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ACOUSTIC AUDIT - IMMISSION REPORT

Bluewater Wind Energy Centre

Municipality of Bluewater, Ontario

Report Number: 01800912.002

Project Number: 01800912

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May 1, 2019

VERSION CONTROL

Bluewater Wind Energy Centre
Acoustic Audit - Immission Report

Version	Date	Version Description
1	April 26, 2019	Original Report
2	May 1, 2019	Report updated to address turbine yaw position correction. BLW1769 analysis updated.

EXECUTIVE SUMMARY

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by Varna Wind, LP to complete an Immission Audit of the Bluewater Wind Energy Centre ("Wind Project") in the Municipality of Bluewater, Ontario. The project includes 37 General Electric GE 1.6-100 LNTE wind turbine generators, each rated at 1.6 MW. The Immission Audit is required as a condition of Provincial Officer's Order number 1700-B88MYE issued to Varna Wind, LP by the Ontario Ministry of the Environment, Conservation and Parks ("MECP"). HGC Engineering has assessed the acoustic impact against the acoustic criteria of the MECP and in accordance with the requirements of the MECP's *Compliance Protocol for Wind Turbine Noise*. This report presents the results of the measurement campaign, completed between January 11 and April 1, 2019. The sound level measurements and analysis, as performed in accordance with the MECP's *Compliance Protocol for Wind Turbine Noise*, indicate that the Wind Project meets the applicable sound level limits at the selected monitoring locations. Details of the measurements and analysis are provided herein.

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1 INTRODUCTION

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by Varna Wind, LP to complete an Acoustic Audit – Immission of the Bluewater Wind Energy Centre ("Wind Project"). The Wind Project is located in the Municipality of Bluewater, Ontario and consists of 37 General Electric GE 1.6-100 LNTE wind turbine generators, each with 80 m hub height, and rated at 1.6 MW.

The Immission Audit is required as a condition of Provincial Officer's Order number 1700-B88MYE [1] ("Order") issued to Varna Wind, LP on January 8, 2019 by the Ontario Ministry of the Environment, Conservation and Parks ("MECP"). Specifically, this report summarizes the Revised Assessment Methodology - Immission audit (RAM-I) measurements that were conducted in order to satisfy Item No. 4 and Item No. 5 of the Order.

The RAM-I audit was completed according to the latest version of the MECP *Compliance Protocol for Wind Turbine Noise – Guidelines for Acoustic Assessment and Measurement* ("Compliance Protocol") [2].

2 MONITORING LOCATIONS

The Noise Assessment Report prepared by Aecom [3] ("NAR") provided sound level predictions for receptors within 2000 m of the project wind turbine generators. The Compliance Protocol requires that measurements be completed at three different points of reception that meet the following criteria:

- The points of reception should represent the location of the greatest predicted noise impact.
- The points of reception should be located in the direction of prevailing wind from the facility.

The monitoring locations were selected based on their downwind location, predicted sound level, and consultation with the land owners. A summary of the monitoring location selection and the historical wind rose for the area can be found in Appendix A. An overview of each of the selected monitoring locations is shown in Figures 1a to 1c and photos of the installations are provided in Appendix B.

HGC Engineering developed an acoustic predictive model of the site to determine the sound levels at the three selected monitoring and receptor locations, without the contribution of the four alternate turbine locations. The predicted sound levels at the receptor and monitoring locations, along with their respective UTM coordinates can be found in Table 1.

Table 1: Predicted Sound Levels and UTM Coordinates of Selected Locations

Location		Easting	Northing	Predicted Sound Level [dBA]*
BLW1536	Receptor	448465	4814070	38.4
	Monitoring Location	448376	4814048	38.2
BLW1750	Receptor	450534	4814130	38.6
	Monitoring Location	450522	4814137	38.7
BLW1769	Receptor	449933	4818242	38.5
	Monitoring Location	449977	4818238	38.2

* Sound level predicted by acoustic model created by HGC Engineering

Monitoring location M1536 is representative of receptor BLW1536, a two-storey home located on the north side of the project. The closest turbine, T16, is located approximately 826 m to the southwest. Monitoring location M1750 represents receptor BLW1750, a non-participating vacant lot. The closest turbine, T28, is located approximately 556 m to the southwest. Monitoring location M1769 represents receptor BLW1769, a participating vacant lot. The closest turbine, T38, is located approximately 730 m to the southwest.

The Wind Project area is generally rural in nature with infrequently travelled gravel roads.

3 INSTRUMENTATION

The Compliance Protocol provides instrumentation requirements for acoustical audits of wind energy projects. The instrumentation used for this acoustic audit satisfies the requirements of the Compliance Protocol.

Audio frequency sound levels were measured using Svantek 977 and Norsonic Nor140 sound level meters, each connected to ½" microphones. The microphones were set at a height of 4.5 m

and equipped with 175 mm diameter windscreens to minimize wind-induced microphone self-noise.

The energy-equivalent average sound level, denoted L_{EQ}, was recorded by the instrumentation. The audio-frequency measurements are presented as A-weighted sound levels as they are intended to represent the loudness of sounds as perceived by the human ear. The overall audio-frequency sound level monitoring results are summarized in this report.

In addition to the acoustic instrumentation, meteorological instruments were used. A meteorological station was deployed at Monitoring Location M1750 to collect ground weather conditions including temperature, humidity, and precipitation. NRG and RMYoung anemometers and wind vanes were used at each receptor location to collect 10 m height wind speed and direction.

The various instruments deployed by HGC Engineering are summarized in Table 2, and their respective locations are shown in Figures 1a to 1c.

Table 2: Measurement Instrumentation

Location	Instrumentation Make and Model	Serial Number
M1536	Svantek 977 sound level meter	36428
	RMYoung anemometer connected to a Campbell Scientific datalogger	93557
M1750	Svantek 977 sound level meter	45420
	NRG #40C anemometer connected to a Campbell Scientific datalogger	179500235190
M1769	Norsonic Nor140 sound level meter	1403362
	Svantek 977 sound level meter	36426
	NRG #40C anemometer connected to a Campbell Scientific datalogger	179500239925

The sound level meters were configured to measure and record spectral (frequency-dependent) one-minute L_{EQ} sound level measurements. For identification of dominant sources and to conduct the tonality assessment, the sound level meters were configured to record audio files.

