Noise Analysis

Proposed Palmer's Creek Wind Farm

Prepared for:

Palmer’s Creek Wind Farm, LLC

March 20, 2018

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Definitions

A-Weighting: A-weighting is applied to instrument-measured sound levels in an effort to account for the relative loudness perceived by the human ear

C-Weighting: C-weighting measures uniformly over the frequency range of 30 to 10,000 Hz. This weighting scale is useful for monitoring sources such as engines, and machinery

dBA: A-weighted decibel level

dBC: C-weighted decibel level

L_{10}: Statistical noise level that is exceeded 10% of the time in a defined time frame

L_{50}: Statistical noise level that is exceeded 50% of the time in a defined time frame, or the arithmetic mean of all data in a defined time frame.

L_{eq}: When a noise varies over time, the Leq is the equivalent continuous sound which would contain the same sound energy as the time varying sound

LA_{eq}: A-weighted equivalent continuous sound

LC_{eq}: C-weighted equivalent continuous sound

MW: Megawatt, unit of power equivalent to 1 million watts, commonly used for classifying outputs of wind turbines.

NOAA: National Oceanic and Atmospheric Administration

Pascal (Pa): Unit of air pressure, normal atmosphere is equal to 101,325 Pa

I. Purpose

Palmer's Creek Wind Farm, LLC has proposed the installation of 18 wind turbines for the Palmer's Creek Wind Farm Project just north of Granite Falls, MN. The boundaries of the proposed wind farm are 100th Street SE to the north, 30th Avenue SE to the east, Palmer Creek Road to the south, and Palmer Creek to the west. The area of study can be found in **Figure 1**. This report details the existing conditions found within the proposed project limits and also the modeled results for a single configuration of turbines upon the identified receptors.

II. Noise

Any unwanted sound is called noise. Sound is carried through the air in compression waves of measurable frequency and amplitude. Sound can be tonal, predominating at a few frequencies, or it can contain a random mix of a broad range of frequencies and lack any tonal quality. This type of noise is often called white noise.

The human ear is sensitive to only a relatively narrow frequency range of air pressure changes – approximately 20-20,000 cycles per second or Hertz (Hz). Sub-audible frequency sound is often called infrasound. It cannot be heard, but it may be sensed as a vibration. Humans are also sensitive to changes in the amplitude of the air compression waves. Increasing amplitude, or increasing sound pressure, is perceived as increasing volume or loudness. The sound pressure level (SPL) is measured in micro Pascals (μPa). SPLs are typically converted to decibels (dB), which is a log scale, relative to a reference air pressure value of 20 μPa. When measuring sound, A-weighted decibels (dBA) are typically used to normalize readings to equal loudness over the audible range of frequencies at low loudness. **Table 1** shows a range of sound pressure levels and the associated Noise sources.

Table 1 – Decibel Levels of Common Noise Sources

Sound Pressure Level (dBA)	Noise Source
140	Jet Engine (at 25 meters)
130	Jet Aircraft (at 100 meters)
120	Rock and Roll Concert
110	Pneumatic Chipper
100	Jointer/Planer
90	Chainsaw
80	Heavy Truck Traffic
70	Business Office
60	Conversational Speech
50	Library
40	Bedroom
30	Secluded Woods
20	Whisper
Source: "A Guide to Noise Control in Minnesota," MPCA	

Along with the volume of the noise source there are other factors (such as topography of the area) that contribute to the loudness of noise. The distance of a receptor from a sound's source is also an important factor. Sound levels decrease as distance from a source increases. The following rule of thumb regarding sound decreases due to distance is commonly used: beyond approximately 50 feet, each time the distance between a source and a receptor is doubled, sound levels decrease by three decibels over hard ground (such as pavement or water) and by 4.5 decibels over vegetated areas.

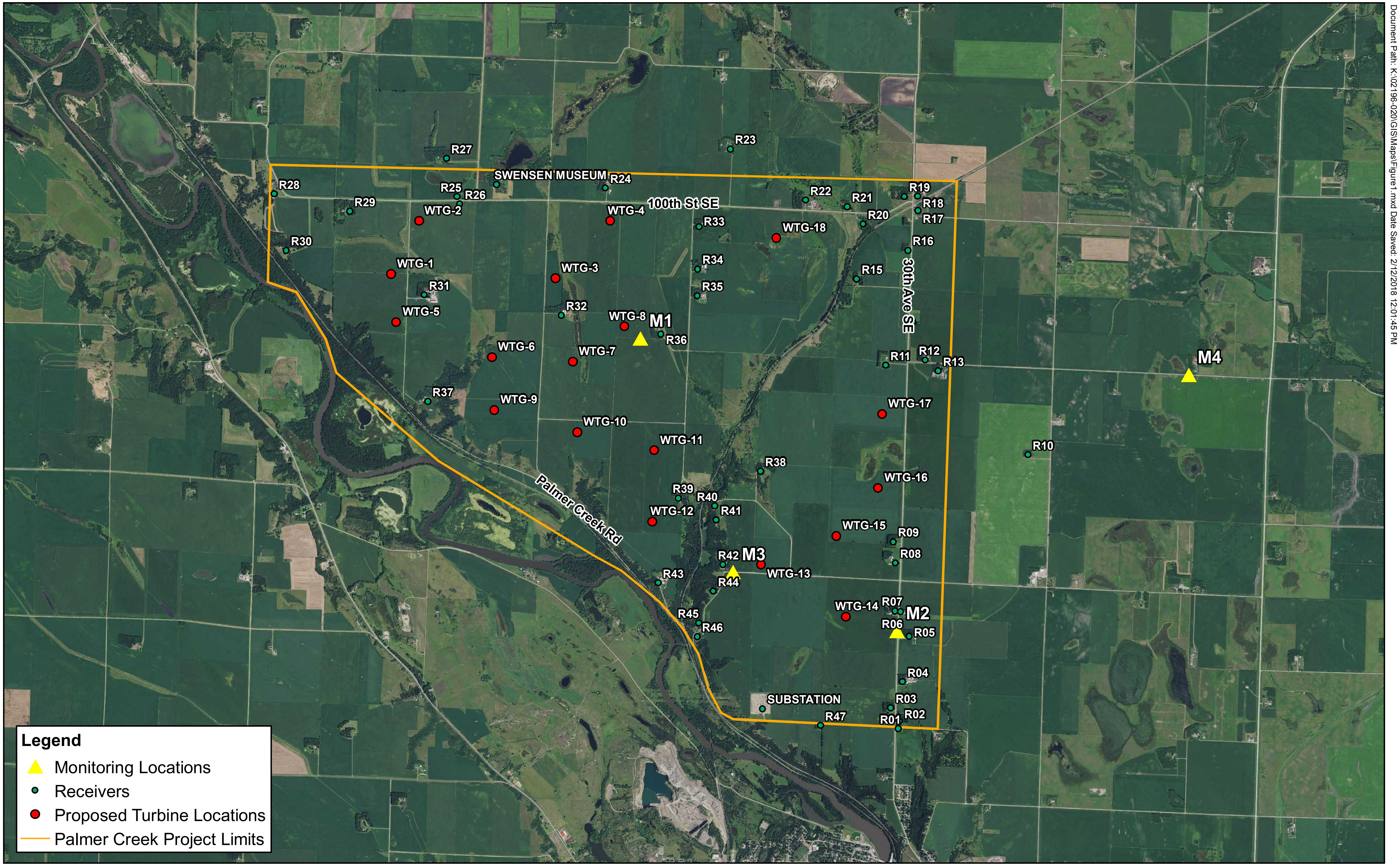

Figure 1 - Project Limits & Monitoring Locations

Palmer's Creek Wind Farm

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A. Noise from Wind Turbines

Mechanical Noise

Mechanical noise from a wind turbine is sound that originates in the generator, gearbox, yaw motors (that intermittently turn the nacelle and blades to face the wind), tower ventilation system, and transformer. Generally, theses sounds are limited in new wind turbines so that they are a negligible fraction of the aerodynamic noise. Mechanical noise from the turbine or gearbox would only be heard above aerodynamic noise when they are not functioning properly.

