COMMERCE DEPARTMENT

September 28, 2017
Mr. Daniel Wolf
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

RE: Bent Tree Wind Farm Noise Monitoring – Monitoring Report
Docket No. ET6657/WS-08-573

Dear Mr. Wolf:

The Department of Commerce's Energy Environmental Review and Analysis (EERA) staff submits the enclosed Bent Tree Wind Farm Post-Construction Noise Assessment Report (Report) pursuant to the Commission's August 24th, 2016 order requiring noise monitoring, noise study and further study to address noise-related complaints filed by three landowners regarding the Bent Tree project (E-dockets WS-08-573, Document ID 20168-124382-01).

DNV GL-Energy was selected to complete noise monitoring at the Bent Tree Wind Farm as ordered by the Commission, and EERA consulted with Commission staff on the contract, work terms, and scope of work. DNV GL-Energy conducted the noise assessment in accordance with the Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report authored by the Minnesota Department of Commerce[1] and the Post Construction Noise Measurement Study Protocol developed by DNV GL- Energy (attached to this letter). The enclosed Report details the outcomes of the monitoring and identifies 16 total hours of non-compliance during the monitoring period.

As discussed in Appendix A of the Large Wind Energy Conversion System Noise Study Protocol and Report, if noise exceedances are recorded, it is necessary to determine the increment due to the turbine noise. Due to the exceedances documented during the monitoring period, an additional measurement campaign to properly isolate wind turbine sound from total measured sound is recommended in the Report.

Based on the recommendation in the Report and consultation with Commission staff, EERA has requested DNV-GL to conduct further measurements to isolate noise contribution from Bent Tree

[1] Minnesota Department of Commerce, Energy Facilities Permitting. October 8, 2012. Guidance for Large wind Energy Conversion System Noise Study Protocol and Report. https://mn.gov/commerce/energyfacilities/documents/FINAL%20LWECS%20Guidance%20Noise%20Study%20Protocol%20OCT%208%202012.pdf

Wind Farm turbines. Specifically, at EERA's request, DNV-GL has developed the attached Phase 2 Post-Construction Noise Measurement Study Protocol. Following this protocol, wind turbine sound will be isolated from total measured sound by conducting measurements with all turbines operational and also conducting measurements with a subset of wind turbines in proximity to complaint receptors turned off ("on/off monitoring") across a range of wind and atmospheric conditions. We believe completion of an "on/off" monitoring campaign is necessary to fulfill the Commission's August 24th order to conduct monitoring consistent with the guidance contained in the Large Wind Energy Conversion System Noise Study Protocol and Report.

EERA plans to move forward with DNV GL conducting this additional monitoring according to the Phase 2 Post-Construction Noise Measurement Study Protocol and will continue to consult with Commission staff on an ongoing basis.

Please do not hesitate to contact me if you have any questions concerning this letter.

Sincerely,

s/ Louise I. Miltich

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enclosure: Report: Bent Tree Wind Farm Post-Construction Noise Assessment
Report/Protocol: Post Construction Noise Measurement Study Protocol
Report/Protocol: Phase 2 Post-Construction Noise Measurement Study Protocol

DNV·GL

BENT TREE WIND FARM

Post-Construction Noise Assessment

Wisconsin Power and Light Co

Document No.: 10046144-HOU-R-02
Issue: B**, Status:** Final
Date: 30 August 2017

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Project name:	Bent Tree Wind Farm	DNV GL - Energy
Report title:	Post-Construction Noise Assessment	Advisory Americas
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Project No.:	10046144	
Document No.:	10046144-HOU-R-02	
Issue/Status	B/Final	

Task and objective:

This report presents the results of analysis conducted by DNV GL on behalf of Wisconsin Power and Light Co.

Prepared by:	Verified by:	Approved by:
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A	14 August 2017	Draft	D. Schoborg	A. Nercessian	S. Dokouzian
B	30 August 2017	Final	D. Schoborg	A. Nercessian	S. Dokouzian

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1 INTRODUCTION

The Department of Commerce, Energy, Environment Review and Analysis (EERA, formerly Energy Facilities Permitting) of the state of Minnesota has requested, on behalf of Wisconsin Power and Light Co ("WPL" or the "Company"), that Garrad Hassan America, Inc. (DNV GL) perform a post-construction noise assessment for the Bent Tree Wind Farm (the "Project"). The Project is located in Freeborn County, MN, approximately 90 miles south of Minneapolis, consisting of 122 Vestas V82-1.65 MW wind turbine generators (WTG) with a hub height of 80 m and a rotor diameter of 82 m. The Project began operation in 2011.

This post-construction noise assessment (the "Assessment") has been completed in accordance with the Guidance for Large Wind Energy Conversion System Nosie Study Protocol and Report (LWECS Guidance) authored by the Minnesota Department of Commerce [1], and the Post-Construction Noise Measurement Study Protocol (DNV GL Protocol) developed by DNV GL [2]. More specifically, the Assessment was requested by EERA due to on-going complaints at two receptors within the Project Area; the Hagen and Langrud receptors.

The purpose of this Assessment is to determine the post-construction noise levels and compliance with Minnesota noise standards.

2 BACKGROUND

2.1 Environmental Sound Background

Sound levels are expressed in the decibel unit and are quantified on a logarithmic scale to account for the large range of acoustic pressures to which the human ear is exposed. A decibel (dB) is used to quantify sound levels relative to a 0 dB reference. The reference level of 0 dB is defined as a sound pressure level of 20 micropascals (μpa), which is the typical lower threshold of hearing for humans.

Sound levels can be presented both in broadband (sound energy summed across the entire audible frequency spectrum) and in octave band spectra (audible frequency spectrum divided into bands). Frequency is expressed in the Hertz unit (Hz), measuring the cycles per second of the sound pressure waves. The audible range of the human ear spans from 20 to 20,000 Hz. Since the human ear does not perceive every frequency with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighting filter is applied to closely approximate the human ear's response to sound. Sound expressed in the A-weighted scale is denoted dBA. A C-weighting filter can also be applied, which can be used to evaluate the potential presence of low-frequency sounds and is denoted as dBC.

A sound source has a certain sound power level (PWL) rating which describes the amount of sound energy per unit of time. This is a basic measure of how much acoustical energy a sound source can produce and is independent of its surroundings. Sound pressure is created as sound energy flows away from the source. The measured sound pressure level (SPL) at a given point depends not only on the power rating of the source and the distance between the source and the measurement point (geometric divergence), but also on the amount of sound energy absorbed by environmental elements between the source and the measurement point (attenuation). Sound attenuation factors include meteorological conditions such as wind direction, temperature, and humidity; sound interaction with the ground; atmospheric absorption; terrain effects; diffraction of sound around objects and topographical features; and foliage.

2.2 Minnesota Noise Limits

The regulations applicable to the Project are the Minnesota Noise Standards [3].

Minnesota Pollution Control Agency (MPCA) 7030.0040 Noise Standards state the following:

> ***7030.0040 Noise Standards.***
>
> ***Subpart 1. Scope.*** *These standards describe the limiting levels of sound established on the basis of present knowledge for the preservation of public health and welfare. These standards are consistent with speech, sleep, annoyance, and hearing conservation requirements for receivers within areas grouped according to land activities by the noise area classification (NAC) system established in part 7030.0050. However, these standards do not, by themselves, identify the limiting levels of impulsive noise needed for the preservation of public health and welfare. Noise standards in subpart 2 apply to all sources.*
>
> ***Subpart. 2. Noise Standards.***

Table 2-1 Minnesota Noise Standards

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

Nighttime hours are between 10 pm and 7 am, as per the MPCA noise standards.

The Project is considered under noise area classification 1, which includes homes, other residential uses, religious activities, and educational services. The applicable nighttime L_{50} limit is therefore 50 dBA and the applicable nighttime L_{10} limit is 55 dBA at each receptor. Daytime L_{50} and L_{10} limits are 60 dBA and 65 dBA, respectively.

Sound pressure levels can be reported in a variety of ways. L_{50} and L_{10} represent noise levels that are exceeded 50% and 10% of the time, respectively. Leq represents the average sound over a period of time. L_{50}, L_{10}, and Leq sound pressure levels can be reported in dBA and dBC, both of which are used throughout this report. All sound levels are presented as hourly averages as per Minnesota standards.

2.3 Sources of Sound

Measurement of Project-related sound requires an understanding of sound produced by Project components. The sources of noise produced by the Project are comprised of the wind turbine generators and transformers, and the substation.

The broadband sound power level for the Vestas V82-1.65 MW wind turbine generators, at a hub height of 80 m, was provided by EERA and the Company [4]. According to the information obtained, the maximum acoustic emission at standard setting (no sound restriction control mode) is 103.2 dBA ± 2 dB for the Vestas V82-1.65 MW.

2.4 Measurement Methods

All instrumentation, measurement settings, data collection, processing and reporting procedures have been conducted in accordance with the LWECS Guidance as well as with the MPCA's Measurement Procedure for Non-impulsive noise, designated as method NTP-1 [5]. The methodology additionally considered the following ISO standards related to acoustic sound measurements: 1996-1, 1996-2 and 1996-3 [6].

2.5 Instrumentation

The instrumentation used for the post-construction noise monitoring included the following:

- Larson Davis soundmeters model 831 Class I;
- FreeField ½ inch microphone model 377B02;
- Preamplifier model PRM831;
- Vaisala Weather Transmitter model SEN-031;
- Larson Davis Precision Acoustic on-site Calibrator model CAL200; and
- Complete kit for outside sound measurement (including large tripods, wind and rain screen, protective Pelican case and long range batteries).

The sound meters meet the IEC 61672 Class 1 specifications. All instruments had a valid calibration, and calibration sheets are included in Appendix C of this document. Based on the above descriptions, the instrumentation complies with the requirements of the Guidance and NTP-1 [3].

Table 2-2 below summarizes the equipment used at each monitoring location.

Table 2-2 Monitoring Equipment Serial Numbers by Monitoring Location

Monitoring location	Sound Level Meter	Preamplifier	Microphone	Weather sensor
Langrud (M01)	3308	19107	152980	G404008
Hagen (M02)	3004	46571	163147	H4720002

The following meteorological parameters were recorded, with the Vaisala weather station, at the in-situ measurement locations that were within the Project area:

- Wind speed and direction;
- Relative humidity and precipitation;
- Temperature.

2.6 Data Collection

Over two weeks (17 days) of data was collected from midday 6 June 2017 through the afternoon of 23 June 2017 to collect data in various wind conditions, during day and night, and during different operational regimes. During this period, ambient sound was not overly affected by farming activity such as significant planting or harvesting. However, the ambient sound was relatively high at both receptors due to wind induced noise on nearby vegetation and tree leaves, and frequent bird chirping and insect sounds within the

vicinity of the measurement points. This type of ambient noise typically results in higher measured sounds throughout a campaign as opposed to a measurement campaign in early spring or late fall.

During the two weeks of measurements collected for the Assessment, the wind turbines were operational except during periods of maintenance or forced utility curtailment which resulted in reduced turbine production (i.e. turbine curtailment). Curtailment and maintenance records were provided by EERA on behalf of the Project operator [7]. To accurately capture the noise levels, DNV GL excluded noise measurements from the Assessment when turbine downtime or curtailment occurred at turbines within 1.5 miles of the measurement points (see Appendix A), distance at which wind turbine sound becomes negligible at the audited receptors. These measurements represent the core of the post-construction measurement campaign.

It should be noted that the LWECS Guidance requires a minimum of 7 days of measurements; due to the un-planned forced utility curtailment during the 1st week of measurements, the campaign was extended by more than 1 week to ensure a sufficient and representative dataset was gathered for the Assessment.

Microphones were installed on tripods approximately 5 feet above ground, and site calibration was performed before and after each monitoring period, as well as at the midway point of the measurement campaign. As per the Table 2-3, the differential calibration was not greater than 0.5 dBA. The microphones were both placed at least 20 feet from large reflecting surfaces. Photos of sound equipment stations at each measurement point are included in Appendix B.

Table 2-3 Site Calibration log

Monitoring location	**Mid-campaign site calibration**		**End-of-campaign site calibration**	
	Date	Differential (dBA)	Date	Differential (dBA)
Langrud (BT-M01)	14 June 2017	-0.04	23 June 2017	-0.17
Hagen (BT-M02)	14 June 2017	-0.04	23 June 2017	0.12

Sound measurements were made continuously using a FAST response setting and were averaged and stored every 10 seconds and hour, along with the relevant statistics for the periods. Sound events louder than 60 dBA were recorded for analysis and possible filtering.

The recorded measurements included un-weighted sound (in dB); A-weighted as L_{10}, L_{50}, L_{90} and Leq (dBA); and C-weighted L_{10}, L_{50}, L_{90} and Leq (dBC). Third octave band measurements ranging from 16 Hz to 8000 Hz were also recorded. A-weighted Leq, L_{10}, L_{50}, and L_{90}; and C-weighted Leq were also recorded on an hourly basis. C-weighted L_{10}, L_{50}, and L_{90} were calculated from the 10 second C-weighted Leq records.

Because environmental sound measurements are greatly influenced by wind-induced sound, the measurement stations included a foam wind screen, as per industry standards. This enabled the measurement of sound (without significant wind-induced sound effects on the microphone) in winds up to 11 miles per hour (mph) (i.e. 5 m/s) at the measurement level. Measurements taken during winds higher than 11 miles per hour and other adverse conditions such as rain were not used in the measurement campaign as per Monitoring Condition 4 of the LWECS Guidance.

It should be noted that units in this report are generally provided in English units, to suit the Minnesota regulatory body and related guidance document. However, wind turbine data is generally reported worldwide in metric units, as per the international standards that govern certification.

Table 2-4 below provides a comparison between wind speed in miles per hour and meters per second.

Table 2-4 Wind speed units comparison

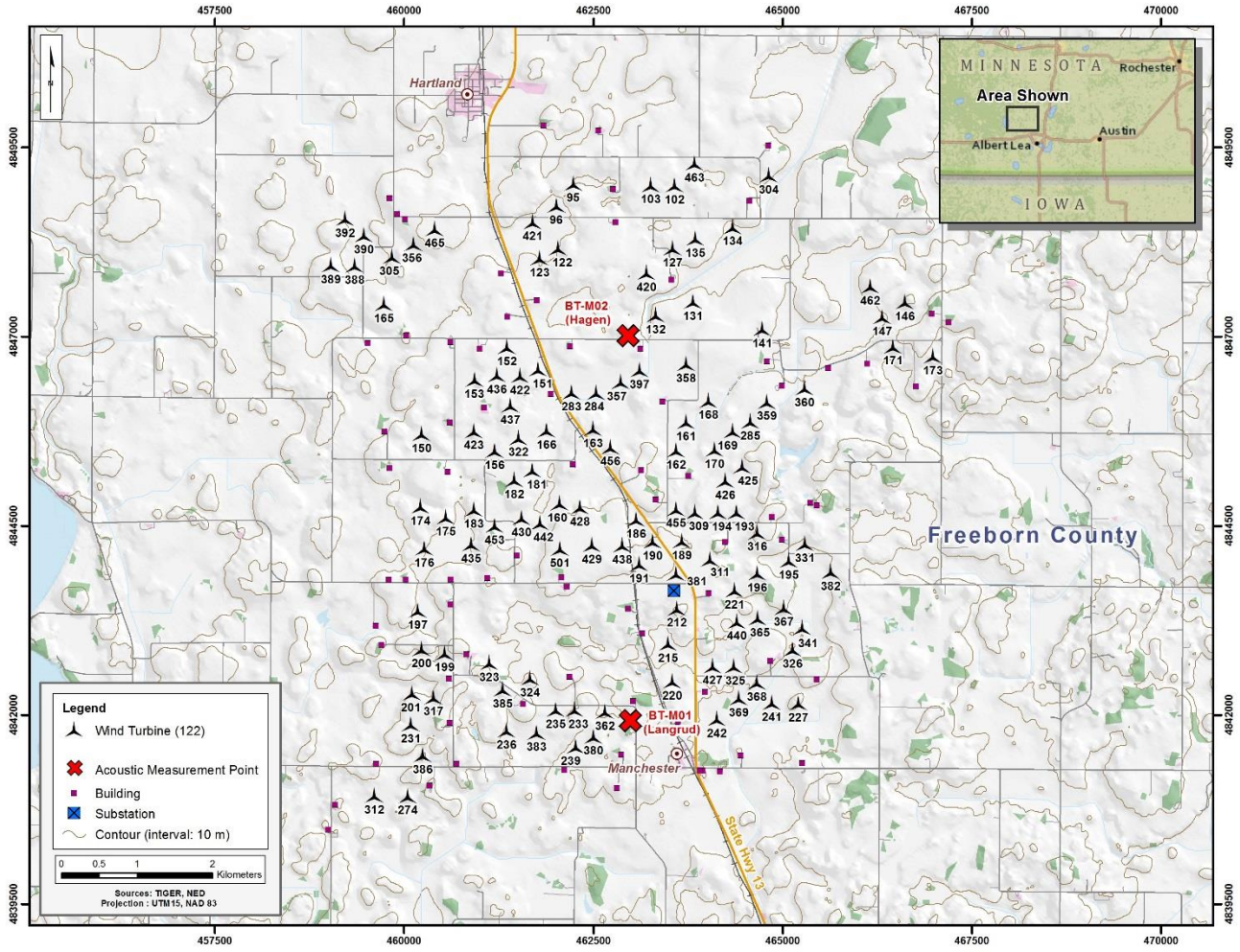
Miles per hour (mph)	Meters per second (m/s)
1	0.4
2	0.9
3	1.3
4	1.8
5	2.2
6	2.7
7	3.1
8	3.6
9	4.0
10	4.5
11	4.9
12	5.4
13	5.8
14	6.3
15	6.7
16	7.2
17	7.6
18	8.0
19	8.5
20	8.9

In addition to wind speed and wind direction, temperature, relative humidity and precipitation at the microphone height and location were recorded by the weather stations; and hub height hourly anemometry and operational data were also provided from the turbines' internal SCADA system [7]. Precipitation data obtained on-site was compared to the nearest National Oceanic and Atmospheric Administration (NOAA) station, and data broadly concurred. Due to the benefit of the in-situ weather stations, the related data was used for data processing in lieu of data from a distant NOAA station.

3 MEASUREMENT LOCATIONS

Post-construction sound levels were measured at two locations (BT-M01, BT-M02). These locations are shown below in Figure 1.