Correct calibration of the acoustic instrumentation was verified using an acoustic calibrator manufactured by Brüel & Kjær. Calibration verification was carried out on a bi-weekly basis throughout the measurement period.

Windscreens were used on the microphones, consistent with the requirements of MECP technical publication *NPC-103, Procedures* [4]. A large wind screen, 175 mm in diameter, was used on each sound level meter to minimize wind-induced microphone self-noise at higher wind speeds. Sound level data included herein has not been adjusted for the sound insertion loss of the large wind screen.

All the equipment was within its annual or bi-annual calibration, confirmed by the calibration certificates found in Appendix C.

4 ASSESSMENT CRITERIA

The MECP publication *Noise Guidelines for Wind Farms – Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities* [5] indicates the applicable sound level limit for wind energy projects in a Class 3 environment. Additionally, the Compliance Protocol includes the same sound level limits which are shown in Table 3.

Table 3: Wind Turbine Noise Criteria [dBA]

10 m Height Wind Speed [m/s]	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits Class 3 Area [dBA]	40.0	40.0	40.0	43.0	45.0	49.0	51.0

It should be noted that the sound level limits of the MECP apply only to the sound level contribution of the sound source under assessment, in this case the sound from the wind turbine generators. Thus, where a sound level measured at a receptor location includes significant sound due to the relevant sound source and unrelated background sound sources (i.e., road vehicles, trains, air traffic, farming machinery, wind, etc.), some form of evaluation must be made to determine the sound level contribution of the source under assessment in the absence of the background sounds. Methodology prescribed by the MECP to complete an assessment of a wind energy project is discussed in the following section.

5 METHODOLOGY

The MECP requested the acoustic audit be completed in accordance with Part D of the 2017 Compliance Protocol. Part D includes requirements for instrumentation, measurement, and data reduction procedures to assist with determining compliance.

A series of one-minute energy-equivalent sound level measurements are collected with ("ON") and without ("OFF") the turbines operating. Simultaneously, wind speed and direction at 10 m height are measured and collected in one-minute intervals. The measured sound level data is separated into integer wind speed "bins" where the sound levels corresponding to each integer wind speed are logarithmically averaged to determine the average sound level when the wind turbines are operational and when they are parked. The ambient L_{EQ} (turbines parked) is logarithmically subtracted from the overall L_{EQ} (turbines operational) to determine the sound level contribution of the wind turbines alone. Supplementary data including wind speed at turbine hub height, wind speed at noise measurement height, turbine electrical power output, turbine yaw position, temperature, humidity, and statistical noise indices (Ln) can also be measured during the monitoring campaign to aid in the analysis.

Part D of the Compliance Protocol requires at least 120 one-minute intervals be measured for each 10 m height wind speed between 4 and 7 m/s when the turbines are operating and at least 60 one-minute intervals be measured for each 10 m height wind speed between 4 and 7 m/s when the turbines are parked (OFF).

As described in Part E5.5 of the Compliance Protocol, a revised Assessment Methodology Immission Audit requires complete data sets in three wind speed bins between 1 and 7 m/s or two wind speed bins between 1 and 4 m/s. With appropriate justification, the number of one-minute intervals required in each bin may be reduced to 60 for turbine operational measurements (ON) and 30 for ambient measurements (OFF). Appropriate justification for a reduced amount of data is determined on a case-by-case basis, and may include the length of the monitoring campaign (greater than 6 weeks) and lower standard deviation of the sound levels. If there is insufficient ambient sound level data (OFF), a value of 30 dBA or data from a lower wind speed bin may be used to represent the ambient sound level at higher wind speed bins.

Prior to determining the number of data points measured in each wind speed bin, the data is filtered to only include night-time hours (between 22:00 and 05:00) and data outside of rainfall (no rain within one hour of the measurement interval). Data is also filtered to only include periods where the closest turbine is operating at greater or equal to 85% of its rated electrical power output and at least 90% of its maximum sound power, and the turbine yaw position is +/- 45 degrees from the line of sight between the closest turbine and the measurement location (measurement location is downwind).

The Compliance Protocol allows for the removal of individual events to improve the signal to noise ratio. A review of the audio recordings allows for the identification of the dominant noise source within a given one-minute interval, and the subsequent removal of data points that contain interference.

Adjustments to the measured sound levels may be required based on wind turbine tonality, if any. If during the acoustic measurement campaign the project wind turbines exhibit tonal characteristics (a whine, screech, buzz or hum) then an assessment of the tonal audibility is required according to the International Electrotechnical publication *61400-11:2018 - Wind turbine generator systems - Part 11: Acoustical noise measurement techniques.* [6]. The average tonal audibility correction must be determined for each integer wind speed and the correction added to the final noise contribution of the Wind Project at those wind speeds, in accordance with International Standards Organization *1996-2* [7].

6 TONALITY ASSESSMENT

Based on our site observations and review of the audio recordings there were no tones identified/observed at the monitoring locations.

As required under the Order, a detailed tonality analysis was completed in accordance with the requirements under the MECP Compliance Protocol. For each integer wind speed, the valid ON data points were assessed for tonality. The audio recordings collected during the monitoring were utilized to generate narrow-band spectra, from approximately 20 Hz to 3000 Hz, for each one-minute data point. Tonality was assessed for each one-minute data point following the International Electrotechnical publication IEC 61400-11:2018 [6].

The tonal audibility results for each one-minute data point were binned into integer wind speeds and logarithmically averaged to determine the tonal audibility value for each wind speed bin. Under IEC 61400-11, a tone is reported only if the average audibility is greater than -3 dB and the tone is present in at least 20% of the data points. If either of these conditions were not met, the report indicates “no relevant tones”.

No adjustments were made to the wind project only sound levels based on the procedure described in ISO 1996-2, Annex J [7]. The results of the tonality analysis are found in Appendix D.