Aerodynamic Noise

Aerodynamic noise is caused by wind passing over the blade of the wind turbine. As wind passes over a moving blade, the blade interrupts the laminar flow of air, causing turbulence and noise. Unexpectedly high aerodynamic noise can be caused by improper blade angle or improper alignment of the rotor to the wind. This is correctable and is usually adjusted during the turbine break-in period. This is the primary source of noise produced by wind turbines. Wind turbines are generally quiet enough for people to hold a normal conversation while standing at the base of the tower.

Modulation of Aerodynamic Noise

Rhythmic modulation of noise, especially low frequency noise, is also perceptible by the human ear. To a receptor on the ground in front of the wind turbine, the detected blade noise is loudest as the blade is at the bottom of its rotation, and quietest when the blade is at the top of its rotation. For a modern 3-blade turbine, this distance-to-blade effect can cause a pulsing of the blade noise about once per second (1 Hz). The distance-to-blade effect diminishes as receptor distance increases because the relative difference in distance from the receptor to the top or bottom of the blade becomes smaller.

Another source of rhythmic modulation may occur if the wind through the rotor is not uniform. Horizontal layers with different wind speeds or directions can form in the atmosphere. This wind condition is called shear. If the winds at the top and bottom of the blade rotation are different, blade noise will vary between the top and bottom of blade rotation, causing modulation of aerodynamic noise.

Wind Farm Noise

The noise from multiple turbines similarly distant from a residence can be noticeably louder than a lone turbine through the addition of multiple noise sources. Under steady wind conditions, noise from a wind turbine farm may be greater than noise from the nearest turbine due to synchrony between noise from more than one turbine. If the dominant frequencies of different turbines vary by small amounts, an audible dissonance may be heard when wind conditions are stable.

B. Assessment and Regulation

The Minnesota Pollution Control Agency (MPCA) is given power to adopt noise standards in Minnesota Statute 116.07 Subd. 2. The adopted standards are given in Minnesota Administrative Rules Chapter 7030. The MPCA standards require A-weighted noise measurements. Different standards are specified for daytime (7:00 AM – 10:00 PM) and nighttime (10:00 PM – 7:00 AM) hours. The noise standards specify the maximum allowable noise volumes that may not be exceeded for more than 10 percent of any hour (L_{10}) and 50 percent of any hour (L_{50}). Household units, including farm houses, are included in Noise Area Classification (NAC)-1. **Table 2** shows the MPCA State noise standards. All the land within the project area is considered NAC-1.

Table 2 - MPCA State Noise Standards – Hourly A-Weighted Sound Levels

Land Use	NAC: Noise Area Classification	Exterior Hourly Noise Livel Limit, dBA			
		Daytime		Nighttime	
		7:00 am to 10:00 pm		10:00 pm to 7:00 am	
		L10	L50	L10	L50
Residential	NAC-1	65	60	55	50
Commercial	NAC-2	70	65	70	65
Industrial	NAC-3	80	75	80	75
Notes,					
1. NAC-1 includes household units, transient lodging and hotels, educational, religious, cultural entertainment, camping, and picnicking land uses					
2. NAC-2 includes retail and resturants, transportation terminals, professional offices, parks, recreational and amusement land uses					
3. NAC-3 includes industrial, manufacturing, transportation facilities (except terminals), and utilities land uses					
4. From Minnesota Pollution Control Agency, Minn. Rules sec 7030.0040					

Since wind farms generate a relatively constant noise volume, the anticipated noise from wind farms are typically reported in terms of an equivalent sound level (L_{eq}) that has the same energy and A-weighted level as the community noise over a given time interval rather than reporting both L_{10} and L_{50}. When describing relatively constant sound levels, the L_{10} and L_{50} values will be roughly equal. This equivalent sound level is most appropriately compared to the State L_{50} standards. The difference between L_{eq} and L_{50} is mathematically similar to the difference between the mean and the median for a data set. These values will be roughly equal for data sets without extreme values or statistical outliers (such as wind turbine noise).

III. Monitoring Conditions & Methodology

Noise monitoring was conducted at four sites; three within the project area and a fourth that is outside (but nearby) the project area. All four noise monitors were left to collect data for seven days (January 3 to January 10, 2017) at locations that represent the receptors within the project area. The monitoring locations can be found in **Figure 1**. The conditions for the seven days were typical of a Minnesota winter, with temperatures in the single digits and snow on two of the seven days.

Each of the three locations within the project limits (M1-M3) was picked to represent typical distances from receptors to the proposed turbines and were all within public road right-of-way. As required by the LWECS Guidance for Noise Study Protocol and Report, one of the monitoring locations (M1) was located in proximity to the worst-case receptor as predicted by the model (R36). Since the topographical surroundings of the project area are predominately flat, distance from the proposed turbines was the most important factor in collecting the existing conditions. Monitoring location M2 was selected because it represents a total of six receptors in proximity to five proposed turbines on the east edge of the project boundary. Monitoring location M3 was selected because it represents a receptor that may be impacted by at least six proposed turbines. Monitoring location M4 was selected for its similarity to the existing conditions found at the other three monitoring locations, such as near an impacted receptor on a township road.

Each of the monitoring sites was equipped with a Larson Davis 831 Precision Integrating Sound Level Meter that meets compliance with the following American National Standards Institute (ANSI) regulations:

- S1.4-1983 (R2006) Type1
- S1.4A-185 (10Hz-26kHz)
- S1.43-1997 (R2007) Type 1

- S1.11-2004: 1/1 & 1/3 Octave Band Class 0
- S1.25-1991 (R2002)

The microphones attached to the monitoring units were mounted to tripods at a height of at least 3 feet above the ground. Monitoring units were calibrated prior to, and following, the monitoring period. A Vaisala weather station was attached to each of the monitoring locations to record not only wind speed and direction, but also temperature, barometric pressure, humidity, and precipitation. The weather data are included in each of the noise measurements recorded by the Larson Davis 831 units. The average wind speed for the one-hour measurement histories varied between calm conditions and 19 miles per hour with gusts over 30 miles per hour in some cases. Wind direction was typically out of the west or west-southwest. Temperatures remained low and varied from -16°F to 27°F with the coldest conditions in the first three days of collection. There was no rain recorded but the M1 weather station recorded trace amounts of precipitation on January 10. NOAA data reported up to an inch of snow falling in the area between January 9 and January 10.

The instrumentation was set up to collect the following noise values:

- 1/3 Octave Band Data
- A – Weighted Time History (60 second)
- A-Weighted Measurement History (1 hour)
- C-Weighted Time History (60 second, L_{min}, L_{max} and L_{eq} only)
- C-Weighted Measurement History (1 hour, L_{min}, L_{max} and L_{eq} only)

All data from the noise monitors were downloaded and exported to Excel spreadsheets for analysis. Data points were collected every 60 seconds and supplemented with a 60-minute measurement history that is used to represent the monitoring data results.

Graphs were created from the seven days of data for each monitoring location to compare noise levels to wind speed and create a reasonable expectation for background noise while modeling the proposed turbine locations. The following values were used for the graphs based on protocol found in the Minnesota Department of Commerce's LWECS Guidance for Noise Study Protocol and Report:

- LA_{eq}
- LC_{eq}
- L_{10} (A-Weighted)
- L_{50} (A-Weighted)
- L_{90} (A-Weighted)
- Wind Speed

The graphs can be found in **Figures 2, 3, 4,** and **5.**

The 21-amp batteries powering the noise monitors had to be replaced on January 7 due to the extreme cold conditions experienced at each of the sites. During this process, it was found that the off-site monitor (site M4) had stopped recording data for a period of nearly 54 hours. This was due to battery failure caused by the cold conditions. The unit was able to resume recording data after the batteries were exchanged, but then failed again during the afternoon of January 9. The data in **Figure 5** indicates these gaps. Data gaps are not uncommon when monitoring noise for long periods of time. These gaps in data can be caused by natural events that the MPCA requests be removed from data analysis (e.g., wind speeds in excess of 11 mph, rain events) or mechanical failure. Although some data loss was experienced, there was enough data collected on January 3, 4, 7, 8 and 9 to provide an accurate portrayal of ambient noise for this off-site location. Site M1 also experienced a short gap in data near the end of the collection period on the afternoon of January 9 and during the morning of January 10. This was found to be also due to low battery power caused by cold weather over the course of the final three days of data collection. The data collected during between January 3 and January 9 is sufficient to provide an accurate portrayal of the ambient noise in that location.