Figure 1 Sound Measurement Locations



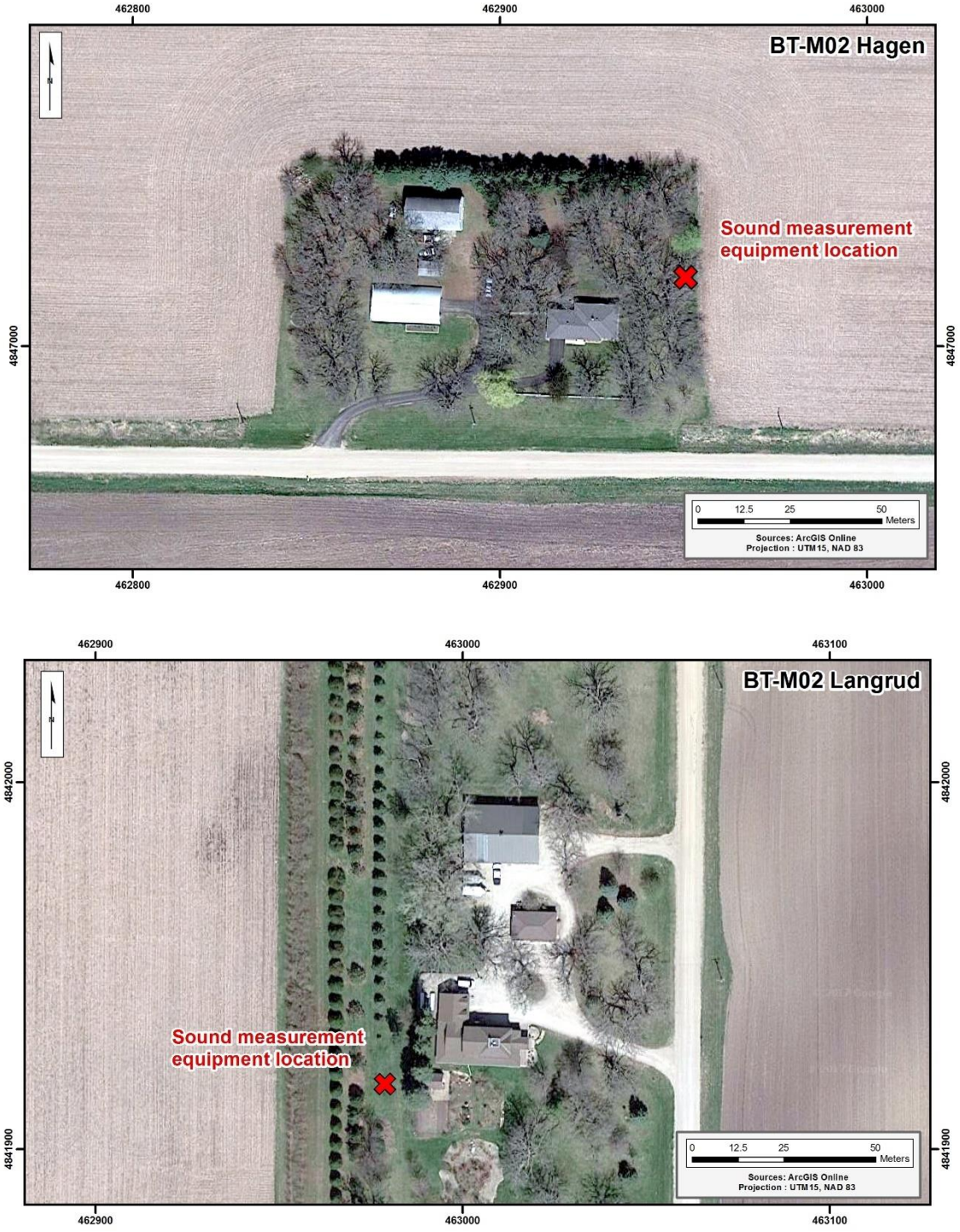
The two on-site measurement points, BT-M01 and BT-M02, were located at the two complaint receptor locations to adequately characterize the total sound levels, including the contribution of the Project, as required by the LWECS Guidance. The measurement location coordinates are listed in Table 3-1 and shown in more detail in Figure 2.

Table 3-1 Final Measurement Point Locations

Final Measurement Point	Easting	Northing	Distance to nearest turbine, ft
Langrud (BT-M01)	462985	4841921	1150 – Turbine 362
Hagen (BT-M02)	462949	4847019	1525 – Turbine 132

UTM NAD83 zone 15

Figure 2 Sound Measurement Locations – Detailed view



Existing ambient noise levels at the measurement points were characterized mainly by wind induced noise on nearby tree leaves and vegetation, domestic and rural activities, natural bird and insect sounds,

transportation noise on secondary gravel and asphalted roads, and occasional noise from the wind farm. The Project has no nearby neighboring wind farms.

Photos of the measurement points and stations can be found in Appendix B.

4 NOISE MONITORING RESULTS

The results presented in this section include the full two weeks of measurement data, meeting the conditions of 1.b. of the LWECS Guidance for BT-M01 and BT-M02.

Data is presented at hourly intervals and excludes periods of precipitation and microphone height winds greater than 11 miles per hour (mph) per the LWECS Guidance. For BT-M01 and BT-M02, precipitation and microphone height wind speed data was taken from the weather stations located at each measurement station. It should be noted that due to overhead shielding by trees, some light precipitation might not have been recorded by the precipitation sensor at BT-M02.

Periods of extraneous sound not associated with the Project or the typical natural environment (lawn mowers, farm equipment, etc.), which are in excess of 60 dBA, were excluded from the dataset. The sound meters used for the campaign record the sound exceedances above 60 dBA, which allows for proper data analysis and filtering of extraneous events.

In addition, records coinciding with periods of turbine downtime due to maintenance or utility curtailment were excluded as sound levels would likely be affected by the down turbine(s). DNV GL identified those periods based on a turbine downtime report provided by EERA on behalf of the Company [7]. This was done to eliminate any sound recordings that would be quieter than expected due to turbine downtime. Doing so ensures that all valid data presented demonstrates sounds levels typically expected during Project operations at corresponding hub height wind speeds. It should be noted that records when the wind turbines were not operating due to winds below the cut-in wind speed were not excluded from the dataset. Therefore, the results shown in Section 4 graphs do not include contribution from the facility when hub height wind speeds are generally below 6.7 mph (i.e. 3 m/s).

It shall be noted that the timestamps were adjusted on the datasets acquired after the mid-campaign site intervention, in order to accurately coincide with the actual date and time of measurements. No other adjustments were applied to the data.

In the figures presented for each measurement point, excluded data is identified by gray and green vertical shading. For each measurement point, as required by the LWECS Guidance, hourly data series for the measurement period is presented as A-weighted and C-weighted Leq, L_{10}, L_{50}, and L_{90}. These data series are compared against microphone wind speed, hub height wind speed, and precipitation. Hourly L_{10} and L_{50} data are also charted against the daytime and nighttime L_{10} and L_{50} MPCA noise limits to demonstrate instances of non-compliance. Nighttime hours are between 10 pm and 7 am, as per the MPCA noise standards.

4.1 Measurement Point BT-M01 - Langrud

BT-M01 is in the south of the Project area. Excluded data includes periods of precipitation and microphone height wind speeds greater than 11 mph; and 101 hours of excluded data due to turbine curtailment and the operation of a lawn mower and other miscellaneous farm equipment near the measurement station. Records

when the wind turbines were not operating due to winds below the cut-in wind speed, were not excluded. There was a short period where recordings were not taken from 14 June to 15 June due to data collection and battery maintenance on the sound equipment.

Table 4-1 below summarizes the excluded and remaining data, as a percentage and number of hours based on the overall measurement hours.

Table 4-1 BT-M01 Excluded data

BT-M01 Excluded data as a % of total data and number of hours		
	Percentage (%)	Hours
Turbine curtailment	24.5%	93
Precipitation	6.3%	24
Microphone wind speed >11 mph	0.0%	0
Extraneous noise	3.1%	8
Total Hours Remaining	**67.0%**	**254**

Hourly A-weighted Leq values during valid hours over the course of the measurement period ranged from 28.1 dBA to 59.6 dBA.

The A-weighted and C-weighted Leq values are plotted with precipitation in Figure 3, and with hub height wind speed in Figure 4. The grey- and green-shaded areas represent the excluded data discussed above and in Table 4-1. The majority of excluded time periods are due to turbine curtailment events during the first week of the measurement campaign. Some spikes in Leq values correspond to periods of lawn mowing and/or farm machinery near the measurement station. There is general correlation between Leq values and hub height wind speeds.

The relevant portion of the graph with regards to potential sound level exceedances with the LWECS Guidance are outside of the shaded areas.

Figure 3 BT-M01 Hourly Leq with Precipitation

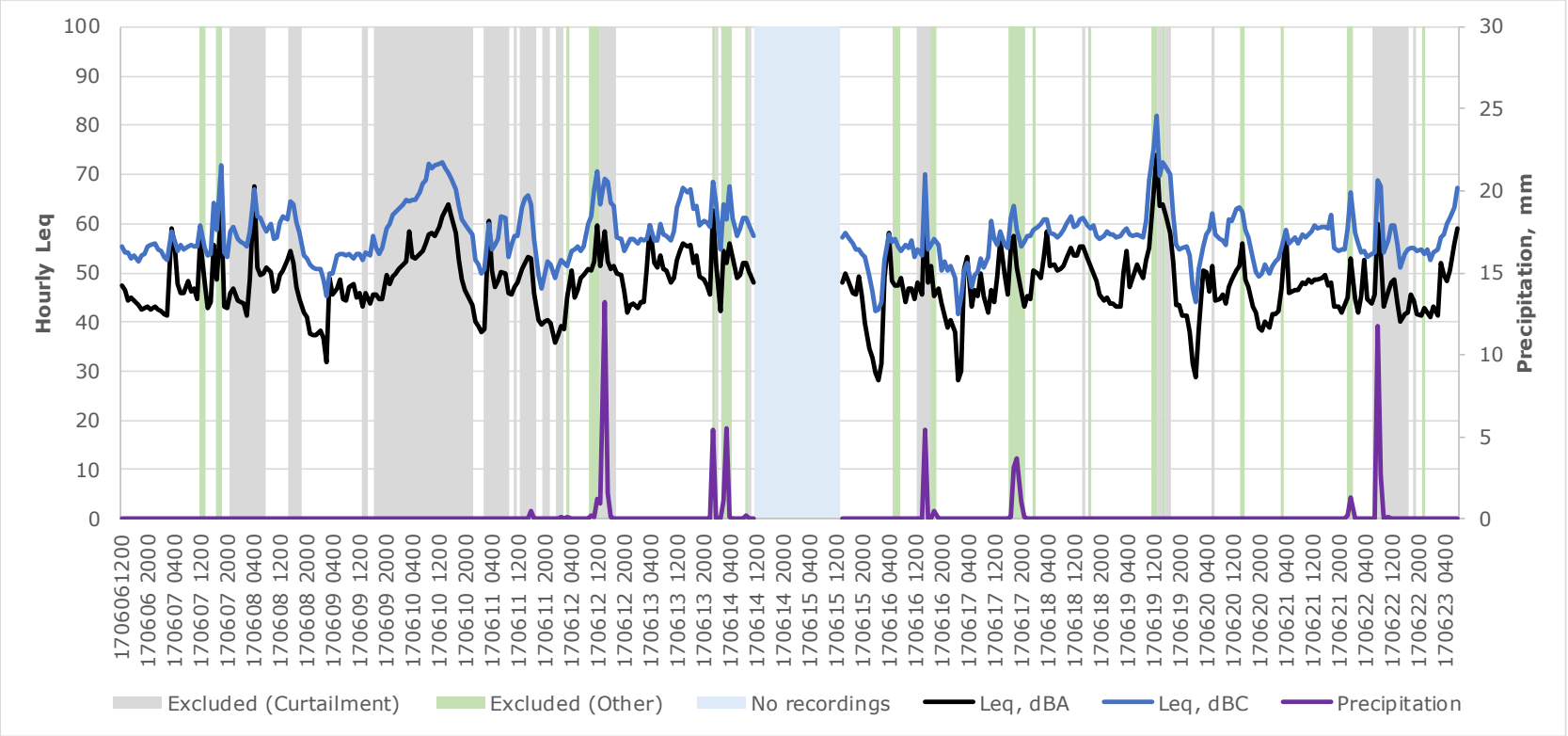


Figure 4 BT-M01 Hourly Leq with Hub Height Wind Speed

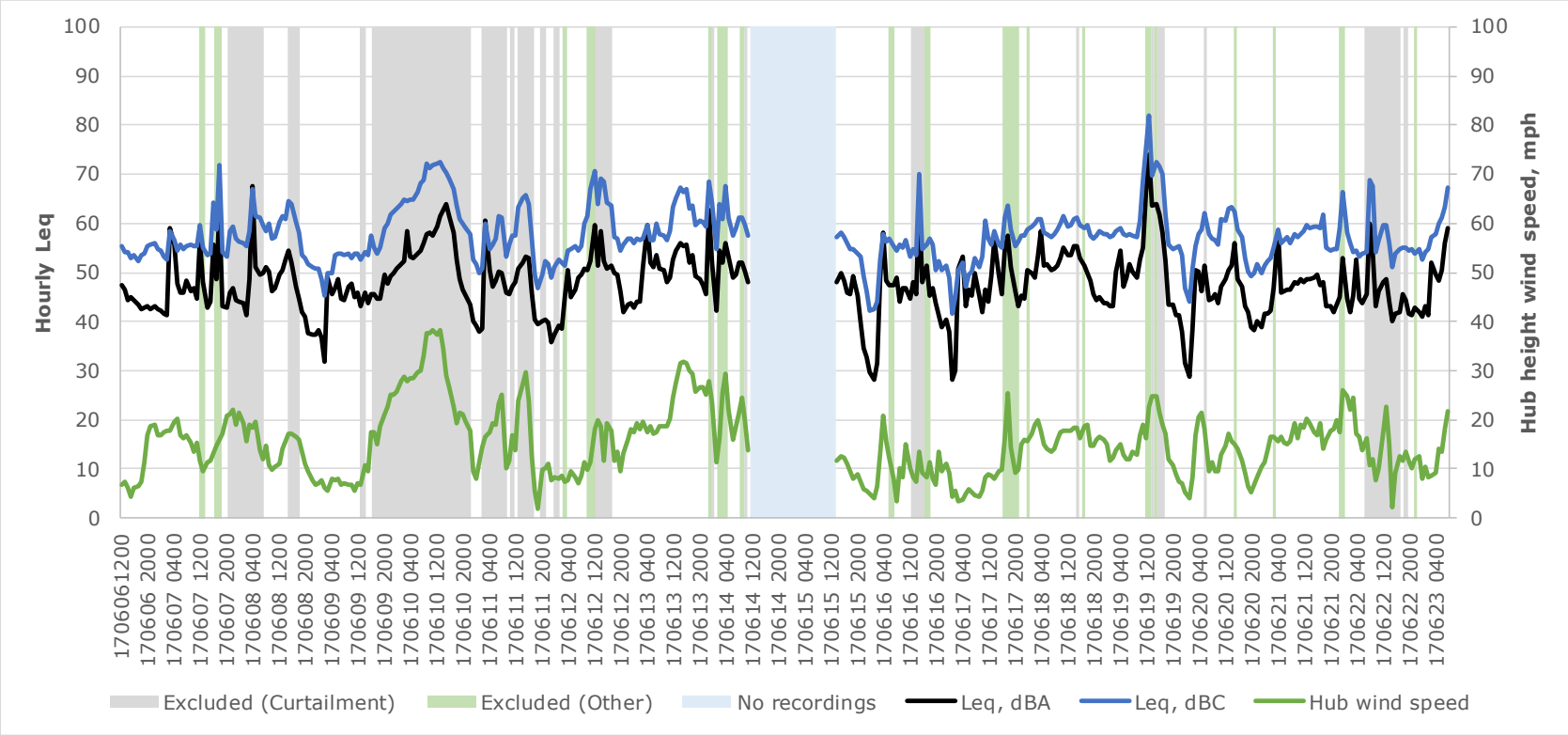


Figure 5 and Figure 6, A-weighted and C-weighted centiles are plotted with hub height wind speeds. The marker on these figures represents the L_{50}, with the top of the line representing the L_{10} and the bottom of the line representing the L_{90}. A longer line between the L_{10} and L_{90} values means that there was more variability within the hour's sound levels. During the campaign, general correlation between centile levels and hub winds were observed during most periods of valid data.

Figure 5 BT-M01 Hourly A-Weighted Centiles with Hub Height Wind Speed

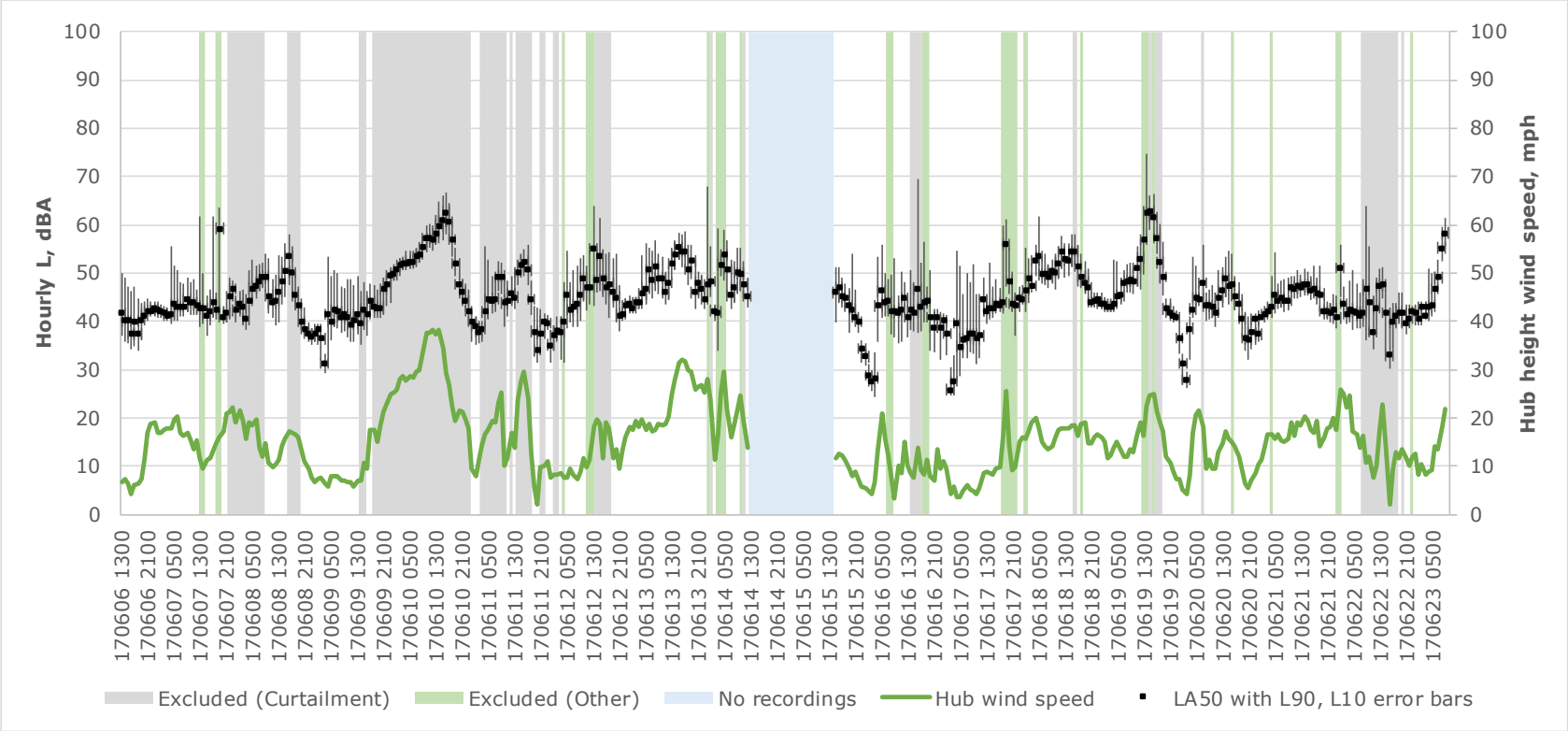
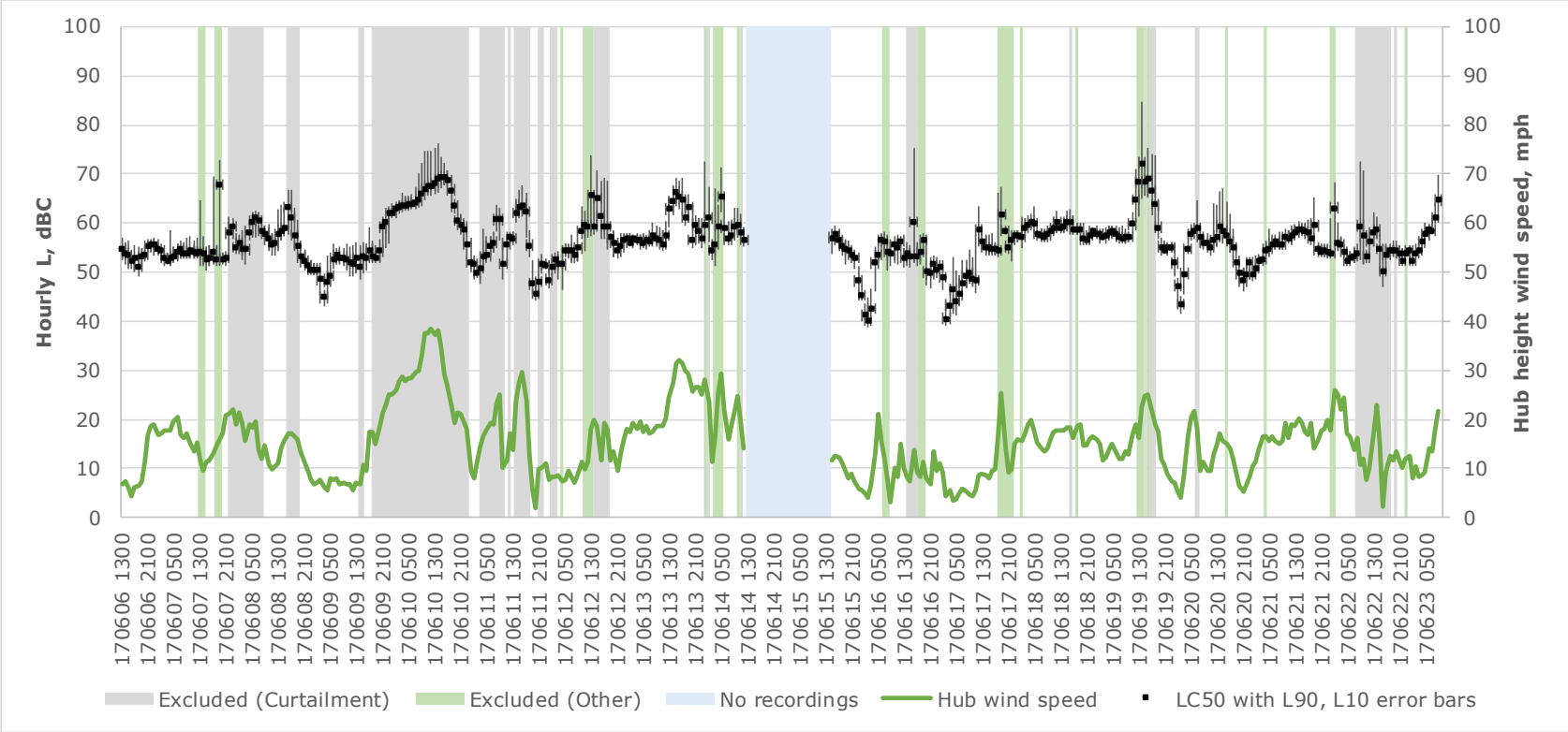


Figure 6 BT-M01 Hourly C-Weighted Centiles with Hub Height Wind Speed



In Figure 7 and Figure 8, A-weighted and C-weighted centiles are plotted with microphone height wind speeds. Microphone height winds can indicate the influence of wind noise on measured levels observed during periods of excluded data when microphone wind speeds were greater than 11 mph. Sound levels are generally correlated with microphone height wind speeds demonstrating the general effect of wind influence on ambient sound, regardless of wind turbine operations.

