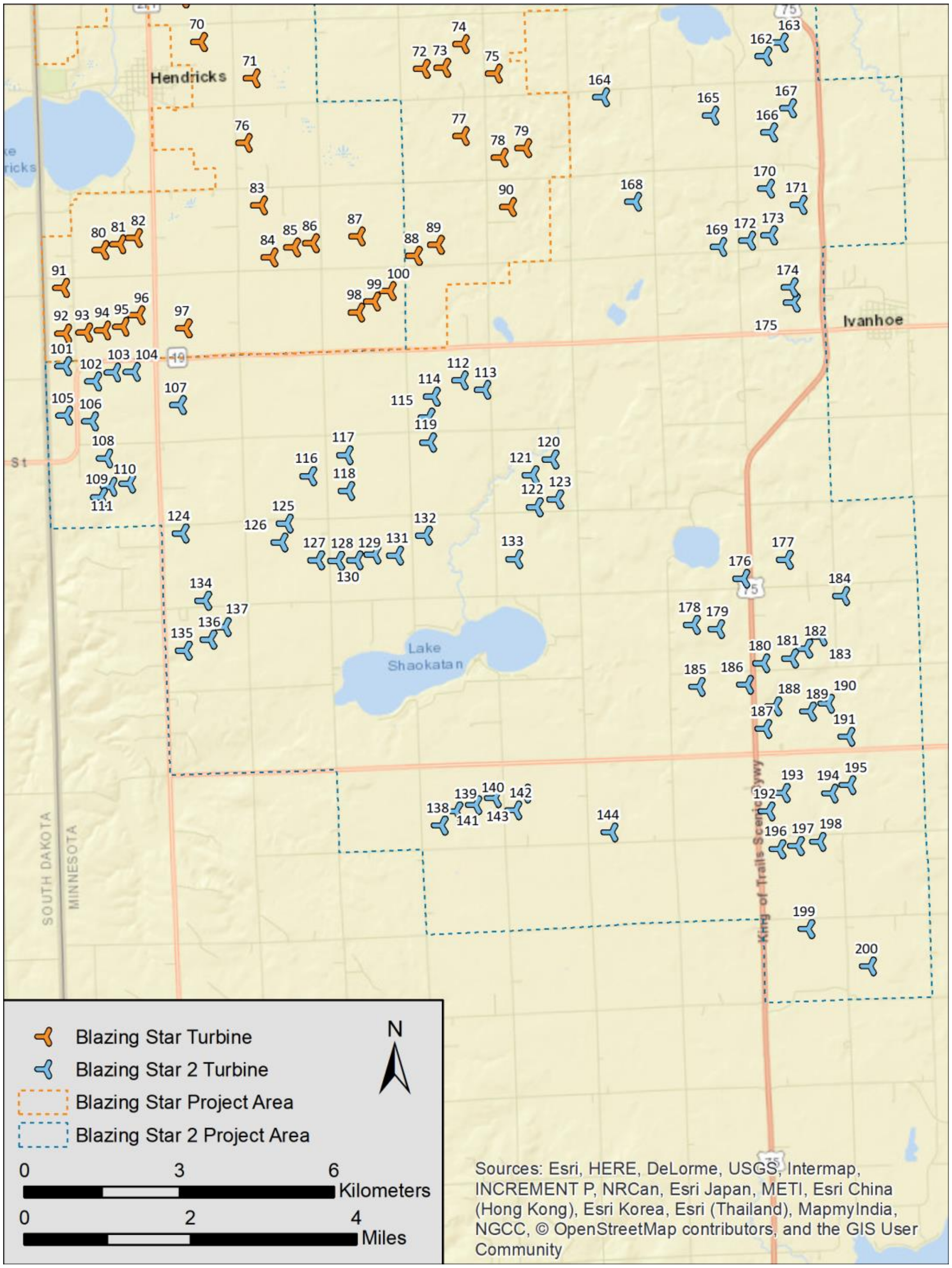

FIGURE 32: SOURCE LOCATIONS SOUTHERN HALF

TABLE 9: SOUND PROPAGATION MODELING PARAMETERS

Parameter	Setting
Ground Absorption	Spectral for all sources, Mixed Ground (G=0.7)
Atmospheric Attenuation	Based on 10 Degrees Celsius, 70% Relative Humidity
Reflections	None
Receiver Height	4 meters for residences, 1.5 meters for grid
Search Distance	10,000 meters

TABLE 10: TURBINE HUB HEIGHT AND 1/1/ OCTAVE BAND MODELED TURBINE SPECTRA (dBZ UNLESS OTHERWISE INDICATED)[25]

TABLE 10 EXCLUDED due to proprietary information. The sound power level of some turbines are considered proprietary information, but may be provided under a proper protective agreement. The modeled sound power levels in Table 11 below, are also excluded in this document version.

TABLE 11: MODELED TURBINE SOUND POWER LEVELS & LOCATIONS

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
1	Blazing Star	V120 STE			80	710819	4942834
2	Blazing Star	V120 STE			80	711517	4942340
3	Blazing Star	V120 STE			80	711930	4942398
4	Blazing Star	V120 STE			80	707209	4940907
5	Blazing Star	V120 STE			80	707535	4941039
6	Blazing Star	V120 STE			80	708426	4941849
7	Blazing Star	V120 STE			80	708183	4940657
8	Blazing Star	V120 STE			80	708520	4940934
9	Blazing Star	V120 STE			80	709055	4940720
10	Blazing Star	V120 STE			80	709865	4940660
11	Blazing Star	V120 STE			80	710500	4941233
12	Blazing Star	V120 STE			80	710954	4941961
13	Blazing Star	V120 STE			80	712472	4940658
14	Blazing Star	V120 STE			80	712694	4941077
15	Blazing Star	V120 STE			80	707077	4939147
16	Blazing Star	V120 STE			80	707334	4939129
17	Blazing Star	V120 STE			80	707846	4939352

[25] STE: Serrated Trailing Edges

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
18	Blazing Star	V120 STE			80	708291	4939030
19	Blazing Star	V120 STE			80	708465	4939418
20	Blazing Star	V120 STE			80	708726	4939777
21	Blazing Star	V120 STE			80	709203	4939799
22	Blazing Star	V120 STE			80	709500	4940325
23	Blazing Star	V120 STE			80	709911	4939675
24	Blazing Star	V120 STE			80	710197	4939936
25	Blazing Star	V120 STE			80	711708	4939868
26	Blazing Star	V120 STE			80	712071	4939905
27	Blazing Star	V120 STE			80	712849	4940089
28	Blazing Star	V120 STE			80	707185	4938340
29	Blazing Star	V120 STE			80	707542	4938402
30	Blazing Star	V120 STE			80	707901	4938614
31	Blazing Star	V120 STE			80	708004	4937856
32	Blazing Star	V120 STE			80	708472	4937952
33	Blazing Star	V120 STE			80	711857	4937906
34	Blazing Star	V120 STE			80	712468	4937614
35	Blazing Star	V120 STE			80	712578	4938739
36	Blazing Star	V120 STE			80	713396	4938535
37	Blazing Star	V120 STE			80	713844	4938216
38	Blazing Star	V120 STE			80	703991	4935687
39	Blazing Star	V120 STE			80	704291	4935988
40	Blazing Star	V120 STE			80	704734	4936210
41	Blazing Star	V120 STE			80	707002	4935766
42	Blazing Star	V120 STE			80	707376	4935767
43	Blazing Star	V120 STE			80	708664	4936849
44	Blazing Star	V120 STE			80	708577	4936235
45	Blazing Star	V120 STE			80	709092	4936225
46	Blazing Star	V120 STE			80	709880	4935861
47	Blazing Star	V120 STE			80	711952	4936869
48	Blazing Star	V120 STE			80	712166	4937109
49	Blazing Star	V120 STE			80	703180	4935196
50	Blazing Star	V120 STE			80	703506	4935325
51	Blazing Star	V120 STE			80	703244	4934439

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
52	Blazing Star	V120 STE			80	704130	4934758
53	Blazing Star	V120 STE			80	705823	4934372
54	Blazing Star	V120 STE			80	706054	4934968
55	Blazing Star	V120 STE			80	706514	4934986
56	Blazing Star	V120 STE			80	707103	4934408
57	Blazing Star	V120 STE			80	708528	4934734
58	Blazing Star	V120 STE			80	708887	4934922
59	Blazing Star	V120 STE			80	709172	4935246
60	Blazing Star	V120 STE			80	709835	4934806
61	Blazing Star	V120 STE		-1 dB	80	710131	4935017
62	Blazing Star	V120 STE			80	705336	4933038
63	Blazing Star	V120 STE			80	706748	4933702
64	Blazing Star	V120 STE			80	707089	4933843
65	Blazing Star	V120 STE			80	708456	4933254
66	Blazing Star	V120 STE			80	708803	4933368
67	Blazing Star	V120 STE			80	709701	4934011
68	Blazing Star	V120 STE			80	709727	4933339
69	Blazing Star	V120 STE			80	711540	4933355
70	Blazing Star	V120 STE			80	705692	4932195
71	Blazing Star	V120 STE			80	706718	4931484
72	Blazing Star	V120 STE			80	710006	4931673
73	Blazing Star	V120 STE			80	710410	4931690
74	Blazing Star	V110 STE			80	710772	4932147
75	Blazing Star	V120 STE			80	711415	4931582
76	Blazing Star	V120 STE			80	706571	4930236
77	Blazing Star	V120 STE			80	710772	4930363
78	Blazing Star	V120 STE			80	711524	4929945
79	Blazing Star	V120 STE			80	711991	4930128
80	Blazing Star	V110 STE			80	703790	4928160
81	Blazing Star	V110 STE			80	704120	4928270
82	Blazing Star	V110 STE			80	704440	4928388
83	Blazing Star	V120 STE			80	706864	4929022
84	Blazing Star	V120 STE			80	707071	4928015
85	Blazing Star	V120 STE			80	707500	4928209

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
86	Blazing Star	V120 STE			80	707861	4928289
87	Blazing Star	V120 STE			80	708756	4928425
88	Blazing Star	V120 STE			80	709856	4928041
89	Blazing Star	V120 STE			80	710284	4928262
90	Blazing Star	V120 STE			80	711689	4928991
91	Blazing Star	V110 STE			80	703027	4927424
92	Blazing Star	V110 STE			80	703066	4926541
93	Blazing Star	V110 STE			80	703466	4926556
94	Blazing Star	V110 STE			80	703826	4926603
95	Blazing Star	V110 STE			80	704186	4926665
96	Blazing Star	V110 STE			80	704487	4926890
97	Blazing Star	V110 STE			80	705401	4926637
98	Blazing Star	V120 STE			80	708750	4926949
99	Blazing Star	V120 STE			80	709049	4927155
100	Blazing Star	V120 STE			80	709354	4927361
101	Blazing Star 2	V110 STE			80	703063	4925908
102	Blazing Star 2	V110 STE			80	703640	4925607
103	Blazing Star 2	V110 STE			80	704023	4925788
104	Blazing Star 2	V110 STE			80	704400	4925795
105	Blazing Star 2	V110 STE			80	703086	4924943
106	Blazing Star 2	V110 STE			80	703580	4924831
107	Blazing Star 2	V110 STE			80	705280	4925148
108	Blazing Star 2	V110 STE			80	703871	4924124
109	Blazing Star 2	V120 STE			80	703751	4923373
110	Blazing Star 2	V110 STE			80	703951	4923572
111	Blazing Star 2	V110 STE			80	704309	4923633
112	Blazing Star 2	V120 STE			80	710755	4925631
113	Blazing Star 2	V120 STE			80	711190	4925449
114	Blazing Star 2	V120 STE			80	710201	4925318
115	Blazing Star 2	V120 STE			80	710099	4924907
116	Blazing Star 2	V120 STE			80	707812	4923781
117	Blazing Star 2	V120 STE			80	708526	4924189
118	Blazing Star 2	V120 STE			80	708550	4923492
119	Blazing Star 2	V120 STE			80	710129	4924432

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
120	Blazing Star 2	V120 STE			80	712506	4924104
121	Blazing Star 2	V120 STE			80	712127	4923795
122	Blazing Star 2	V120 STE			80	712199	4923179
123	Blazing Star 2	V120 STE			80	712599	4923324
124	Blazing Star 2	V120 STE			80	705340	4922664
125	Blazing Star 2	V120 STE			80	707363	4922860
126	Blazing Star 2	V120 STE			80	707255	4922491
127	Blazing Star 2	V120 STE			80	707965	4922147
128	Blazing Star 2	V120 STE			80	708353	4922138
129	Blazing Star 2	V120 STE			80	708713	4922147
130	Blazing Star 2	V120 STE			80	709068	4922261
131	Blazing Star 2	V120 STE			80	709502	4922235
132	Blazing Star 2	V120 STE			80	710056	4922625
133	Blazing Star 2	V120 STE			80	711811	4922172
134	Blazing Star 2	V120 STE			80	705770	4921358
135	Blazing Star 2	V120 STE			80	705397	4920394
136	Blazing Star 2	V120 STE			80	705879	4920604
137	Blazing Star 2	V120 STE			80	706158	4920857
138	Blazing Star 2	V120 STE			80	710361	4917005
139	Blazing Star 2	V120 STE			80	710640	4917280
140	Blazing Star 2	V120 STE			80	711023	4917402
141	Blazing Star 2	V120 STE			80	711397	4917536
142	Blazing Star 2	V120 STE			80	711792	4917297
143	Blazing Star 2	V120 STE			80	711970	4917619
144	Blazing Star 2	V120 STE			80	713660	4916873
145	Blazing Star 2	V120 STE			80	715423	4939070
146	Blazing Star 2	V120 STE			80	716109	4938582
147	Blazing Star 2	V120 STE			80	716701	4937895
148	Blazing Star 2	V120 STE			80	716808	4936928
149	Blazing Star 2	V120 STE			80	717270	4936493
150	Blazing Star 2	V120 STE			80	716979	4936122
151	Blazing Star 2	V120 STE			80	717825	4935863
152	Blazing Star 2	V120 STE			80	717911	4935429
153	Blazing Star 2	V120 STE			80	714905	4933753

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
154	Blazing Star 2	V120 STE			80	715269	4933826
155	Blazing Star 2	V120 STE			80	715626	4934027
156	Blazing Star 2	V120 STE			80	716148	4933760
157	Blazing Star 2	V120 STE			80	717094	4934480
158	Blazing Star 2	V120 STE			80	717443	4934460
159	Blazing Star 2	V120 STE			80	717893	4933999
160	Blazing Star 2	V120 STE			80	717338	4933628
161	Blazing Star 2	V120 STE			80	717089	4933303
162	Blazing Star 2	V120 STE			80	716637	4931916
163	Blazing Star 2	V120 STE			80	716946	4932182
164	Blazing Star 2	V120 STE			80	713493	4931120
165	Blazing Star 2	V120 STE			80	715611	4930769
166	Blazing Star 2	V120 STE			80	716747	4930435
167	Blazing Star 2	V120 STE			80	717110	4930903
168	Blazing Star 2	V120 STE			80	714118	4929093
169	Blazing Star 2	V120 STE			80	715766	4928216
170	Blazing Star 2	V120 STE			80	716696	4929349
171	Blazing Star 2	V120 STE			80	717319	4929033
172	Blazing Star 2	V120 STE			80	716322	4928341
173	Blazing Star 2	V120 STE			80	716740	4928441
174	Blazing Star 2	V120 STE			80	717140	4927430
175	Blazing Star 2	V120 STE			80	717178	4927136
176	Blazing Star 2	V120 STE			80	716219	4921792
177	Blazing Star 2	V120 STE			80	717049	4922155
178	Blazing Star 2	V120 STE			80	715242	4920897
179	Blazing Star 2	V120 STE			80	715724	4920812
180	Blazing Star 2	V120 STE			80	716606	4920149
181	Blazing Star 2	V120 STE			80	717148	4920246
182	Blazing Star 2	V120 STE			80	717427	4920436
183	Blazing Star 2	V120 STE			80	717708	4920671
184	Blazing Star 2	V120 STE			80	718150	4921453
185	Blazing Star 2	V120 STE			80	715349	4919693
186	Blazing Star 2	V120 STE			80	716285	4919732
187	Blazing Star 2	V120 STE			80	716642	4918877