Figure 2 – Noise Monitoring Results, Site M1

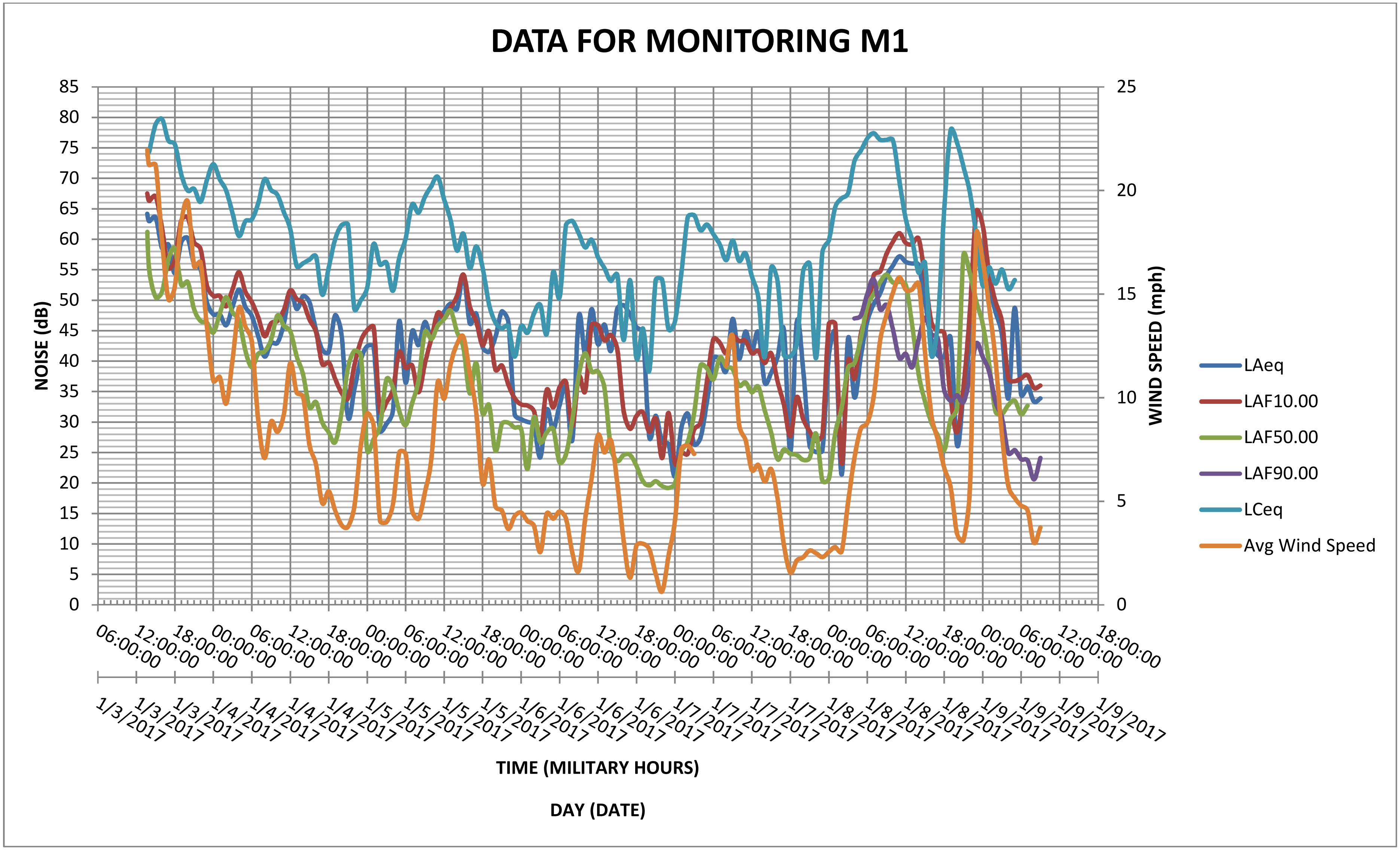


Figure 3 – Noise Monitoring Results, Site M2

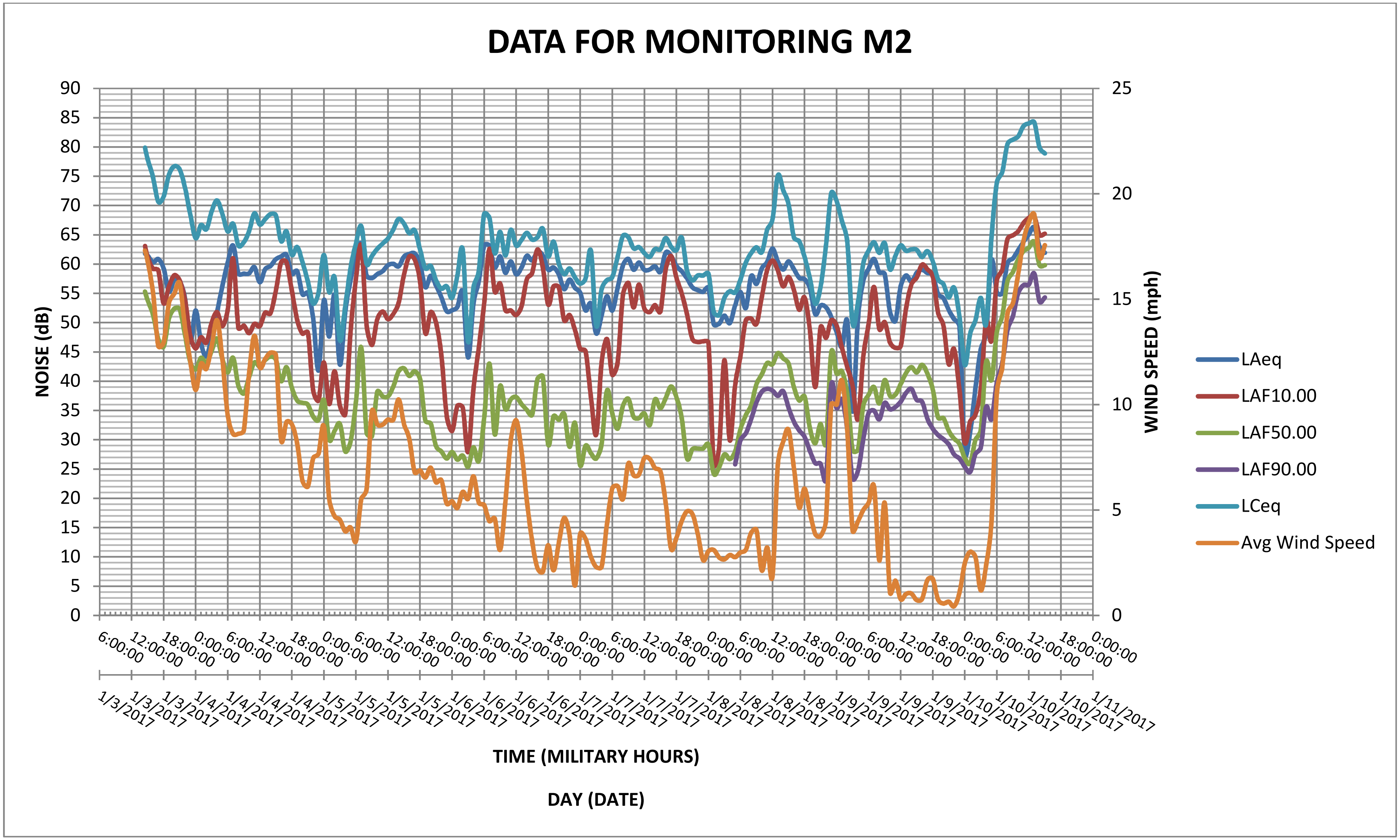


Figure 4 – Noise Monitoring Results, Site M3

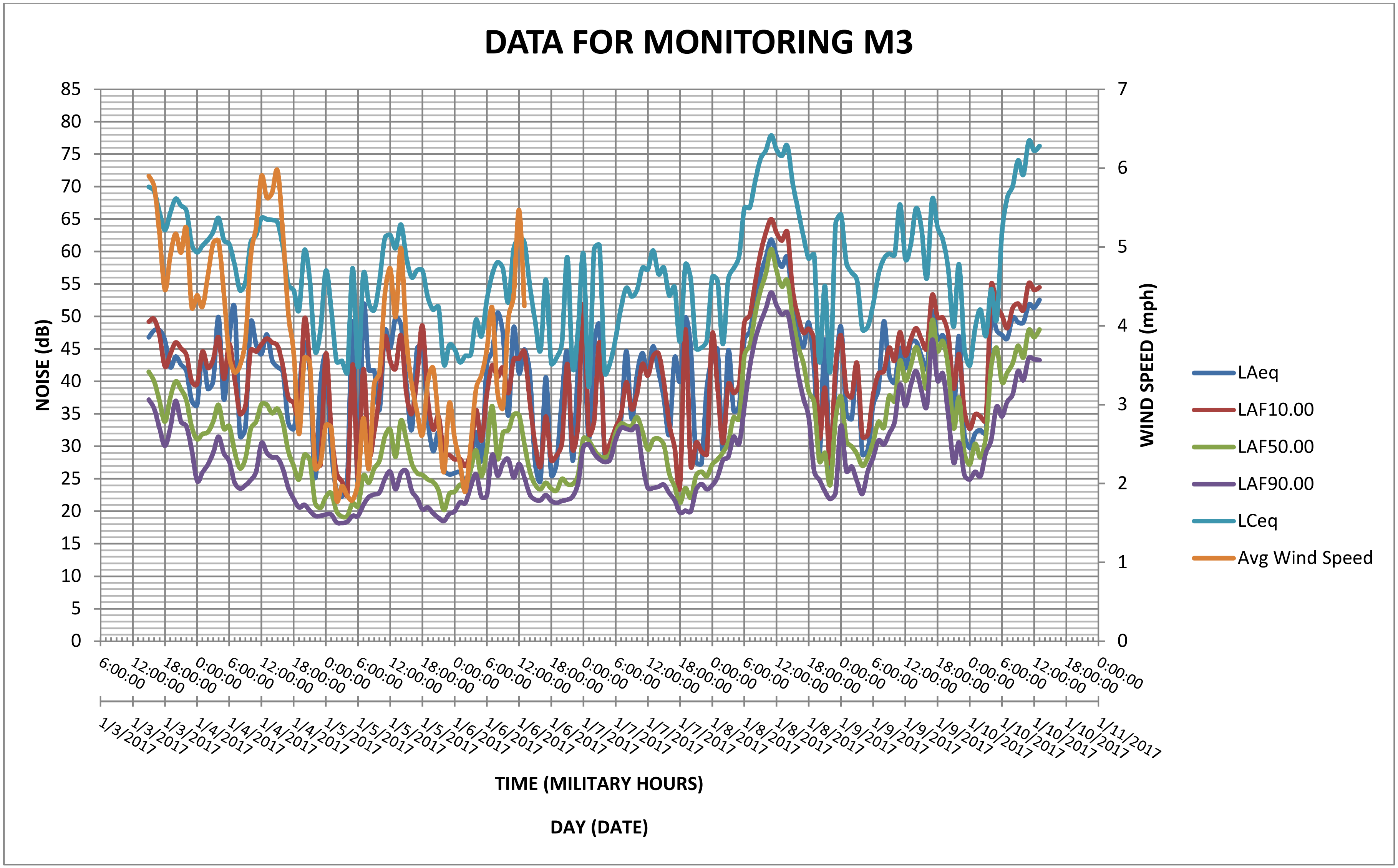
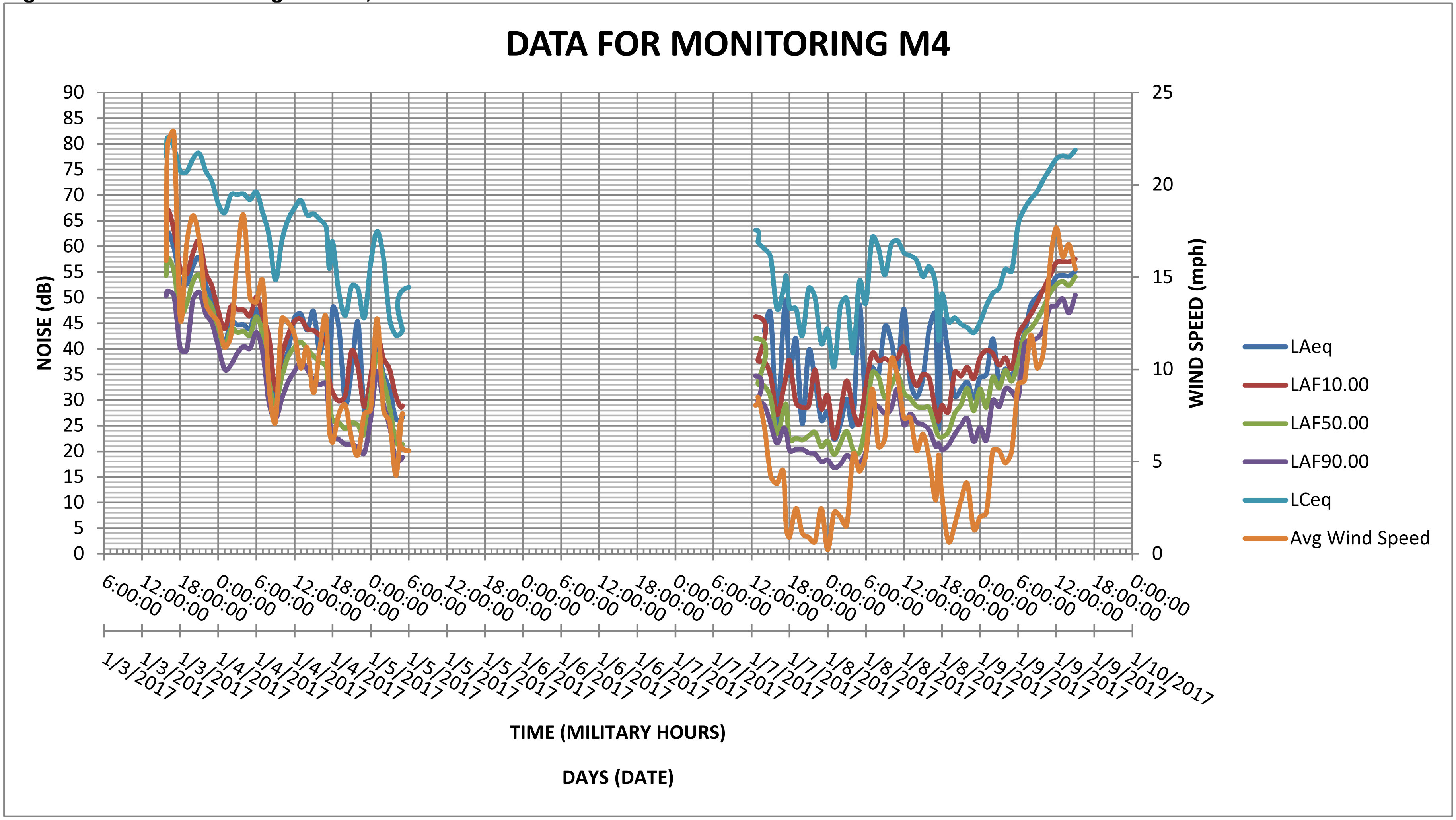


Figure 5 – Noise Monitoring Results, Site M4



IV. Comparison to Minnesota Noise Standards

Figures 6, 7, 8 and **9** show the hourly L_{10} and L_{50} values over the seven days with any measurements indicating wind speeds over 11 miles-per-hour (mph) removed. Wind speeds in excess of 11 mph may distort sound; therefore those measurements are removed at the request of MPCA. With a few exceptions, the existing sound levels at most sites are below Minnesota standards for daytime and nighttime L_{10} and L_{50} values. Site M1 experienced a spike at 3:00 PM on January 3. The Granite Falls area experienced nearly 3.5 inches of snowfall on January 1 and January 2. This spike could be attributed to snowplows operating near the monitoring equipment. Site M3 experienced a spike in noise around noon on January 8. The spike in noise reached the threshold for the daytime L_{10} standard and exceeded the L_{50} standard. This spike could be explained by the proximity of railroad tracks to the site. Nighttime L_{50} standards are also already exceeded at Site M1 during the early morning hours of January 9. The spike could also be attributed to snow removal equipment since Granite Falls experienced 6.5 inches of snowfall between January 9 and January 10. The L_{10} and L_{50} range for each of the monitoring sites is found below in **Table 3**. Existing sound levels that exceed the State Noise Standards are bolded.