Figure 7 BT-M01 Hourly A-Weighted Centiles with Microphone Wind Speed

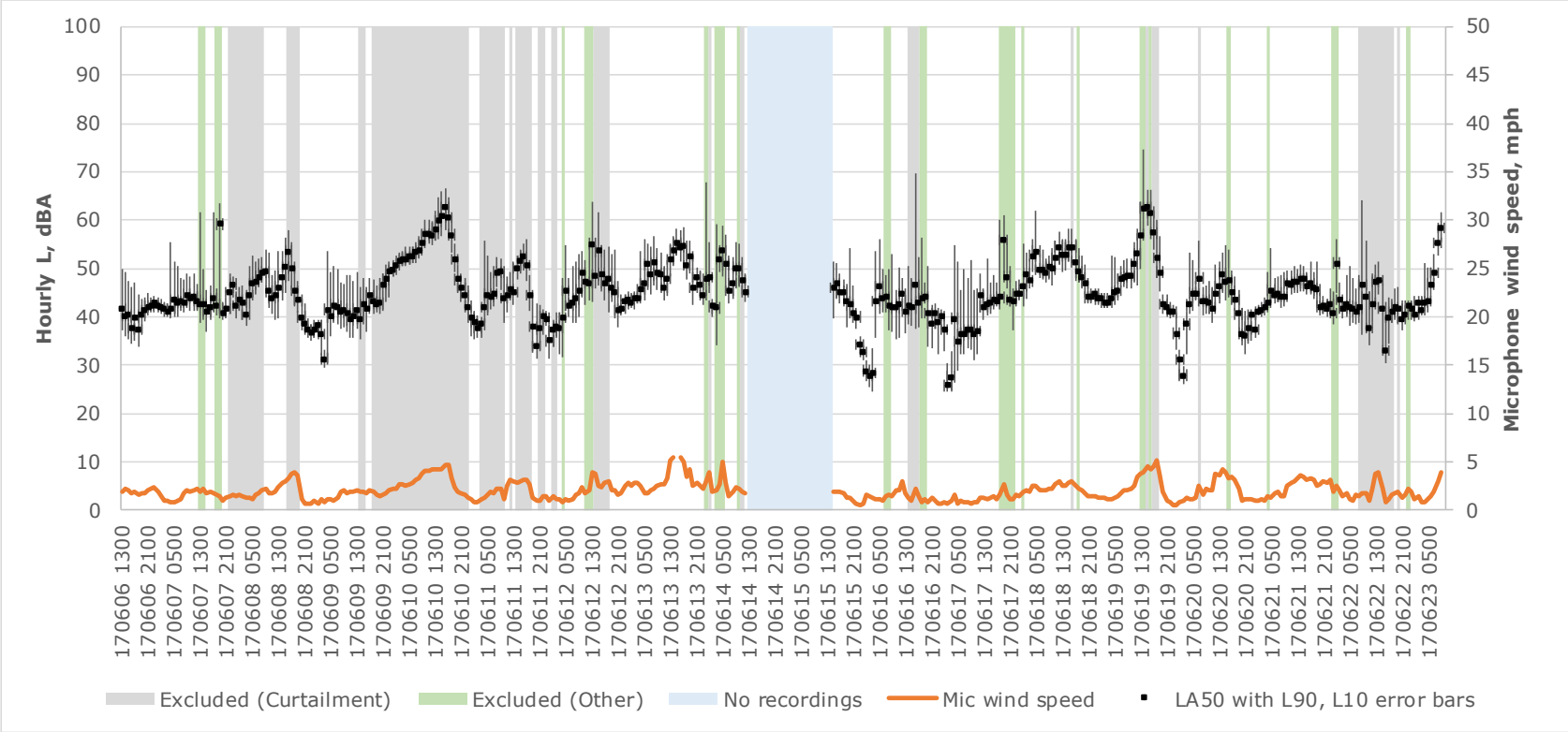


Figure 8 BT-M01 Hourly C-Weighted Centiles with Microphone Wind Speed

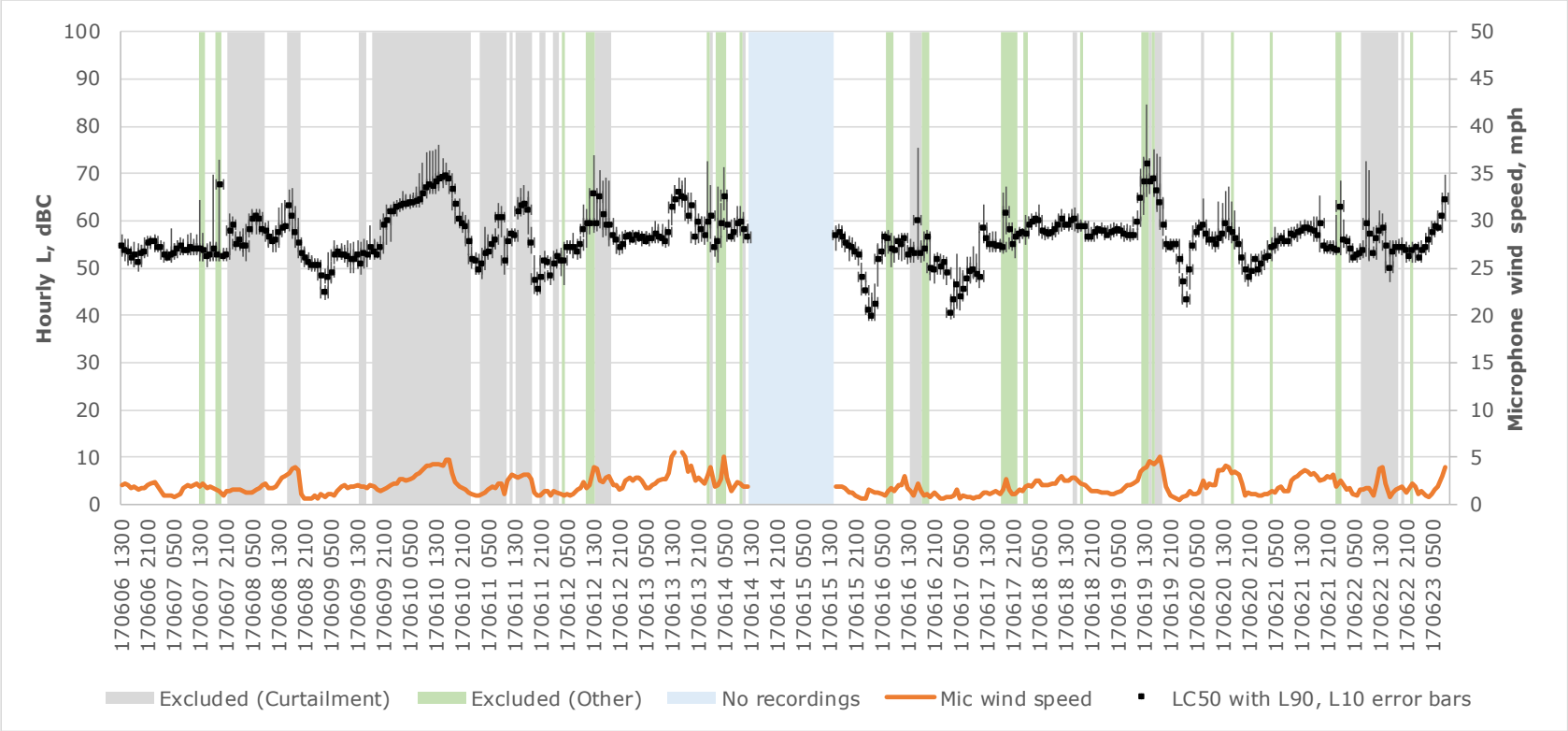


Figure **9** and Figure **10** compare the measurement data against the MPCA L10 and L50 nighttime and daytime limits. Excluded data points are shown as light grey dots, while valid data points are shown as black dots. Seven (7) hours of exceedance of the L_{10} and/or L_{50} limits were identified at BT-M01; the exceedances are shown as black dots circled in red on the graphs. Further details are provided in Table 4-2 below.

Table 4-2 BT-M01 MPCA Limit Exceedances

BT-M01 Exceedances				
Date	**Time (1 hour period starting at)**	**Statistic Exceeded**	**L_{10} Sound Level**	**L_{50} Sound Level**
7 June	4:00 am	LA10 nighttime limit of 55.0	55.5	n/a
13 June	5:00 am	LA10 nighttime limit of 55.0	56.2	n/a
13 June	6:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	55.2	50.8
14 June	6:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	56.9	50.8
16 June	5:00 am	LA10 nighttime limit of 55.0	55.9	n/a
18 June	4:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	55.9	52.6
18 June	5:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	61.8	53.5

During most of the seven exceedance periods, bird sounds and/or wind induced sound on tree leaves appear to be the primary contributor to the exceedances. Birds are chirping and singing in several of the recordings at the beginning of most exceedance periods between the hours of 4:00 am and 6:00 am. Wind turbine sound appears to be audible in the recordings during some of the exceedance periods. However, the contribution from the wind turbines cannot be determined without further detailed investigations in order to isolate wind turbine sound from total measured sound.

However, exceedance cannot be attributed to the wind turbines without further detailed investigations, in order to isolate wind turbine sound from total measured sound.

Figure 9 BT-M01 Houly L10 Sound Levels vs. MPCA Noise Limits

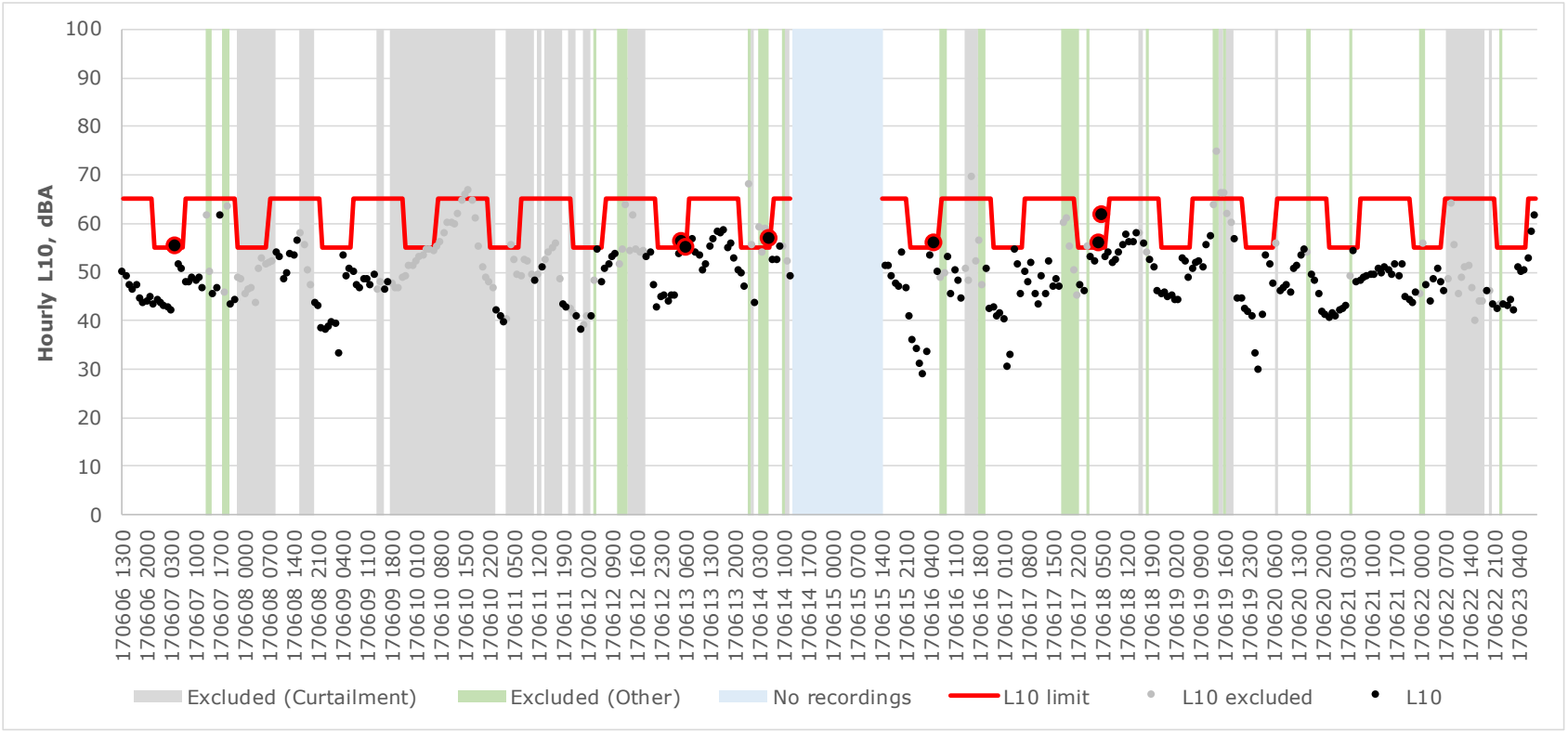
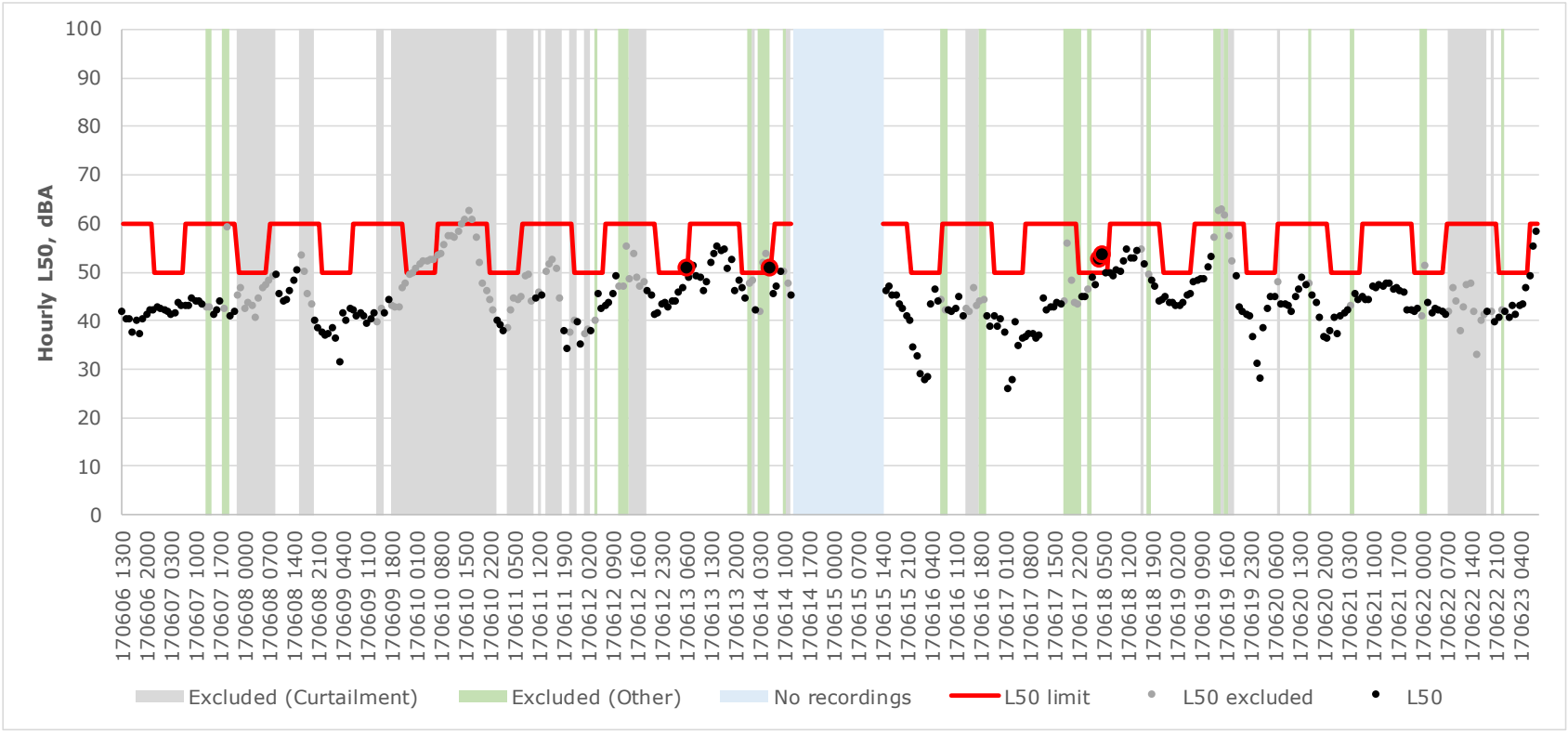


Figure 10 **BT-M01 Hourly L50 Sound Levels vs. MPCA Noise Limits**



4.2 Measurement Point BT-M02 - Hagens

BT-M02 is in the northern portion of the Project area. Excluded data includes periods of precipitation and microphone height wind speeds greater than 11 mph; and 108 hours of excluded data due to turbine curtailment and lawn mowing and other extraneous sound near the measurement station. Records when the wind turbines were not operating due to winds below the cut-in wind speed, were not excluded. There was a short period without recordings from 14 June to 15 June for data collection and battery maintenance on the sound equipment.

Table 4-3 below summarizes the excluded and remaining data, as a percentage and number of hours based on the overall measurement hours.