Turbine ID	Project	Turbine Model	Modeled Sound Power Level (dBA)	Applied Noise Reduced Operation (NRO)	Hub Height (m)	Coordinates (UTM NAD83 Z14N)	
						X (m)	Y (m)
188	Blazing Star 2	V120 STE			80	716829	4919310
189	Blazing Star 2	V120 STE			80	717495	4919213
190	Blazing Star 2	V120 STE			80	717851	4919370
191	Blazing Star 2	V120 STE			80	718247	4918726
192	Blazing Star 2	V120 STE			80	716699	4917277
193	Blazing Star 2	V120 STE			80	716988	4917638
194	Blazing Star 2	V120 STE			80	717928	4917629
195	Blazing Star 2	V120 STE			80	718273	4917788
196	Blazing Star 2	V120 STE			80	716908	4916549
197	Blazing Star 2	V120 STE			80	717266	4916608
198	Blazing Star 2	V120 STE			80	717688	4916691
199	Blazing Star 2	V120 STE			80	717463	4914997
200	Blazing Star 2	V120 STE			80	718668	4914273

APPENDIX C. RECEIVER INFORMATION

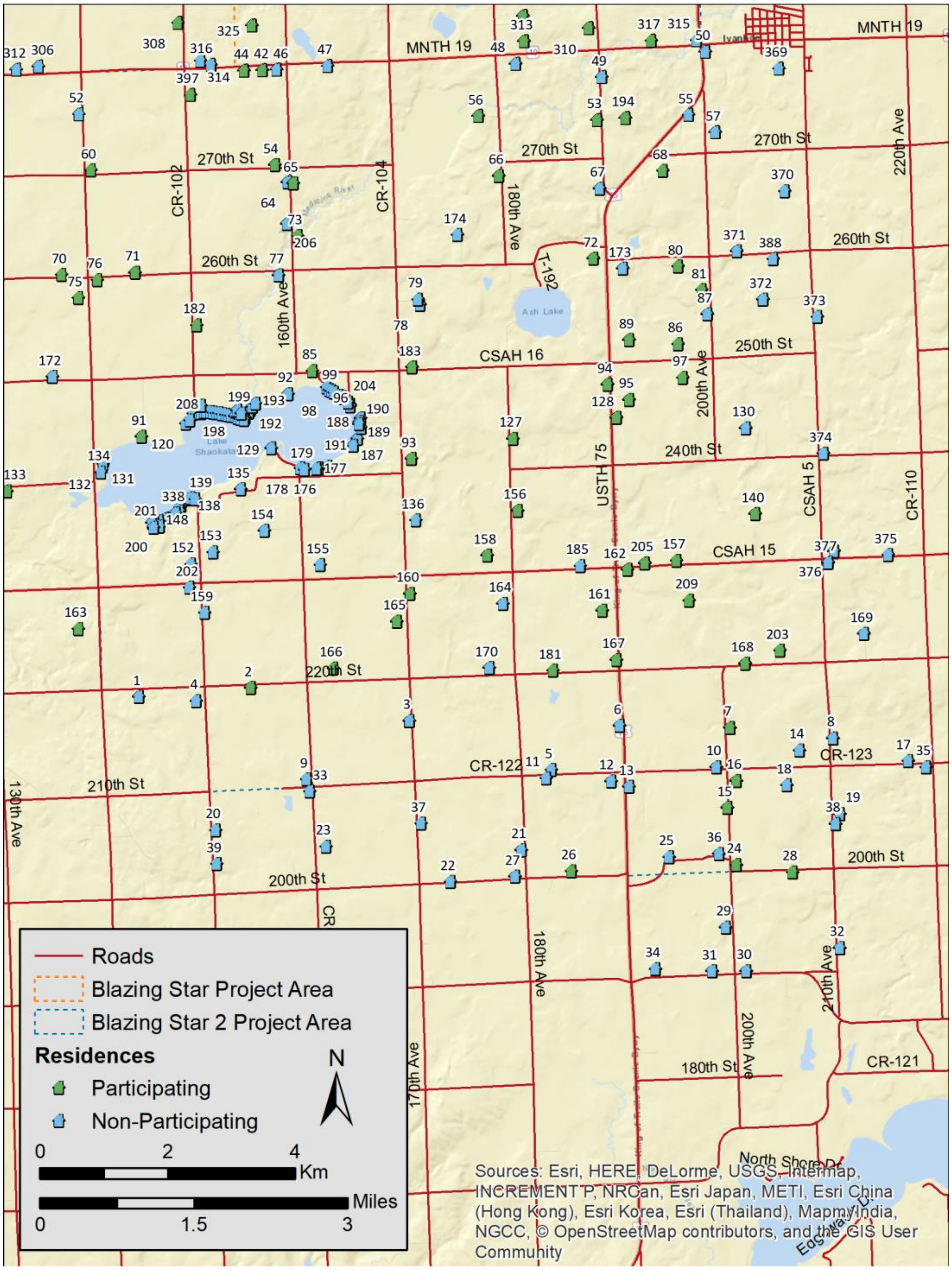

FIGURE 33: RECEIVER LOCATIONS - SOUTHEASTERN AREA

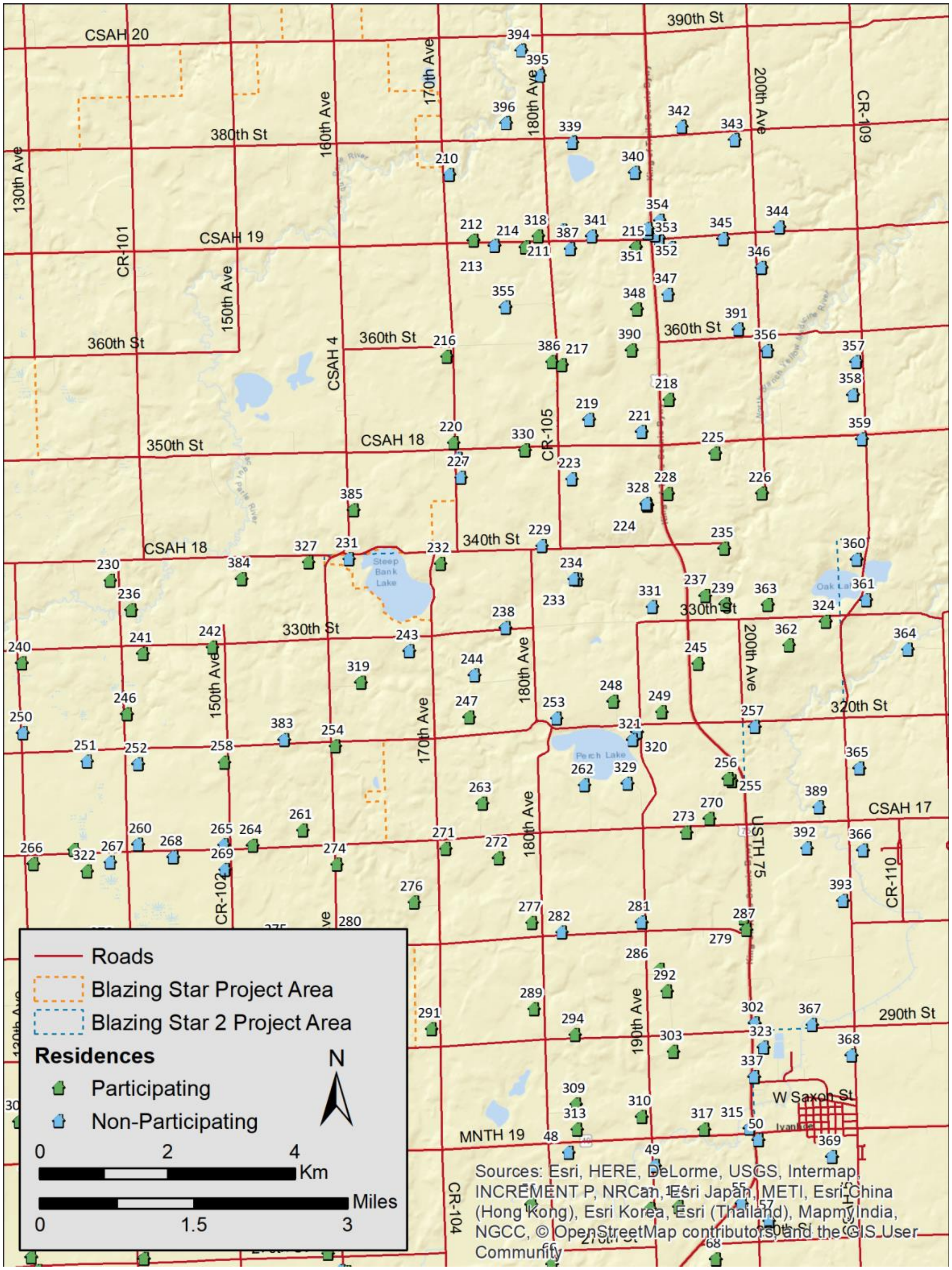

FIGURE 34: RECEIVER LOCATIONS - NORTHEASTERN AREA

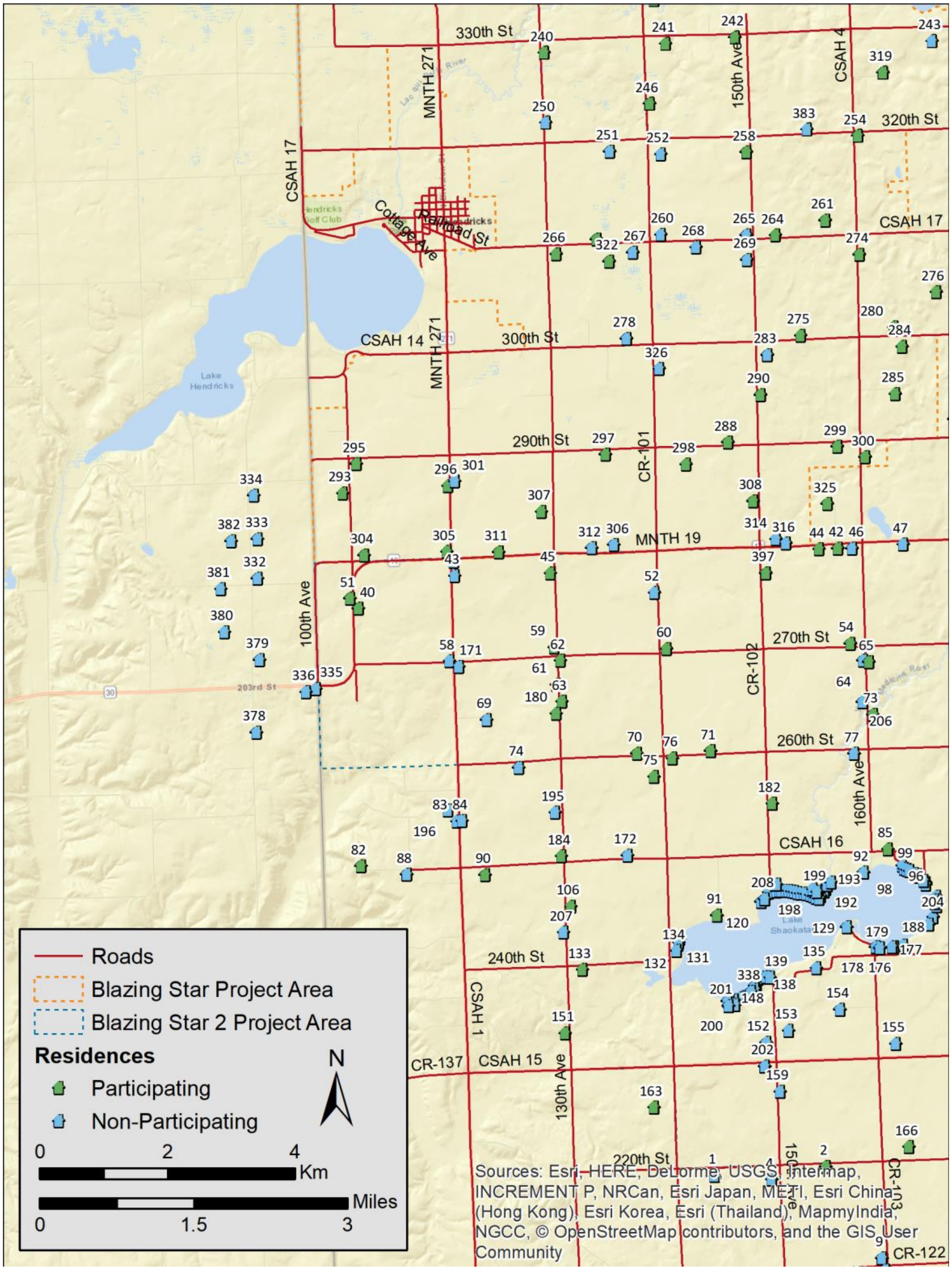

FIGURE 35: RECEIVER LOCATIONS - WESTERN AREA

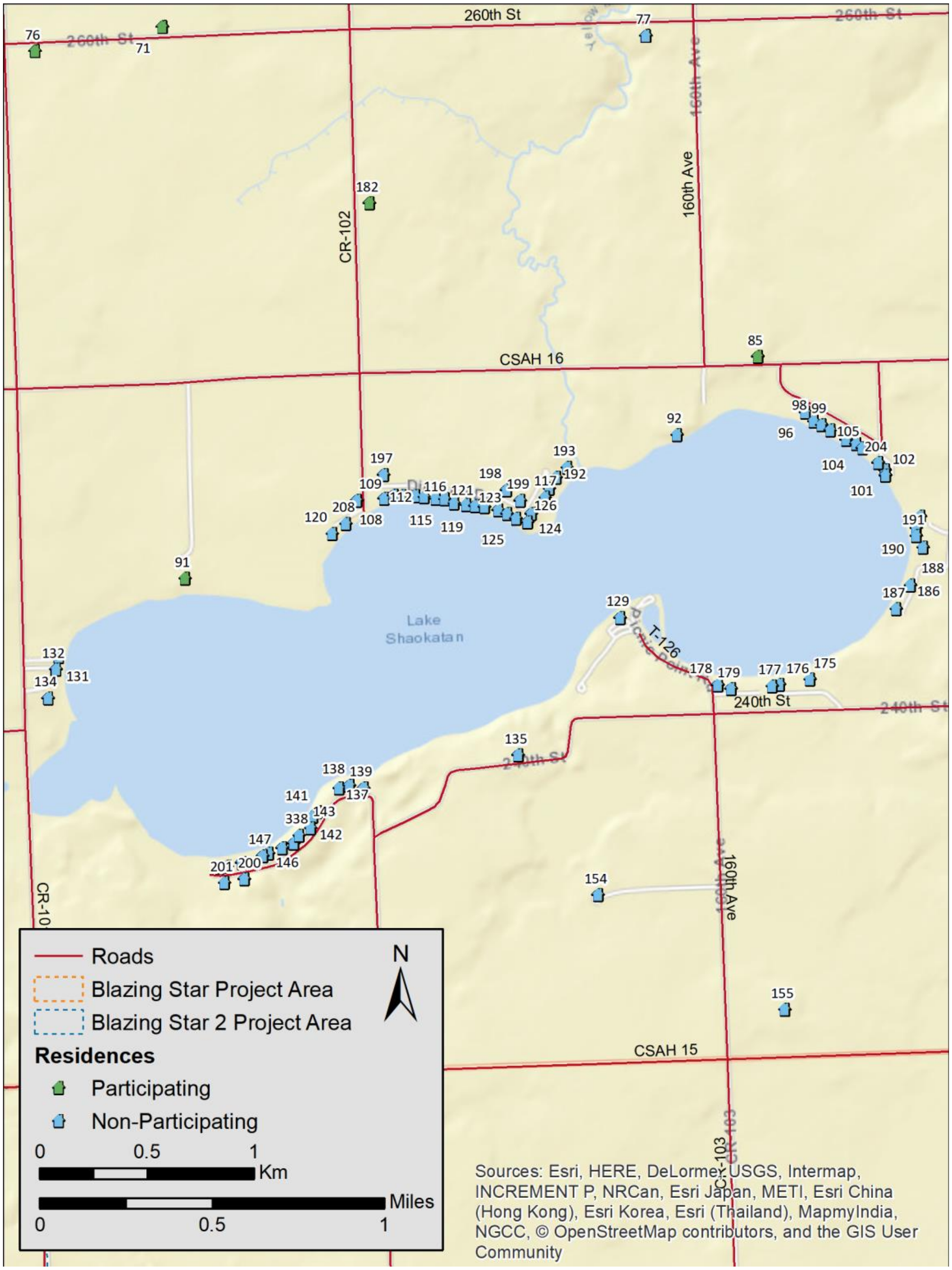

FIGURE 36: RECEIVER LOCATIONS - LAKE SHAOKATAN AREA

TABLE 12: DISCRETE RECEIVER RESULTS - WITH & WITHOUT BACKGROUND SOUND LEVELS

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
1	Non-Participant	37	39	42	46	50	55	4	708990	4916373	570
2	Participant	46	46	47	48	51	55	4	710742	4916514	556
3	Non-Participant	40	41	43	46	50	55	4	713236	4915998	551
4	Non-Participant	42	43	44	47	51	55	4	709890	4916313	560
5	Non-Participant	37	39	42	46	50	55	4	715464	4915228	555
6	Non-Participant	44	45	45	48	51	55	4	716542	4915922	549
7	Participant	43	43	45	47	51	55	4	718276	4915893	540
8	Non-Participant	35	38	41	45	50	55	4	719896	4915727	535
9	Non-Participant	36	39	41	46	50	55	4	711621	4915079	556
10	Non-Participant	44	44	45	47	51	55	4	718060	4915274	545
11	Non-Participant	37	39	42	46	50	55	4	715385	4915097	554
12	Non-Participant	40	41	43	46	50	55	4	716410	4915051	553
13	Non-Participant	42	43	44	47	51	55	4	716692	4914964	550
14	Non-Participant	38	40	42	46	50	55	4	719365	4915537	533
15	Participant	45	45	46	48	51	55	4	718232	4914631	546
16	Participant	43	43	45	47	51	55	4	718377	4915057	546
17	Non-Participant	33	37	41	45	50	55	4	721072	4915368	531
18	Non-Participant	40	42	43	46	50	55	4	719163	4914986	539
19	Non-Participant	35	38	41	45	50	55	4	720001	4914540	532
20	Non-Participant	33	37	41	45	50	55	4	710192	4914282	576
21	Non-Participant	33	37	41	45	50	55	4	714996	4913970	549
22	Non-Participant	32	37	41	45	50	55	4	713883	4913470	550
23	Non-Participant	33	37	41	45	50	55	4	711928	4914027	560
24	Participant	43	44	45	47	51	55	4	718377	4913739	546
25	Non-Participant	38	40	42	46	50	55	4	717317	4913859	547
26	Participant	34	38	41	45	50	55	4	715780	4913639	547
27	Non-Participant	33	37	41	45	50	55	4	714898	4913552	547
28	Participant	39	41	43	46	50	55	4	719258	4913620	544
29	Non-Participant	34	38	41	45	50	55	4	718212	4912757	551

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
30	Non-Participant	31	36	41	45	50	55	4	718534	4912071	551
31	Non-Participant	31	37	41	45	50	55	4	717996	4912065	548
32	Non-Participant	31	36	40	45	50	55	4	719997	4912432	537
33	Non-Participant	35	38	41	45	50	55	4	711672	4914890	558
34	Non-Participant	31	36	41	45	50	55	4	717100	4912104	550
35	Non-Participant	32	37	41	45	50	55	4	721355	4915271	533
36	Non-Participant	42	43	44	47	51	55	4	718105	4913908	545
37	Non-Participant	34	37	41	45	50	55	4	713418	4914384	552
38	Non-Participant	36	38	41	45	50	55	4	719931	4914381	533
39	Non-Participant	31	36	41	45	50	55	4	710210	4913750	578
40	Participant	49	49	49	50	52	56	4	703399	4925277	562
41	Non-Participant	45	46	47	48	51	55	4	704897	4926016	552
42	Participant	46	46	47	48	51	55	4	710928	4926220	546
43	Non-Participant	45	46	47	48	51	55	4	704911	4925791	553
44	Participant	46	46	47	49	51	56	4	710635	4926209	543
45	Participant	40	41	43	46	50	55	4	706416	4925836	545
46	Non-Participant	45	45	46	48	51	55	4	711153	4926224	545
47	Non-Participant	41	42	44	47	51	55	4	711948	4926284	538
48	Non-Participant	36	39	42	46	50	55	4	714906	4926316	524
49	Non-Participant	39	40	42	46	50	55	4	716262	4926106	525
50	Non-Participant	41	42	43	46	50	55	4	717886	4926508	516
51	Participant	48	48	49	50	52	56	4	703267	4925432	563
52	Non-Participant	42	42	44	47	51	55	4	708045	4925527	547
53	Participant	37	39	42	46	50	55	4	716183	4925434	527
54	Participant	46	46	47	48	51	56	4	711128	4924729	551
55	Non-Participant	37	39	42	46	50	55	4	717620	4925512	521
56	Participant	37	39	42	46	50	55	4	714319	4925497	535
57	Non-Participant	36	38	41	45	50	55	4	718047	4925242	527
58	Non-Participant	43	44	45	47	51	55	4	704830	4924452	551
59	Participant	41	42	43	46	50	55	4	706468	4924670	545

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
60	Participant	46	46	47	49	51	56	4	708238	4924645	545
61	Participant	42	42	44	47	51	55	4	706506	4924083	554
62	Participant	41	42	43	46	50	55	4	706570	4924459	549
63	Participant	42	43	44	47	51	55	4	706596	4923817	555
64	Non-Participant	45	45	46	48	51	55	4	711325	4924460	545
65	Participant	45	45	46	48	51	55	4	711412	4924439	543
66	Participant	37	39	42	46	50	55	4	714639	4924560	542
67	Non-Participant	37	39	42	46	50	55	4	716231	4924362	536
68	Participant	36	38	41	45	50	55	4	717219	4924636	533
69	Non-Participant	43	43	45	47	51	55	4	705415	4923531	550
70	Participant	49	49	50	51	53	56	4	707776	4923004	547
71	Participant	48	48	48	50	52	56	4	708927	4923039	547
72	Participant	39	40	42	46	50	55	4	716128	4923258	529
73	Participant	46	46	47	48	51	55	4	711480	4923615	543
74	Non-Participant	45	45	46	48	51	55	4	705920	4922780	556
75	Participant	50	50	50	51	53	56	4	708039	4922639	549
76	Participant	48	48	49	50	52	56	4	708332	4922926	546
77	Non-Participant	44	45	45	48	51	55	4	711187	4922999	546
78	Non-Participant	41	42	43	46	50	55	4	713406	4922538	536
79	Non-Participant	42	42	44	47	51	55	4	713373	4922621	538