Table 3 – Daytime and Nighttime Noise Monitoring Results

Time Period	Location	L_{10} Range (dBA)	L_{50} Range (dBA)	L_{eq} Range (dBA)
Daytime 7:00 AM to 10:00 PM	M1	27.7 - **67**	20.3 – **61.2**	25.1-63.6
	M2	39 - 63.1	26.8 - 45.8	50.3-66.3
	M3	24 - 65	21.3 - **60.4**	24.8-61.9
	M4	25.9 - 51.7	22.2 - 48.1	25.4-62.7
Nighttime 10:00 PM to 7:00 AM	M1	23.2 - **57.7**	18.2 - **51.2**	21.1-60.3
	M2	25.9 - **57.4**	24.2 - 48.4	27.6-63.2
	M3	22.6 - 54.8	19.2 - 45.2	22.3-50.1
	M4	22.6 - 42.6	19.4 - 37.5	22.3-52.7
MN State Standards		L_{10}	L_{50}	L_{eq}
Daytime		65	60	N/A
Nighttime		55	50	N/A

Figure 6 - Noise Monitoring Results, Site M1 L_{10} and L_{50} Values Only

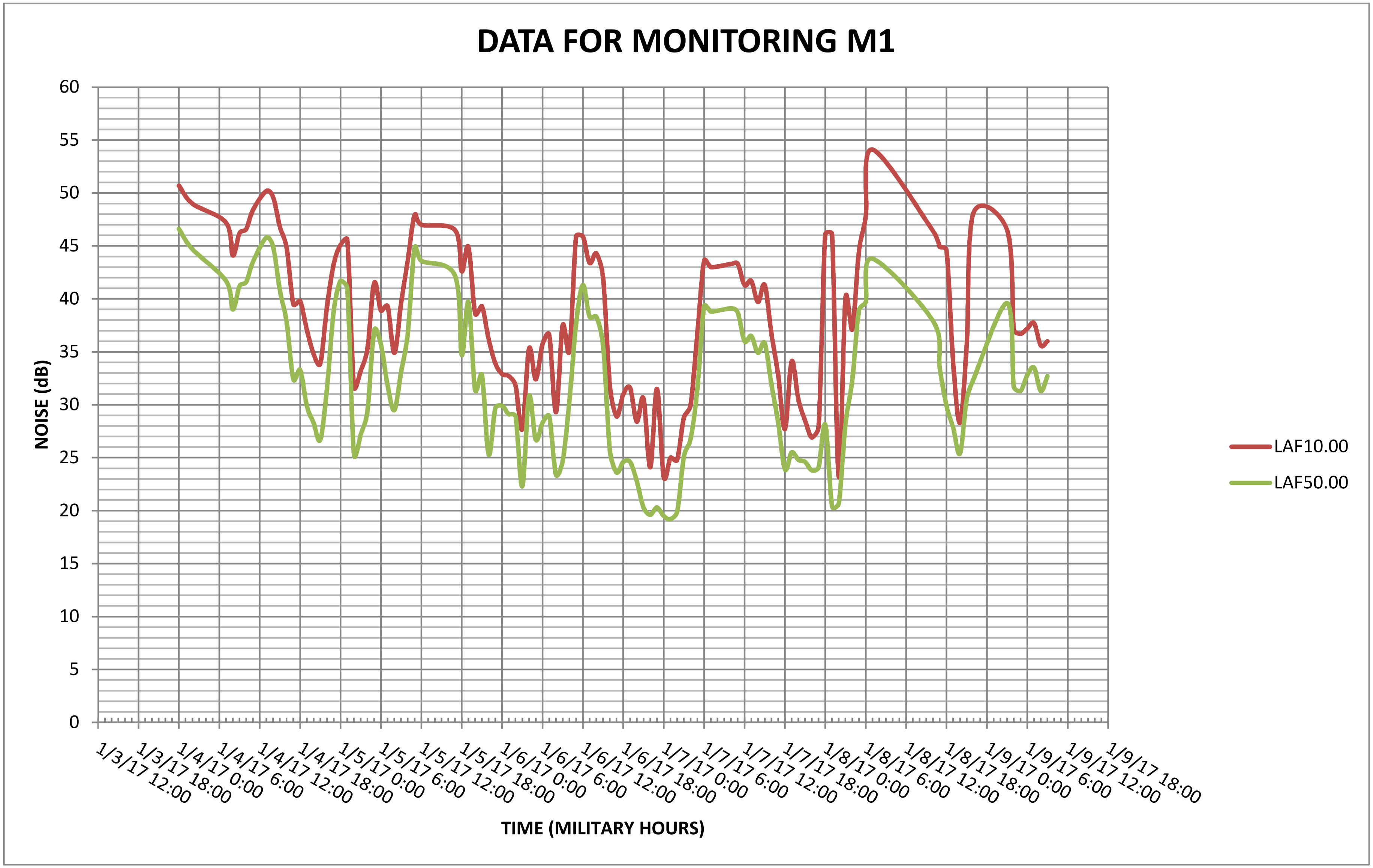


Figure 7 - Noise Monitoring Results, Site M2 L_{10} and L_{50} Values Only

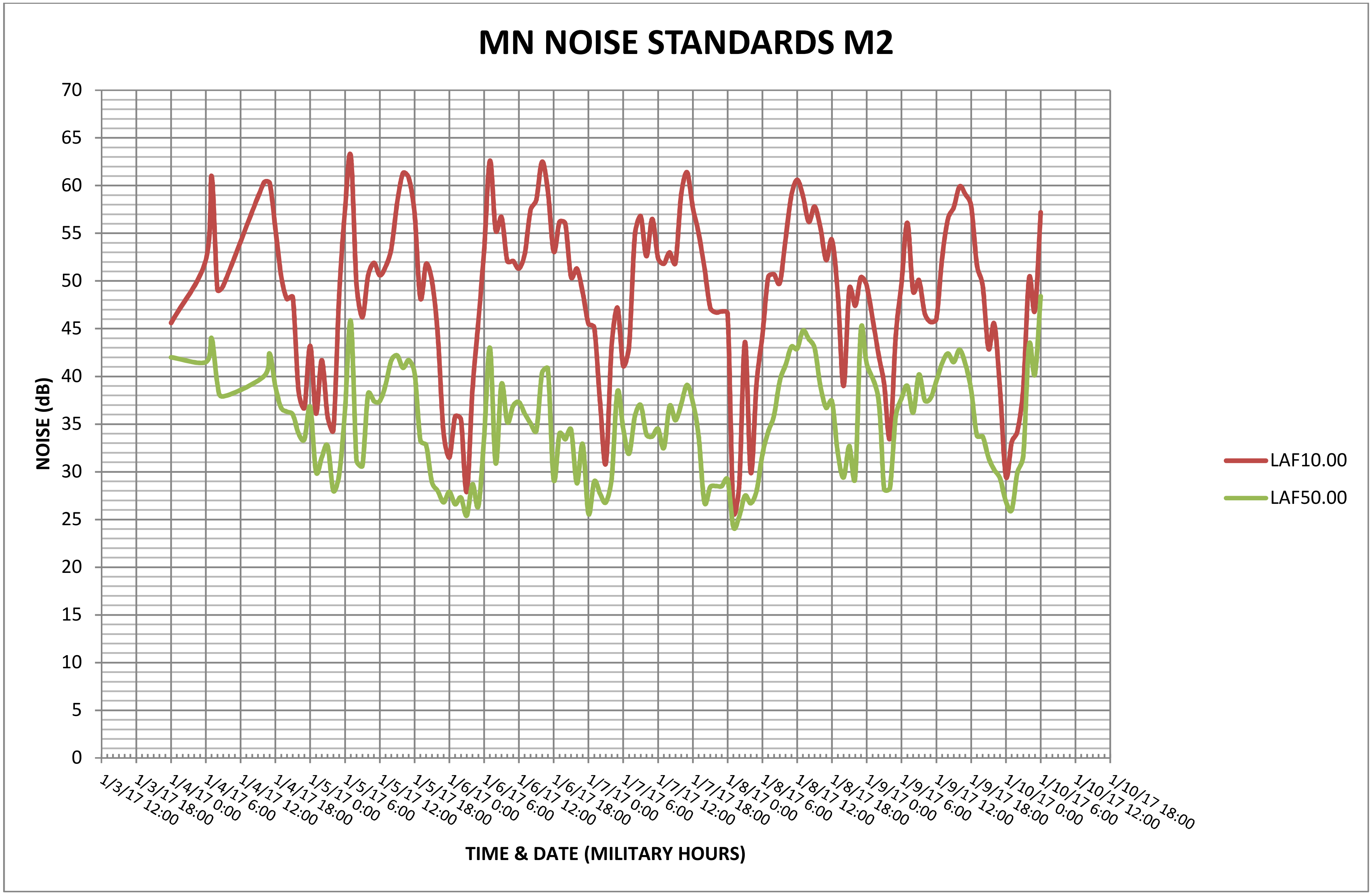


Figure 8 - Noise Monitoring Results, Site M3 L_{10} and L_{50} Values Only

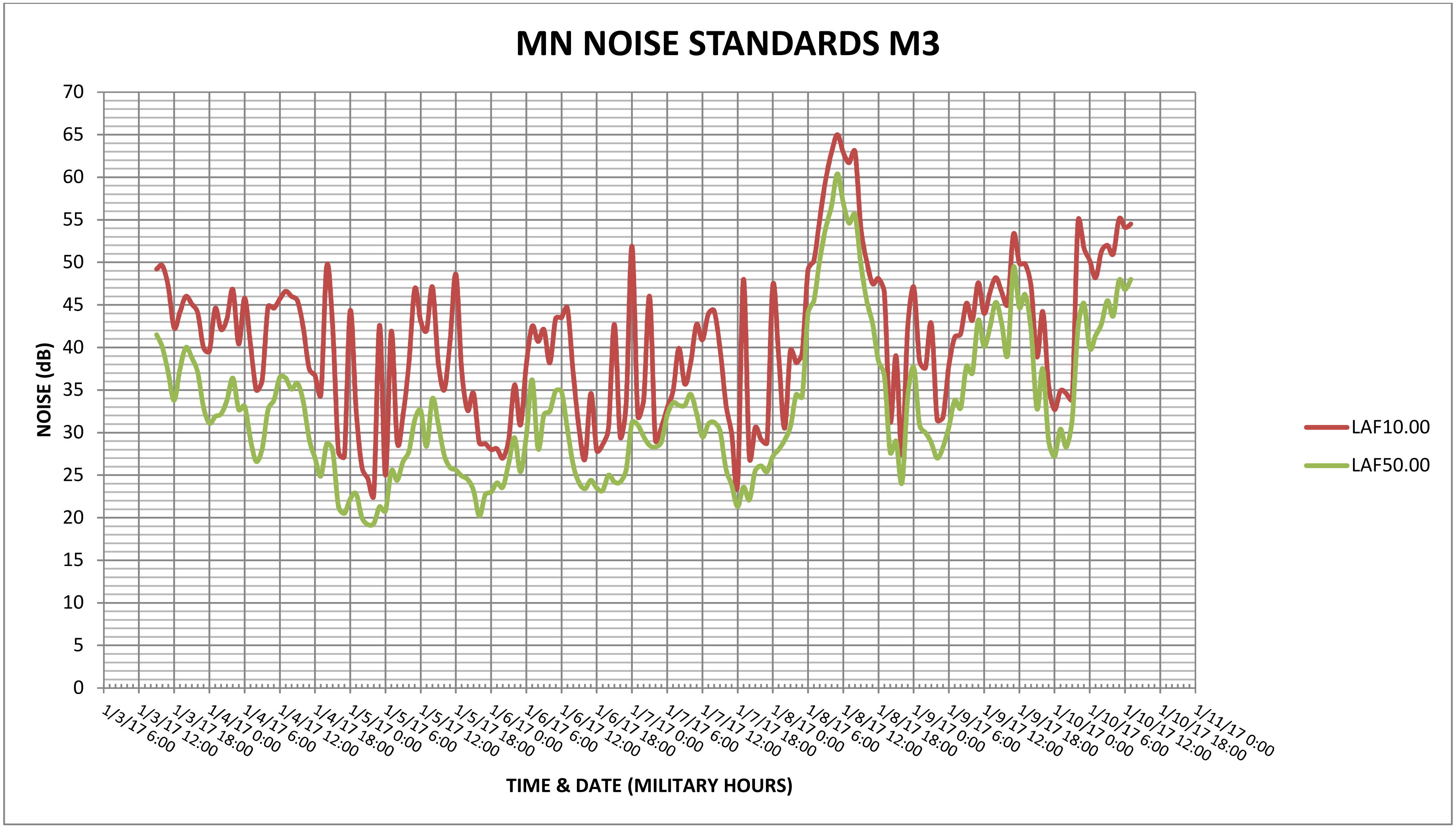
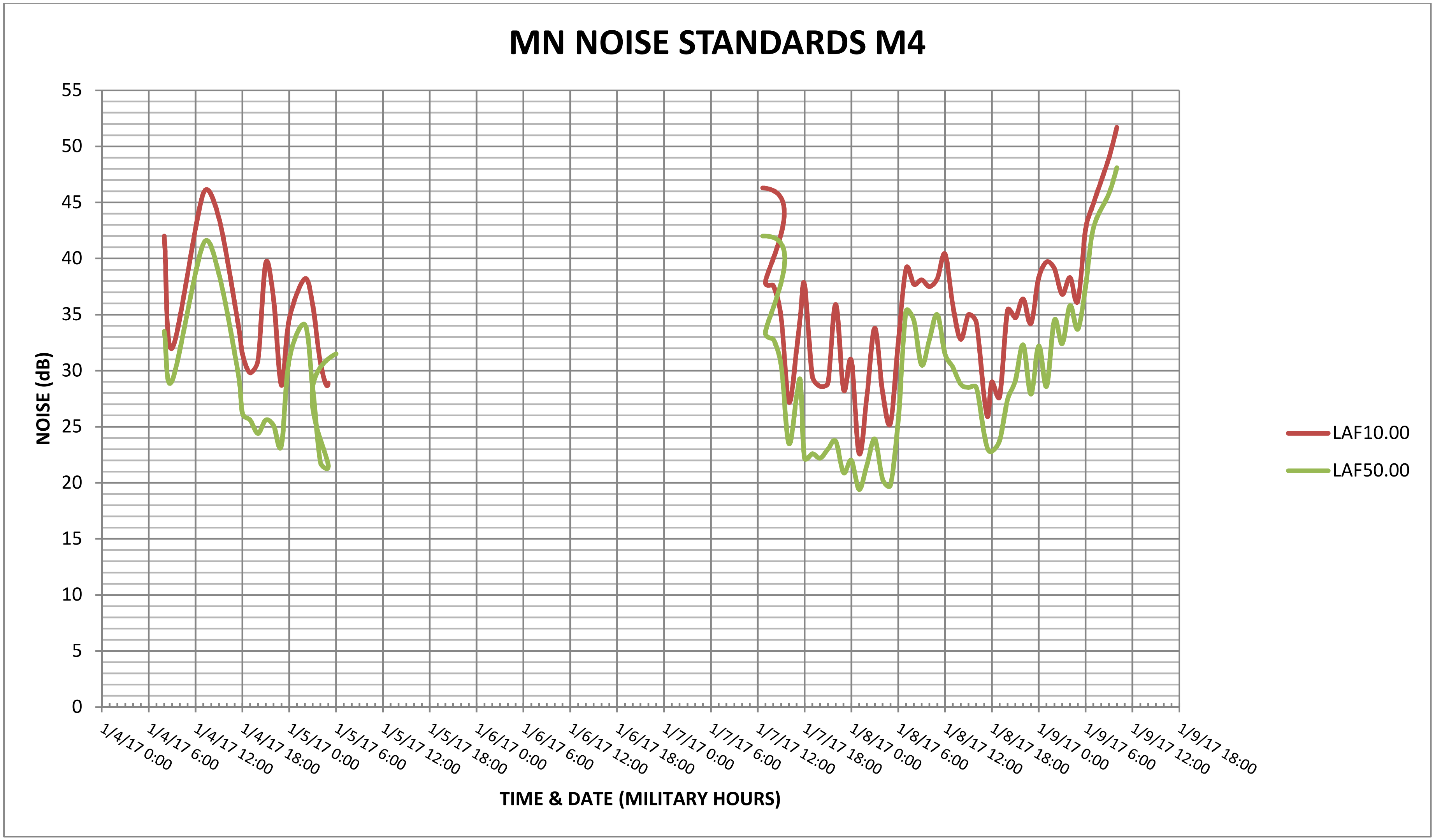