Table 4-3 BT-M02 Excluded data

BT-M02 Excluded data as a % of total data and number of hours		
	Percentage (%)	Hours
Turbine curtailment	22.4%	85
Precipitation	4.7%	18
Microphone wind speed >11 mph	0.5%	2
Extraneous noise	6.1%	23
Total Hours Remaining	**66.2%**	**251**

Hourly A-weighted Leq values during valid hours over the course of the measurement period ranged from 25.0 dBA to 60.3 dBA. It shall be noted that most periods of winds >11 mph occurred during periods of turbine forced utility curtailment and are therefore accounted for under "Turbine curtailment".

The A-weighted and C-weighted Leq values are plotted with precipitation in Figure 11, and with hub height wind speed in Figure 12. The grey- and green-shaded areas represent the excluded data discussed above and in Table 4-3. The majority of excluded time periods are due to turbine curtailment events during the first week of the measurement campaign. There is general correlation between Leq values and hub height wind speeds.

The relevant portion of the graph with regards to potential exceedances as per the LWECS Guidance are outside of the shaded areas.

Figure 11 BT-M02 Hourly Leq with Precipitation

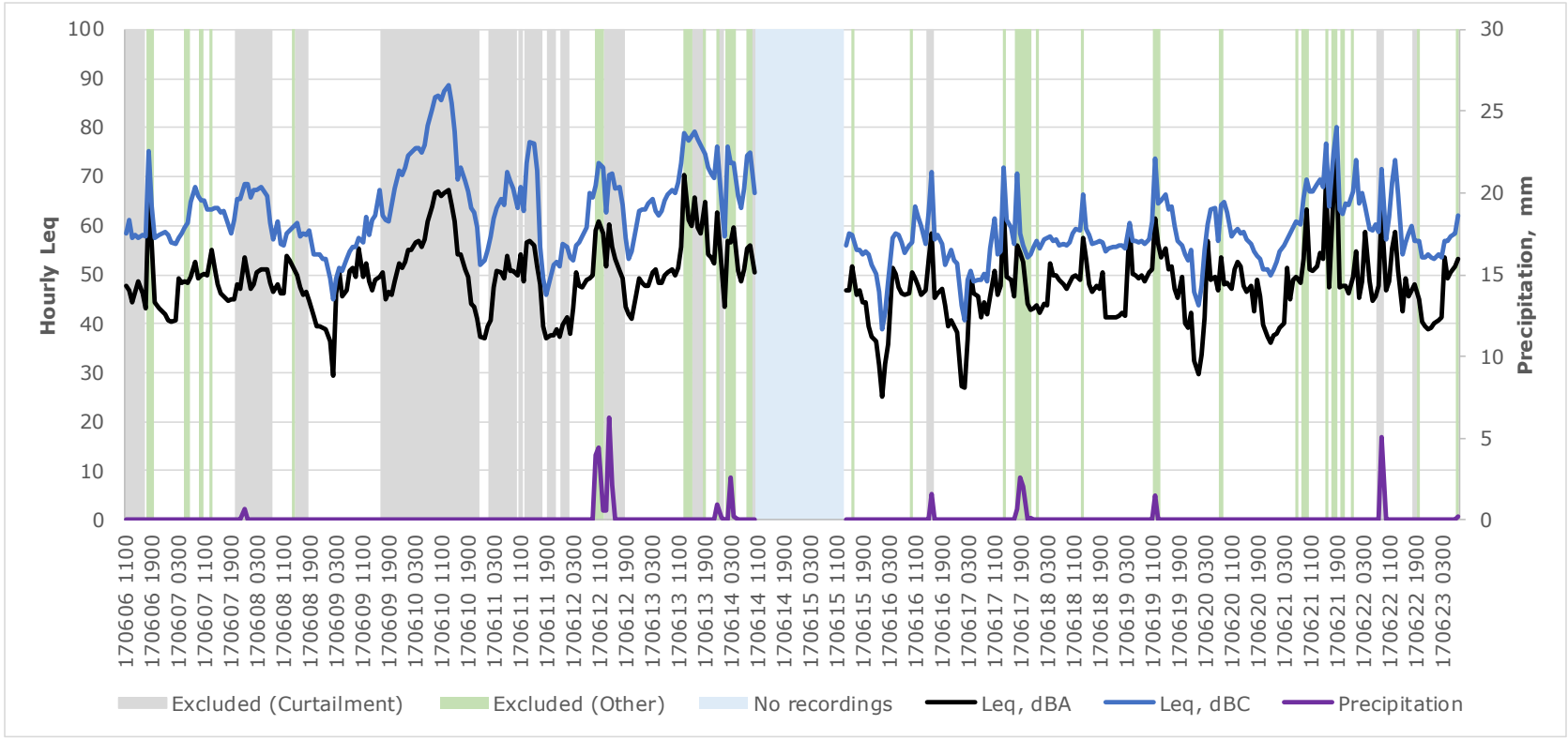
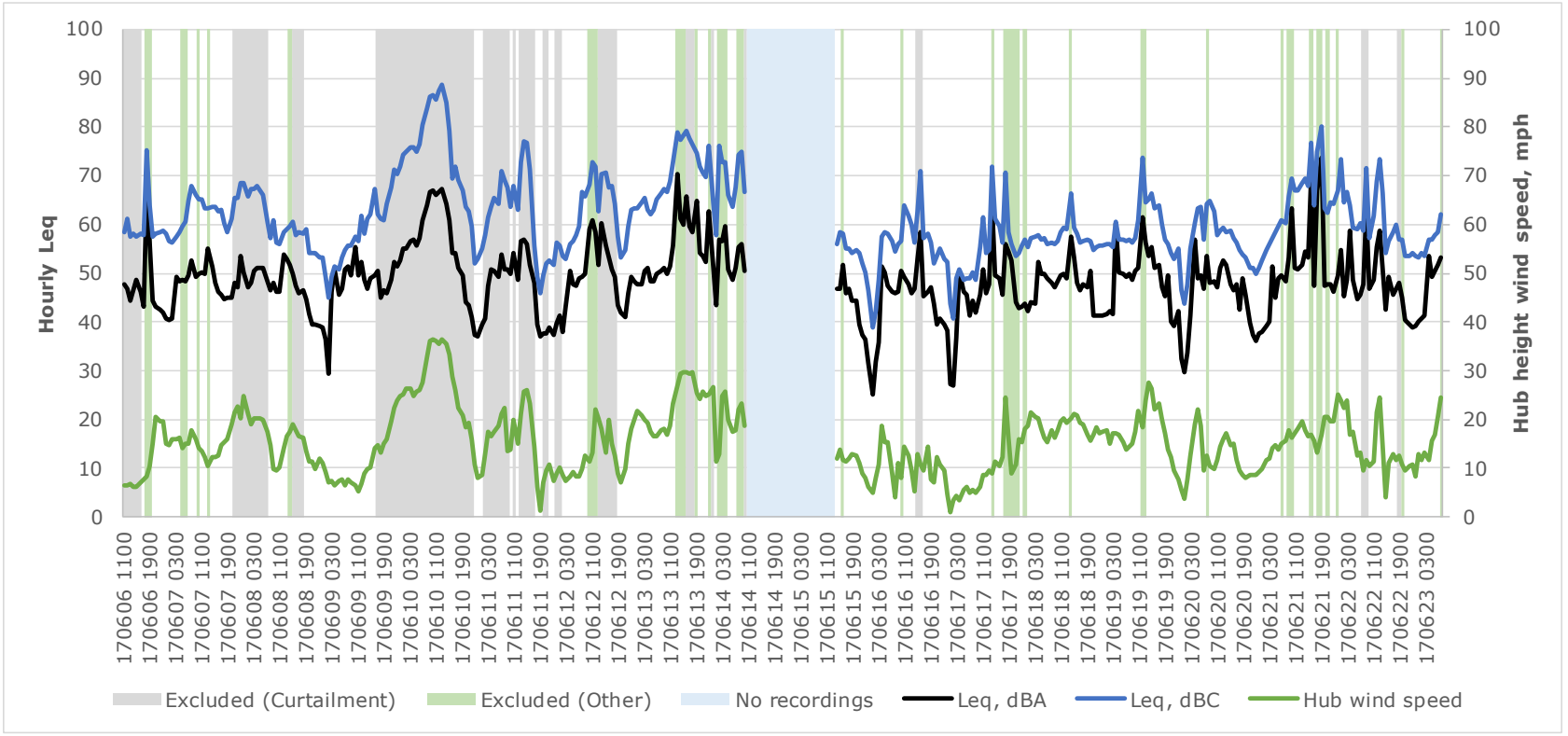


Figure 12 BT-M02 Hourly Leq with Hub Height Wind Speed



In Figure 13 and Figure 14, A-weighted and C-weighted centiles are plotted with hub height wind speeds. The marker on these figures represents the L50, with the top of the line representing the L10 and the bottom of the line representing the L90. A longer line between the L10 and L90 values means that there was more variability within the hour's sound levels. During the campaign, general correlation between centile levels and hub winds were observed during most periods of valid data.

Figure 13 BT-M02 Hourly A-Weighted Centiles with Hub Height Wind Speed

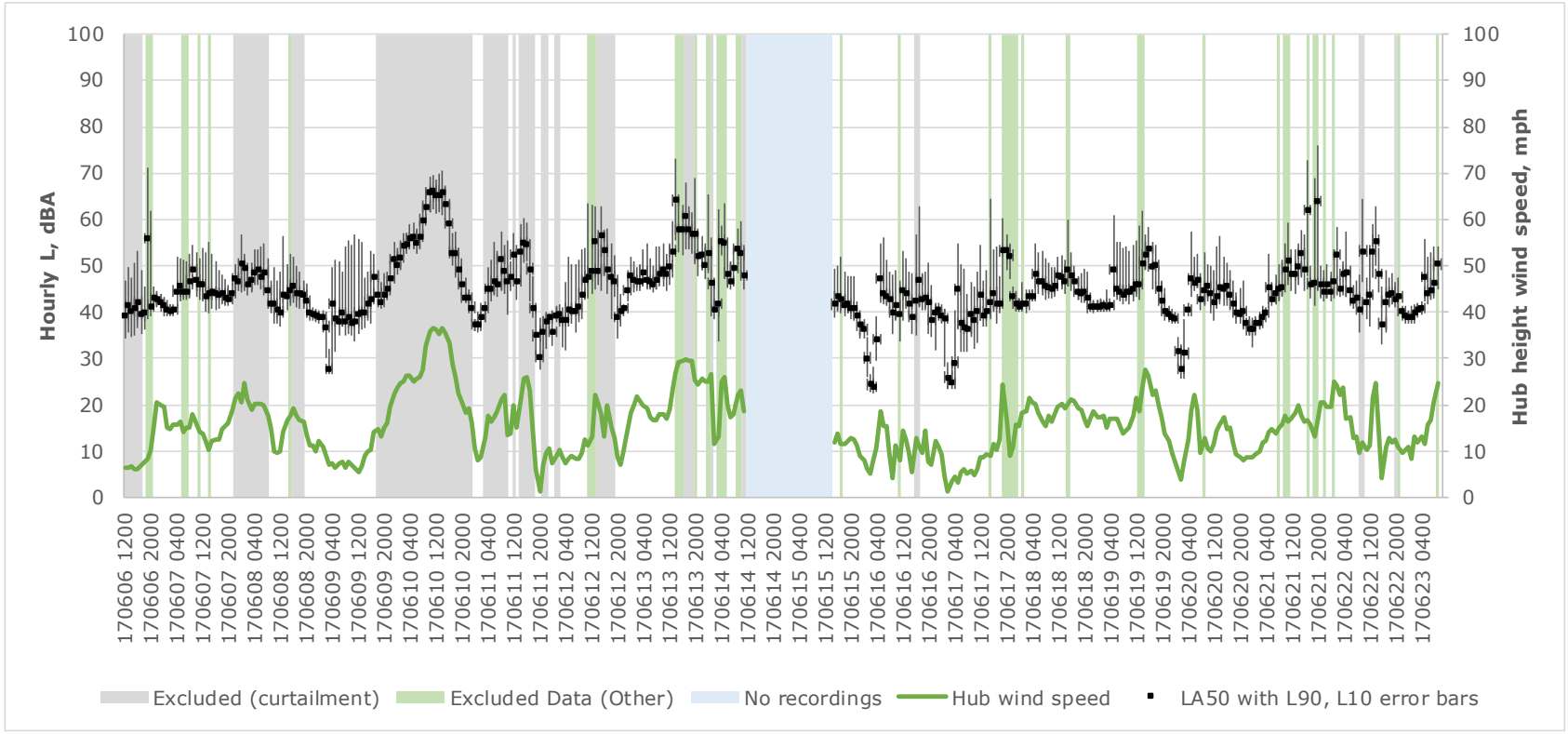
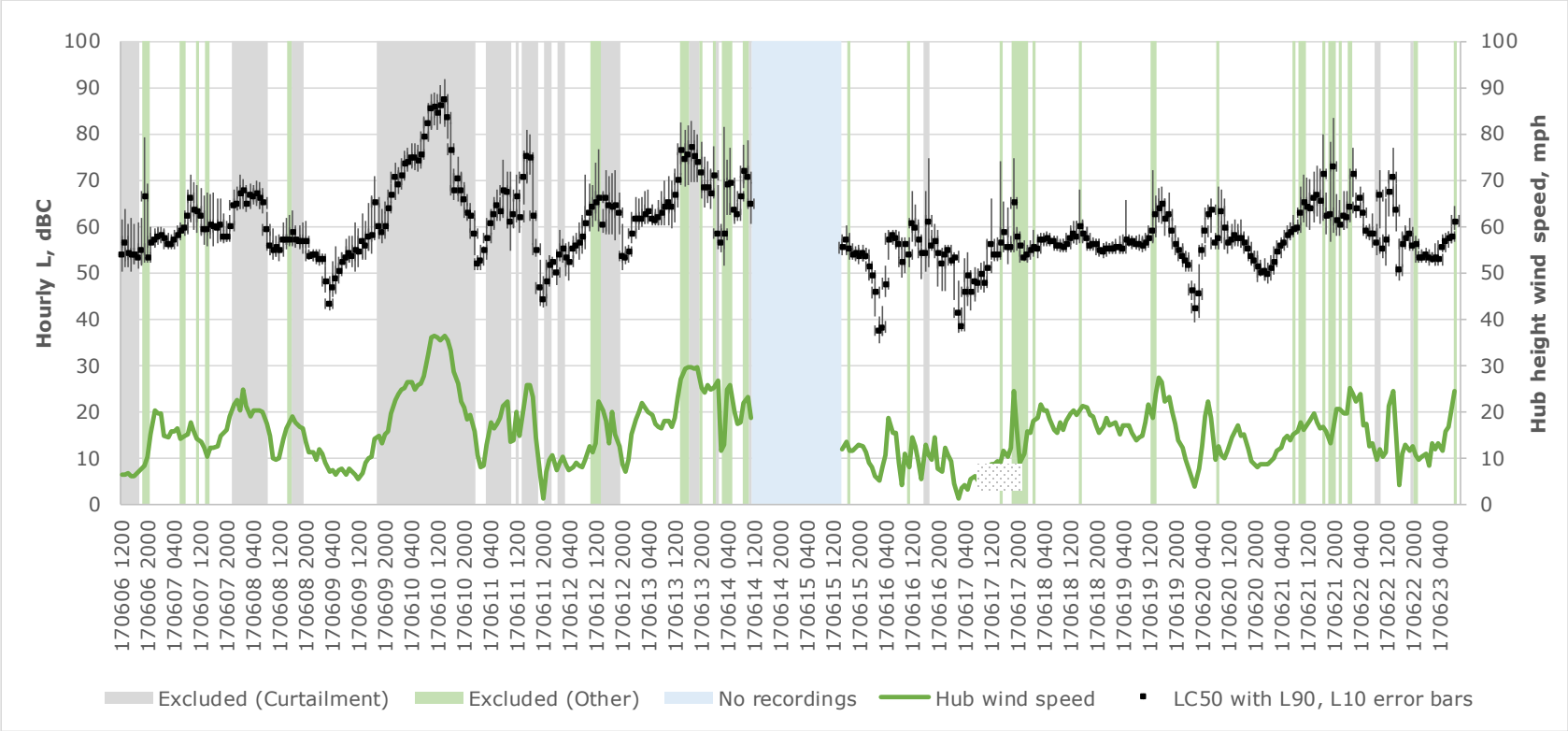


Figure 14 BT-M02 Hourly C-Weighted Centiles with Hub Height Wind Speed



In Figure 15 and Figure 16, A-weighted and C-weighted centiles are plotted with microphone height wind speeds. As mentioned above in Section 4.1, microphone height winds can be an indicator of the influence of wind noise on measured levels.