80	Participant	40	41	43	46	50	55	4	717458	4923136	531
81	Participant	41	42	43	46	50	55	4	717831	4922764	533
82	Participant	33	37	41	45	50	55	4	703440	4921233	577
83	Non-Participant	43	44	45	47	51	55	4	704947	4921937	569
84	Non-Participant	44	44	45	47	51	55	4	705030	4921942	569
85	Participant	43	44	45	47	51	55	4	711710	4921498	551
86	Participant	47	47	48	49	52	56	4	717453	4921917	531
87	Non-Participant	43	43	45	47	51	55	4	717919	4922384	535
88	Non-Participant	39	41	43	46	50	55	4	704156	4921099	584
89	Participant	49	49	49	50	52	56	4	716686	4921980	538

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
90	Participant	48	49	49	50	52	56	4	705393	4921095	572
91	Participant	40	41	43	46	50	55	4	709032	4920461	550
92	Non-Participant	40	41	43	46	50	55	4	711332	4921133	548
93	Participant	38	40	42	46	50	55	4	713273	4920115	553
94	Participant	47	48	48	49	52	56	4	716348	4921279	536
95	Participant	47	47	48	49	52	56	4	716687	4921042	540
96	Non-Participant	41	42	43	46	50	55	4	711933	4921239	547
97	Participant	47	47	48	49	52	56	4	717534	4921390	532
98	Non-Participant	40	42	43	46	50	55	4	711972	4921196	548
99	Non-Participant	40	41	43	46	50	55	4	712009	4921180	549
100	Non-Participant	40	41	43	46	50	55	4	712049	4921156	547
101	Non-Participant	39	40	42	46	50	55	4	712305	4920969	547
102	Non-Participant	39	40	42	46	50	55	4	712308	4920943	547
103	Non-Participant	39	41	43	46	50	55	4	712124	4921110	547
104	Non-Participant	40	41	43	46	50	55	4	712171	4921090	548
105	Non-Participant	39	41	43	46	50	55	4	712201	4921072	548
106	Participant	45	46	46	48	51	55	4	706731	4920599	561
107	Non-Participant	41	42	43	46	50	55	4	709835	4920825	549
108	Non-Participant	40	41	43	46	50	55	4	709964	4920835	548
109	Non-Participant	40	41	43	46	50	55	4	710008	4920849	547
110	Non-Participant	40	41	43	46	50	55	4	710045	4920847	547
111	Non-Participant	40	41	43	46	50	55	4	710107	4920848	547
112	Non-Participant	40	41	43	46	50	55	4	710150	4920844	547
113	Non-Participant	39	40	42	46	50	55	4	710735	4920882	550
114	Non-Participant	40	41	43	46	50	55	4	710203	4920836	548
115	Non-Participant	40	41	43	46	50	55	4	710245	4920832	548
116	Non-Participant	40	41	43	46	50	55	4	710290	4920814	548
117	Non-Participant	39	40	42	46	50	55	4	710716	4920841	550
118	Non-Participant	39	41	43	46	50	55	4	710346	4920806	548
119	Non-Participant	39	41	43	46	50	55	4	710389	4920801	548

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
120	Non-Participant	40	41	43	46	50	55	4	709721	4920672	549
121	Non-Participant	39	40	42	46	50	55	4	710433	4920796	548
122	Non-Participant	38	40	42	46	50	55	4	710496	4920781	548
123	Non-Participant	39	40	42	46	50	55	4	710539	4920763	548
124	Non-Participant	38	40	42	46	50	55	4	710652	4920763	550
125	Non-Participant	39	40	42	46	50	55	4	710581	4920741	550
126	Non-Participant	38	40	42	46	50	55	4	710635	4920726	548
127	Participant	46	46	47	48	51	55	4	714867	4920433	551
128	Participant	48	48	49	50	52	56	4	716488	4920759	538
129	Non-Participant	38	40	42	46	50	55	4	711067	4920278	546
130	Non-Participant	44	45	46	48	51	55	4	718523	4920598	529
131	Non-Participant	39	40	42	46	50	55	4	708442	4920096	548
132	Non-Participant	38	40	42	46	50	55	4	708429	4920036	549
133	Participant	39	40	43	46	50	55	4	706915	4919604	564
134	Non-Participant	38	40	42	46	50	55	4	708392	4919902	549
135	Non-Participant	38	40	42	46	50	55	4	710590	4919635	558
136	Non-Participant	38	40	42	46	50	55	4	713334	4919149	554
137	Non-Participant	37	39	42	46	50	55	4	709751	4919482	551
138	Non-Participant	37	39	42	46	50	55	4	709800	4919494	552
139	Non-Participant	37	39	42	46	50	55	4	709867	4919482	550
140	Participant	45	46	47	48	51	55	4	718674	4919247	529
141	Non-Participant	37	39	42	46	50	55	4	709649	4919370	554
142	Non-Participant	37	39	42	46	50	55	4	709628	4919348	554
143	Non-Participant	38	40	42	46	50	55	4	709620	4919295	557
144	Non-Participant	37	39	42	46	50	55	4	709541	4919223	555
145	Non-Participant	36	39	41	46	50	55	4	709486	4919202	552
146	Non-Participant	36	38	41	45	50	55	4	709423	4919176	546
147	Non-Participant	36	38	41	45	50	55	4	709395	4919165	546
148	Non-Participant	36	38	41	45	50	55	4	709297	4919133	547
149	Non-Participant	36	38	41	45	50	55	4	709229	4919116	548

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
150	Non-Participant	36	38	41	45	50	55	4	709194	4919113	547
151	Participant	32	37	41	45	50	55	4	706645	4918611	550
152	Non-Participant	39	41	43	46	50	55	4	709803	4918460	563
153	Non-Participant	40	41	43	46	50	55	4	710154	4918650	560
154	Non-Participant	40	41	43	46	50	55	4	710963	4918982	558
155	Non-Participant	44	44	45	47	51	55	4	711836	4918446	559
156	Participant	45	45	46	48	51	55	4	714936	4919299	550
157	Participant	48	48	48	50	52	56	4	717432	4918515	545
158	Participant	40	41	43	46	50	55	4	714460	4918595	550
159	Non-Participant	45	45	46	48	51	55	4	710017	4917694	560
160	Participant	41	42	43	46	50	55	4	713247	4917995	551
161	Participant	46	47	47	49	52	56	4	716265	4917732	546
162	Participant	48	48	49	50	52	56	4	716660	4918372	542
163	Participant	34	38	41	45	50	55	4	708036	4917442	577
164	Non-Participant	40	41	43	46	50	55	4	714706	4917839	549
165	Participant	43	43	44	47	51	55	4	713041	4917561	553
166	Participant	47	47	47	49	52	56	4	712044	4916822	555
167	Participant	50	50	50	51	53	56	4	716488	4916955	548
168	Participant	45	45	46	48	51	55	4	718510	4916899	539
169	Non-Participant	36	39	41	46	50	55	4	720380	4917366	533
170	Non-Participant	41	42	44	47	51	55	4	714490	4916829	554
171	Non-Participant	43	43	44	47	51	55	4	704980	4924364	551
172	Non-Participant	45	45	46	48	51	55	4	707630	4921401	559
173	Non-Participant	41	42	43	46	50	55	4	716588	4923101	540
174	Non-Participant	40	41	43	46	50	55	4	713994	4923631	540
175	Non-Participant	37	39	42	46	50	55	4	711955	4919989	549
176	Non-Participant	37	39	42	46	50	55	4	711811	4919965	550
177	Non-Participant	37	39	42	46	50	55	4	711778	4919959	550
178	Non-Participant	37	39	42	46	50	55	4	711523	4919964	549
179	Non-Participant	37	39	42	46	50	55	4	711586	4919945	551