7 MEASUREMENTS AND RESULTS

Sound level measurements were conducted between January 11 and April 1, 2019. The weather during the monitoring period varied, including several days with rain. Temperatures ranged from approximately -20°C to 15°C. Wind speeds at 10 m height ranged from 0 m/s up to 20 m/s. The prevailing wind direction during the measurement campaign was from the northwest and west, inconsistent with the historical wind rose, which indicates the wind is predominantly from the west and southwest. Figures 2a through 4b show the wind roses for the monitoring locations during the ON and OFF conditions.

The yaw position of the closest turbines was utilized to filter for downwind conditions. During the data review process, it was determined there was a discrepancy between the turbine yaw data provided by the wind project and the local meteorological equipment. The turbine yaw data was corrected using the onsite meteorological equipment and guidance from the Wind Project and General Electric.

The sound level summary for data collected at Monitoring Location M1536 is shown in Tables 4a and 4b. Data were collected between January 11 and April 1, 2019.

Table 4a: Monitoring Location M1536 - Summary of Valid Data Points

	10 m Height Wind Speed [m/s]		
Wind Project Condition	**5**	**6**	**7**
Operating (ON)	172	72	62
Ambient (OFF)	106	89	33

Table 4b: Monitoring Location M1536 - Sound Level Summary

	10 m Height Wind Speed [m/s]					
L_{EQ} Sound Level [dBA]	**5**		**6**		**7**	
Average Operating (ON) / Std Dev.	41	1.6	44	1.4	47	2.4
Average Ambient (OFF) / Std Dev.	39	1.4	42	1.5	46	1.4
Wind Project Only	37		40		42	
Criteria	40.0		40.0		43.0	
Excess	**0**		**0**		**0**	

Based on the data presented above, and in Figures 5a and 5b, the Wind Project is compliant with the MECP's sound level criteria at Monitoring Location M1536.

The sound level summary for data collected at Monitoring Location M1750 is shown in Tables 5a and 5b. Data were collected between January 11 and February 12, 2019.

Table 5a: Monitoring Location M1750 - Summary of Valid Data Points

	10 m Height Wind Speed [m/s]			
Wind Project Condition	**4**	**5**	**6**	**7**
Operating (ON)	147	129	167	221
Ambient (OFF)	-[1]	47	158	57

[1] Less than 30 data points for Ambient (OFF) condition

Table 5b: Monitoring Location M1750 - Sound Level Summary

	10 m Height Wind Speed [m/s]							
L_{EQ} Sound Level [dBA]	**4**		**5**		**6**		**7**	
Average Operating (ON) / Std Dev.	39	0.5	40	1.6	44	1.7	47	2.1
Average Ambient (OFF) / Std Dev.	30[2]	-	41	1.9	44	1.6	47	1.2
Wind Project Only	38		-[3]		-[3]		-[3]	
Criteria	40.0		40.0		40.0		43.0	
Excess	**0**		**0**		**0**		**0**	

[2] Assumed 30 dBA sound level for Ambient (OFF) condition
[3] Operation (ON) and Ambient (OFF) sound levels are effectively equal

Based on the data presented above, and in Figures 6a and 6b, the Wind Project is compliant with the MECP's sound level criteria at Monitoring Location M1750.

The sound level summary for data collected at Monitoring Location M1769 is shown in Tables 6a and 6b. Data were collected between January 11 and April 1, 2019.

Table 6a: Monitoring Location M1769 - Summary of Valid Data Points

	10 m Height Wind Speed [m/s]			
Wind Project Condition	**4**	**5**	**6**	**7**
Operating (ON)	87	207	133	89
Ambient (OFF)	85	-[1]	30	52

[1] Less than 30 data points for Ambient (OFF) condition

Table 6b: Monitoring Location M1769 - Sound Level Summary

	10 m Height Wind Speed [m/s]							
L_{EQ} Sound Level [dBA]	**4**		**5**		**6**		**7**	
Average Operating (ON) / Std Dev.	40	1.1	41	1.5	44	1.6	45	1.2
Average Ambient (OFF) / Std Dev.	38	1.1	38	-	42	2.2	44	2.4
Wind Project Only	35		38[2]		39		38	
Criteria	40.0		40.0		43.0		43.0	
Excess	**0**		**0**		**0**		**0**	

[2] Ambient (OFF) sound level from 4 m/s wind speed bin utilized due to insufficient data

Based on the data presented above, and in Figures 7a and 7b, the Wind Project is compliant with the MECP's sound level criteria at Monitoring Location M1769.

Appendix E includes a statement from the Wind Project indicating the wind turbine generators were operating normally from January 11 to April 1, 2019.

8 CONCLUSIONS

The measurements and analysis, performed in accordance with the methods prescribed by the Ontario Ministry of the Environment, Conservation and Parks' 2017 publication *Compliance Protocol for Wind Turbine Noise* indicate that the Bluewater Wind Energy Centre is operating in compliance with the MECP's sound level criteria at monitoring locations M1536, M1750 and M1769.

REFERENCES

1. Ontario Ministry of the Environment, Conservation and Parks, Provincial Officer's Order number 1700-B88MYE, January 8, 2019.
2. Ontario Ministry of the Environment, Conservation and Parks, *Compliance Protocol for Wind Turbine Noise Guideline for Acoustic Assessment and Measurement*, April 2017.
3. Aecom, *Bluewater Wind Energy Centre – Noise Assessment Report*, March, 2013.
4. Ontario Ministry of the Environment, Conservation and Parks Publication, NPC-103, *Procedures.*
5. Ontario Ministry of the Environment, Conservation and Parks Publication, *Noise Guidelines for Wind Farms*, May 2016.
6. International Electrotechnical Commission, 61400-11:2018 *Wind turbine generator systems – Part 11: Acoustic noise measurement techniques*.
7. International Standards Organization 1996-2, *Acoustics – Description, assessment and measurement of environmental noise – Part 2: Determination of environmental noise levels*, 2017.
8. Government of Canada, *Canadian Wind Energy Atlas*, Retrieved from http://www.windatlas.ca/rose-en.php?field=EU&height=30&season=ANU&no=24&postal=p0p1k0 on March 12, 2019.