Figure 15 BT-M02 Hourly A-Weighted Centiles with Microphone Wind Speed

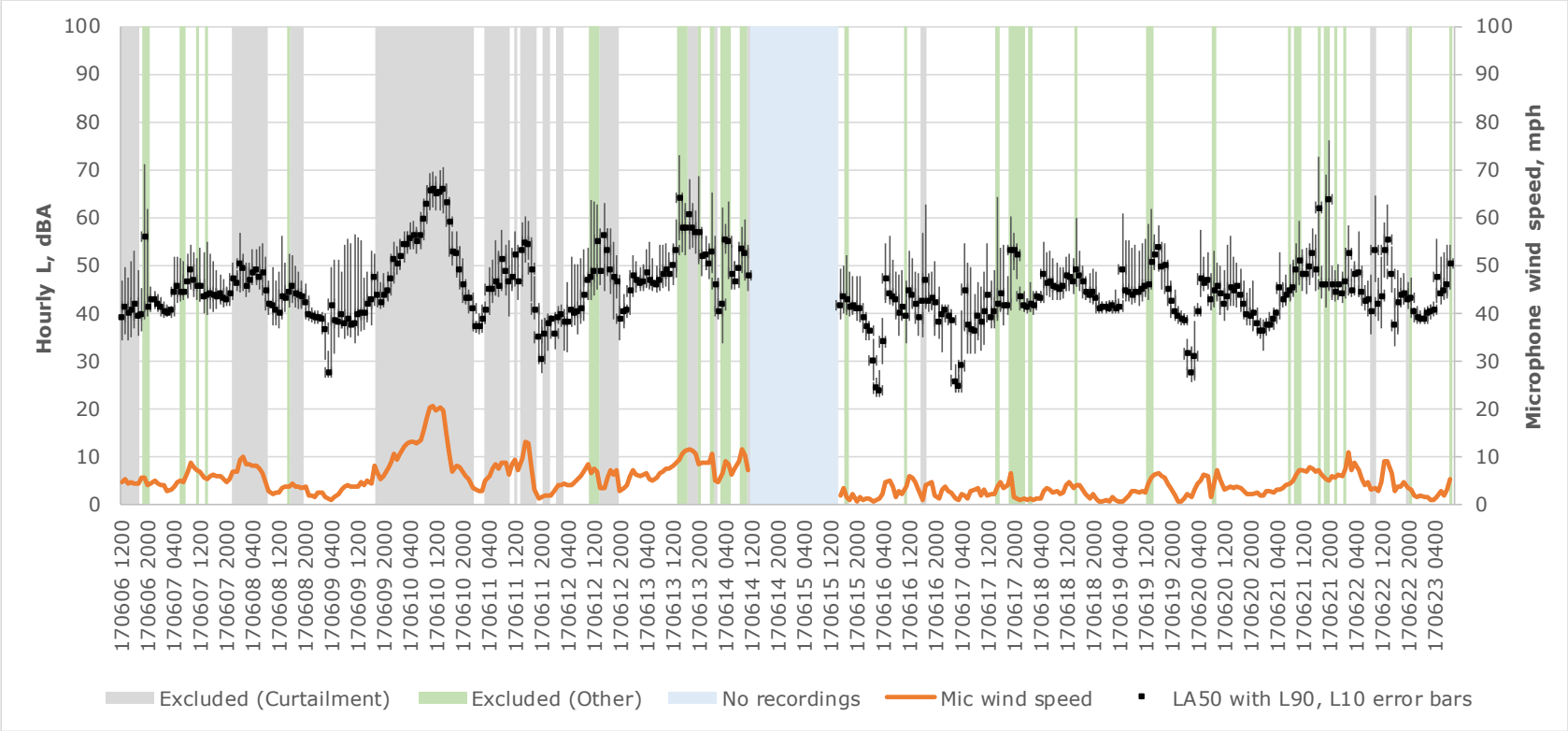


Figure 16 BT-M02 Hourly C-Weighted Centiles with Microphone Wind Speed

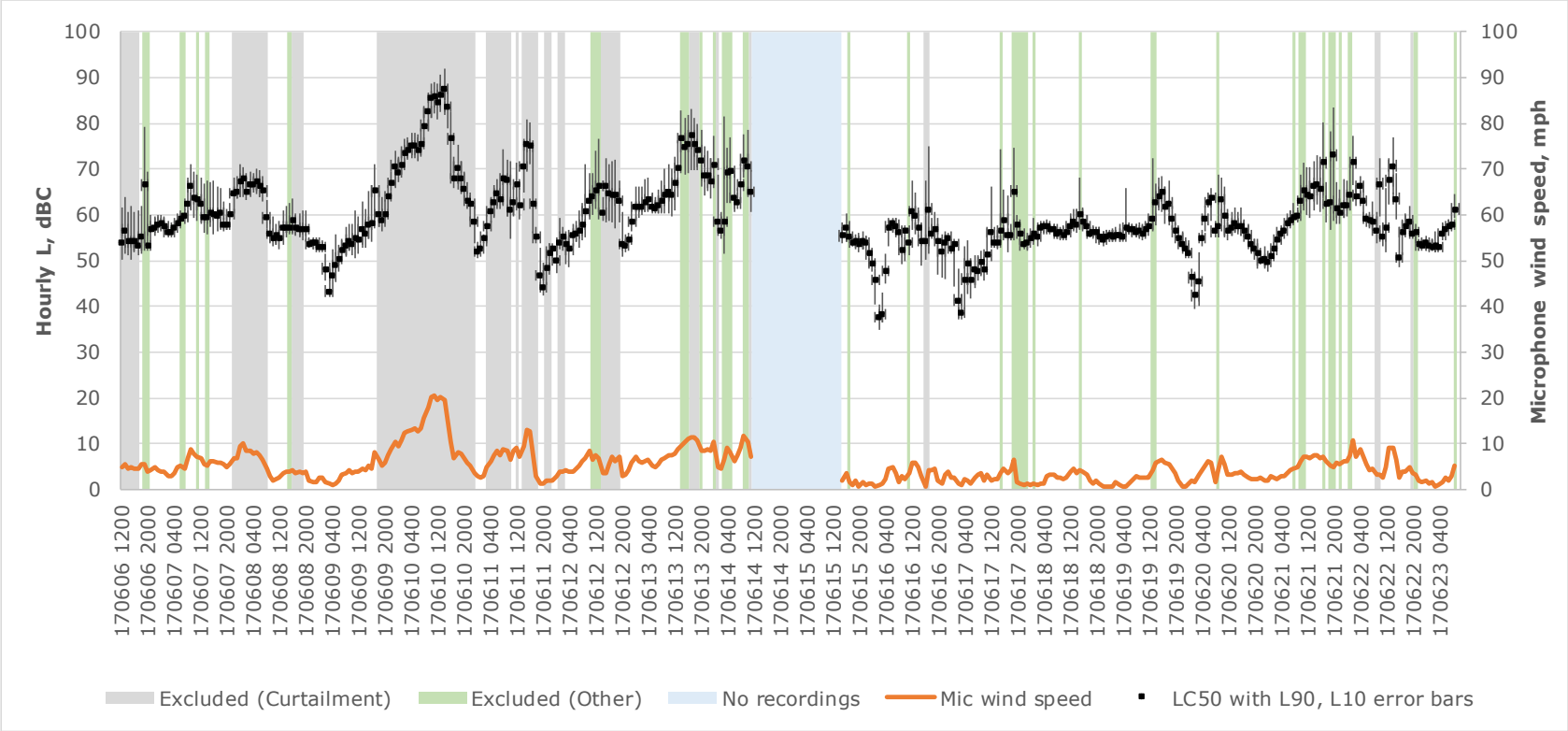


Figure 17 and Figure 18compare the measurement data against the MPCA L_{10} and L_{50} nighttime and daytime limits. Excluded data points are shown as light grey dots, while valid data points are shown as black dots. Nine (9) hours of exceedance of the L_{10} and/or L_{50} limits were identified at BT-M02; the exceedances are shown as black dots circled in red on the graphs. Further details are provided in Table 4-4 below.

Table 4-4 BT-M02 MPCA Limit Exceedances

BT-M02 Exceedances				
Date	**Time (1 hour period starting at)**	**Statistic Exceeded**	**L_{10} Sound Level**	**L_{50} Sound Level**
13 June	10:00 pm	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	56.3	52.3
13 June	11:00 pm	LA50 nighttime limit of 50.0	n/a	50.3
16 June	6:00 am	LA10 nighttime limit of 55.0	56.1	n/a
19 June	5:00 am	LA10 nighttime limit of 55.0	61.0	n/a
19 June	6:00 am	LA10 nighttime limit of 55.0	55.3	n/a
20 June	5:00 am	LA10 nighttime limit of 55.0	57.5	n/a
22 June	2:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	58.4	52.5
22 June	5:00 am	LA10 nighttime limit of 55.0	57.3	n/a
23 June	5:00 am	LA10 nighttime limit of 55.0	55.7	n/a

During most of the nine exceedance periods, bird sounds and/or wind induced sound on tree leaves appear to be the primary contributor to the exceedances. Birds are chirping and singing in several of the recordings at the beginning of most exceedance periods between the hours of 4:00 am and 6:00 am. Wind turbine sound appears to be audible in the recordings during some of the exceedance periods. However, the contribution from the wind turbines cannot be determined without further detailed investigations in order to isolate wind turbine sound from total measured sound.

Figure 17 BT-M02 Hourly L10 Sound Levels vs. MPCA Noise Limits

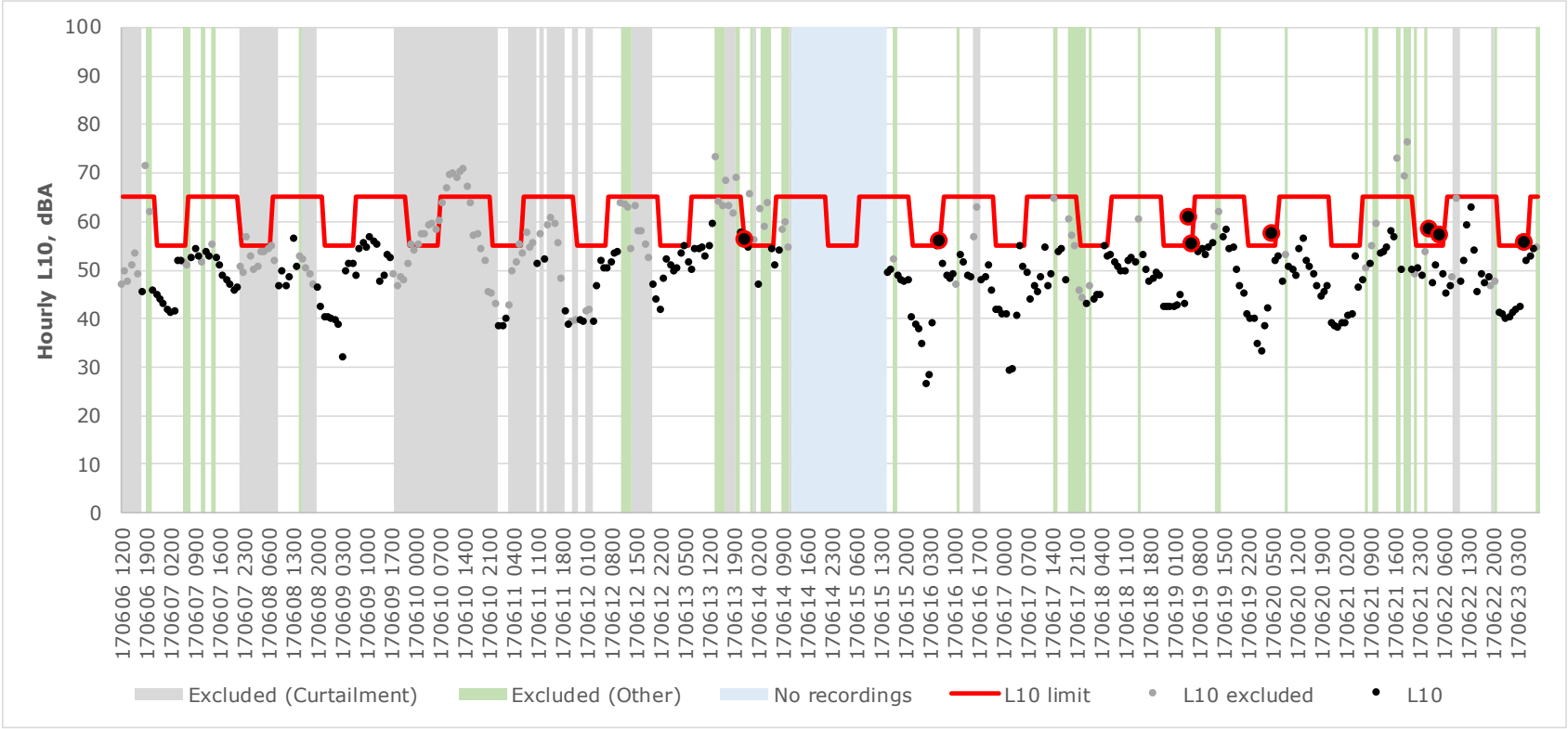
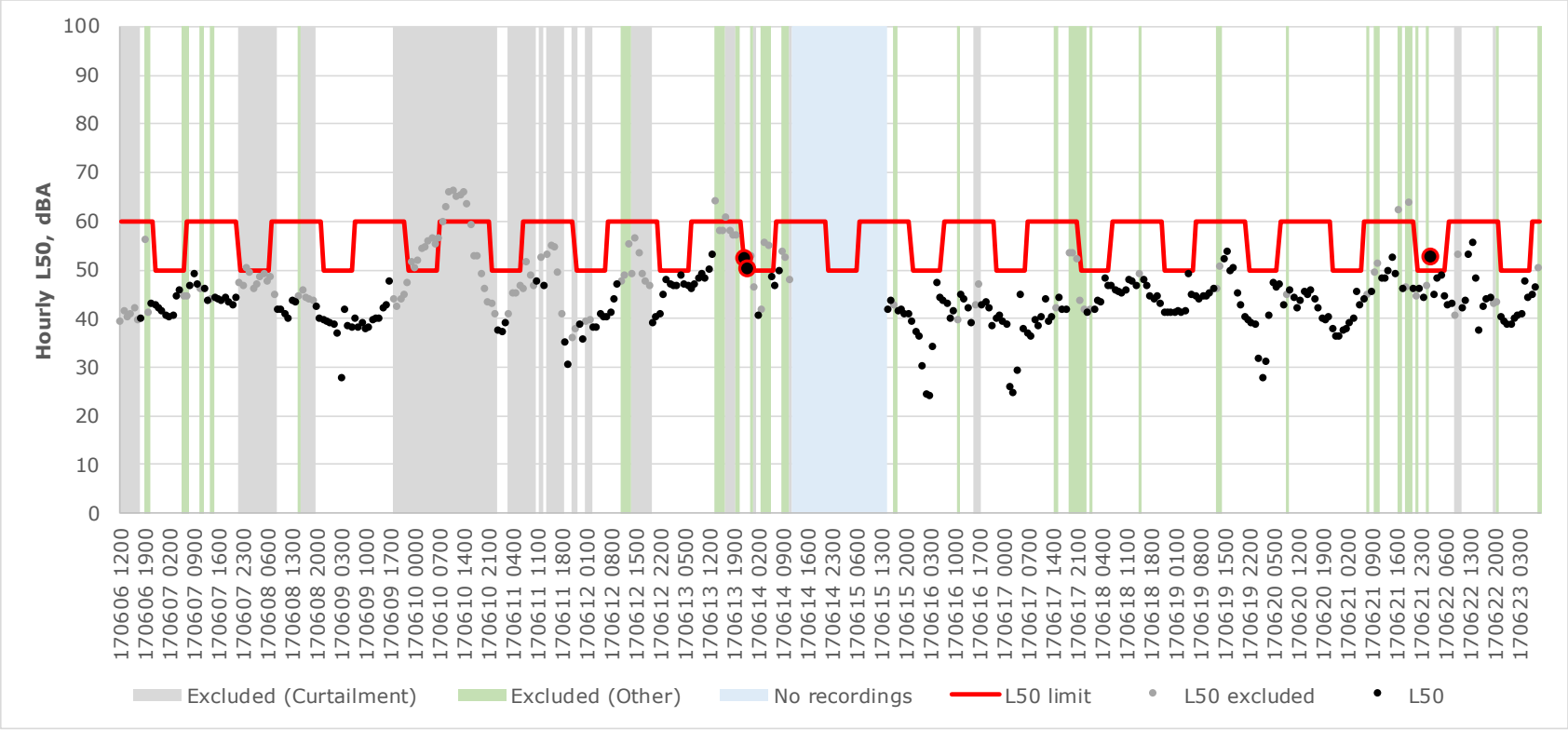


Figure 18 BT-M02 Hourly L50 Sound Levels vs. MPCA Noise Limits



4.3 Summary of Exceedances

16 total hours of non-compliance were identified at BT-M01 and BT-M02, as described in Table 4-5 and Table 4-6 below, and accompanying summaries.

Table 4-5 BT-M01 Langrud MPCA Limit Exceedances

Date	Time (1 hour period starting at)	Statistic Exceeded	L_{10} Sound Level	L_{50} Sound Level
7 June	4:00 am	LA10 nighttime limit of 55.0	55.5	n/a
13 June	5:00 am	LA10 nighttime limit of 55.0	56.2	n/a
13 June	6:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	55.2	50.8
14 June	6:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	56.9	50.8
16 June	5:00 am	LA10 nighttime limit of 55.0	55.9	n/a
18 June	4:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	55.9	52.6
18 June	5:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	61.8	53.5

Table 4-6 BT-M02 Hagens MPCA Limit Exceedances

Date	Time (1 hour period starting at)	Statistic Exceeded	L_{10} Sound Level	L_{50} Sound Level
13 June	10:00 pm	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	56.3	52.3
13 June	11:00 pm	LA50 nighttime limit of 50.0	n/a	50.3
16 June	6:00 am	LA10 nighttime limit of 55.0	56.1	n/a
19 June	5:00 am	LA10 nighttime limit of 55.0	61.0	n/a
19 June	6:00 am	LA10 nighttime limit of 55.0	55.3	n/a
20 June	5:00 am	LA10 nighttime limit of 55.0	57.5	n/a
22 June	2:00 am	LA10 nighttime limit of 55.0; LA50 nighttime limit of 50.0	58.4	52.5
22 June	5:00 am	LA10 nighttime limit of 55.0	57.3	n/a
23 June	5:00 am	LA10 nighttime limit of 55.0	55.7	n/a

During most of the 16 exceedance periods, bird sounds and/or wind induced sound on vegetation and tree leaves appear to be the primary contributor to the exceedances. Aside from two (2) 13 June and one (1) 22 June exceedances at BT-M02, all exceedances occurred between the hours of 4 and 7 am. Birds are chirping and singing in several of the recordings at the beginning of most exceedance periods starting between the hours of 4:00 am and 6:00 am.

Wind turbines were producing power during all exceedances, however with varying production ranging from 50 kW to 1,500 kW. Wind turbine sound appears to be audible in the recordings during some of the exceedance periods. However, the contribution from the wind turbines cannot be determined without further detailed investigations in order to isolate wind turbine sound from total measured sound.

5 CONCLUSION

DNV GL has completed this post-construction noise assessment in accordance with the Guidance for Large Wind Energy Conversion System Nosie Study Protocol and Report (LWECS Guidance) authored by the Minnesota Department of Commerce [1], and the Post-Construction Noise Measurement Study Protocol (DNV GL Protocol) developed by DNV GL [2]. More specifically, the Assessment was requested by EERA due to on-going complaints at two receptors within the Project Area; the Hagen and Langrud receptors.

Post-construction noise levels were hence determined at two locations within the Project area using in-situ sound meters and weather sensors.

Hourly A-weighted Leq values fluctuated at each measurement point as follows:

- 28.1 dBA to 59.6 dBA for BT-M01 (Langrud); and
- 25.0 dBA to 60.3 dBA for BT-M02 (Hagen).

16 total hours of non-compliance with the LWECS Guidance were identified at BT-M01 and BT-M02. During most of the exceedance periods, bird sounds and/or wind induced sound on vegetation and tree leaves appear to be the primary contributor to the exceedances. Wind turbine sound appears to be audible in the recordings during some of the exceedance periods. However, as stipulated in Appendix A of the LWECS Guidance, further detailed investigations would be necessary to assess the contribution of the wind turbines to the total sound levels experienced at the receptors.

As such, it is recommended to perform an additional measurement campaign to properly isolate wind turbine sound from total measured sound. This is achieved by conducting measurements where a subset of wind turbines in proximity of the complaint receptors are turned off and on under various wind and atmospheric conditions.

6 REFERENCES

[1] Minnesota Department of Commerce, Energy Facilities Permitting. Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report. 8 October 2012.

[2] DNV GL. Bent Tree Wind Farm Post-Construction Noise Measurement Study Protocol. 18 April 2017.

[3] Minnesota Administrative Rules 7030.0040 Noise Standards. Posted 12 December 2003, https://www.revisor.leg.state.mn.us/rules/?id=7030.0040.

[4] Email from Louise Miltich, EERA to Shant Dokouzian, DNV GL on 29 June 2017.

[5] Minnesota Pollution Control Agency. A Guide to Noise Control in Minnesota – Acoustic Properties, Measurement, Analysis and Regulation. 2008.

[6] International Organization for Standardization. ISO 1996-2: Acoustics – Description, measurement, and assessment of environmental noist – Part 2: Determination of environmental noise levels. 2008.

[7] Turbine curtailment and wind speed records sent by email from L. Miltich, Minnesota Department of Commerce, to S. Dokouzian, DNV GL, 27 June 2017, "BT Sound Study Curtailment Update.xlsx".

APPENDIX A – NEARBY TURBINES TO MEASUREMENTS POINTS

Turbines within 1.5 miles of each measurement point are listed in the table below.