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
180	Participant	42	43	44	47	51	55	4	706507	4923628	555
181	Participant	41	42	43	46	50	55	4	715490	4916787	553
182	Participant	50	50	50	51	53	56	4	709895	4922216	550
183	Participant	39	41	43	46	50	55	4	713282	4921549	555
184	Participant	46	46	47	48	51	55	4	706585	4921389	560
185	Non-Participant	44	45	46	48	51	55	4	715918	4918432	548
186	Non-Participant	38	40	42	46	50	55	4	712423	4920431	546
187	Non-Participant	38	40	42	46	50	55	4	712357	4920319	546
188	Non-Participant	38	40	42	46	50	55	4	712483	4920607	548
189	Non-Participant	38	40	42	46	50	55	4	712470	4920752	547
190	Non-Participant	38	40	42	46	50	55	4	712451	4920697	547
191	Non-Participant	38	40	42	46	50	55	4	712450	4920660	547
192	Non-Participant	39	40	42	46	50	55	4	710767	4920933	549
193	Non-Participant	39	41	43	46	50	55	4	710818	4920981	547
194	Participant	37	39	42	46	50	55	4	716634	4925466	527
195	Non-Participant	45	45	46	48	51	55	4	706489	4922073	558
196	Non-Participant	43	44	45	47	51	55	4	704802	4922109	568
197	Non-Participant	41	42	43	46	50	55	4	709962	4920947	547
198	Non-Participant	39	41	43	46	50	55	4	710535	4920875	552
199	Non-Participant	39	41	43	46	50	55	4	710600	4920826	551
200	Non-Participant	36	39	42	46	50	55	4	709310	4919055	552
201	Non-Participant	36	38	41	45	50	55	4	709215	4919038	550
202	Non-Participant	41	42	43	46	51	55	4	709783	4918092	563
203	Participant	42	43	44	47	51	55	4	719061	4917101	537
204	Non-Participant	39	40	42	46	50	55	4	712274	4921002	547
205	Participant	48	49	49	50	52	56	4	716933	4918476	546
206	Non-Participant	44	45	46	48	51	55	4	711314	4923808	541
207	Non-Participant	44	44	45	47	51	55	4	706620	4920191	569
208	Non-Participant	40	41	43	46	50	55	4	709784	4920718	549
209	Participant	50	50	50	51	53	56	4	717630	4917888	543

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
210	Non-Participant	44	45	46	48	51	55	4	713029	4941667	497
211	Non-Participant	38	40	42	46	50	55	4	714802	4940793	487
212	Participant	45	45	46	48	51	55	4	713412	4940636	506
213	Non-Participant	43	43	45	47	51	55	4	713742	4940553	503
214	Participant	40	41	43	46	50	55	4	714229	4940533	503
215	Participant	38	39	42	46	50	55	4	715959	4940531	489
216	Participant	49	50	50	51	53	56	4	712992	4938813	521
217	Participant	44	44	45	47	51	55	4	714797	4938680	511
218	Participant	50	50	50	51	53	56	4	716478	4938133	496
219	Non-Participant	42	43	44	47	51	55	4	715228	4937824	514
220	Participant	46	46	47	48	51	55	4	713093	4937461	511
221	Non-Participant	45	45	46	48	51	55	4	716055	4937632	506
222	Non-Participant	45	45	46	48	51	55	4	713161	4937212	514
223	Non-Participant	40	41	43	46	50	55	4	714957	4936887	519
224	Non-Participant	44	45	46	48	51	55	4	716146	4936476	521
225	Participant	47	47	48	49	52	56	4	717206	4937293	489
226	Participant	45	46	47	48	51	55	4	717942	4936662	496
227	Non-Participant	43	44	45	47	51	55	4	713209	4936911	511
228	Participant	48	48	49	50	52	56	4	716463	4936661	509
229	Non-Participant	39	41	43	46	50	55	4	714486	4935837	507
230	Participant	48	48	48	50	52	56	4	707707	4935296	534
231	Non-Participant	41	42	44	47	51	55	4	711455	4935634	514
232	Participant	39	41	43	46	50	55	4	712890	4935559	522
233	Non-Participant	41	42	43	46	50	55	4	715041	4935308	501
234	Non-Participant	41	42	43	46	50	55	4	714985	4935323	502
235	Participant	50	50	50	51	53	56	4	717351	4935795	508
236	Participant	48	48	49	50	52	56	4	708040	4934831	525
237	Participant	48	48	48	49	52	56	4	717052	4935052	494
238	Non-Participant	39	41	43	46	50	55	4	713916	4934555	503
239	Participant	49	49	50	51	53	56	4	717361	4934920	493

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
240	Participant	49	49	49	50	52	56	4	706316	4934001	546
241	Participant	47	47	48	49	52	56	4	708221	4934147	536
242	Participant	49	49	50	51	53	56	4	709312	4934247	544
243	Non-Participant	40	41	43	46	50	55	4	712405	4934189	518
244	Non-Participant	40	41	43	46	50	55	4	713425	4933806	511
245	Participant	50	50	50	51	53	56	4	716937	4933989	509
246	Participant	47	48	48	49	52	56	4	707970	4933200	539
247	Participant	40	41	43	46	50	55	4	713343	4933146	515
248	Participant	48	49	49	50	52	56	4	715608	4933393	527
249	Participant	47	48	48	49	52	56	4	716367	4933232	522
250	Non-Participant	45	45	46	48	51	55	4	706339	4932903	543
251	Non-Participant	43	44	45	47	51	55	4	707345	4932455	544
252	Non-Participant	43	44	45	47	51	55	4	708143	4932412	544
253	Non-Participant	45	45	46	48	51	55	4	714711	4933133	526
254	Participant	45	45	46	48	51	55	4	711238	4932697	540
255	Participant	46	47	47	49	52	56	4	717466	4932151	507
256	Participant	47	47	48	49	52	56	4	717411	4932179	510
257	Non-Participant	45	46	46	48	51	55	4	717829	4933003	505
258	Participant	45	45	46	48	51	55	4	709496	4932443	556
259	Participant	45	45	46	48	51	55	4	707136	4931070	544
260	Non-Participant	40	42	43	46	50	55	4	708146	4931152	548
261	Participant	48	49	49	50	52	56	4	710728	4931372	541
262	Non-Participant	41	42	44	47	51	55	4	715152	4932082	520
263	Participant	43	44	45	47	51	55	4	713550	4931793	526
264	Participant	47	47	48	49	52	56	4	709944	4931138	553
265	Non-Participant	44	45	46	48	51	55	4	709491	4931140	553
266	Participant	46	46	47	48	51	55	4	706505	4930843	549
267	Non-Participant	42	42	44	47	51	55	4	707710	4930871	544
268	Non-Participant	41	42	43	46	51	55	4	708698	4930954	550
269	Non-Participant	43	43	44	47	51	55	4	709504	4930754	550

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
270	Participant	47	48	48	49	52	56	4	717116	4931552	515
271	Participant	45	46	46	48	51	55	4	712974	4931085	524
272	Participant	48	48	48	50	52	56	4	713808	4930934	519
273	Participant	48	48	48	50	52	56	4	716750	4931337	517
274	Participant	46	47	47	49	52	56	4	711267	4930835	541
275	Participant	44	44	45	47	51	55	4	710342	4929567	548
276	Participant	46	46	47	49	51	56	4	712476	4930245	527
277	Participant	42	43	44	47	51	55	4	714331	4929922	529
278	Non-Participant	44	44	45	47	51	55	4	707612	4929518	545
279	Participant	43	44	45	47	51	55	4	717654	4929997	503
280	Participant	50	50	50	51	53	56	4	711803	4929693	543
281	Non-Participant	45	45	46	48	51	55	4	716051	4929930	525
282	Non-Participant	42	43	44	47	51	55	4	714796	4929776	529
283	Non-Participant	43	44	45	47	51	55	4	709823	4929258	550
284	Participant	48	48	48	50	52	56	4	711938	4929392	539
285	Participant	48	48	49	50	52	56	4	711827	4928649	536
286	Participant	49	49	49	50	52	56	4	716337	4929184	521
287	Participant	44	44	45	47	51	55	4	717694	4929817	509
288	Participant	49	49	49	50	52	56	4	709204	4927886	550
289	Participant	44	45	46	48	51	55	4	714358	4928564	530
290	Participant	47	47	48	49	52	56	4	709716	4928632	555
291	Participant	40	41	43	46	50	55	4	712754	4928255	530
292	Participant	50	50	50	51	53	56	4	716451	4928848	519
293	Participant	48	48	48	50	52	56	4	703149	4927091	556
294	Participant	43	44	45	47	51	55	4	715008	4928162	530
295	Participant	47	47	48	49	52	56	4	703370	4927548	552
296	Participant	46	46	47	48	51	55	4	704805	4927206	547
297	Participant	49	50	50	51	53	56	4	707280	4927695	545
298	Participant	48	48	48	50	52	56	4	708546	4927545	546
299	Participant	44	44	45	47	51	55	4	710923	4927818	539

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
300	Participant	42	43	44	47	51	55	4	711357	4927653	537
301	Non-Participant	44	45	46	48	51	55	4	704913	4927276	548
302	Non-Participant	44	44	45	47	51	55	4	717828	4928341	513
303	Participant	49	49	49	50	52	56	4	716548	4927900	521
304	Participant	49	49	50	51	53	56	4	703491	4926113	560
305	Participant	46	46	47	48	51	56	4	704785	4926170	551
306	Non-Participant	41	42	43	46	51	55	4	707412	4926275	546
307	Participant	42	42	44	47	51	55	4	706276	4926798	550
308	Participant	49	49	49	50	52	56	4	709595	4926963	544
309	Participant	39	41	43	46	50	55	4	715024	4927070	528
310	Participant	42	42	44	47	51	55	4	716051	4926875	526
311	Participant	44	44	45	47	51	55	4	705601	4926162	551
312	Non-Participant	40	41	43	46	50	55	4	707067	4926227	546
313	Participant	38	40	42	46	50	55	4	715040	4926673	527
314	Non-Participant	44	45	46	48	51	55	4	709952	4926366	541
315	Non-Participant	43	44	45	47	51	55	4	717743	4926690	514
316	Non-Participant	45	45	46	48	51	55	4	710115	4926300	539
317	Participant	46	47	47	49	52	56	4	717035	4926679	522
318	Participant	39	41	43	46	50	55	4	714422	4940700	498
319	Participant	48	48	49	50	52	56	4	711642	4933694	527
320	Non-Participant	45	46	46	48	51	55	4	715979	4932921	521
321	Non-Participant	45	45	46	48	51	55	4	715909	4932794	519
322	Participant	43	44	45	47	51	55	4	707341	4930732	546
323	Non-Participant	43	43	44	47	51	55	4	717966	4927968	507
324	Participant	41	42	44	46	51	55	4	718941	4934653	493
325	Participant	43	43	45	47	51	55	4	710766	4926921	545
326	Non-Participant	45	46	46	48	51	55	4	708119	4929042	545
327	Participant	44	44	45	47	51	55	4	710815	4935585	517
328	Non-Participant	44	45	46	48	51	55	4	716131	4936498	520
329	Non-Participant	44	44	45	47	51	55	4	715829	4932110	519

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
330	Participant	42	43	44	47	51	55	4	714223	4937345	515
331	Non-Participant	45	45	46	48	51	55	4	716218	4934879	497
332	Non-Participant	38	40	42	46	50	55	4	701812	4925752	575
333	Non-Participant	39	40	42	46	50	55	4	701812	4926372	573
334	Non-Participant	38	40	42	46	50	55	4	701756	4927052	565
335	Non-Participant	41	42	44	47	51	55	4	702728	4924019	576
336	Non-Participant	40	41	43	46	50	55	4	702578	4923968	577
337	Non-Participant	45	45	46	48	51	55	4	717819	4927505	513
338	Non-Participant	36	38	41	45	50	55	4	709565	4919261	552
339	Non-Participant	35	38	41	45	50	55	4	714962	4942174	484
340	Non-Participant	32	37	41	45	50	55	4	715947	4941701	474
341	Non-Participant	38	40	42	46	50	55	4	715270	4940703	487
342	Non-Participant	32	37	41	45	50	55	4	716678	4942419	476
343	Non-Participant	31	36	40	45	50	55	4	717510	4942213	470
344	Non-Participant	32	37	41	45	50	55	4	718214	4940842	474
345	Non-Participant	34	38	41	45	50	55	4	717334	4940664	487
346	Non-Participant	34	37	41	45	50	55	4	717933	4940203	477
347	Non-Participant	40	41	43	46	50	55	4	716468	4939782	495
348	Participant	43	43	45	47	51	55	4	715974	4939553	488
349	Non-Participant	37	39	42	46	50	55	4	716516	4940518	495
350	Non-Participant	36	39	41	46	50	55	4	716326	4940672	490
351	Non-Participant	36	39	42	46	50	55	4	716258	4940715	489
352	Non-Participant	37	39	42	46	50	55	4	716147	4940756	488
353	Non-Participant	36	39	41	46	50	55	4	716143	4940818	487
354	Non-Participant	35	38	41	45	50	55	4	716333	4940947	486
355	Non-Participant	43	43	45	47	51	55	4	713915	4939589	509
356	Non-Participant	37	39	42	46	50	55	4	718029	4938904	482
357	Non-Participant	34	37	41	45	50	55	4	719418	4938731	479
358	Non-Participant	34	38	41	45	50	55	4	719368	4938213	485
359	Non-Participant	36	38	41	45	50	55	4	719511	4937517	495

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
360	Non-Participant	39	40	42	46	50	55	4	719426	4935625	488
361	Non-Participant	38	40	42	46	50	55	4	719573	4934987	486
362	Participant	46	47	47	49	52	56	4	718362	4934283	508
363	Participant	48	48	48	49	52	56	4	718034	4934913	500
364	Non-Participant	34	38	41	45	50	55	4	720226	4934217	475
365	Non-Participant	36	39	41	46	50	55	4	719471	4932351	514
366	Non-Participant	35	38	41	45	50	55	4	719526	4931063	504
367	Non-Participant	38	40	42	46	50	55	4	718731	4928316	506
368	Non-Participant	36	38	41	45	50	55	4	719343	4927842	514
369	Non-Participant	35	38	41	45	50	55	4	719040	4926244	522
370	Non-Participant	31	36	41	45	50	55	4	719132	4924320	524
371	Non-Participant	36	39	41	46	50	55	4	718385	4923374	532
372	Non-Participant	38	40	42	46	50	55	4	718797	4922617	537
373	Non-Participant	36	39	42	46	50	55	4	719642	4922343	530
374	Non-Participant	38	39	42	46	50	55	4	719740	4920197	537
375	Non-Participant	35	38	41	45	50	55	4	720762	4918604	531
376	Non-Participant	38	40	42	46	50	55	4	719905	4918664	536
377	Non-Participant	39	40	42	46	50	55	4	719815	4918486	538
378	Non-Participant	36	38	41	45	50	55	4	701799	4923334	588
379	Non-Participant	37	39	42	46	50	55	4	701848	4924470	583
380	Non-Participant	35	38	41	45	50	55	4	701291	4924911	581
381	Non-Participant	35	38	41	45	50	55	4	701238	4925586	575
382	Non-Participant	36	39	42	46	50	55	4	701404	4926339	575
383	Non-Participant	45	46	46	48	51	55	4	710438	4932798	552
384	Participant	50	50	51	51	53	56	4	709767	4935318	531
385	Participant	45	46	46	48	51	55	4	711531	4936398	525
386	Participant	44	44	45	47	51	55	4	714637	4938730	512
387	Non-Participant	38	40	42	46	50	55	4	714927	4940501	489
388	Non-Participant	36	38	41	45	50	55	4	718947	4923250	531
389	Non-Participant	38	40	42	46	50	55	4	718832	4931737	502

Receiver ID	Receiver Status	Modeled Sound Pressure Level (dBA)	Combined Background and Modeled Sound Pressure (L_{50} dBA)					Relative Height (m)	Coordinates (UTM NAD83 Z14N)		
			35 dBA Background	40 dBA Background	45 dBA Background	50 dBA Background	55 dBA Background		X (m)	Y (m)	Z (m)
390	Participant	49	49	49	50	52	56	4	715897	4938912	494
391	Non-Participant	38	40	42	46	50	55	4	717570	4939243	492
392	Non-Participant	39	40	42	46	50	55	4	718648	4931091	509
393	Non-Participant	37	39	42	46	50	55	4	719213	4930270	511
394	Non-Participant	34	37	41	45	50	55	4	714160	4943614	478
395	Non-Participant	34	38	41	45	50	55	4	714454	4943223	484
396	Non-Participant	37	39	42	46	50	55	4	713926	4942475	490
397	Participant	46	46	47	48	51	56	4	709794	4925833	541

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Attachment G – 2019 Shadow Flicker Assessment

Final Report
Blazing Star II Wind Farm
Shadow Flicker Study
Hendricks, MN

April 15,

2019

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Report Update

EAPC bears no responsibility to update this report for any changes occurring subsequent to the final issuance of this report.