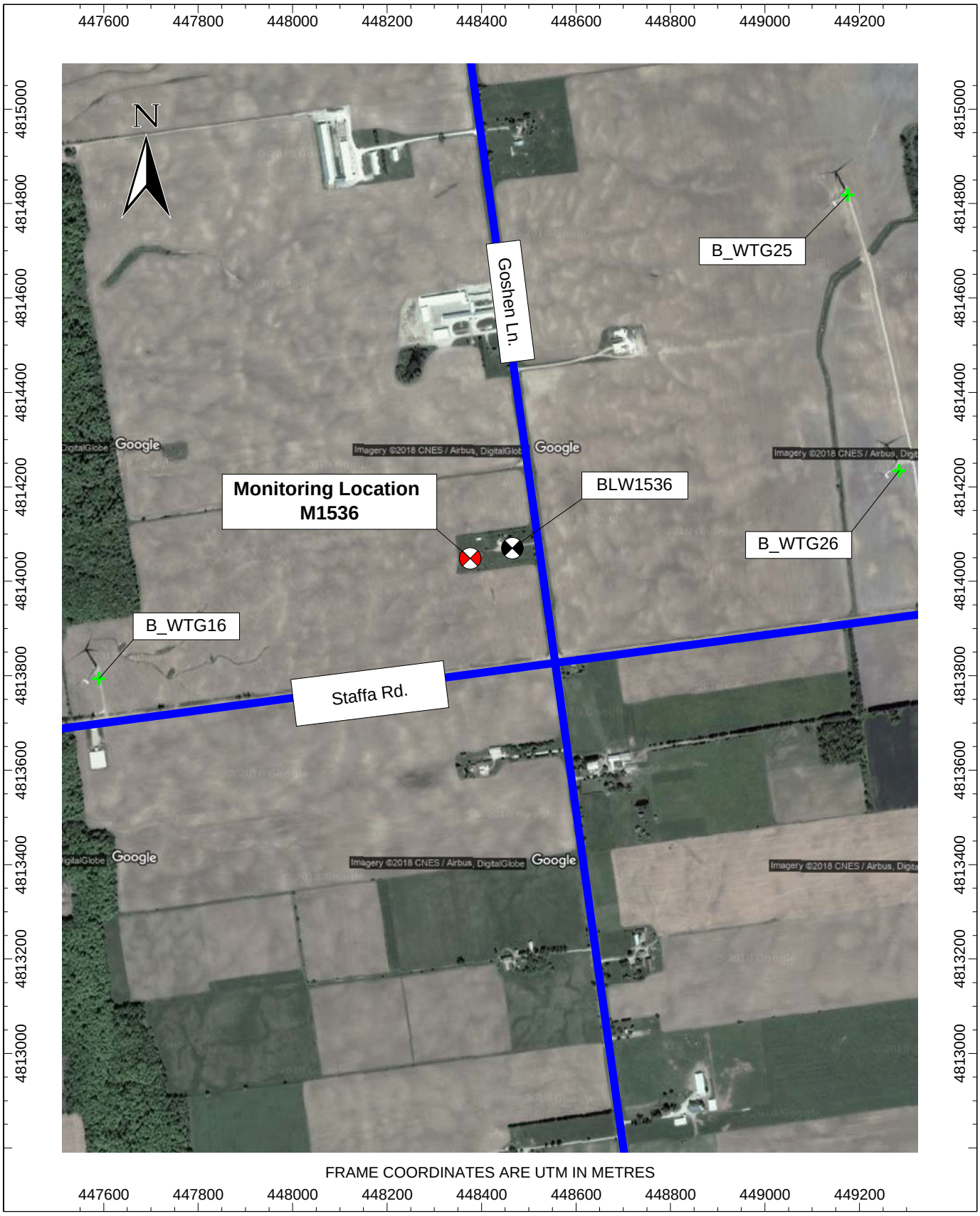


Figure 1a: Location of Receptor BLW1536 and Monitoring Location M1536

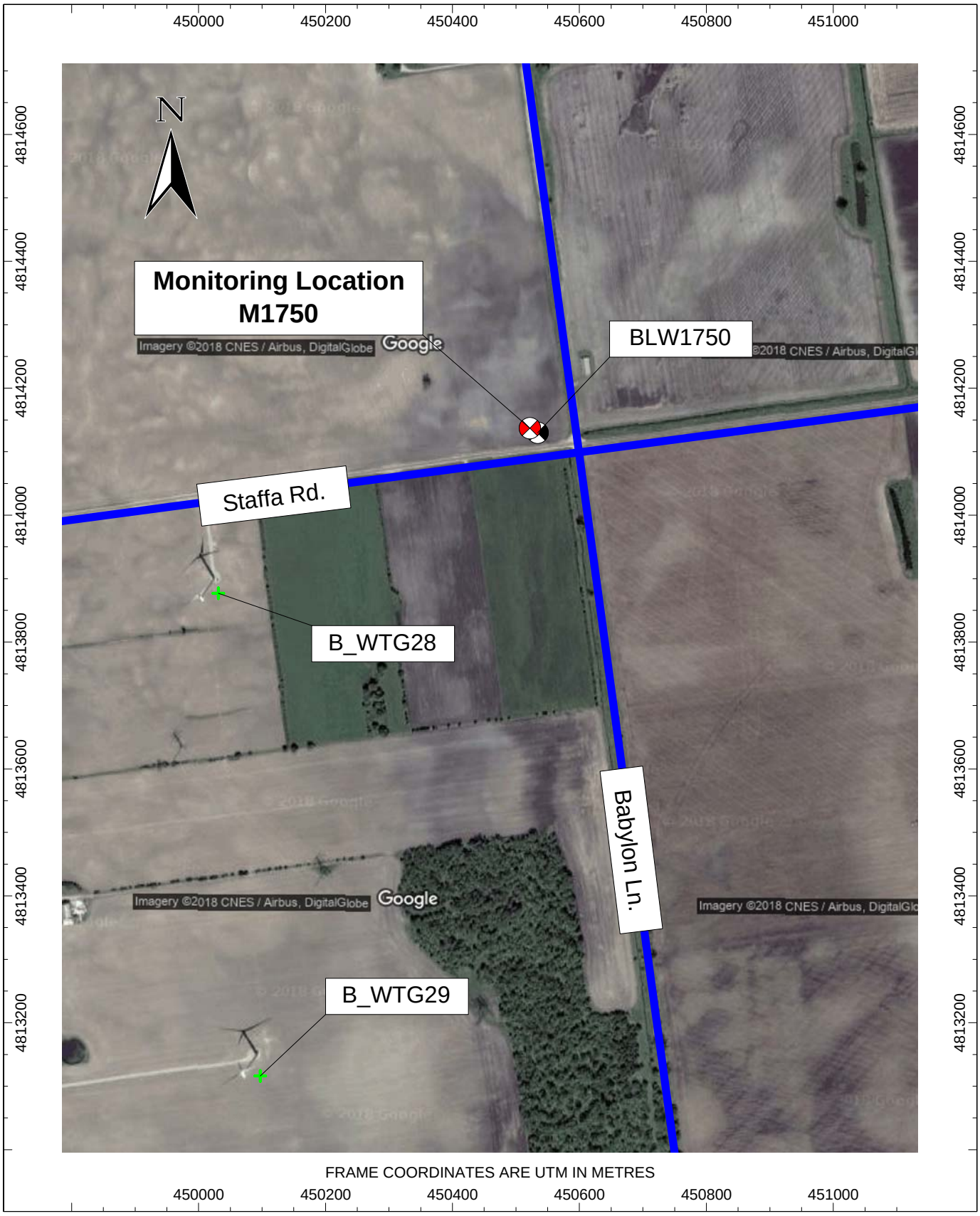


Figure 1b: Location of Receptor BLW1750 and Monitoring Location M1750