Turbine ID	Easting	Northing	Corresponding Measurement Point
T212	463605	4843373	Langrud (M01)
T215	463487	4842910	Langrud (M01)
T220	463543	4842412	Langrud (M01)
T233	462250	4842035	Langrud (M01)
T235	462002	4842033	Langrud (M01)
T236	461353	4841760	Langrud (M01)
T239	462266	4841548	Langrud (M01)
T241	464857	4842126	Langrud (M01)
T242	464133	4841911	Langrud (M01)
T323	461124	4842656	Langrud (M01)
T324	461661	4842451	Langrud (M01)
T325	464357	4842609	Langrud (M01)
T362	462655	4842008	Langrud (M01)
T368	464659	4842396	Langrud (M01)
T369	464424	4842187	Langrud (M01)
T380	462503	4841682	Langrud (M01)
T383	461749	4841732	Langrud (M01)
T385	461300	4842304	Langrud (M01)
T427	464076	4842611	Langrud (M01)
T440	464399	4843200	Langrud (M01)
T122	462032	4848134	Hagen (M02)
T123	461789	4848005	Hagen (M02)
T127	463548	4848137	Hagen (M02)
T131	463816	4847430	Hagen (M02)
T132	463324	4847251	Hagen (M02)
T134	464343	4848417	Hagen (M02)
T135	463846	4848264	Hagen (M02)
T141	464733	4847071	Hagen (M02)
T151	461771	4846535	Hagen (M02)
T152	461356	4846831	Hagen (M02)
T161	463727	4845838	Hagen (M02)
T162	463592	4845462	Hagen (M02)
T163	462497	4845748	Hagen (M02)
T166	461883	4845729	Hagen (M02)
T168	464023	4846121	Hagen (M02)
T169	464341	4845718	Hagen (M02)
T170	464102	4845475	Hagen (M02)
T283	462210	4846230	Hagen (M02)
T284	462537	4846228	Hagen (M02)
T285	464575	4845843	Hagen (M02)

T357	462865	4846369	Hagen (M02)
T358	463725	4846605	Hagen (M02)
T359	464791	4846106	Hagen (M02)
T397	463111	4846525	Hagen (M02)
T420	463205	4847812	Hagen (M02)
T422	461531	4846450	Hagen (M02)
T436	461228	4846459	Hagen (M02)
T437	461406	4846058	Hagen (M02)
T456	462723	4845507	Hagen (M02)

UTM NAD83 Zone 15

APPENDIX B – MEASUREMENT POINT PHOTOS

BT-M01 facing Project

BT-M01 facing residence

BT-M02 facing Project

BT-M02 facing residence

APPENDIX C – CALIBRATION SHEETS

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

Manufacturer:	Larson Davis	Temperature:	74.9	°F
Model Number:	831		23.83	°C
Serial Number:	3004	Rel. Humidity:	41.4	%
Customer:	TMS Rental	Pressure:	979	mbars
Description:	Sound Level Meter		979	hPa
Note:	As Found/As Left: In Tolerance			

Upon receipt for testing, this instrument was found to be:

Within the stated tolerance of the manufacturer's specification.

Calibration Date: 5/5/2017 Calibration Due:

Calibration Standards Used:

Manufacturer	Model	Serial Number	Cal Due
Stanford Research Systems	DS360	123270	4/25/2018

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Adam Magee Signature:

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A PCB GROUP COMPANY

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Cincinnati, OH 45241
Ph: 513-351-9919
Fax: 513-458-2172
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~Certificate of Calibration~

Manufacturer: PCB
Model Number: 377B02
Serial Number: 163147
Asset ID:
Description: Free-Field Microphone

Customer: TMS Rental
Address:

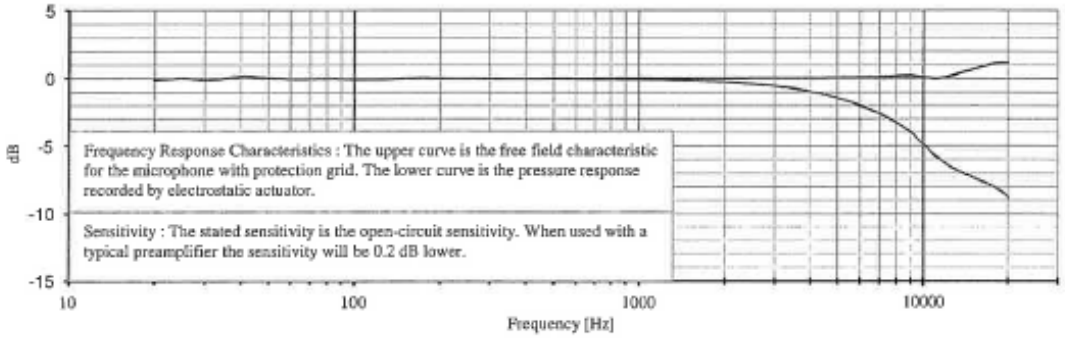
Calibration Date: Apr 20, 2017 11:58:29
Due Date:

Sensitivity:	**250 Hz**	**1 kHz**	
	-26.24	-26.33	dB re. 1V/Pa
	48.73	48.22	mV/Pa

Temperature:	75 (24)	°F (°C)
Humidity:	42	%
Ambient Pressure:	994.6	mbar

Cal. Results: In Tolerance

Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/284413-14.

Notes:
Calibration results relate only to the items calibrated.
This certificate may not be reproduced, except in full, without written permission.
This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.
Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.
Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)
20	-0.15	630	-0.01	4500	0.06		
25	-0.01	800	0.02	5000	0.07		
31.5	-0.13	1000	0.03	5600	0.09		
40	0.15	1120	0.03	6300	0.10		
50	0.05	1250	0.03	7100	0.13		
63	-0.08	1400	0.03	8000	0.18		
80	-0.03	1600	0.02	9000	0.21		
100	-0.08	1800	0.02	10000	0.09		
125	-0.08	2000	0.03	11200	0.02		
160	0.03	2240	0.03	12500	0.18		
200	0.02	2500	0.04	14000	0.48		
250	0.00	2800	0.05	16000	0.85		
315	-0.02	3150	0.05	18000	1.15		
400	-0.02	3550	0.05	20000	1.17		
500	0.01	4000	0.04				

Technician: Ed Devlin

Approval:

Reference Equipment Used:

Manuf.	*Model*	*Serial*	*Cal. Date*	*Due Date*
GRAS	40AG	9542	9/20/2016	9/20/2017

ACCREDITED
Calibration Lab
CALIBRATION CERT 2649.01

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Cincinnati, OH 45241
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Fax: 513-458-2172
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~Calibration Certificate~

Manufacturer:	Larson Davis	Asset ID:	
Model:	CAL200	Calibration Date:	Apr 20, 2017 12:43:17
Serial Number:	11085	Due Date:	
Description:	Acoustic Calibrator	Technician:	Ed Devlin
Customer:	TMS Rental	Approval:	

Calibration Results:

Measured SPL : 93.91 dB re. 20µPa

Measured Frequency : 1,000.00 Hz

Temperature:	24 °C (75 °F)
Humidity:	42.00%
Pressure:	993.9 mbar

Upon receipt for calibration, the instrument was found to be:
WITHIN the stated tolerance of the manufacturer's specification.

Note: **As Found / As Left: In Tolerance.**

Measurement uncertainty at 95% confidence level: 0.25 dB

The subject instrument was calibrated to the indicated specification using standards stated below or to accepted values of natural physical constants. This document certifies that the instrument met the following specification

This calibration is traceable through : 683/284413-14

Notes:
The calibration was performed under operating procedures intended to implement the requirements of ISO 9001, ISO 17025 and ANSI Z540. Unless otherwise noted, the reported value is both "as found" and "as left" data. Calibration results relate only to the items calibrated. This certificate may not be reproduced, except in full, without written permission.

Reference Equipment Used:

Manuf.	*Model*	*Serial*	*Cal. Date*	*Due Date*
GRAS	40AG	9542	9/20/2016	9/20/2017

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~Calibration Certificate~

3149 East Kemper Rd.
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Ph : 513-351-9919
Fax: 513-458-2172
www.modalshop.com

Manufacturer:	Larson Davis	Asset ID:	
Model:	CAL200	Calibration Date:	Apr 20, 2017 12:50:20
Serial Number:	11085	Due Date:	
Description:	Acoustic Calibrator	Technician:	Ed Devlin
Customer:	TMS Rental	Approval:	

Calibration Results:

Measured SPL : 113.90 dB re. 20µPa

Measured Frequency : 1,000.00 Hz

Temperature:	24 °C (75 °F)
Humidity:	42.00%
Pressure:	993.9 mbar

Upon receipt for calibration, the instrument was found to be:
WITHIN the stated tolerance of the manufacturer's specification.

Note: **As Found / As Left: In Tolerance.**

Measurement uncertainty at 95% confidence level: 0.25 dB

The subject instrument was calibrated to the indicated specification using standards stated below or to accepted values of natural physical constants. This document certifies that the instrument met the following specification

This calibration is traceable through : 683/284413-14

Notes:
The calibration was performed under operating procedures intended to implement the requirements of ISO 9001, ISO 17025 and ANSI Z540. Unless otherwise noted, the reported value is both "as found" and "as left" data. Calibration results relate only to the items calibrated. This certificate may not be reproduced, except in full, without written permission.

Reference Equipment Used:

Manuf.	*Model*	*Serial*	*Cal. Date*	*Due Date*
GRAS	40AG	9542	9/20/2016	9/20/2017

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

Manufacturer:	Larson Davis	Temperature:	75.5	°F
Model Number:	831		24.20	°C
Serial Number:	3308	Rel. Humidity:	37.9	%
Customer:	TMS Rental	Pressure:	986.9	mbars
Description:	Sound Level Meter		986.9	hPa
Note:	As Found / As Left: In Tolerance			

Upon receipt for testing, this instrument was found to be:

Within the stated tolerance of the manufacturer's specification.

Calibration Date: 4/5/2017 Calibration Due:

Calibration Standards Used:

Manufacturer	Model	Serial Number	Cal Due
Stanford Research Systems	DS360	123270	4/19/2017
Larson Davis	2239	109	4/22/2017

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Adam Magee Signature:

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~Certificate of Calibration~

Manufacturer: PCB
Model Number: 377B02
Serial Number: 152980
Asset ID:
Description: Free-Field Microphone

Customer: TMS Rental
Address:

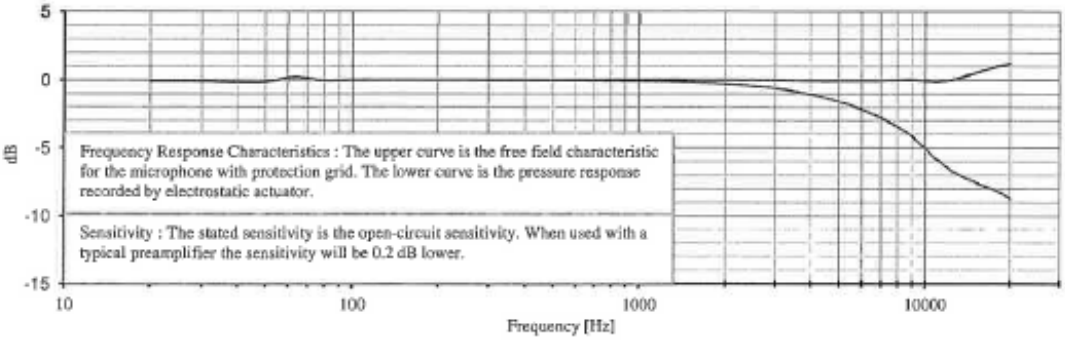
Calibration Date: Apr 20, 2017 11:54:25
Due Date:

Sensitivity:	**250 Hz**	**1 kHz**	
	-26.76	-26.85	dB re. 1V/Pa
	45.92	45.44	mV/Pa

Temperature:	75 (24)	°F (°C)
Humidity:	42	%
Ambient Pressure:	994.6	mbar

Cal. Results: In Tolerance

Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/284413-14.

Notes:
Calibration results relate only to the items calibrated.
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This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.
Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.
Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)	Frequency (Hz)	Upper (dB)
20	-0.08	**630**	0.00	**4500**	-0.08		
25	-0.09	**800**	0.02	**5000**	-0.08		
31.5	-0.11	**1000**	0.03	**5600**	-0.07		
40	-0.18	**1120**	0.03	**6300**	-0.07		
50	-0.15	**1250**	0.03	**7100**	-0.06		
63	0.21	**1400**	0.03	**8000**	-0.01		
80	-0.03	**1600**	0.01	**9000**	0.03		
100	0.01	**1800**	0.00	**10000**	-0.09		
125	0.02	**2000**	0.01	**11200**	-0.14		
160	0.01	**2240**	0.00	**12500**	0.02		
200	0.01	**2500**	0.00	**14000**	0.29		
250	0.00	**2800**	-0.01	**16000**	0.66		
315	0.01	**3150**	-0.02	**18000**	1.00		
400	0.00	**3550**	-0.05	**20000**	1.18		
500	0.01	**4000**	-0.07				

Technician: Ed Devlin

Approval: Edward A. Devlin

Reference Equipment Used:

Manuf.	*Model*	*Serial*	*Cal. Date*	*Due Date*
GRAS	40AG	9542	9/20/2016	9/20/2017

ACCREDITED
Calibration Lab
CALIBRATION CERT 2649.01

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BENT TREE WIND FARM

Post-Construction Noise Measurement Study Protocol

Wisconsin Power and Light Co

Document No.: 10046144-HOU-R-01-A
Date: 18 April 2017
Revision: A

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Project name:	Bent Tree Wind Farm	DNV GL - Energy
Report title:	Post-Construction Noise Measurement Study Protocol	Renewables Advisory 333 SW 5th Ave
Customer:	Wisconsin Power and Light Co, 31072 State Highway 13 Hartland, MN 56042	Portland, OR 97213 1-503-222-5590, x132 Enterprise No.: 94-3402236
Contact person:	Andrew Hanson	
Date of issue:	18 April 2017	
Project No.:	10046144	
Document No.:	10046144-HOU-R-01-A	
Issue:	A	
Status:	Draft	

Task and objective: Prepare a protocol for post-construction noise measurements

Prepared by:	Verified by:	Approved by:
A. Nercessian Engineer, Development and Engineering Services	K. Kallevig-Childers Project Manager, Environmental and Permitting Services	S. Dokouzian Senior Project Manager, Development and Engineering Services

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☐ Published

Keywords:
Post Construction Noise measurement, Wind Farm

Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	18 April 2017	DRAFT	A. Nercessian	K. Kallevig-Childers	S. Dokouzian

Table of contents

1 INTRODUCTION

1.1 Background

The Department of Commerce, Energy, Environment Review and Analysis (EERA, formerly Energy Facilities Permitting) of the state of Minnesota has requested, on behalf of Wisconsin Power and Light Co ("WPL" or the "Customer"), that Garrad Hassan America, Inc. ("DNV GL") provide Acoustic audit services, in the form of a post-construction noise measurement audit for the Bent Tree Wind Farm ("Bent Tree" or "Project"). The Project is located near the town of Hartland, in Freeborn County, Minnesota, approximately 90 miles south of Minneapolis. The Project consists of 122 Vestas V82-1.65 MW wind turbine generators, which began operation in 2011.

The purpose of the proposed noise measurement protocol is to satisfy the requirements of the Project's permit while following the "Guidance for Large Wind Energy Conversion System (LWECS) Noise Study Protocol and Report" ("Guidance") [1] issued by the EERA, in collaboration with the Minnesota Pollution Control Agency (MPCA) 7030.0040 Noise standards [2]. More specifically, the audit will be conducted, at the request of EERA, due to on-going complaints at two receptors within the Project Area; the Hagen and Langrud receptors.

The present document outlines the noise measurement protocol that has been developed prior to undertaking the post-construction noise measurements. The measurement campaign will enable the EERA to validate if compliance is met at the complainants, as evaluated according to the Guidance.

1.2 Compliance with the Guidance Requirements

Table 1-1 below helps demonstrate the compliance of the protocol proposed herein by providing the key to Sections of this report relevant to the requirements of the Guidance.

Table 1-1 Compliance Matrix.

Guidance Requirements	Relevant Section in this Report	Comments on the Protocol described in this Report
Monitoring Conditions		
1. Monitoring Within the Project, Same Locations, Turbines On, Turbines Off.	Sections 2.2.1 & 2.3.1	Compliant with Guidance 1.b as it is a post-construction audit
2. Monitoring Off-Site, Same Timeframe**.**	Section 2.2.1	As agreed with the EERA
3. Results from Monitoring Without Turbines Present or Operating**.**	N/A	Compliant with Guidance 1.b as it is a post-construction audit
4. Data Sets.	Sections 2.3.1 & 2.4	Compliant
5. Seasonal Timing.	Section 2.3.2	Compliant
6. All Turbines Operating.	Section 2.2.1	Compliant
Monitoring Locations **7, 8, 9, 10, 11, 12 & 13**	Section 2.2	Compliant, with consideration that the locations are for two complaints (e.g. at two receptors) and will not include an off-site location
Monitoring Duration **14.**	Section 2.3.1	Compliant
Monitoring Wind Speeds **15, 16 & 17**	Sections 2.1 & 2.3.1	Compliant
Instruments **18.**	Section 2.1	Compliant
Methodology **19, 20, 21 & 22**	Section 2.3.1 & 2.4	Compliant
Processing the Data **23, 24 & 25**	Sections 2.4 & 2.4.1	Compliant
Results and Charts		
26. Results at Varying Wind Speeds	Section 2.4	Compliant

Guidance Requirements	Relevant Section in this Report	Comments on the Protocol described in this Report
27. Results at Varying Frequencies.	Section 2.4	Compliant
28. Document Varying Wind Directions and Other Meteorological Conditions	Section 2.4	Compliant; will be obtained from turbine anemometry and weather sensors at measurement locations
29. Comparison to Minnesota Noise Standards.	Section 2.4.4	Compliant
30. Map Location of Monitoring Points.	Section 2.4 & Figure 2-1	Compliant
31. Results of Noise Modeling.	Sections 2.4.2 & 2.4.3	Compliant
Conclusions **32.**	Section 2.4	Compliant
Noise Study Protocol **33 & 34**	Sections 2.4 & 3	Compliant
Noise Study Report **35 & 36**	Sections 2.4 & 3	Compliant
E-Filing **37**	Section 3	Compliant

2 METHODOLOGY

All instrumentation, measurement settings, data collection, processing and reporting procedures will be compliant with the Guidance as well as with the MPCA's Measurement Procedure for Non-impulsive noise, designated as method NTP-1 [3]. The methodology will additionally consider the following ISO standards related to acoustic sound measurements: 1996-1, 1996-2 and 1996-3 [4]. The following subsections provide details and description.

2.1 Instrumentation

The acoustic and meteorological measurements data gathered in the context of this study will be obtained using the following instruments (see Appendix A for photographs):

- Larson Davis sound meter model 831 Class I;
- FreeField ½ inch microphone model 377B02;
- Preamplifier model PRM831; and
- Complete kit for outside noise measurement (including a wind and rain screen, protective Pelican case, long range batteries, etc.).

The sound meters used by DNV GL meet the IEC 61672 Class 1 specifications. The accuracy of the sound meter calibration will be verified on site before and after each measurement with a Larson Davis CAL200 Class I calibrator: the differential calibration will not be greater than 0.5 dBA. All instruments will have a valid calibration. In addition to recording sound levels, the Larson Davis sound meter will also record sounds at the beginning of each monitoring hour and when certain levels are attained. In addition to observations from the DNV GL field engineer, this facilitates the screening of particular events and determining if the corresponding high sound level is representative of the ambient noise or if it is an exceptional event which should be rejected from the final dataset.

The following meteorological parameters will be recorded, at the measurement locations and heights:

- Wind speed and direction;
- Precipitation and relative humidity;
- Temperature.

In addition, operational data, including wind turbine anemometry data, will be considered during the post-construction campaign.

Based on the above descriptions, the instrumentation will comply with the requirements of the Guidance and NTP-1 [3].

2.2 Selection of Measurement Locations

It is expected that existing ambient noise levels (e.g. without the contribution of the Project) will be characterized mainly by domestic and rural activities, natural sounds and transportation noise on secondary roads. The following subsections describe the approach suggested to comply with the requirements of the Guidance.

2.2.1 On-site monitoring

On-site monitoring will be conducted at the two receptors, identified as BT-M01 and BT-M02, while the Project is in full operation. Table 2-1 summarizes the selected monitoring locations.

Figure 2-1 presents a general overview map of the measurement locations in relation to the Project. Figure 2-2 provide preliminary locations for the equipment on the properties. Final locations on the properties will be confirmed during equipment set-up in order to ensure compliance with the Guidance and measurement best practices.

As discussed with EERA, off-site monitoring will not be conducted as it does not provide additional benefit in evaluating compliance at the complainants receptors.