Figure 9 - Noise Monitoring Results, Site M4 L_{10} and L_{50} Values Only



V. Modeling and Results

Along with the noise data collected in the field, a model of the proposed turbines and existing receptors was created to determine the impact of the proposed wind farm. CadnaA software was used for analysis and assumes the attenuation of sound propagation as specified by the International Organization for Standardization (ISO) Standard 9613-2 and a ground attenuation factor of 0.5. Turbine locations were provided by Palmer's Creek Wind Farm, LLC. The turbines modeled were 16 General Electric (GE) 2.5-116 and two GE 2.3-116 that produce 2.5 and 2.3 MW respectively. The model included the following scenario:

1. Two 2.3 MW turbines at an 80-meter hub-height (WTG-14 and WTG-15) with the remaining 2.5 MW turbines at a 90-meter hub-height.

The 2.5 MW turbines are projected to generate an apparent maximum sound level of 107 dB per the manufacturer's specifications adjacent to the turbine hub, and the 2.3 MW turbines will generate a maximum 107.5 dB output per the manufacturer's specifications (also adjacent to the turbine hub). All conditions were modeled slightly above these specifications at 109 dB.

The worst-case noise output would produce the sound contours found in **Figure 10**. The resultant noise produced drops below 50 dBA at distances greater than approximately 160 meters (500 feet). Turbines WTG-3, WTG-7 and WTG-8 will generate the greatest noise impact on Receptor R32. The overall noise at Receptor R32 was predicted to be 45.1 dBA. This is due to Receptor R32's proximity to three turbines; 1,355 feet to WTG-3, 1,740 feet to WTG-7 and 2,335 feet to WTG-8.

Figure 11 represents the sound contours predicted by the construction of the 18 turbines in the single scenario. These contours only represent the turbine-generated sound and do not include any cumulative noise from existing background sources. The existing background noise is not known for each specific receptor. Due to this unknown, values of 25, 30 35, 40, 45, 50, 55 and 60 dBA were used to depict varying degrees of existing noise. This is consistent with the results of the noise monitoring data in the previous section of the report, which showed the existing hourly L_{eq} noise levels at monitoring locations within the project area to range between 24.8-66.3 dBA during the day and 22.3-63.2 dBA during the night. The resultant noise from the turbines on each receptor was added to the eight projected background noise levels, and the summary of Scenario 1 can be found in **Table 4**. None of the modeled receptors indicate an impact from the turbines greater than 45.1 dBA.

The largest noise increase possible within the model was to be 20.1 dBA at R32 if the existing hourly L_{eq} is 25 dBA. This means that in exceptionally quiet hours, the model shows turbine noise is very noticeable. However, the model is based on maximum output from the turbines which is associated with high wind speeds. In this condition, ambient noise from the wind will be much higher. When looking at the wind speed data collected at site M1 (closest to R32), wind speeds were less than 3 mph during the quietest measured Leq values (<30 dBA). Typically, these wind speeds would be below the cut-in wind speed (6.7 mph or 3 m/s) required for turbine operation. When higher wind speeds of 8-9 miles per hour at microphone height were examined, the background L_{eq} noise was approximately 45-50 dBA. This wind speed is below conditions that would produce maximum turbine noise. Even when maximum noise output is added to a background L_{eq} noise of 45 dBA, the difference is calculated to be 3.1 dBA, which is just slightly greater than increases in noise that are perceptible to the human ear (3.0 dBA). When background noise reaches the 50 dBA limit set by the MPCA for nighttime L_{50}, the worst case impact from the turbines (R32) increases total noise by 1.2 dBA. This noise produced by the turbines at this point should be indistinguishable from the background noise conditions.

Figure 10 - Closest Reciever to Turbine Impact

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N

0 650 Feet

1 inch = 936 feet

WSB

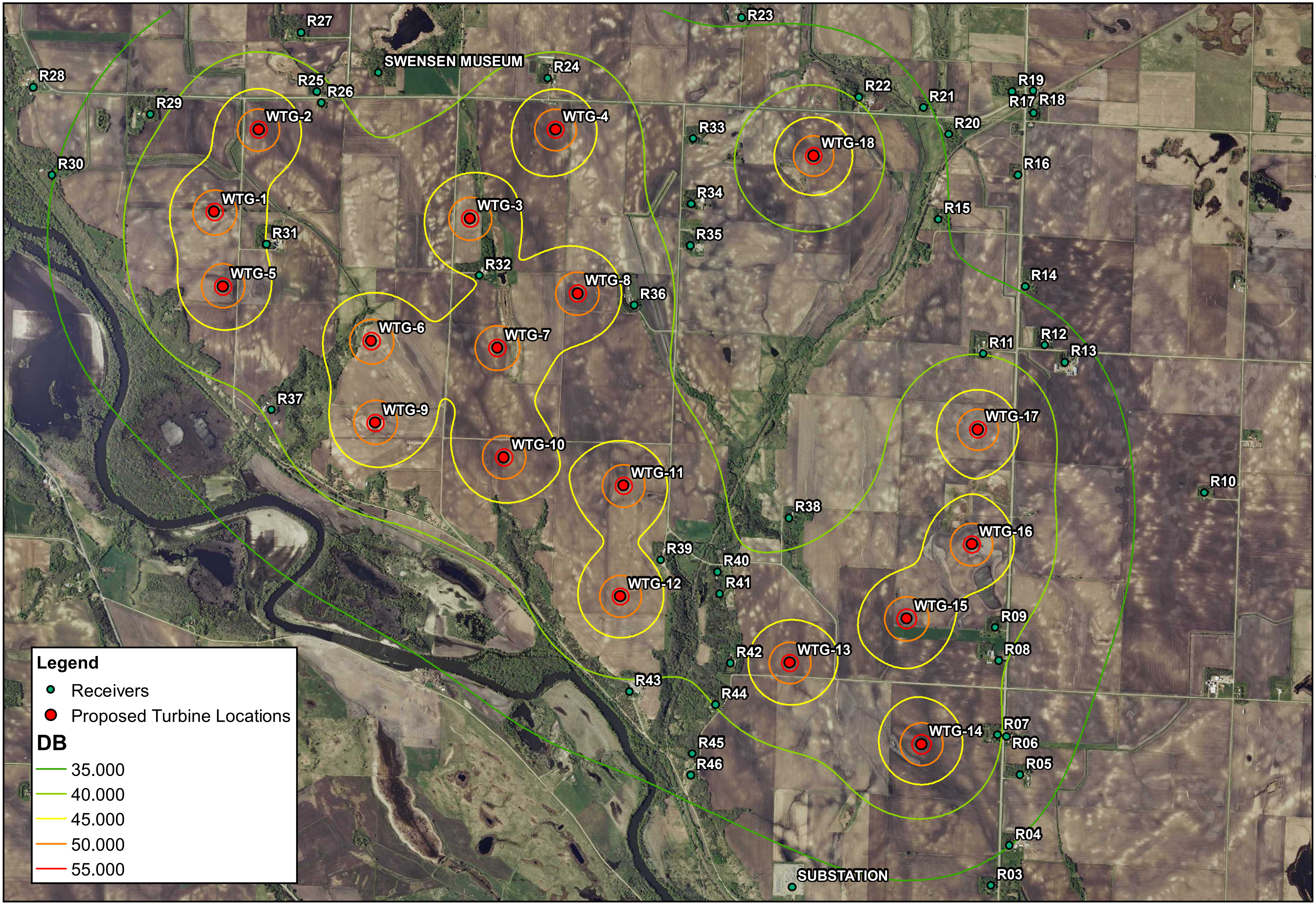

Figure 11 - Turbine Scenario 1

2.3 WM Turbines at 80m Hub Height, 2.5 MW Turbines at 90m Hub Height

Palmer's Creek Wind Farm

Fagen Engineering

N

0 3,000 Feet

1 inch = 3,000 feet

WSB

Table 4 – Noise Modeling Results (Scenario 1)