Revision History

Revision No.	Revision Purpose	Date	Revised By
0	Original	04/15/2019	J. Haley

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Executive Summary

EAPC was hired by Merjent to provide estimates of the shadow flicker potential for a proposed wind turbine layout for the Blazing Star II Wind Energy project in southern Minnesota. Locations of area dwellings and a wind turbine layout were provided to EAPC by the client. A windPRO model was built combining digital elevation data with the information supplied to generate a shadow flicker model for the site. The resulting model was then used to perform shadow flicker calculations for the area. Based on the shadow flicker calculation, a site-wide realistic shadow flicker map was produced and an evaluation of the shadow flicker at all 215 area dwellings within one mile of any proposed Blazing Star II turbine location was performed.

The 215 dwellings were represented in the model by omni-directional shadow receptors that simulate a 1 m x 1 m window 1 m above ground level. Reductions based on turbine operational time, turbine operational direction, and sunshine probabilities were used to calculate a realistic number of hours of shadow flicker to be expected at each shadow receptor. No obstacles were used so that shadow flicker reductions due to interference from trees and structures were not included.

The number of occupied residences registering more than 30 hours per year was 13, ranging from 30 hours to 56 hours and 49 minutes. In all cases, the occupied residences that registered more than 30 hours per year were project participants.

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1. Introduction

Merjent hired EAPC to conduct a shadow flicker analysis for the Blazing Star II wind farm layout located in southern Minnesota near the town of Hendricks. The turbine models used in the array were 10 Vestas V110-2.0 MW – 80 meter hub height turbines and 92 Vestas V120-2.0 MW – 80 meter hub height turbines (including 2 alternates), for a total of 102 wind turbines. Additionally, the 100 wind turbines (10 Vestas V110-2.0's and 90 Vestas V120-2.0's) from Blazing Star I were included in the study to account for any cumulative effects from the Blazing Star I project.

Coordinates for the 202 wind turbines and the 215 dwellings which could potentially experience shadow flicker from the proposed wind farm were supplied by the client.

2. Background

Shadow flicker from wind turbines occurs when rotating wind turbine blades move between the sun and the observer. Shadow flicker is generally experienced in areas near wind turbines where the distance between the observer and wind turbine blade is short enough that sunlight has not been significantly diffused by the atmosphere. When the blades rotate, this shadow creates a pulsating effect, known as shadow flicker. If the blade's shadow is passing over the window of a building, it will have the effect of increasing and decreasing the light intensity in the room at a low frequency in the range of 0.5 to 1.2 Hz, hence the term "flicker". This flickering effect can also be experienced outdoors, but the effect is typically less intense, and becomes less intense when farther from the wind turbine causing the flicker. The moving shadow of a wind turbine blade on the ground is similar to the effect one experiences when driving on a road when there are shadows cast across the road by an adjacent row of trees.

This flickering effect is most noticeable within approximately 1,000 meters of the turbine, and becomes more and more diffused as the distance increases. There are no uniform standards defining what distance from the turbine is regarded as an acceptable limit beyond which, the shadow flicker is considered to be insignificant. The same applies to the number of hours of flickering that is deemed to be acceptable.

Shadow flicker is typically greatest in the winter months when the angle of the sun is lower and casts longer shadows. The effect is also more pronounced around sunrise and sunset when the sun is near the horizon and the shadows are longer. A number of factors influence the amount of shadow flicker on the shadow receptors (simulated windows). One consideration is the environment around the shadow receptor. Obstacles such as terrain, trees or buildings between the wind turbine and the receptor can significantly reduce or eliminate shadow flicker effects. Deciduous trees may block the shadow flickering effect to some degree, depending on the tree density, species present and time of year. Deciduous trees can lead to a reduction of shadow flicker during the summer when the trees are bearing leaves. However, during the winter months, these trees are without their leaves and their impact on shadow flicker is not as significant. Coniferous

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trees tend to provide shading year round. For this study, no credit was taken for any potential shading effects from any type of trees or other obstacles that would reduce the number of shadow flickering hours at the structures.

Another consideration is the time of day when shadow flicker occurs. For example, a factory or office building would not be significantly affected if all the shadow flicker impact occurred before or after business hours whereas, it may be more acceptable for private homes to experience the shadow flickering during working hours when family members may be at work or school.

The climate also needs be considered when assessing shadow flicker. In areas with a significant amount of overcast weather, there would be less shadow flicker. Also, if the wind is not blowing, the turbines would not be operational and therefore not creating shadow flickering.

3. *Study Methodology*

This shadow flicker analysis was performed utilizing windPRO[1], a sophisticated wind modeling software program. windPRO has the ability to calculate detailed shadow flicker maps across an entire area of interest or at site-specific locations using shadow receptors.

Shadow maps which indicate where the shadows will be cast and for how long, are generated using windPRO, calculating the shadow flicker in varying user-defined resolutions. Standard resolution was used for this study and represents shadow flicker being calculated every three minutes of every day over the period of an entire year over a grid with a 20 m by 20 m resolution.

In addition to generating a shadow flicker map, the amount of shadow flicker that may occur at a specific point can be calculated more precisely by placing a shadow receptor at the location of interest and essentially "recording" the shadow flicker that occurs as the relative sunrise to sunset motion of the sun is simulated throughout an entire year.

The point-specific shadow flicker calculation is run at a higher resolution as compared to the shadow flicker map calculation to include the highest precision possible within windPRO. Shadow flicker at each shadow receptor location is calculated every minute of every day for an entire year. Shadow receptors can be configured to represent an omni-directional window of a specific size at a specific point (greenhouse mode) or a window facing a single direction of a specific size at a specific point (single direction mode). The shadow receptors used in this analysis were configured as greenhouse-mode receptors

[1] windPRO is the world's leading software tool for wind farm design including shadow flicker analysis.

representing a 1 m x 1 m window located 1 m above ground level. This represents more of a “worst-case” scenario and thus will produce more conservative results.

As a part of the calculation method, windPRO must determine whether or not a turbine will be visible at the receptor locations. It does this by performing a preliminary Zones of Visual Influence (ZVI) calculation, utilizing 10 m grid spacing. If a particular turbine is not visible within the 10 m x 10 m area that the shadow receptor is contained within, then that turbine is not included in the shadow flicker calculation for that receptor.

The maximum distance limit for which shadow flicker should be counted was set to 1,500 meters. Any shadow flicker contributions from turbines within this distance limit are added to the total for each receptor.

The inputs for the windPRO shadow flicker calculation include the following:

- Turbine Coordinates
- Turbine Specifications
- Shadow Receptor Coordinates
- Monthly Sunshine Probabilities
- Joint Wind Speed and Direction Frequency Distribution
- USGS Digital Elevation Model (DEM) (height contour data)

A description of each input variable and how they affect the shadow flicker calculation are included below.

Turbine Coordinates: The location of a wind turbine in relation to a shadow receptor is one of the most important factors in determining shadow flicker impacts. A line-of-site is required for shadow flicker to occur. The intensity of the shadow flicker is dependent upon the distance from the wind turbine and weather conditions.

Turbine Specifications: A wind turbines total height and rotor diameter will be included in the windPRO shadow flicker model. The taller the wind turbine, the more likely shadow flicker could have an impact on local shadow receptors as the ability to clear obstacles (such as hills or trees) is greater. The larger the rotor diameter is, the wider the area where shadows will be cast. Also included with the turbine specifications are the cut-in and cut-out wind speeds within which the wind turbine is operational. If the wind speed is below the cut-in threshold or above the cut-out threshold, the turbine rotor will not be spinning and thus shadow flicker will not occur. The specifications for the two wind turbine models used in this study are included in Table 1 below.

Table 1: Blazing Star II wind turbine specifications.

Blazing Star II Wind - Shadow Modeled Turbine Specifications					
Manufacturer	**Model**	**Hub Height (m)**	**Rotor Diameter (m)**	**Cut-In Wind Speed (m/s)**	**Cut-Out Wind Speed (m/s)**
Vestas	V110	80	110	3	20
Vestas	V120	80	120	3	18

Shadow Receptor Coordinates: As with the wind turbine coordinates, the elevation, distance and orientation of a shadow receptor in relation to the wind turbines and the sun are the main factors in determining the impact of shadow flicker. EAPC was provided with coordinates for 215 structures found to be located within one mile of the proposed wind turbine locations.

Monthly Sunshine Probabilities: windPRO calculates sunrise and sunset times to determine the total annual hours of daylight for the modeled area. To further refine the shadow flicker calculations, the monthly probability of sunshine is included to account for cloud cover. The greater the probability of cloud cover, the less of an impact from shadow flicker. The monthly sunshine probabilities for many of the larger cities across the United States are available from the National Climatic Data Center (NCDC). For this study, 18 years' worth of monthly sunshine probability data were retrieved for Minneapolis, MN, which was the closest, most representative station, to create the long-term representative monthly sunshine probabilities. The long-term representative monthly average sunshine probabilities are presented in Table 2.

Table 2: Minneapolis, MN monthly sunshine probabilities.

Minneapolis, MN Monthly Sunshine Probabilities (1965-1983)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sunshine %	53%	59%	57%	56%	62%	67%	74%	69%	62%	51%	37%	38%
retrieved from: http:// http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.dat												

Joint Wind Speed and Direction Frequency Distribution: A set of long-term corrected wind distributions generated from an on-site meteorological mast was provided by the client to represent the annual wind speed and direction distribution for the project site for the three proposed turbine hub heights. This data was used to estimate the probable number of operational hours for the wind turbines from each of the 12 wind direction sectors. During operation, the wind turbine rotors will always be assumed to face into the wind and automatically orient themselves as the wind direction changes. Shadow flicker can only occur when the blades are turning and the wind turbine rotor is between the sun and the receptor. Shadow flicker is most significant when the rotor is facing the sun.

USGS Digital Elevation Model (DEM) (height contour data): For this study, 10-meter USGS National Elevation Database (NED) DEM's were used to construct 10-foot interval

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height contour lines for the windPRO shadow flicker model. The height contour information is important to the shadow flicker calculation since it allows the model to place the wind turbines and the shadow receptors at the correct elevations. The height contour lines also allow the model to include the topography of the site when calculating the zones of visual influence surrounding the wind turbine and shadow receptor locations.

The actual calculation of potential shadow flicker at a given shadow receptor is carried out by simulating the environment near the wind turbines and the shadow receptors. The position of the sun relative to the turbine rotor disk and the resulting shadow is calculated in time steps of one minute throughout an entire year. If the shadow of the rotor disk (which in the calculation is assumed solid) at any time casts a shadow on a receptor window, then this step will be registered as one minute of shadow flicker. The calculation also requires that the sun must be at least 3.0° above the horizon in order to register shadow flicker.

The sun's path with respect to each wind turbine location is calculated by the software to determine the paths of cast shadows for every minute of every day over a full year. The turbine runtime and direction are calculated from the site's long-term wind speed and direction distribution. Finally, the effects of cloud cover are calculated using long-term reference data (monthly sunshine probability) to arrive at the projected annual flicker time at each receptor.

4. *Site Overview*

The area of interest is located in Lincoln County near the town of Hendricks in southern Minnesota. It is located on the just off of the Buffalo Ridge along the eastern slope of the Coteau des Prairies which is a long expanse of rolling hills running northwest to southeast through the southwest corner of Minnesota. The surrounding terrain has a change in elevation across the project site ranging from 488 meters to 567 meters (1,601 feet to 1,860 feet). The regions vegetation is comprised primarily of agricultural land. The area also has a number of existing wind energy projects currently in operation, primarily to the south of the Blazing Star II project along the Buffalo Ridge.

5. *Results of Analysis*

The term "realistic " as used in this report means that turbine operational hours and direction as well as local sunshine probabilities have been factored in, but no blocking or shading effects due to trees or structures have been accounted for. This means that the "realistic" estimates are still inherently conservative values. The realistic shadow flicker hours predicted by windPRO assumes an availability factor of 100% which is very unlikely to be the case. The realistic shadow flicker hours predicted by windPRO were reduced by 4.2% to account for wind turbine downtime attributable to an assumed realistic availability factor of 95.8%

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A total of 215 residential structures within project vicinity were analyzed and standard resolution realistic shadow flicker maps and individual maps were generated for each turbine array.

The 215 shadow receptors were then modeled as greenhouse-mode receptors and the estimated shadow flicker was calculated for each array using a 1,500 meter distance limit. The percentage of the 215 receptors that registered no shadow flicker hours was 27%.

Table 3 contains the shadow flicker distribution of the 215 residential structures within one mile of any turbine location along with a breakdown of how many are non-participating.

Table 3: Residential structures realistic shadow flicker distribution

Realistic Shadow Flicker (hrs/year)	Number of Non-Participating Occupied Structures	Number of Participating Occupied Structures
0	45	14
0 to 5	38	22
5 to 10	24	11
10 to 15	6	12
15 to 20	7	8
20 to 25	3	5
25 to 30	1	6
30+	0	13

Tables 4 and 5 below provide a breakdown of the maximum and average number of shadow flicker hours that are projected at participating and non-participating residences for both the worst and realistic cases.

Table 4: Summary of shadow flicker hours per year at participating residences

Statistic	Hh/yr
Max - Worst Case	185:35
Avg - Worst Case	42:03
Max - Real Case	56:49
Avg - Real Case	13:37

Table 5: Summary of shadow flicker hours per year at non-participating residences

Statistic	Hr/yr
Max - Worst Case	79:02
Avg - Worst Case	12:52
Max - Real Case	25:32
Avg - Real Case	4:10

6. *Conclusions*

The conservative results of this study indicate that for the 215 receptors modeled, 13 measured more than 30 hours per year at participating landowners' occupied residences with none measuring over 25 hours and 32 minutes or more per year of realistic shadow flicker at a non-participating landowner's occupied residence. The shadow flicker impact on the receptors was calculated from turbines within 1 mile with reductions due to turbine operational time, turbine operational direction and sunshine probabilities included. This shadow flicker analysis is based on a number of conservative assumptions including:

- No credit was taken for the blocking effects of trees or buildings.
- The receptors were omni-directional rather than modeling specific facades of buildings.

The overall effect of using these conservative assumptions indicate that realistically, the number of hours of shadow flicker that would be observed will be less than those predicted by this study.