Table 2-1 Measurement Point Summary

Measurement point ID	Receptor address	Distance to nearest turbine	Notes
BT-M01 (Langrud)	25887 – 705th Avenue, Alden, MN 56009	350 m (1150 feet) from Turbine 362	Closest wind turbines are NE and SE
BT-M02 (Hagen)	70286 – 290th Street, Hartland, MN 56042	465 m (1525 feet) from Turbine 132	Closest wind turbine is West

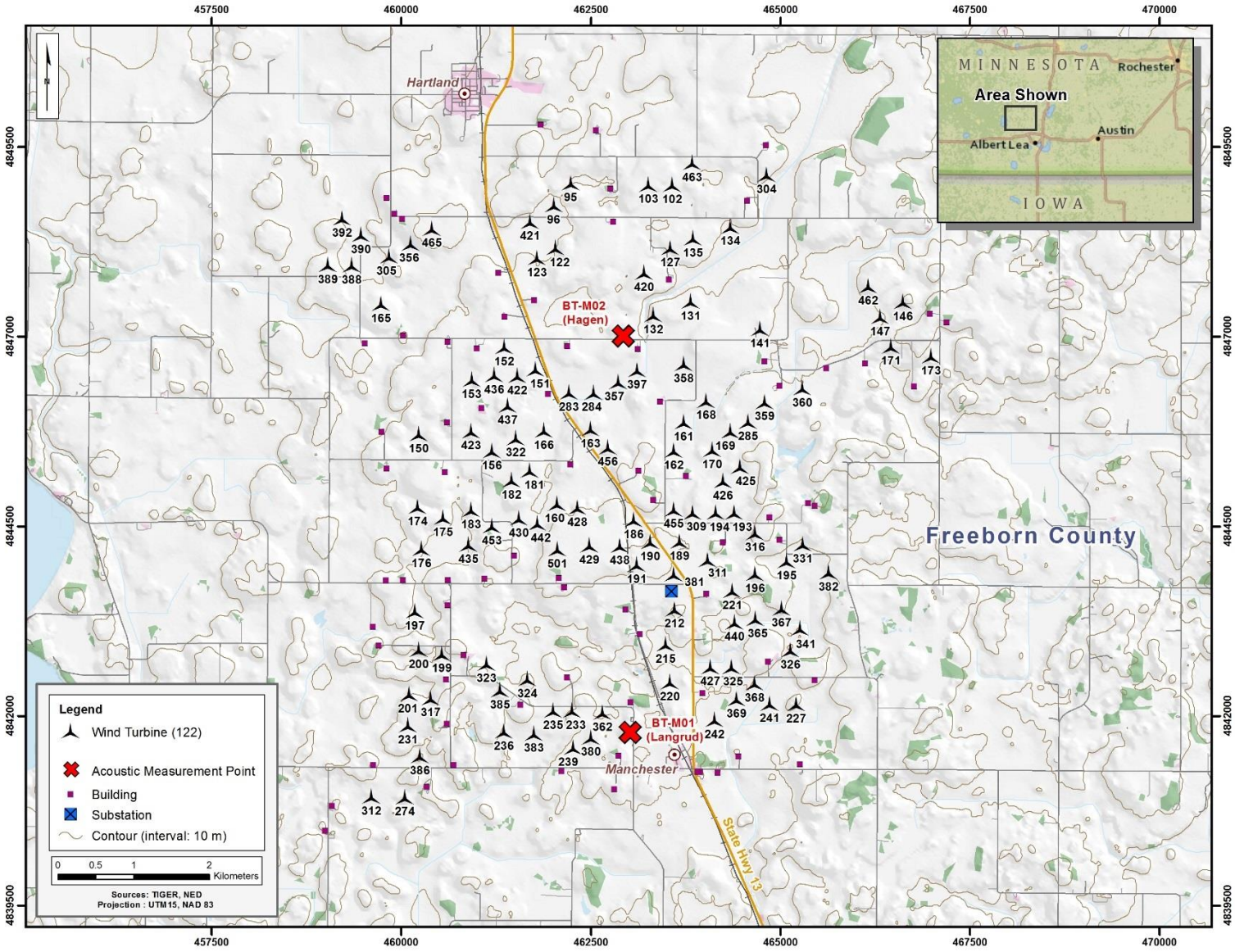

Figure 2-1 Map of Project and Monitoring Locations

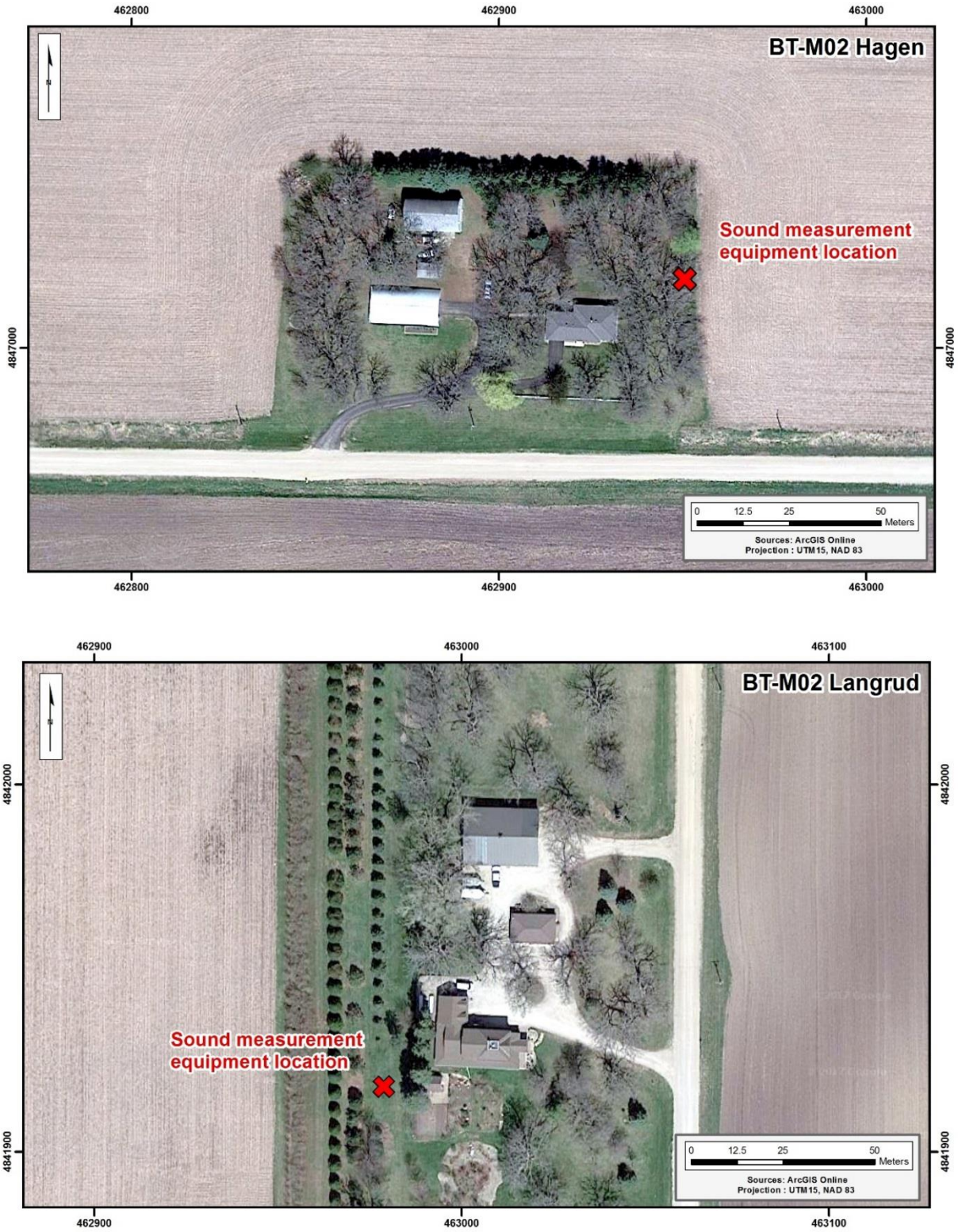

Figure 2-2 Equipment Locations

2.3 Data Collection

2.3.1 Measurements

Un-attended measurements will last for at least 7 days, in order to collect data in various wind conditions, during day and night. This timeframe may be extended if it is deemed that too much data will be filtered out due to extended periods of high wind or precipitation.

Microphones will be installed approximately 1.5 m (5 feet) above ground, and site calibration will be performed before and after each monitoring period. The microphones will also be placed at least 6 m (20 feet) from large reflecting surfaces.

Measurements will be made continuously using a FAST response setting and will be averaged and stored every 10 seconds, along with the relevant statistics for that period. Sound events louder than 60 dBA will be recorded for analysis and possible filtering. The remaining data will be averaged on an hourly basis during post processing.

The measurements will include un-weighted sound (in dB); A-weighted as L_{10}, L_{50}, L_{90} and Leq (dBA); and C-weighted L_{10}, L_{50}, L_{90} and Leq (dBC). Third octave band measurements ranging from 16 Hz to 8000 Hz will also be recorded.

Environmental sound measurements are greatly influenced by wind-induced sound. To avoid this unwanted effect, DNV GL uses a foam wind screen, as per industry standards. This enables the measurement of sound (without wind-induced sound effects on the microphone) in winds up to 11 miles/hour (i.e. 5 m/s) at the measurement level. Measurements taken during winds higher than 11 miles per hour and other adverse conditions such as rain will not be used in the measurement campaign as per Monitoring Condition 4 of the Guidance. For each location both raw and filtered data will be provided along with the percentage of data removed.

In addition to wind speed and direction, temperature, precipitation and relative humidity monitoring at the microphone level, hub height hourly anemometry and operational data will be provided from the turbines internal SCADA system.

A log of precipitation events occurring during the measurement period will be obtained from the nearest weather station.

2.3.2 Seasonal Timing

Post-construction measurements will be conducted in spring 2017, while the Project is in full operation. Spring has a variety of wind and atmospheric conditions, with less intrusion of natural sounds.

2.4 Data Processing and Reporting

Once the post-construction measurement campaign is complete, all data sets will be quality controlled as per the Guidance requirements notably including:

- Results at varying wind speeds,

- Results at varying frequencies,
- Wind speed, direction and relevant meteorological conditions, and
- Percentage of filtered data for each hour will be reported.

Collected data and reporting will align with the Guidance's requirements and identification of any hourly exceedances, if any. As per the Guidance's requirements, the report will discuss the following:

- A narrative conclusion regarding how well the results compare to the expected sound levels for the project; including explanations, to the extent possible, if the results do not compare favorably.
- A summary of the L_{10} and L_{50} hourly determinations that are above the Minnesota noise standards for each monitoring location.
- A narrative conclusion regarding how well the results provide information regarding the modeling as a predictor of probable compliance with the Minnesota noise standards; including explanations, to the extent possible, if the results do not compare favorably.

2.4.1 Data processing in compliance with the Guidance

Hourly data series for the entire measurement period for each point will be created in the form of L_{10}, L_{50} L_{90} and Leq sound levels, in dB, dBA and dBC. These cleaned data series as well as concurrent data series of wind speed (miles per hour) at hub height and microphone height and relative humidity will be presented in different charts (one per measurement point).

For the worst case receptor measurement location, a comparative third-octave band chart will be created for a representative wind speed and over a range of at least 16 Hz to 8000 Hz, using un-weighted, A-weighted, and C-weighted Leq data.

2.4.2 Validation of noise modelling

In order to evaluate the accuracy of pre-construction noise modelling, the total quality-controlled measured night-time A-weighted L_{50} values for each measurement will be compared to modeled sound levels (including ambient noise) at each of the 2 receptors. Large discrepancies, if any, will be documented.

A map of the simulated noise contours will also be presented, adjusted to the final as-built turbine layout.

2.4.3 Discussion of noise modelling performance as a probable predictor of compliance

Should any large discrepancies between modelling and measured data be observed; a discussion will be provided to help understand the differences to the extent possible. The focus will be to provide useful information for future noise modelling and noise measurements.

2.4.4 Identification of hourly exceedances

For compliance purposes, hourly L_{50} and L_{10} data series will be graphed and every data point will be compared to the MPCA limits [2] for every receptor. Periods of high wind and precipitation will be identified. It is understood that the limits apply to total noise and not just facility noise, unless there are exceedances

in which case Project attribution, e.g. assessing contribution from the Project only, may be investigated at a later stage.

3 CONCLUSION

EERA has requested, on behalf of WPL, that DNV GL provide a post-construction noise measurement audit and protocol for the Bent Tree Wind Farm. The Project is located near the town of Hartland, in Freeborn County, Minnesota, approximately 90 miles south of Minneapolis. The Project consists of 122 Vestas V82-1.65 MW wind turbine generators, which began operation in 2011.

This protocol has been developed to follow the "Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report", wherever applicable in the context of a post-construction audit at complainant's properties.

This protocol as well as the final noise measurement report will be E-filed as per the instructions in the Guidance paragraphs 33 through 37.

4 REFERENCES

[1] Minnesota Department of Commerce, Energy Facility Permitting. "Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report." October 8 2012.

[2] Minnesota Administrative Rules. 7030.0040 NOISE STANDARDS. https://www.revisor.leg.state.mn.us/rules/?id=7030.0040

[3] A Guide to Noise Control in Minnesota – Acoustic Properties, Measurement, Analysis and Regulation, Minnesota Pollution Control Agency, 2008.

[4] ISO 1996-2 "Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels".

[5] International Electrotechnical Commission, "IEC 61672 Electroacoustics – Sound Level Meter," First Edition 2002-05.

APPENDIX A – TYPICAL INSTRUMENTATION PHOTOGRAPH

In-situ set-up of Sound Measurement Equipment

DNV·GL

BENT TREE WIND FARM

Phase 2 Post-Construction Noise Measurement Study Protocol

Wisconsin Power and Light Co

Document No.: 10046144-HOU-R-03-A
Date: 27 September 2017
Revision: A

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Project name:	Bent Tree Wind Farm	DNV GL - Energy
Report title:	Phase 2 Post-Construction Noise Measurement Study Protocol	Renewables Advisory 333 SW 5th Ave
Customer:	Wisconsin Power and Light Co, 31072 State Highway 13 Hartland, MN 56042	Portland, OR 97213 1-503-222-5590, x132 Enterprise No.: 94-3402236
Contact person:	Andrew Hanson	
Date of issue:	27 September 2017	
Project No.:	10046144	
Document No.:	10046144-HOU-R-03-A	
Issue:	A	
Status:	Draft	

Task and objective: Prepare a protocol for post-construction noise measurements

Prepared by:	Verified by:	Approved by:
S. Dokouzian, P.Eng. Senior Project Manager, Development and Engineering Services	A. Nercessian Engineer, Development and Engineering Services	S. Dokouzian, P.Eng. Senior Project Manager, Development and Engineering Services

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Keywords:
Post Construction Noise measurement, Wind Farm

Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	27 September 2017	DRAFT	S. Dokouzian	A. Nercessian	S. Dokouzian

Table of contents

1 INTRODUCTION

The Department of Commerce, Energy, Environment Review and Analysis (EERA, formerly Energy Facilities Permitting) of the state of Minnesota has requested, on behalf of Wisconsin Power and Light Co ("WPL" or the "Customer"), that Garrad Hassan America, Inc. ("DNV GL") provide Acoustic audit services, in the form of a post-construction noise measurement audit for the Bent Tree Wind Farm ("Bent Tree" or "Project"). The Project is located near the town of Hartland, in Freeborn County, Minnesota, approximately 90 miles south of Minneapolis. The Project consists of 122 Vestas V82-1.65 MW wind turbine generators, which began operation in 2011.

1.1 Background

An audit was conducted in June 2017 by DNV GL [1], closely following the requirements under the "Guidance for Large Wind Energy Conversion System (LWECS) Noise Study Protocol and Report" ("Guidance") [1] issued by the EERA, in collaboration with the Minnesota Pollution Control Agency (MPCA) 7030.0040 Noise standards [3]. More specifically, the audit was conducted, at the request of the EERA, due to on-going complaints at two receptors within the Project Area; the Hagen and Langrud receptors. The audit, which measured the total noise experienced at the receptors, concluded that:

> *"(…) 16 total hours of non-compliance with the LWECS Guidance were identified at BT-M01 and BT-M02. During most of the exceedance periods, bird sounds and/or wind induced sound on vegetation and tree leaves appear to be the primary contributor to the exceedances. Wind turbine sound appears to be audible in the recordings during some of the exceedance periods. However, as stipulated in Appendix A of the LWECS Guidance, further detailed investigations would be necessary to assess the contribution of the wind turbines to the total sound levels experienced at the receptors.*
>
> *As such, it is recommended to perform an additional measurement campaign to properly isolate wind turbine sound from total measured sound. This is achieved by conducting measurements where a subset of wind turbines in proximity of the complaint receptors are turned off and on under various wind and atmospheric conditions."*

As requested by the EERA, a second audit (i.e Phase 2 audit), will be undertaken with the primary goal of isolating the wind turbine sound from the total measured sound.

The present document outlines the noise measurement protocol for this Phase 2 audit, which has been developed prior to undertaking the noise measurements. The measurement campaign will enable the EERA to validate if compliance is met at the complainants.

2 METHODOLOGY

All instrumentation, measurement settings, data collection, processing and reporting procedures will be compliant with MPCA's Measurement Procedure for Non-impulsive noise, designated as method NTP-1 [4] and will additionally consider the following ISO standards related to acoustic sound measurements: 1996-1, 1996-2 and 1996-3 [5]. The following subsections provide details and description.

2.1 Instrumentation

The acoustic and meteorological measurements data gathered in the context of this study will be obtained using the following instruments (see Appendix A for photographs):

- Larson Davis sound meter model 831 Class I;
- FreeField ½ inch microphone model 377B02;
- Preamplifier model PRM831;
- Vaisala Weather Transmitter model SEN-031; and
- Complete kit for outside noise measurement (including a wind and rain screen, protective Pelican case, long range batteries, etc.).

The sound meters used by DNV GL meet the IEC 61672 Class 1 specifications [6]. The accuracy of the sound meter calibration will be verified on site before and after each measurement with a Larson Davis CAL200 Class I calibrator: the differential calibration will not be greater than 0.5 dBA. All instruments will have a valid calibration. In addition to recording sound levels, the Larson Davis sound meter will also record sounds at the beginning of each monitoring hour and when certain levels are attained. In addition to observations from the DNV GL field engineer, this facilitates the screening of particular events and determining if the corresponding high sound level is representative of the ambient noise or if it is an exceptional event which should be rejected from the final dataset.

The following meteorological parameters will be recorded, at the measurement locations and heights:

- Wind speed and direction;
- Precipitation and relative humidity;
- Temperature.

In addition, operational data, including wind turbine anemometry data, will be considered during the post-construction campaign.

2.2 Measurement Locations

On-site monitoring will be conducted at the two receptors, identified as BT-M01 and BT-M02, while the Project is in full operation and while a subset of wind turbines will be parked. Table 2-1 summarizes the selected monitoring locations, which are the same as for the initial audit [1].

Figure 2-1 presents a general overview map of the measurement locations in relation to the Project. Figure 2-2 provide locations for the equipment on the properties.