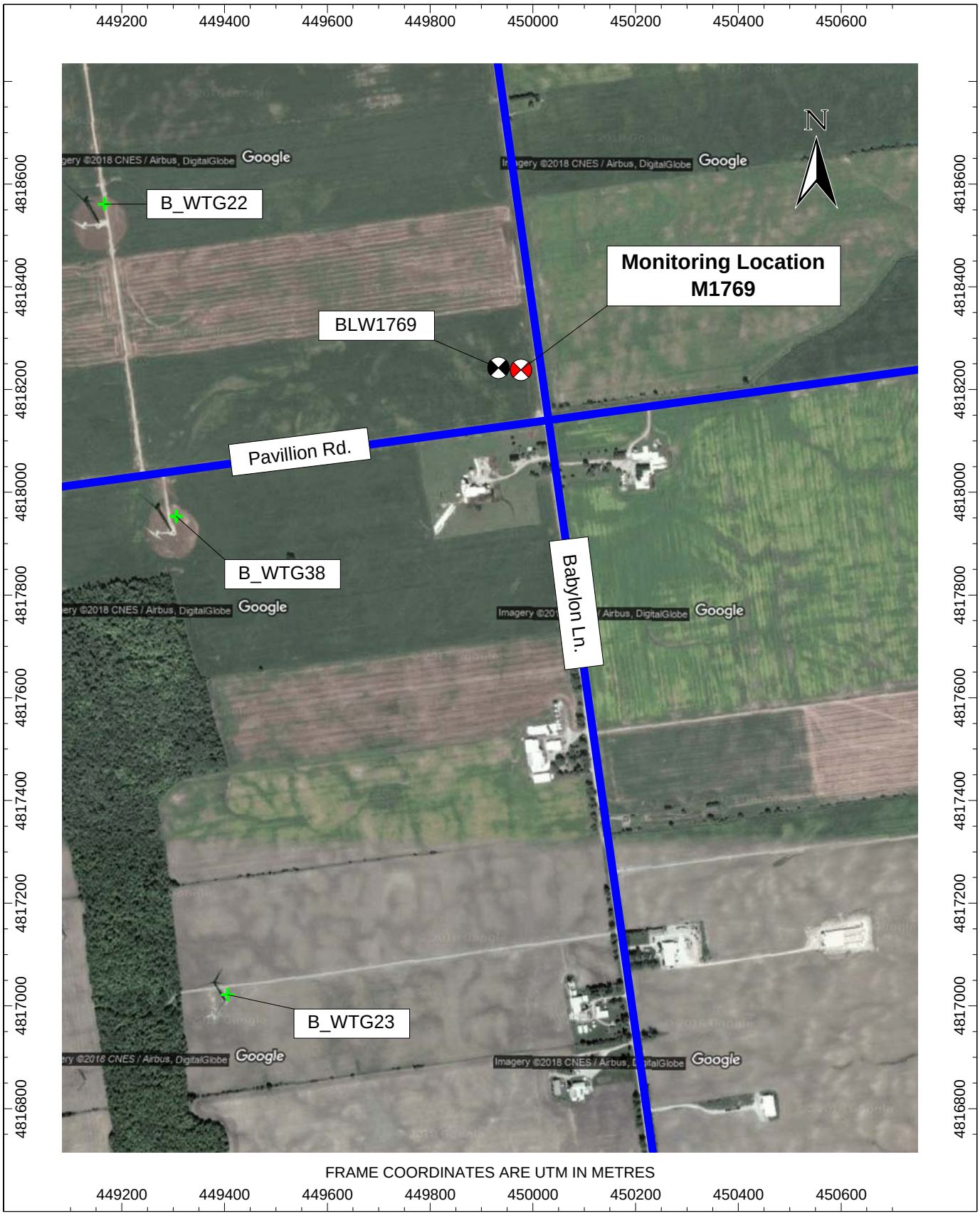


Figure 1c: Location of Receptor BLW1769 and Monitoring Location M1769

Figure 2a: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1536, ON Conditions, January 11 to April 1, 2019