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APPENDIX A: BLAZING STAR II WIND ENERGY WIND TURBINE COORDINATES

Blazing Star II
Vestas V120 & V110 80 m hub height WTG's
UTM NAD83 Zone 14 (meters)

WTG	Model	Easting (m)	Northing (m)	Elevation AMSL (m)
101	V110	703,063	4,925,908	563
102	V110	703,640	4,925,607	552.5
103	V110	704,023	4,925,788	549
104	V110	704,400	4,925,795	545.1
105	V110	703,086	4,924,943	564
106	V110	703,580	4,924,831	561
107	V110	705,280	4,925,148	540.4
108	V110	703,871	4,924,124	563.1
109	V120	703,751	4,923,373	557.4
110	V110	703,951	4,923,572	555
111	V110	704,309	4,923,633	556.8
112	V120	710,755	4,925,631	543.2
113	V120	711,190	4,925,449	541.1
114	V120	710,201	4,925,318	537
115	V120	710,099	4,924,907	537.3
116	V120	707,812	4,923,781	543
117	V120	708,526	4,924,189	540
118	V120	708,550	4,923,492	540
119	V120	710,129	4,924,432	540
120	V120	712,506	4,924,104	522.6
121	V120	712,127	4,923,795	540
122	V120	712,199	4,923,179	540.6
123	V120	712,599	4,923,324	538.8
124	V120	705,340	4,922,664	555.3
125	V120	707,363	4,922,860	546
126	V120	707,255	4,922,491	549
127	V120	707,965	4,922,147	546.3
128	V120	708,353	4,922,138	547.3
129	V120	708,713	4,922,147	546
130	V120	709,068	4,922,261	543.3
131	V120	709,502	4,922,235	543
132	V120	710,056	4,922,625	543
133	V120	711,811	4,922,172	543.2
134	V120	705,770	4,921,358	559.3
135	V120	705,397	4,920,394	566.1
136	V120	705,879	4,920,604	561
137	V120	706,158	4,920,857	560.4
138	V120	710,361	4,917,005	552
139	V120	710,640	4,917,280	552
140	V120	711,023	4,917,402	555
141	V120	711,397	4,917,536	549.7

Blazing Star II
Vestas V120 & V110 80 m hub height WTG's
UTM NAD83 Zone 14 (meters)
continued

WTG	Model	Easting (m)	Northing (m)	Elevation AMSL (m)
142	V120	711,792	4,917,297	550.9
143	V120	711,970	4,917,619	548.2
144	V120	713,660	4,916,873	546
145	V120	715,423	4,939,070	507
146	V120	716,109	4,938,582	489
147	V120	716,701	4,937,895	493.3
148	V120	716,808	4,936,928	501.9
149	V120	717,270	4,936,493	495
150	V120	716,979	4,936,122	504.1
151	V120	717,825	4,935,863	501
152	V120	717,911	4,935,429	498
153	V120	714,905	4,933,753	519.8
154	V120	715,269	4,933,826	519
155	V120	715,626	4,934,027	516
156	V120	716,148	4,933,760	516.5
157	V120	717,094	4,934,480	493.2
158	V120	717,443	4,934,460	509.4
159	V120	717,893	4,933,999	513
160	V120	717,338	4,933,628	504
161	V120	717,089	4,933,303	510.3
162	V120	716,637	4,931,916	516
163	V120	716,946	4,932,182	514.7
164	V120	713,493	4,931,120	518.7
165	V120	715,611	4,930,769	519
166	V120	716,747	4,930,435	508.2
167	V120	717,110	4,930,903	507.3
168	V120	714,118	4,929,093	531
169	V120	715,766	4,928,216	525
170	V120	716,696	4,929,349	516
171	V120	717,319	4,929,033	510.9
172	V120	716,322	4,928,341	514.7
173	V120	716,740	4,928,441	514.2
174	V120	717,140	4,927,430	516
175	V120	717,178	4,927,136	508.5
176	V120	716,219	4,921,792	542.9
177	V120	717,049	4,922,155	529.8
178	V120	715,242	4,920,897	540
179	V120	715,724	4,920,812	540
180	V120	716,606	4,920,149	533.1
181	V120	717,148	4,920,246	534
182	V120	717,427	4,920,436	534

Blazing Star II
Vestas V120 & V110 80 m hub height WTG's
UTM NAD83 Zone 14 (meters)
continued

WTG	Model	Easting (m)	Northing (m)	Elevation AMSL (m)
183	V120	717,708	4,920,671	531
184	V120	718,150	4,921,453	522.2
185	V120	715,349	4,919,693	543
186	V120	716,285	4,919,732	540
187	V120	716,642	4,918,877	543
188	V120	716,829	4,919,310	540
189	V120	717,495	4,919,213	535.3
190	V120	717,851	4,919,370	529.8
191	V120	718,247	4,918,726	534
192	V120	716,699	4,917,277	542.8
193	V120	716,988	4,917,638	542.9
194	V120	717,928	4,917,629	537
195	V120	718,273	4,917,788	536
196	V120	716,908	4,916,549	543
197	V120	717,266	4,916,608	541.1
198	V120	717,688	4,916,691	540.6
199	V120	717,463	4,914,997	540
200	V120	718,668	4,914,273	538.6
ALT-1	V120	713,613	4,916,456	546
ALT-4	V120	718,439	4,919,502	528

APPENDIX B: SHADOW FLICKER RESULTS TABLES

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
1	Non-Participant	708,990.00	4,916,373.00	564.0	1:19 hr/yr
2	Non-Participant	710,742.00	4,916,514.00	552.0	
3	Non-Participant	713,236.00	4,915,998.00	546.0	
4	Non-Participant	709,890.00	4,916,313.00	555.0	
6	Non-Participant	716,542.00	4,915,922.00	545.7	:33 hr/yr
7	Non-Participant	718,276.00	4,915,893.00	534.0	5:16 hr/yr
10	Non-Participant	718,060.00	4,915,274.00	538.1	8:37 hr/yr
12	Non-Participant	716,410.00	4,915,051.00	549.0	2:26 hr/yr
13	Non-Participant	716,692.00	4,914,964.00	543.9	5:52 hr/yr
14	Non-Participant	719,365.00	4,915,537.00	528.0	
15	Participant	718,232.00	4,914,631.00	540.0	32:34 hr/yr
16	Participant	718,377.00	4,915,057.00	540.0	3:53 hr/yr
18	Non-Participant	719,163.00	4,914,986.00	534.3	
19	Non-Participant	720,001.00	4,914,540.00	528.0	1:20 hr/yr
24	Participant	718,377.00	4,913,739.00	540.0	
25	Non-Participant	717,317.00	4,913,859.00	540.0	1:22 hr/yr
28	Participant	719,258.00	4,913,620.00	538.7	
29	Non-Participant	718,212.00	4,912,757.00	546.0	
36	Non-Participant	718,105.00	4,913,908.00	540.0	6:05 hr/yr
38	Non-Participant	719,931.00	4,914,381.00	528.2	1:45 hr/yr
40	Participant	703,399.00	4,925,277.00	558.1	25:25 hr/yr
41	Non-Participant	704,897.00	4,926,016.00	547.1	18:29 hr/yr
42	Participant	710,928.00	4,926,220.00	537.9	
43	Non-Participant	704,911.00	4,925,791.00	547.6	18:41 hr/yr
44	Participant	710,635.00	4,926,209.00	538.6	
45	Participant	706,416.00	4,925,836.00	540.3	1:20 hr/yr
46	Non-Participant	711,153.00	4,926,224.00	540.0	:36 hr/yr
47	Non-Participant	711,948.00	4,926,284.00	534.0	1:32 hr/yr
49	Non-Participant	716,262.00	4,926,106.00	521.3	
50	Non-Participant	717,886.00	4,926,508.00	510.0	
51	Participant	703,267.00	4,925,432.00	558.3	34:06 hr/yr
52	Non-Participant	708,045.00	4,925,527.00	543.0	
54	Participant	711,128.00	4,924,729.00	546.0	5:50 hr/yr
58	Non-Participant	704,830.00	4,924,452.00	547.5	5:18 hr/yr
59	Participant	706,468.00	4,924,670.00	540.8	4:59 hr/yr
60	Participant	708,238.00	4,924,645.00	541.3	
61	Participant	706,506.35	4,924,082.62	549.0	1:10 hr/yr
62	Participant	706,570.00	4,924,459.00	543.7	3:52 hr/yr

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)
continued

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
63	Participant	706,596.00	4,923,817.00	549.0	1:40 hr/yr
64	Non-Participant	711,325.00	4,924,460.00	540.9	10:23 hr/yr
65	Participant	711,412.00	4,924,439.00	540.0	8:16 hr/yr
69	Non-Participant	705,415.00	4,923,531.00	546.0	4:56 hr/yr
70	Participant	707,776.00	4,923,004.00	543.4	34:25 hr/yr
71	Participant	708,927.15	4,923,038.91	543.0	4:33 hr/yr
72	Participant	716,128.46	4,923,257.57	525.0	
73	Non-Participant	711,480.40	4,923,614.58	537.6	25:32 hr/yr
74	Non-Participant	705,920.00	4,922,780.00	552.0	12:16 hr/yr
75	Participant	708,039.00	4,922,639.00	544.4	38:20 hr/yr
76	Participant	708,332.00	4,922,926.00	542.8	9:58 hr/yr
77	Non-Participant	711,187.00	4,922,999.00	543.0	5:13 hr/yr
78	Non-Participant	713,405.61	4,922,538.41	534.1	3:26 hr/yr
79	Non-Participant	713,373.00	4,922,621.00	535.3	7:51 hr/yr
80	Participant	717,458.00	4,923,136.00	528.7	
81	Participant	717,831.40	4,922,763.67	530.6	5:50 hr/yr
83	Non-Participant	704,947.00	4,921,937.44	566.2	6:29 hr/yr
84	Non-Participant	705,030.00	4,921,942.00	565.9	6:52 hr/yr
85	Participant	711,710.00	4,921,498.00	546.0	
86	Participant	717,453.23	4,921,916.59	527.5	17:12 hr/yr
87	Non-Participant	717,919.00	4,922,384.00	530.1	3:27 hr/yr
88	Non-Participant	704,156.00	4,921,099.00	579.0	1:12 hr/yr
89	Participant	716,686.00	4,921,980.00	532.1	50:44 hr/yr
90	Participant	705,393.00	4,921,095.00	567.3	16:23 hr/yr
92	Non-Participant	711,332.00	4,921,133.00	546.0	
94	Participant	716,348.02	4,921,279.31	532.0	15:04 hr/yr
95	Participant	716,687.00	4,921,042.00	535.9	13:34 hr/yr
96	Non-Participant	711,933.00	4,921,239.00	543.0	
97	Participant	717,534.00	4,921,390.00	525.0	13:08 hr/yr
98	Non-Participant	711,972.00	4,921,196.00	543.1	
99	Non-Participant	712,009.00	4,921,180.00	543.2	
100	Non-Participant	712,049.00	4,921,156.00	543.0	
101	Non-Participant	712,305.00	4,920,969.00	543.0	
102	Non-Participant	712,308.00	4,920,943.00	543.0	
103	Non-Participant	712,124.00	4,921,110.00	543.0	
104	Non-Participant	712,171.00	4,921,090.00	543.1	
105	Non-Participant	712,201.00	4,921,072.00	543.1	
106	Participant	706,731.00	4,920,599.00	558.0	27:14 hr/yr

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)
continued

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
107	Non-Participant	709,835.00	4,920,825.00	543.0	
108	Non-Participant	709,964.00	4,920,835.00	543.0	
109	Non-Participant	710,008.00	4,920,849.00	543.0	
110	Non-Participant	710,045.00	4,920,847.00	543.0	
111	Non-Participant	710,107.21	4,920,847.59	543.0	
112	Non-Participant	710,150.00	4,920,844.00	543.0	
114	Non-Participant	710,203.00	4,920,836.00	543.5	
115	Non-Participant	710,245.00	4,920,832.00	543.5	
120	Non-Participant	709,721.00	4,920,672.00	543.0	
127	Participant	714,867.43	4,920,432.98	548.0	8:04 hr/yr
128	Participant	716,488.00	4,920,759.00	531.8	23:54 hr/yr
130	Non-Participant	718,523.00	4,920,598.00	528.0	9:36 hr/yr
133	Participant	706,915.00	4,919,604.00	561.0	
140	Participant	718,674.00	4,919,247.00	525.0	14:39 hr/yr
152	Non-Participant	709,803.00	4,918,460.00	558.0	
153	Non-Participant	710,154.00	4,918,650.00	555.9	
154	Non-Participant	710,963.42	4,918,981.53	554.8	
155	Non-Participant	711,836.00	4,918,446.00	555.0	
156	Participant	714,935.50	4,919,299.32	546.0	1:17 hr/yr
157	Participant	717,432.00	4,918,515.00	540.8	20:38 hr/yr
158	Participant	714,459.56	4,918,595.46	545.2	
159	Non-Participant	710,017.00	4,917,694.00	556.1	15:29 hr/yr
160	Participant	713,247.00	4,917,995.00	546.4	1:59 hr/yr
161	Participant	716,265.00	4,917,732.00	542.3	14:58 hr/yr
162	Participant	716,660.38	4,918,371.74	538.9	2:10 hr/yr
164	Non-Participant	714,706.00	4,917,839.00	546.0	:49 hr/yr
165	Participant	713,041.00	4,917,561.00	548.2	4:05 hr/yr
166	Participant	712,044.00	4,916,822.00	551.3	4:45 hr/yr
167	Participant	716,488.00	4,916,955.00	545.0	21:50 hr/yr
168	Participant	718,510.00	4,916,899.00	533.6	4:22 hr/yr
170	Non-Participant	714,490.00	4,916,829.00	549.0	8:37 hr/yr
171	Non-Participant	704,980.00	4,924,364.00	546.0	7:39 hr/yr
172	Non-Participant	707,630.00	4,921,401.00	555.0	:54 hr/yr
173	Non-Participant	716,588.00	4,923,101.00	536.3	
174	Non-Participant	713,994.00	4,923,631.00	537.0	1:45 hr/yr
180	Non-Participant	706,507.00	4,923,628.00	549.0	3:42 hr/yr
181	Participant	715,490.00	4,916,787.00	546.0	3:16 hr/yr
182	Participant	709,894.68	4,922,215.63	546.0	32:49 hr/yr

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)
continued

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
183	Participant	713,282.37	4,921,548.69	550.7	1:30 hr/yr
184	Participant	706,585.00	4,921,389.00	555.7	13:43 hr/yr
185	Non-Participant	715,918.00	4,918,432.00	544.5	10:23 hr/yr
189	Non-Participant	712,470.00	4,920,752.00	543.0	
190	Non-Participant	712,451.00	4,920,697.00	543.2	
193	Non-Participant	710,818.00	4,920,981.00	543.0	
195	Non-Participant	706,489.00	4,922,073.00	553.6	20:16 hr/yr
196	Non-Participant	704,802.00	4,922,109.00	564.0	3:37 hr/yr
197	Non-Participant	709,962.00	4,920,947.00	543.0	
202	Non-Participant	709,783.00	4,918,092.00	558.0	1:30 hr/yr
203	Participant	719,061.00	4,917,101.00	534.0	8:44 hr/yr
204	Non-Participant	712,274.00	4,921,002.00	543.0	
205	Participant	716,933.00	4,918,476.00	540.0	2:26 hr/yr
206	Non-Participant	711,314.00	4,923,808.00	537.6	18:41 hr/yr
207	Non-Participant	706,620.00	4,920,191.00	564.0	6:59 hr/yr
208	Non-Participant	709,784.00	4,920,718.00	543.0	
209	Participant	717,630.00	4,917,888.00	537.0	56:49 hr/yr
215	Participant	715,959.07	4,940,530.56	486.0	
217	Participant	714,797.00	4,938,680.00	506.6	13:09 hr/yr
218	Participant	716,478.00	4,938,133.00	492.0	46:59 hr/yr
219	Non-Participant	715,227.58	4,937,823.85	510.0	2:39 hr/yr
221	Non-Participant	716,054.70	4,937,632.09	502.8	15:23 hr/yr
224	Non-Participant	716,146.00	4,936,476.00	517.7	8:05 hr/yr
225	Non-Participant	717,206.00	4,937,293.00	485.2	20:02 hr/yr
226	Participant	717,942.00	4,936,662.00	489.0	13:29 hr/yr
228	Participant	716,463.00	4,936,661.00	505.3	8:08 hr/yr
233	Non-Participant	715,041.00	4,935,308.00	498.5	
234	Non-Participant	714,985.00	4,935,323.00	498.0	
235	Participant	717,351.00	4,935,795.00	503.6	34:19 hr/yr
237	Participant	717,051.77	4,935,052.29	491.9	8:47 hr/yr
238	Non-Participant	713,916.07	4,934,554.58	498.0	5:22 hr/yr
239	Participant	717,361.00	4,934,920.00	490.0	4:12 hr/yr
244	Non-Participant	713,425.00	4,933,806.00	508.0	1:12 hr/yr
245	Participant	716,937.00	4,933,989.00	507.0	29:51 hr/yr
248	Participant	715,608.00	4,933,393.00	522.0	14:38 hr/yr
249	Participant	716,367.00	4,933,232.00	519.0	15:16 hr/yr
253	Non-Participant	714,711.00	4,933,133.00	525.0	1:06 hr/yr
255	Participant	717,466.00	4,932,151.00	504.0	22:20 hr/yr