Table 2-1 Measurement Point Summary

Measurement point ID	Receptor address	Distance to nearest turbine	Notes
BT-M01 (Langrud)	25887 – 705th Avenue, Alden, MN 56009	350 m (1150 feet) from Turbine 362	Closest wind turbines are NE and SE
BT-M02 (Hagen)	70286 – 290th Street, Hartland, MN 56042	465 m (1525 feet) from Turbine 132	Closest wind turbine is West

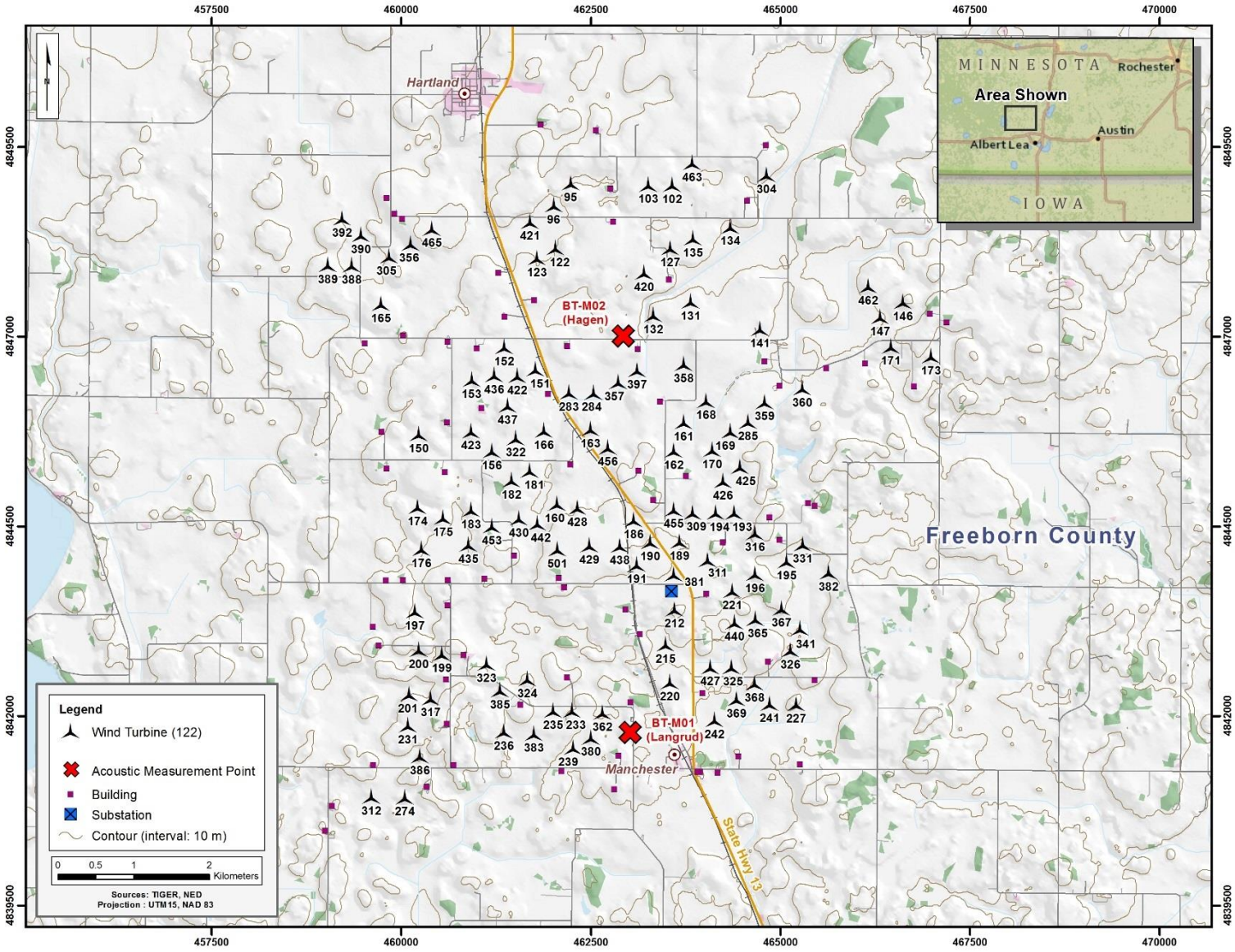

Figure 2-1 Map of Project and Monitoring Locations

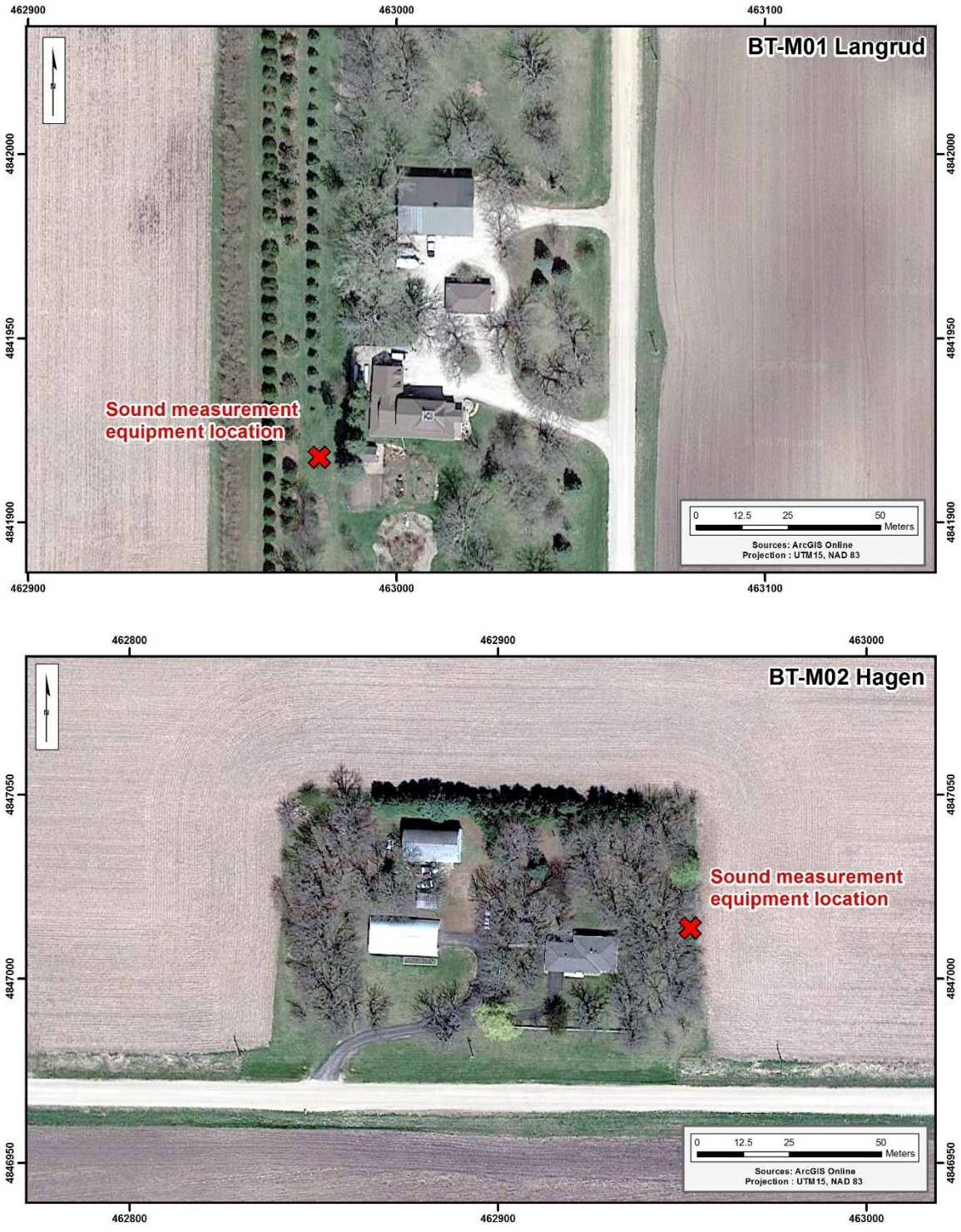

Figure 2-2 Equipment Locations on properties

2.3 Data Collection

2.3.1 Measurements

Un-attended measurements will last for approximately 7 days, in order to collect data in various wind conditions, during day and night. This timeframe may be extended if it is deemed that too much data will be filtered out due to extended periods of very high wind or precipitation.

Microphones will be installed approximately 1.5 m (5 feet) above ground, and site calibration will be performed before and after each monitoring period. The microphones will be placed at least 6 m (20 feet) from large reflecting surfaces.

Measurements will be made continuously using a FAST response setting and will be averaged and stored every 10 seconds, along with the relevant statistics for that period. Sound events louder than 60 dBA will be recorded for analysis and possible filtering.

The measurements will include un-weighted sound (in dB) and A-weighted as L_{10}, L_{50}, L_{90} and Leq (dBA). Third octave band measurements ranging from 16 Hz to 16000 Hz will be recorded.

Environmental sound measurements are greatly influenced by wind-induced sound. To avoid this unwanted effect, DNV GL will use a 175 mm (7 in) foam wind screen, as per industry standards. This enables the measurement of sound (without significant wind-induced sound effects on the microphone) in winds across a wider range of wind turbine operational wind speeds. For each location both raw and filtered data will be stored along with the percentage of data removed.

In addition to wind speed and direction, temperature, precipitation and relative humidity monitoring at the microphone level, hub height hourly anemometry and operational data will be provided from the turbines internal SCADA system.

A log of precipitation events occurring during the measurement period will be obtained from the nearest weather station.

2.3.2 Operational wind turbines (ON)

Measurements will last for 3-4 days, in order to collect data under various wind conditions. This timeframe may be extended if it is deemed that too much data will be filtered out due to extended periods of high wind or precipitation. The timeframe may also be extended if it is deemed that a representative range of wind turbine operational noise conditions did not occur.

2.3.3 Parked wind turbines (OFF)

Measurements will be conducted with turbines in a parked or "off" condition, for a duration of 2-3 days, during nighttime hours only. This will allow collection of data in various wind and atmospheric conditions when the ambient sound is at its lowest, i.e. at night, and without the contribution of the facility. Nighttime hours are between 10 pm and 7 am, as per [2].

73 turbines out of the 122 operational turbines will be parked during this period. This represents all wind turbines within 1.5 miles of the measurement points. At a distance beyond 1.5 miles, the noise contribution from the remaining 49 turbines is considered insignificant (i.e. their cumulative noise contribution is

approximately 10 dB lower when compared to the cumulative contribution of the entire wind farm). Figure 2-3 and Appendix B, identifies wind turbines to be parked.

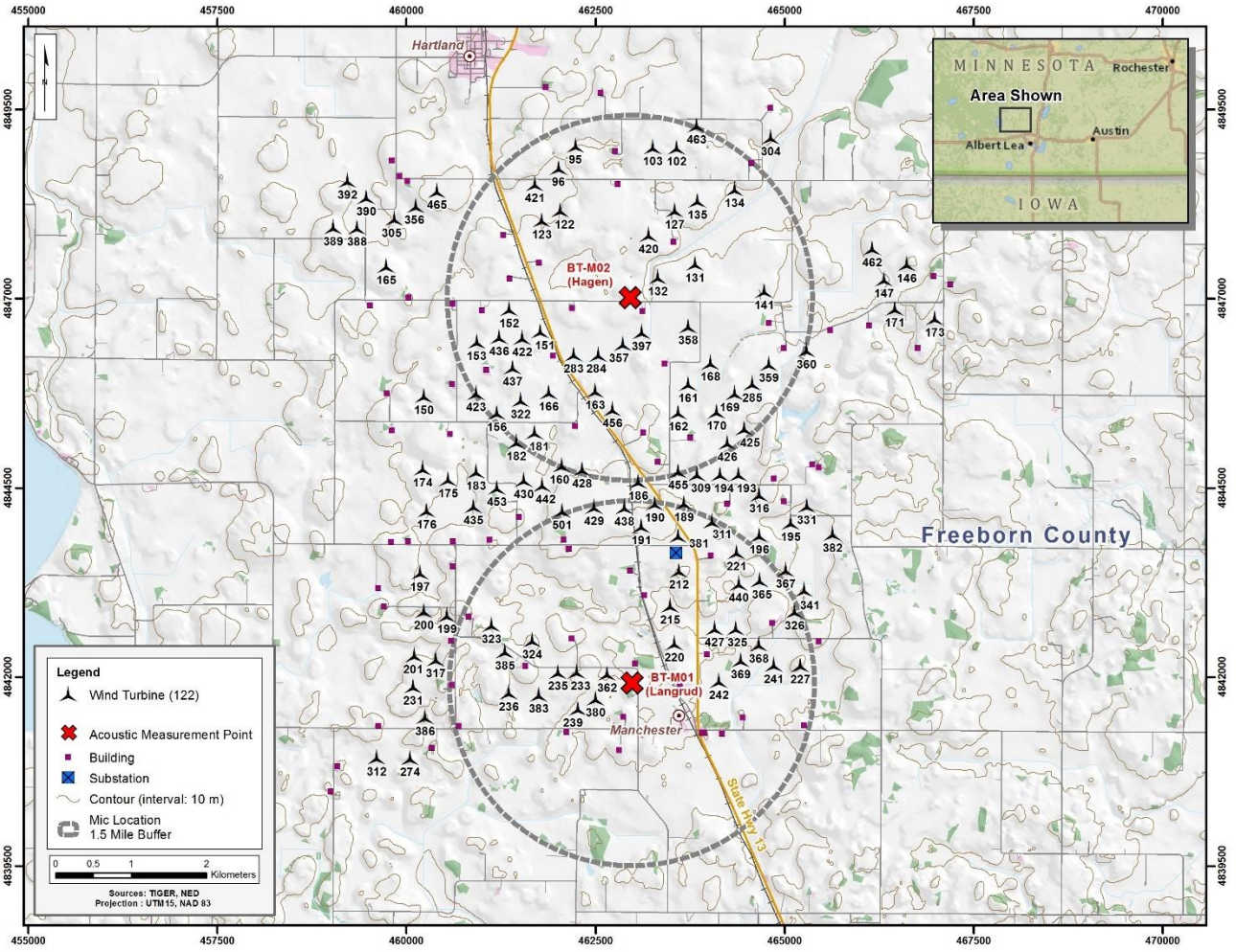

Figure 2-3 Parked wind turbines

2.3.4 Timing

Measurements will be conducted in late Fall 2017. This period has a variety of wind and atmospheric conditions, with less intrusion of natural sounds from nearby vegetation.

2.4 Data Processing and Reporting

Once the post-construction measurement campaign is complete, all data sets will be quality controlled. For each monitoring point, quality controlled A-weighted Leq nighttime data will be binned per wind speed (at

microphone height), for the operational and parked scenarios described under Sections 2.3.2 and 2.3.3. Turbine ON and Turbine OFF plots will be provided, including the 95% confidence interval limits.

The wind turbine only contribution at each wind speed bin will then be computed by logarithmically subtracting the turbine OFF results from the turbine ON results.

The maximum wind turbine only contributions will be compared against the MPCA limits [3] for every receptor, and within the exceedance context identified under the initial audit [1].

The report will include the methodology, analysis results and identification of any wind turbine only exceedances, for review by the EERA.

3 CONCLUSION

EERA has requested, on behalf of WPL, that DNV GL provide a post-construction noise measurement audit and protocol for the Bent Tree Wind Farm. The Project is located near the town of Hartland, in Freeborn County, Minnesota, approximately 90 miles south of Minneapolis. The Project consists of 122 Vestas V82-1.65 MW wind turbine generators, which began operation in 2011.

An initial audit was conducted in June 2017 at two receptors, where total noise exceedances were recorded. As per the Guidance, further detailed investigations are necessary to assess the contribution of the wind turbines to the total sound levels experienced at the receptors. As such, an additional measurement campaign will be undertaken to properly isolate wind turbine sound from total measured sound

This protocol has been developed for the additional measurements, i.e. Phase 2 measurements.

This protocol as well as the final noise measurement report will be E-filed as per the instructions in the Guidance paragraphs 33 through 37.

4 REFERENCES

[1] Bent Tree Wind farm Post-Construction Noise Assessment, 10046144-HOU-R-02-B, dated 30 August 2017, DNV GL.

[2] Minnesota Department of Commerce, Energy Facility Permitting. "Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report." October 8 2012.

[3] Minnesota Administrative Rules. 7030.0040 NOISE STANDARDS. https://www.revisor.leg.state.mn.us/rules/?id=7030.0040

[4] A Guide to Noise Control in Minnesota – Acoustic Properties, Measurement, Analysis and Regulation, Minnesota Pollution Control Agency, 2008.

[5] ISO 1996-2 "Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels".

[6] International Electrotechnical Commission, "IEC 61672 Electroacoustics – Sound Level Meter," First Edition 2002-05.

APPENDIX A – TYPICAL INSTRUMENTATION PHOTOGRAPH

In-situ set-up of Sound Measurement Equipment

APPENDIX B – WIND TURBINES TO BE PARKED

Turbine	UTM Zone 15 NAD83		Parked (Y/N)
	Easting (m)	Northing (m)	
WT102	463573	4848967	Yes
WT103	463259	4848971	Yes
WT122	462032	4848134	Yes
WT123	461789	4848005	Yes
WT127	463548	4848137	Yes
WT131	463816	4847430	Yes
WT132	463324	4847251	Yes
WT134	464343	4848417	Yes
WT135	463846	4848264	Yes
WT141	464733	4847071	Yes
WT146	466619	4847426	
WT147	466317	4847225	
WT150	460233	4845683	
WT151	461771	4846535	Yes
WT152	461356	4846831	Yes
WT153	460931	4846397	Yes
WT156	461197	4845460	Yes
WT160	462054	4844763	
WT161	463727	4845838	Yes
WT162	463592	4845462	Yes
WT163	462497	4845748	Yes
WT165	459734	4847400	
WT166	461883	4845729	Yes
WT168	464023	4846121	Yes
WT169	464341	4845718	Yes
WT170	464102	4845475	Yes
WT171	466459	4846838	
WT173	466986	4846708	
WT174	460218	4844723	
WT175	460552	4844581	
WT176	460268	4844169	
WT181	461692	4845198	Yes
WT182	461457	4845073	
WT183	460923	4844682	
WT186	463064	4844550	
WT189	463669	4844263	

Turbine	UTM Zone 15 NAD83		Parked (Y/N)
WT190	463285	4844258	Yes
WT191	463107	4843959	Yes
WT193	464392	4844644	
WT194	464147	4844644	
WT195	465082	4844005	
WT196	464664	4843838	
WT197	460182	4843345	
WT199	460536	4842783	
WT200	460231	4842839	
WT201	460105	4842253	
WT212	463605	4843373	Yes
WT215	463487	4842910	Yes
WT220	463543	4842412	Yes
WT221	464365	4843615	Yes
WT227	465211	4842121	Yes
WT231	460090	4841843	
WT233	462250	4842035	Yes
WT235	462002	4842033	Yes
WT236	461353	4841760	Yes
WT239	462266	4841548	Yes
WT241	464857	4842126	Yes
WT242	464133	4841911	Yes
WT274	460047	4840894	
WT283	462210	4846230	Yes
WT284	462537	4846228	Yes
WT285	464575	4845843	Yes
WT304	464816	4849101	
WT305	459841	4848023	
WT309	463844	4844648	
WT311	464043	4844020	Yes
WT312	459604	4840902	
WT316	464663	4844379	
WT317	460389	4842200	
WT322	461509	4845628	Yes
WT323	461124	4842656	Yes
WT324	461661	4842451	Yes
WT325	464357	4842609	Yes
WT326	465134	4842830	Yes
WT331	465297	4844229	

Turbine	UTM Zone 15 NAD83		Parked (Y/N)
WT341	465261	4843118	
WT356	460124	4848194	
WT357	462865	4846369	Yes
WT358	463725	4846605	Yes
WT359	464791	4846106	Yes
WT360	465290	4846287	
WT362	462655	4842008	Yes
WT365	464670	4843243	Yes
WT367	465016	4843383	
WT368	464659	4842396	Yes
WT369	464424	4842187	Yes
WT380	462503	4841682	Yes
WT381	463593	4843831	Yes
WT382	465635	4843857	
WT383	461749	4841732	Yes
WT385	461300	4842304	Yes
WT386	460249	4841436	
WT388	459348	4847909	
WT389	459030	4847912	
WT390	459469	4848309	
WT392	459221	4848526	
WT397	463111	4846525	Yes
WT420	463205	4847812	Yes
WT421	461700	4848484	Yes
WT422	461531	4846450	Yes
WT423	460921	4845720	Yes
WT425	464466	4845252	Yes
WT426	464244	4845064	Yes
WT427	464076	4842611	Yes
WT428	462324	4844713	Yes
WT429	462482	4844212	Yes
WT430	461551	4844570	
WT435	460887	4844225	
WT436	461228	4846459	Yes
WT437	461406	4846058	Yes
WT438	462885	4844210	Yes
WT440	464399	4843200	Yes
WT442	461794	4844504	
WT453	461197	4844469	

Turbine	UTM Zone 15 NAD83		Parked (Y/N)
WT455	463596	4844689	Yes
WT456	462723	4845507	Yes
WT462	466158	4847631	
WT463	463836	4849260	
WT465	460405	4848393	
WT501	462059	4844164	
WT95	462237	4848992	Yes
WT96	462013	4848698	Yes