Receptor ID	Turbine Impact (Calculated)	Background Sound Levels + Turbine Impact (dBA)							
		25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
R01	31.7	32.5	33.9	36.7	40.6	45.2	50.1	55.0	60.0
R02	32.2	33.0	34.2	36.8	40.7	45.2	50.1	55.0	60.0
R03	33.5	34.1	35.1	37.3	40.9	45.3	50.1	55.0	60.0
R04	35	35.4	36.2	38.0	41.2	45.4	50.1	55.0	60.0
R05	37.6	37.8	38.3	39.5	42.0	45.7	50.2	55.1	60.0
R06	39.6	39.7	40.1	40.9	42.8	46.1	50.4	55.1	60.0
R07	40.4	40.5	40.8	41.5	43.2	46.3	50.5	55.1	60.0
R08	40.5	40.6	40.9	41.6	43.3	46.3	50.5	55.2	60.0
R09	41.6	41.7	41.9	42.5	43.9	46.6	50.6	55.2	60.1
R10	31.6	32.5	33.9	36.6	40.6	45.2	50.1	55.0	60.0
R11	39.9	40.0	40.3	41.1	43.0	46.2	50.4	55.1	60.0
R12	37	37.3	37.8	39.1	41.8	45.6	50.2	55.1	60.0
R13	36.9	37.2	37.7	39.1	41.7	45.6	50.2	55.1	60.0
R14	34.7	35.1	36.0	37.9	41.1	45.4	50.1	55.0	60.0
R15	35.4	35.8	36.5	38.2	41.3	45.5	50.1	55.0	60.0
R16	32.2	33.0	34.2	36.8	40.7	45.2	50.1	55.0	60.0
R17	30.6	31.7	33.3	36.3	40.5	45.2	50.0	55.0	60.0
R18	30.1	31.3	33.1	36.2	40.4	45.1	50.0	55.0	60.0
R19	30.9	31.9	33.5	36.4	40.5	45.2	50.1	55.0	60.0
R20	34.6	35.1	35.9	37.8	41.1	45.4	50.1	55.0	60.0
R21	35.5	35.9	36.6	38.3	41.3	45.5	50.2	55.0	60.0
R22	39.5	39.7	40.0	40.8	42.8	46.1	50.4	55.1	60.0
R23	34.6	35.1	35.9	37.8	41.1	45.4	50.1	55.0	60.0
R24	43.1	43.2	43.3	43.7	44.8	47.2	50.8	55.3	60.1
SWENSEN MUSEUM	38	38.2	38.6	39.8	42.1	45.8	50.3	55.1	60.0
R25	41.3	41.4	41.6	42.2	43.7	46.5	50.5	55.2	60.1
R26	41.5	41.6	41.8	42.4	43.8	46.6	50.6	55.2	60.1
R27	37.8	38.0	38.5	39.6	42.0	45.8	50.3	55.1	60.0
R28	32.4	33.1	34.4	36.9	40.7	45.2	50.1	55.0	60.0
R29	39	39.2	39.5	40.5	42.5	46.0	50.3	55.1	60.0
R30	34.8	35.2	36.0	37.9	41.1	45.4	50.1	55.0	60.0
R31	44.9	44.9	45.0	45.3	46.1	48.0	51.2	55.4	60.1
R32	45.1	45.1	45.2	45.5	46.3	48.1	51.2	55.4	60.1
R33	38.4	38.6	39.0	40.0	42.3	45.9	50.3	55.1	60.0
R34	38.8	39.0	39.3	40.3	42.5	45.9	50.3	55.1	60.0
R35	39	39.2	39.5	40.5	42.5	46.0	50.3	55.1	60.0

Receptor ID	Turbine Impact (Calculated)	Background Sound Levels + Turbine Impact (dBA)							
		25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
R36	43.2	43.3	43.4	43.8	44.9	47.2	50.8	55.3	60.1
R37	40.5	40.6	40.9	41.6	43.3	46.3	50.5	55.2	60.0
R38	39.2	39.4	39.7	40.6	42.6	46.0	50.3	55.1	60.0
R39	44.1	44.2	44.3	44.6	45.5	47.6	51.0	55.3	60.1
R40	40.9	41.0	41.2	41.9	43.5	46.4	50.5	55.2	60.1
R41	41.2	41.3	41.5	42.1	43.7	46.5	50.5	55.2	60.1
R42	42.7	42.8	42.9	43.4	44.6	47.0	50.7	55.2	60.1
R43	39.1	39.3	39.6	40.5	42.6	46.0	50.3	55.1	60.0
R44	40.1	40.2	40.5	41.3	43.1	46.2	50.4	55.1	60.0
R45	37	37.3	37.8	39.1	41.8	45.6	50.2	55.1	60.0
R46	36.1	36.4	37.1	38.6	41.5	45.5	50.2	55.1	60.0
R47	33.1	33.7	34.8	37.2	40.8	45.3	50.1	55.0	60.0
SUBSTATION	33.3	33.9	35.0	37.2	40.8	45.3	50.1	55.0	60.0

VI. Conclusion

WSB collected noise and meteorological data at four different sites representing the proposed Palmer's Creek Wind Farm. For monitoring locations within the proposed project area, the existing hourly L_{eq} noise levels range between 24.8-66.3 dBA during the day and 22.3-63.2 dBA during the night. The existing sound levels met or exceeded State daytime noise standards at monitoring location 3, and met or exceeded nighttime noise standards at monitoring locations 1 and 2.

The worst case receptor scenario was modeled to determine the sound-related impact of the proposed wind farm. **Table 5** provides a summary of the sound impacts predicted under the worst case receptor scenario. The highest predicted increase in L_{eq} sound level is shown as 20.1 dBA. However, this is misleading as turbine noise would be reduced or absent in calm conditions associated with these quieter time periods. A more realistic condition would be a background L_{eq} value of 45 dBA or greater associated with wind speeds needed for normal turbine operation. For background L_{eq} values of 45 dBA, the increase in noise when the maximum turbine output is applied is calculated to be 3.1 dBA at Receptor 32. Changes in sound levels less than 3 dBA are barely perceptible to the human ear (Bolt, Beranek and Newman, Inc., 1973). With an increase of 3.1 dBA, the turbines may be noticeable to the human ear, but are close to physical perception limits.

Table 5: Summary of Scenario 1 Noise Impacts

Background Sound L_{eq} (dBA)	Highest Cumulative Sound L_{eq} (dBA)	Change in Sound Level (dBA)
25	45.1	20.1
30	45.2	15.2
35	45.5	10.5
40	46.3	6.3
45	48.1	3.1
50	51.2	1.2
55	55.4	0.4
60	60.1	0.1

In Minnesota, the MPCA State Noise Standards (L_{50}) restrict noise levels to 60 dBA during the daytime and 50 dBA during the nighttime. The analysis indicates that construction of the Palmer's Creek Wind Farm project will not have an impact of 60 dBA or greater on any modeled receptor, nor will the cumulative impact on any receptor exceed 60 dBA when assuming a 35 dBA, 40 dBA, 45 dBA, 50 dBA, or 55 dBA background sound level. During the daytime, and only with a background sound level already approaching or exceeding the 60 dBA threshold would the cumulative sound level (background and wind turbine sound) exceed 60 dBA. The same is true for the nighttime threshold; only with a background sound level already approaching or exceeding the 50 dBA threshold would the cumulative sound level exceed 50 dBA. In the case of either daytime or nighttime exceedance with background noise approaching MPCA limits for daytime and nighttime L_{50}, the impact of the turbines would be indistinguishable from background noise levels.

VII. References

Bolt, Beranek and Newman, Inc., Fundamentals and Abatement of Highway Traffic Noise, Report No. PB-222-703. Prepared for Federal Highway Administration, June 1973.