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)
continued

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
256	Participant	717,411.00	4,932,179.00	506.6	26:11 hr/yr
257	Non-Participant	717,829.00	4,933,003.00	501.0	21:34 hr/yr
262	Non-Participant	715,151.71	4,932,082.04	518.0	:53 hr/yr
263	Participant	713,550.00	4,931,793.00	524.5	
270	Participant	717,116.00	4,931,552.00	510.0	
271	Participant	712,974.00	4,931,085.00	518.1	16:02 hr/yr
272	Participant	713,808.00	4,930,934.00	516.0	7:41 hr/yr
273	Participant	716,750.00	4,931,337.00	513.0	6:43 hr/yr
276	Participant	712,476.00	4,930,245.00	524.2	15:02 hr/yr
277	Non-Participant	714,331.00	4,929,922.00	528.0	:35 hr/yr
279	Participant	717,654.00	4,929,997.00	499.9	13:05 hr/yr
281	Non-Participant	716,051.00	4,929,930.00	521.8	6:10 hr/yr
282	Non-Participant	714,796.00	4,929,776.00	525.0	3:32 hr/yr
286	Participant	716,337.00	4,929,184.00	516.5	41:02 hr/yr
287	Non-Participant	717,694.30	4,929,817.21	506.4	2:47 hr/yr
289	Participant	714,358.00	4,928,564.00	525.0	1:01 hr/yr
291	Participant	712,753.68	4,928,254.98	526.4	2:26 hr/yr
292	Participant	716,451.45	4,928,848.32	514.6	16:59 hr/yr
293	Participant	703,149.00	4,927,091.00	552.0	12:42 hr/yr
294	Non-Participant	715,008.00	4,928,162.00	525.0	6:51 hr/yr
296	Participant	704,805.36	4,927,205.66	542.9	31:17 hr/yr
301	Non-Participant	704,913.09	4,927,275.99	543.0	19:06 hr/yr
302	Non-Participant	717,828.00	4,928,341.00	507.0	4:00 hr/yr
303	Participant	716,548.00	4,927,900.00	516.0	29:15 hr/yr
304	Participant	703,490.60	4,926,112.59	555.0	29:29 hr/yr
305	Participant	704,785.07	4,926,169.62	546.3	31:48 hr/yr
309	Non-Participant	715,024.00	4,927,070.00	525.8	
310	Participant	716,051.24	4,926,874.79	521.4	6:35 hr/yr
311	Participant	705,600.57	4,926,162.35	546.0	3:14 hr/yr
314	Non-Participant	709,951.98	4,926,365.77	534.0	10:31 hr/yr
315	Non-Participant	717,743.00	4,926,689.92	509.1	
316	Non-Participant	710,115.00	4,926,300.00	534.0	7:60 hr/yr
317	Participant	717,035.00	4,926,679.00	516.0	
320	Non-Participant	715,979.00	4,932,921.00	516.4	8:32 hr/yr
321	Non-Participant	715,909.00	4,932,794.00	514.4	5:35 hr/yr
323	Non-Participant	717,966.00	4,927,968.00	503.8	8:12 hr/yr
324	Participant	718,941.39	4,934,652.98	489.0	3:50 hr/yr
325	Non-Participant	710,766.00	4,926,921.00	540.0	1:40 hr/yr

Blazing Star II
Real case shadow flicker results at dwellings within one mile of project WTGs
Results using Vestas V120 & V110 80 m hub height WTGs
UTM NAD83 Zone 14 (meters)
continued

Shadow Receptor #	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
328	Non-Participant	716,130.66	4,936,498.42	517.5	11:09 hr/yr
329	Non-Participant	715,829.00	4,932,110.00	515.5	7:11 hr/yr
331	Non-Participant	716,218.00	4,934,879.00	495.3	6:00 hr/yr
332	Non-Participant	701,812.01	4,925,752.44	570.0	3:59 hr/yr
333	Non-Participant	701,812.08	4,926,372.07	567.8	2:27 hr/yr
335	Non-Participant	702,728.00	4,924,019.00	571.8	5:39 hr/yr
336	Non-Participant	702,578.00	4,923,968.00	573.0	3:00 hr/yr
337	Non-Participant	717,819.00	4,927,505.00	508.7	15:13 hr/yr
347	Non-Participant	716,468.41	4,939,782.16	489.0	2:38 hr/yr
348	Participant	715,974.06	4,939,552.62	486.0	12:30 hr/yr
355	Non-Participant	713,915.09	4,939,588.63	504.0	10:26 hr/yr
360	Non-Participant	719,426.26	4,935,624.77	483.0	2:13 hr/yr
362	Participant	718,362.00	4,934,283.02	504.0	21:36 hr/yr
363	Participant	718,034.16	4,934,913.23	496.8	13:32 hr/yr
367	Non-Participant	718,730.54	4,928,316.36	501.0	3:54 hr/yr
372	Non-Participant	718,796.91	4,922,616.77	531.2	
374	Non-Participant	719,740.30	4,920,196.64	531.0	:56 hr/yr
377	Non-Participant	719,814.69	4,918,485.58	534.0	:51 hr/yr
379	Non-Participant	701,848.35	4,924,469.66	579.0	1:20 hr/yr
386	Participant	714,637.33	4,938,730.18	507.0	17:42 hr/yr
387	Non-Participant	714,926.57	4,940,500.71	483.0	
390	Participant	715,897.14	4,938,911.82	489.0	52:39 hr/yr
391	Non-Participant	717,570.02	4,939,243.19	486.0	:46 hr/yr
392	Non-Participant	718,647.60	4,931,090.69	501.0	:51 hr/yr
397	Participant	709,793.61	4,925,832.59	535.3	4:05 hr/yr

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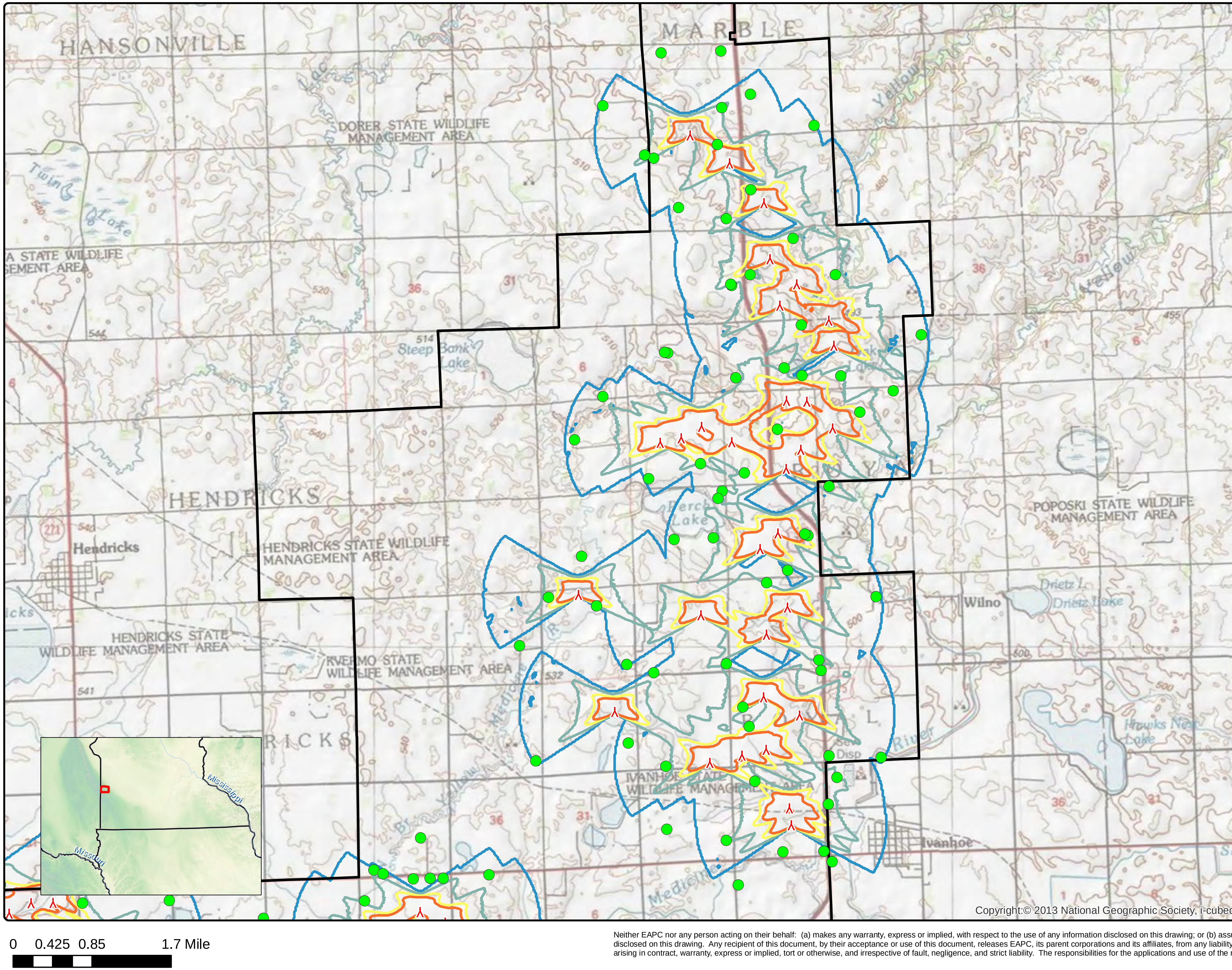
APPENDIX C: STANDARD RESOLUTION SHADOW FLICKER MAP



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Blazing Star II Wind Farm
Shadow Flicker Iso-Lines
North Half

Client

Merjent

Project Description

Primary and Alternate wind turbine layout with occupied structures within one mile of proposed wind turbines.

Location: Hendricks, MN
Project #: 20163620

Issue Dates

#	Description	Date
1	Original	2019.04.04

Drawn By: AS *Checked By: JH*

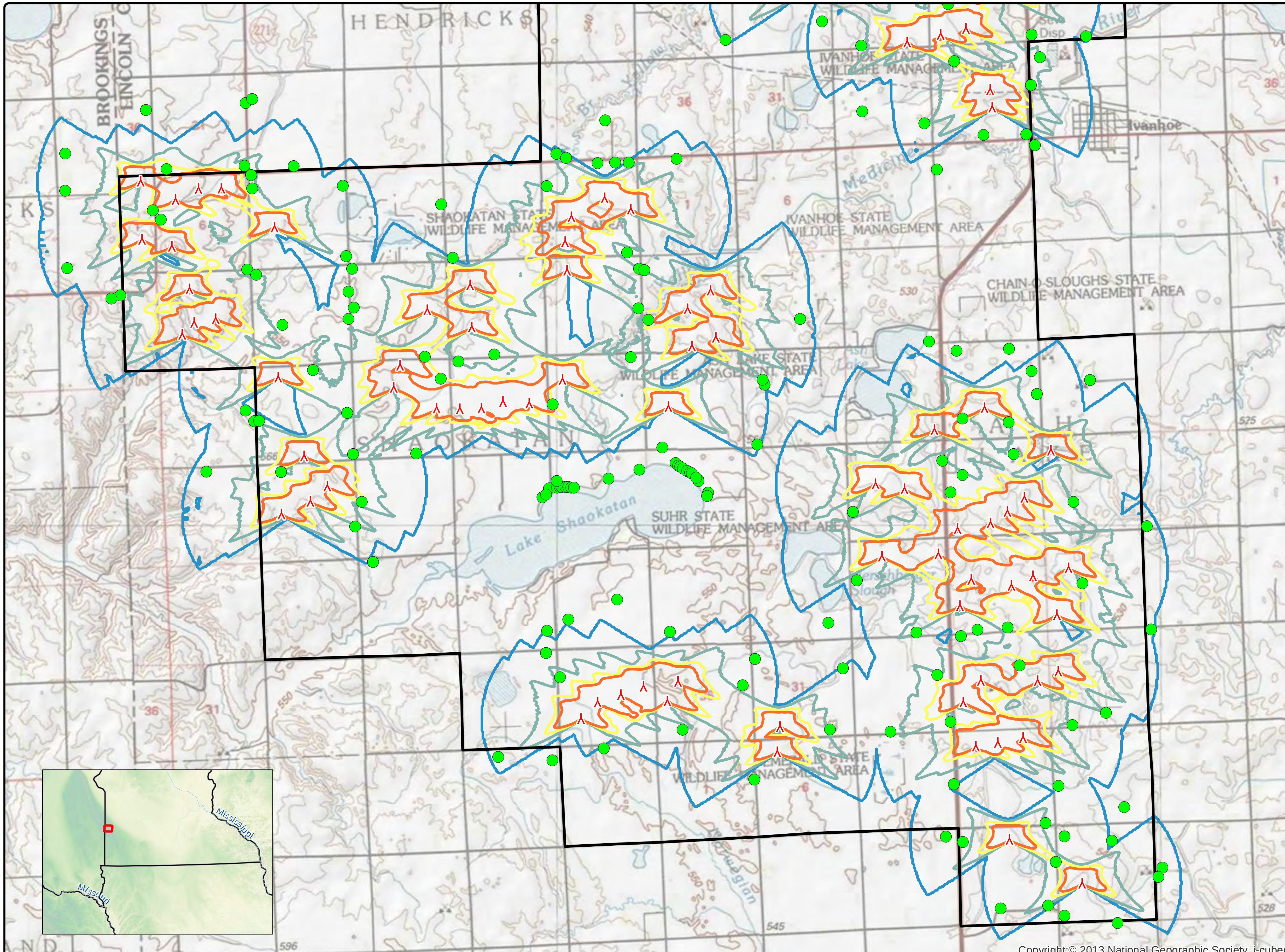
Legend

- Blazing Star II Turbines
- Occupied Residences
- Project Boundary

Shadow Flicker (hr/yr)

- 0
- 10
- 20
- 30
- 40
- 50
- 60

N E S W



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Blazing Star II Wind Farm
Shadow Flicker Iso-Lines
South Half

Client

Merjent

Project Description

Primary and Alternate wind turbine layout with occupied structures within one mile of proposed wind turbines.