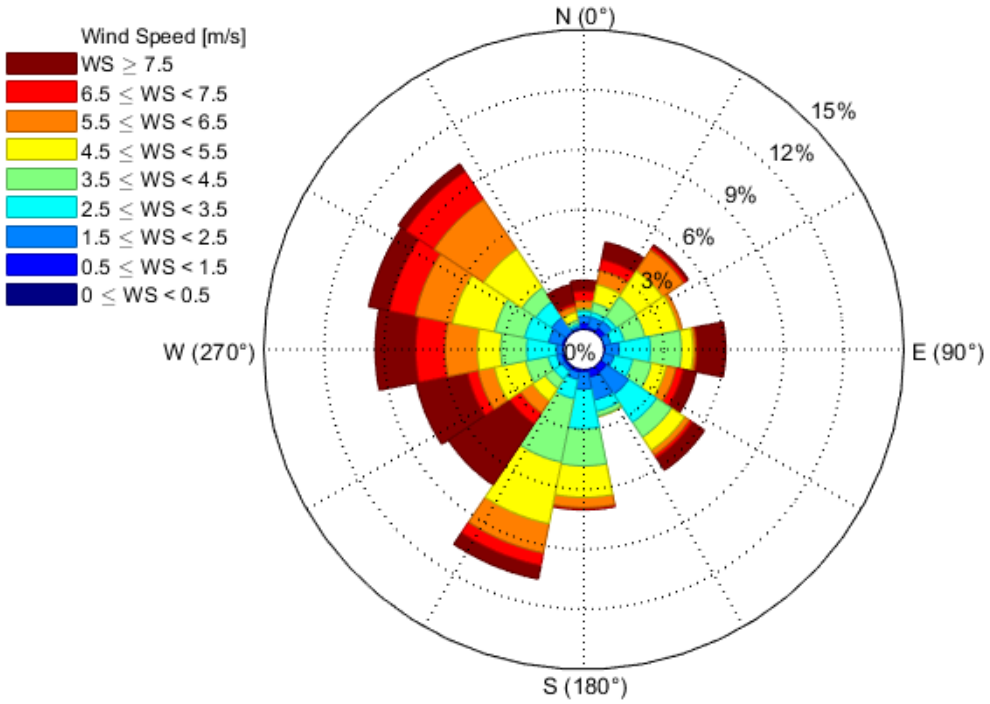


Figure 2b: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1536, OFF Conditions, January 11 to April 1, 2019

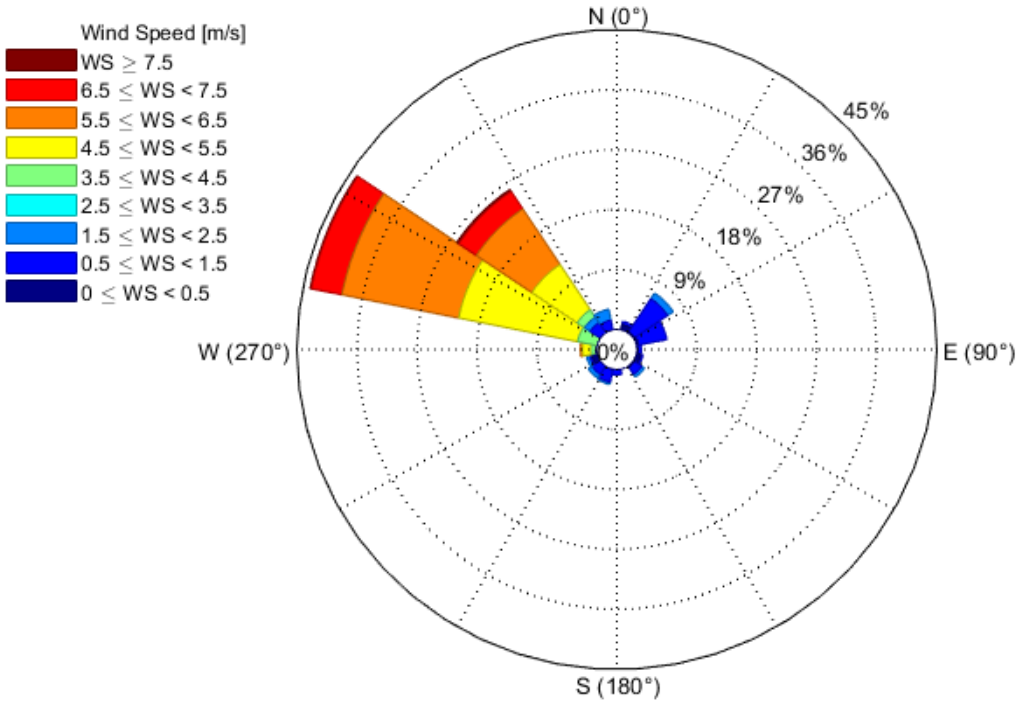


Figure 3a: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1750, ON Conditions, January 11 to February 12, 2019

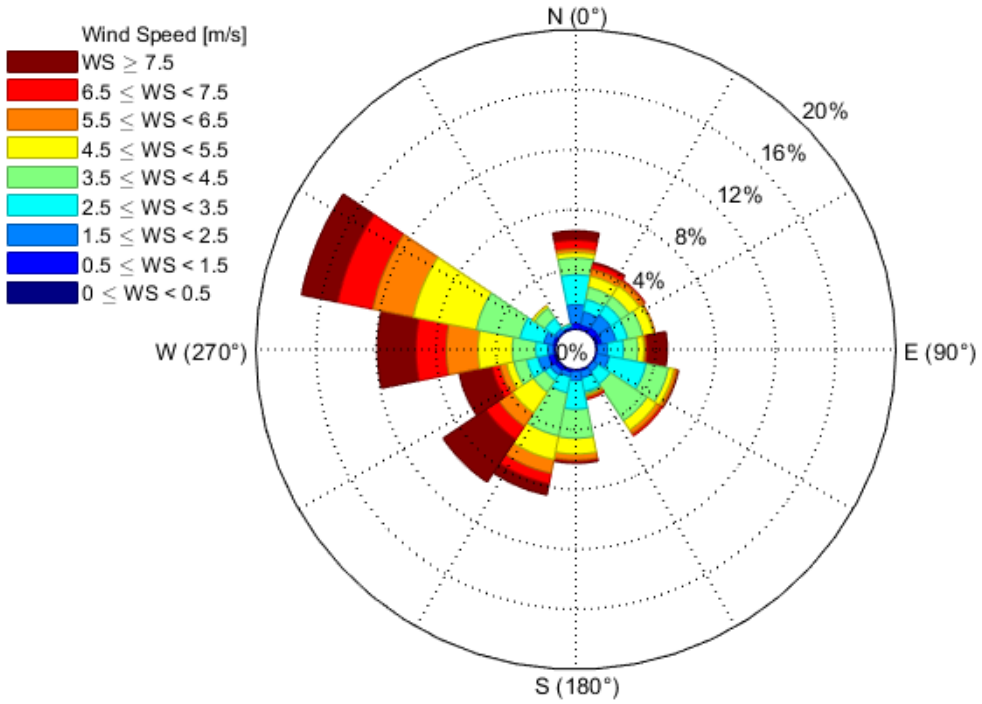


Figure 3b: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1750, OFF Conditions, January 11 to February 12, 2019