Location: *Hendricks, MN*
Project #: *20163620*

Issue Dates

#	Description	Date
1	Original	2019.04.04

Drawn By: *AS* *Checked By:* *JH*

Legend

Blazing Star II Turbines
Occupied Residences
Project Boundary

Shadow Flicker (hr/yr)

0
10
20
30
40
50
60

N E S W

0 0.425 0.85 1.7 Mile

Attachment H – Table Summarizing Turbine Shifts since 2017

Permitted Turbine ID [11/2017]	UTM NAD83 Zone 14N Northing	UTM NAD83 Zone 14N Easting	Landowner [11/2017 array]	Current Turbine ID [4/2019]	Permitted Location Retained? [Y/N]	Turbine Technology	UTM NAD83 Zone 14N Northing	UTM NAD83 Zone 14N Easting	Distance from Permitted Turbine (ft)	Landowner Change from Permitted Layout? [Y/N]	Current Landowern [4/2019 array; if changed]	Notes
				T-101	NA	V110	4925908	703063	NA	NA	NIELSEN/DEAN P & LAYNE/JT	Turbine added.
T10	4925643	703632	VIERHUF/HERBERT & AVIS/LE	T-102	N	V110	4925607	703640	120			
T67	4925836	704009	VIERHUF/HERBERT & AVIS/LE	T-103	N	V110	4925788	704023	165			
T68	4925858	704420	BULLER/DWIGHT&PEGGY/TR 8-9-11	T-104	N	V110	4925795	704400	216			
T87	4924960	703115	NIELSEN/DEAN P & LAYNE/JT	T-105	N	V110	4924943	703086	111			
T14	4924831	703580	BULLER/LINDA J	T-106	Y	V110	4924831	703580	0			
T80	4925151	705282	HAUSCHILD/JEANETTE/LE	T-107	N	V110	4925148	705280	12			
T69	4924109	703772	LARSON/JOAN A/REV LIV TRUST	T-108	N	V110	4924124	703871	328			
T88	4923352	703756	BULLER/DWIGHT&PEGGY/TR 8-9-11	T-109	N	V120	4923373	703751	72			
				T-110	NA	V110	4923572	703951	NA		BULLER/DWIGHT&PEGGY/TR 8-9-11	Turbine added.
T107	4923714	704242	DORN/JOHN D	T-111	N	V110	4923633	704309	345			
T16	4925620	710672	CITTERMAN/MARK A	T-112	N	V120	4925631	710755	275			
T17	4925469	711162	DRITZ/DIANE L/(TODD)	T-113	N	V120	4925449	711190	111			
T19	4925356	710324	JERZAK/JOHN & BRENDA TR 7-15-10	T-114	N	V120	4925318	710201	422			
T11	4924905	710099	JERZAK/JOHN & BRENDA TR 7-15-10	T-115	Y	V120	4924907	710099	0			
T4	4923761	707812	BULLER/DOUGLAS L	T-116	N	V120	4923781	707812	65			
T71	4924185	708551	BULLER/DWIGHT&PEGGY/TR 8-9-11	T-117	N	V120	4924189	708526	84			
T24	4923601	708541	OCHOCKI/AUDREY A/ET AL	T-118	N	V120	4923492	708550	357			
T90	4924379	710165	CITTERMAN/MARK A	T-119	N	V120	4924432	710129	211			
T72	4924050	712576	STERZINGER/DAN	T-120	N	V120	4924104	712506	291			
				T-121	NA	V120	4923795	712127	NA		RYBINSKI/KENNETH & MARIE/JT	Turbine added.
				T-122	NA	V120	4923179	712199	NA		RYBINSKI/KENNETH & MARIE/JT	Turbine added.
T83	4923291	712594	RILEY/BERNARD & MARIANNE	T-123	N	V120	4923324	712599	108			
T81	4922656	705397	BULLER/DWIGHT&PEGGY/TR 8-9-11	T-124	N	V120	4922664	705340	191			
				T-125	NA	V120	4922860	707363	NA		LOOSBROOK/ROBERT L RLT 8-27-14	Turbine added.
T102	4922364	706986	LOOSBROOK/ROBERT L RLT 8-27-14	T-126	N	V120	4922491	707255	979			
				T-127	NA	V120	4922147	707965	NA		MATSUDA/CONNIE/ET AL	Turbine added.
				T-128	NA	V120	4922138	708353	NA		KOOPMAN/MURIEL/RLT	Turbine added.
				T-129	NA	V120	4922147	708713	NA		KOOPMAN/HARVEY J RLT	Turbine added.
				T-130	NA	V120	4922261	709068	NA		BUNTROCK/NATHAN & JEANNINE/JT	Turbine added.
T101	4922240	709504	BUNTROCK/NATHAN & JEANNINE/JT	T-131	N	V120	4922235	709502	18			
T73	4922368	710177	BUCHHOLZ TRUSTS 3-23-04/A &M	T-132	N	V120	4922625	710056	933			
T106	4922131	711843	DRITZ/TIMOTHY T	T-133	N	V120	4922172	711811	169			
T70	4921448	705829	BUCHHOLZ TRUSTS 3-23-04/A &M	T-134	N	V120	4921358	705770	353		BULLER/JOHN DWIGHT	
T2	4920348	705524	EIDEM/CAROLE J TR AGR 3-25-15	T-135	N	V120	4920394	705397	444			
T18	4920604	705879	BULLER/LINDA	T-136	Y	V120	4920604	705879	0			
T21	4920940	706165	BULLER/LINDA	T-137	N	V120	4920857	706158	272			
				T-138	NA	V120	4917005	710361	NA		PETERSEN/HERMAN JR & MAVIS	Turbine added.
T3	4917280	710640	PETERSEN/HERMAN JR & MAVIS	T-139	Y	V120	4917280	710640	0			
T15	4917406	711008	HAUFF/SARA JANE/REV TRUST	T-140	N	V120	4917402	711023	51			
T8	4917536	711397	HAUFF/SARA JANE/REV TRUST	T-141	Y	V120	4917536	711397	0			
T6	4917301	711822	NISSEN/EDWARD J	T-142	N	V120	4917297	711792	99			
				T-143	NA	V120	4917619	711970	NA		GRUHOT/CARAL/&PATTI DREWELOW	Turbine added.
T92	4916942	713735	PALUCH/EUGENE & AILEEN/TRUST	T-144	N	V120	4916873	713660	334			
				T-145	NA	V120	4939070	715423	NA		LOZINSKI/RAYMON TR 9-5-14 ETAL	Turbine added.
				T-146	NA	V120	4938582	716109	NA		PANKA/SCOTT E & CHESNEY M JT	Turbine added.
				T-147	NA	V120	4937895	716701	NA		PANKA/EUGENE F & DIANE B/JT	Turbine added.
				T-148	NA	V120	4936928	716808	NA		LACEK/WAYNE & KATHRYN/JT	Turbine added.
				T-149	NA	V120	4936493	717270	NA		OLSEN/DONALD E RLT 9-5-08 ETAL	Turbine added.
				T-150	NA	V120	4936122	716979	NA		OLSEN/DONALD E RLT 9-5-08 ETAL	Turbine added.
T99	4935277	717945	POPOWSKI/JOHN/TR 2-17-12 ETAL	T-151	N	V120	4935429	717911	511			
				T-152	NA	V120	4935863	717825	NA		POPOWSKI/JOHN/TR 2-17-12 ETAL	Turbine added.
T1	4933889	714815	CITTERMAN/THERESA/(TODD)	T-153	N	V120	4933753	714905	536		CITTERMAN/ARCHIE C	
T12	4933940	715253	CITTERMAN/CLEMENCE/(TODD)	T-154	N	V120	4933826	715269	376			
T66	4933967	715765	CITTERMAN/THERESA/(TODD)	T-155	N	V120	4934027	715626	497			
T98	4933577	716188	PALUCH/SUSAN M/(TODD)	T-156	N	V120	4933760	716148	617			
T78	4934487	717184	NELSON/ROGER&EVANGELINE/RLT	T-157	N	V120	4934480	717094	298			
				T-158	NA	V120	4934460	717443	NA		NELSON/ROGER&EVANGELINE/RLT	Turbine added.
T25	4934163	717939	RATAJCZAK/HARRY & MARLENE/JT	T-159	N	V120	4933999	717893	558			
				T-160	NA	V120	4933628	717338	NA		REMEROWSKI/FRANCIS & J/TRUST	Turbine added.
				T-161	NA	V120	4933303	717089	NA		REMEROWSKI/F & J/TRUST5-4-93	Turbine added.
T96	4931695	716804	CITTERMAN/JESSE D	T-162	N	V120	4931916	716637	909			
T97	4931929	717212	SOVELL FAM IRREV TRU11-06-04	T-163	N	V120	4932182	716946	1205			
T77	4931061	713340	PAVEK/ROBERT D&VIVIAN M/JTTODD	T-164	N	V120	4931120	713493	536			
T85	4930817	715740	REMEROWSKI/FRANCIS & J/TRUST	T-165	N	V120	4930769	715611	452			
T51	4930447	716821	CITTERMAN/STEVEN	T-166	N	V120	4930435	716747	245			
T55	4930903	717110	CITTERMAN/STEVEN	T-167	Y	V120	4930903	717110	0			
T20	4929102	714069	KNOFCZYNSKI/JAMES/ET AL	T-168	N	V120	4929093	714118	163			
T59	4928245	715807	FRENSKO/THOMAS J/TR3-21-12ETAL	T-169	N	V120	4928216	715766	162			
T65	4929349	716696	KABOT/RAYMOND/ET AL	T-170	Y	V120	4929349	716696	0			

Permitted Turbine ID [11/2017]	UTM NAD83 Zone 14N Northing	UTM NAD83 Zone 14N Easting	Landowner [11/2017 array]	Current Turbine ID [4/2019]	Permitted Location Retained? [Y/N]	Turbine Technology	UTM NAD83 Zone 14N Northing	UTM NAD83 Zone 14N Easting	Distance from Permitted Turbine (ft)	Landowner Change from Permitted Layout? [Y/N]	Current Landowern [4/2019 array; if changed]	Notes
T53	4929243	717281	FRENSKO/JOHN A/ETAL	T-171	N	V120	4929033	717319	701			
T60	4928341	716322	FRENSKO/JOHN	T-172	Y	V120	4928341	716322	0			
T56	4928441	716740	FRENSKO/JOHN	T-173	Y	V120	4928441	716740	0			
T58	4927426	717078	KNOFCZYNSKI/JAMES	T-174	N	V120	4927430	717140	204			
T94	4927093	717212	JERZAK/TIMOTHY P	T-175	N	V120	4927136	717178	177			
T5	4921850	716193	KOOPMAN FAMILY FARMS LLC	T-176	N	V120	4921792	716219	208			
T63	4922197	717132	KOOPMAN/LYLE L & BRENDA/JT	T-177	N	V120	4922155	717049	304			
T7	4920897	715242	BUSSELMAN/DONALD & M/TR 5-15-9	T-178	Y	V120	4920897	715242	0			
T22	4920916	715694	PETERSON/WALTER/RLT 7-1-11	T-179	N	V120	4920812	715724	355			
T38	4920204	716616	BRUENING/MAVIS A/RLT 9-28-12	T-180	N	V120	4920149	716606	183			
T50	4920500	717039	BRUENING/MAVIS A/RLT 9-28-12	T-181	N	V120	4920246	717148	906			
T49	4920586	717460	LIETZ/DONALD G	T-182	N	V120	4920436	717427	504			
T37	4921016	717816	LIETZ/CLARENCE & LEONA/JT LE	T-183	N	V120	4920671	717708	1187		LIETZ/DONALD G	
				T-184	NA	V120	4921453	718150	NA		KOOPMAN/LYLE L & BRENDA/JT	Turbine added.
T29	4919755	715287	EVENS/MICHAEL G& RAMONA A/JT	T-185	N	V120	4919693	715349	288			
T35	4919799	715720	EVENS/MICHAEL G& RAMONA A/JT	T-186	N	V120	4919732	716285	1867		JERZAK/JEFFREY J	
T44	4918875	716607	JERZAK/JEFFREY & NATALIE J/JT	T-187	N	V120	4918877	716642	117			
T45	4919310	716829	STUEFEN/JOAN/&SHARON MADDEN	T-188	Y	V120	4919310	716829	0			
T48	4919266	717470	JERZAK/JEFFREY & NATALIE	T-189	N	V120	4919213	717495	191		LUNDBERG/ALLAN/ET AL	
T39	4919362	717872	JERZAK/JEFFREY & NATALIE	T-190	N	V120	4919370	717851	72			
T30	4918689	718137	JERZAK/R.A./LIV TRUST 6-15-12	T-191	N	V120	4918726	718247	380			
T40	4917277	716696	JOHANSEN/DELORIS ETAL	T-192	Y	V120	4917277	716699	0			
T54	4917652	717008	FEHRMAN/PAUL A	T-193	N	V120	4917638	716988	79			
T46	4917592	718054	DEUTZ/ALICE I ETAL	T-194	N	V120	4917629	717928	431			
T33	4917795	718440	BARBER FAMILY FARMS	T-195	N	V120	4917788	718273	549			
				T-196	NA	V120	4916549	716908	NA		APPELEN/JOHN/LLC	Turbine added.
T42	4916598	717073	APPELEN/JOHN/LLC	T-197	N	V120	4916608	717266	635			
T28	4916691	717688	APPELEN/JOHN/LLC	T-198	Y	V120	4916691	717688	0			
T76	4915827	717403	RYLAND/CATHY & JENNIFER	T-199	N	V120	4914997	717463	2729		APPELEN/JOHN/LLC	
T105	4914273	718668	DEUTZ/DANIEL D	T-200	Y	V120	4914273	718668	0			
T75	4916466	713619	PITTENGER/MARGARET/RL TRUST	ALT-1	N	V120	4916456	713613	41			
T62	4919883	718084	BARBER FAMILY FARMS	ALT-4	N	V120	4919502	718439	1708			
T108	4933355	711540	BEDNAREK/VINCENT A		N							Turbine eliminated.
T109	4931569	711368	TWEDT/DAVID & KAREN/TR 4-18-13		N							Turbine eliminated.
T110	4930363	710772	JOHNSON/RUTH L.Y./RLT 3-14-12		N							Turbine eliminated.
T111	4930128	711991	TWEDT/DAVID & KAREN/TR 4-18-13		N							Turbine eliminated.
T112	4930517	712291	PAVEK/ROBERT D&VIVIAN M/JTTODD		N							Turbine eliminated.
T113	4927361	709355	CLAEYS/LOUIS P		N							Turbine eliminated.
T114	4927155	709050	CLAEYS/LOUIS P		N							Turbine eliminated.
T115	4926949	708750	NUESE/RONALD & SANDRA/JT ETAL		N							Turbine eliminated.
T116	4927206	708408	NUESE/RONALD & SANDRA/JT ETAL		N							Turbine eliminated.
T117	4926641	705333	HAUSCHILD/JEANETTE/LE		N							Turbine eliminated.
T118	4926890	704487	DORN/JOHN D		N							Turbine eliminated.
T119	4926665	704186	DORN/JOHN D		N							Turbine eliminated.
T120	4926603	703826	DORN/JOHN D		N							Turbine eliminated.
T121	4926548	703469	LARSON/JOAN A/REV LIV TRUST		N							Turbine eliminated.
T122	4926536	703068	LARSON/JOAN A/REV LIV TRUST		N							Turbine eliminated.
T23	4933986	716349	BEDNAREK/FRANK & JEANNE/JT		N							Turbine eliminated.
T26	4916951	716148	JOHANSON/DELORIS ETAL		N							Turbine eliminated.
T27	4920779	707004	DUMKE/ALLEN C LIV TR 2-5-14		N							Turbine eliminated.
T31	4921042	716031	PETERSON/WALTER/RLT 7-1-11		N							Turbine eliminated.
T34	4930164	716471	CITTERMAN/STEVEN		N							Turbine eliminated.
T36	4921303	716872	KOOPMAN FAMILY FARMS LLC		N							Turbine eliminated.
T41	4927482	716597	FRENSKO/THOMAS J/TR3-21-12ETAL		N							Turbine eliminated.
T47	4929105	715811	KABOT/RAYMOND/ET AL		N							Turbine eliminated.
T52	4928663	717171	FRENSKO/JOHN		N							Turbine eliminated.
T57	4920251	716032	HERSCHBERGER/JAMES/(TODD)		N							Turbine eliminated.
T79	4935363	717164	OLSEN/DONALD E RLT 9-5-08 ETAL		N							Turbine eliminated.
T82	4924836	708547	NUESE/GARY & ANN M/JT		N							Turbine eliminated.
T86	4934912	717720	POPOWSKI/JOHN/TR 2-17-12 ETAL		N							Turbine eliminated.
T89	4920201	707061	BULLER/LINDA J		N							Turbine eliminated.
T9	4925572	711682	NUESE/RONALD & SANDRA/JT ETAL		N							Turbine eliminated.
T43	4924896	711716	DRITZ/DIANE L/(TODD)		N							Turbine eliminated.

CERTIFICATE OF SERVICE

I, Paget Pengelly, hereby certify that I have this day served copies of the foregoing document on the attached list of persons.

xx by depositing a true and correct copy thereof, properly enveloped with postage paid in the United States mail at Minneapolis, Minnesota

xx electronic filing

Docket No. IP-6985/WS-17-700

Dated this 18th day of June 2019

/s/

____

Paget Pengelly
Regulatory Administrator

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