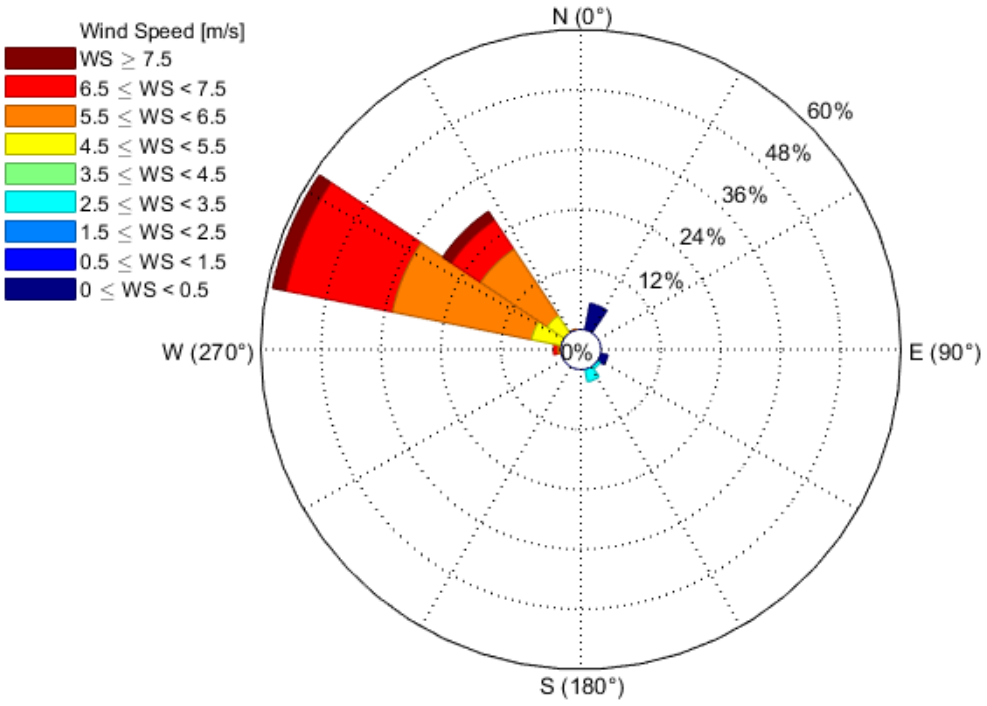


Figure 4a: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1769, ON Conditions, January 11 to April 1, 2019

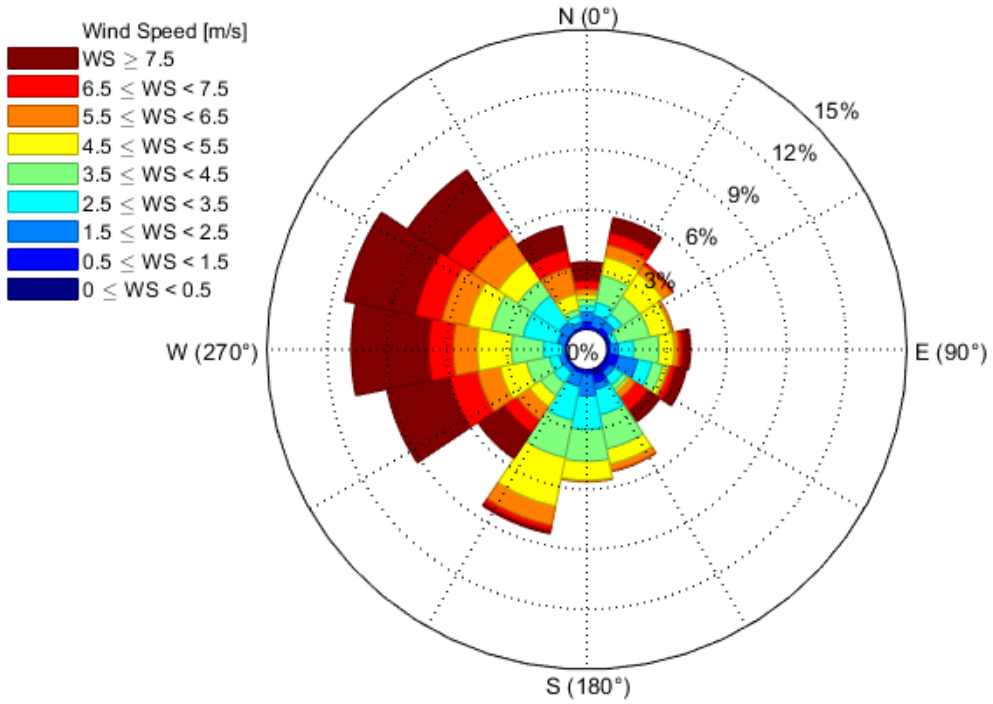


Figure 4b: Wind Direction, Bluewater Wind Energy Centre
Monitoring Location M1769, OFF Conditions, January 11 to April 1, 2019

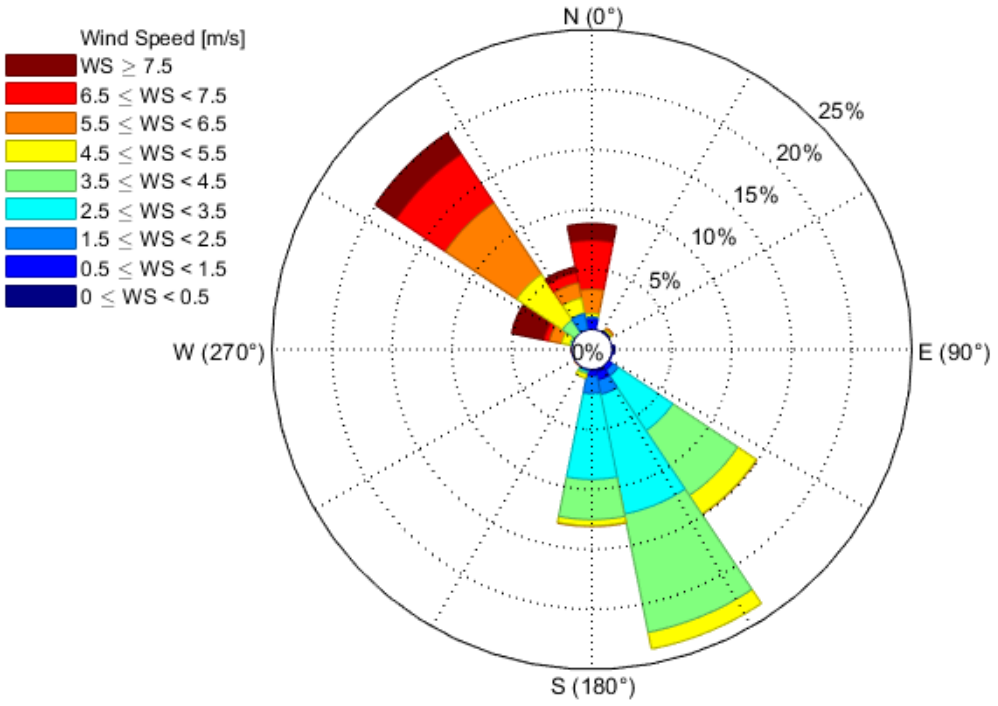


Figure 5a: Bluewater, Immission Results
Monitoring Location M1536, January 11 to April 1, 2019

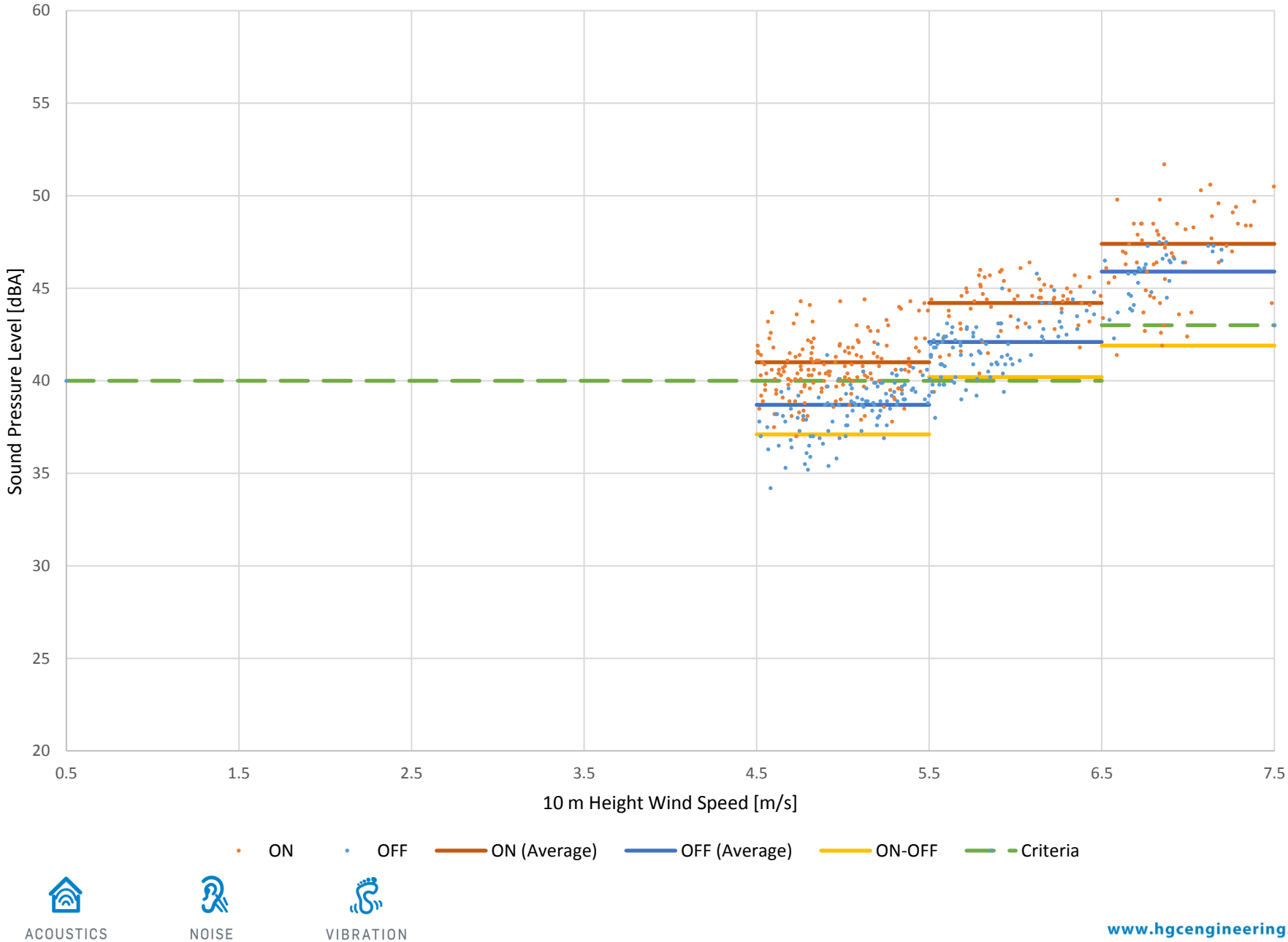


Figure 5b: Bluewater, Immission Results
Monitoring Location M1536, January 11 to April 1, 2019

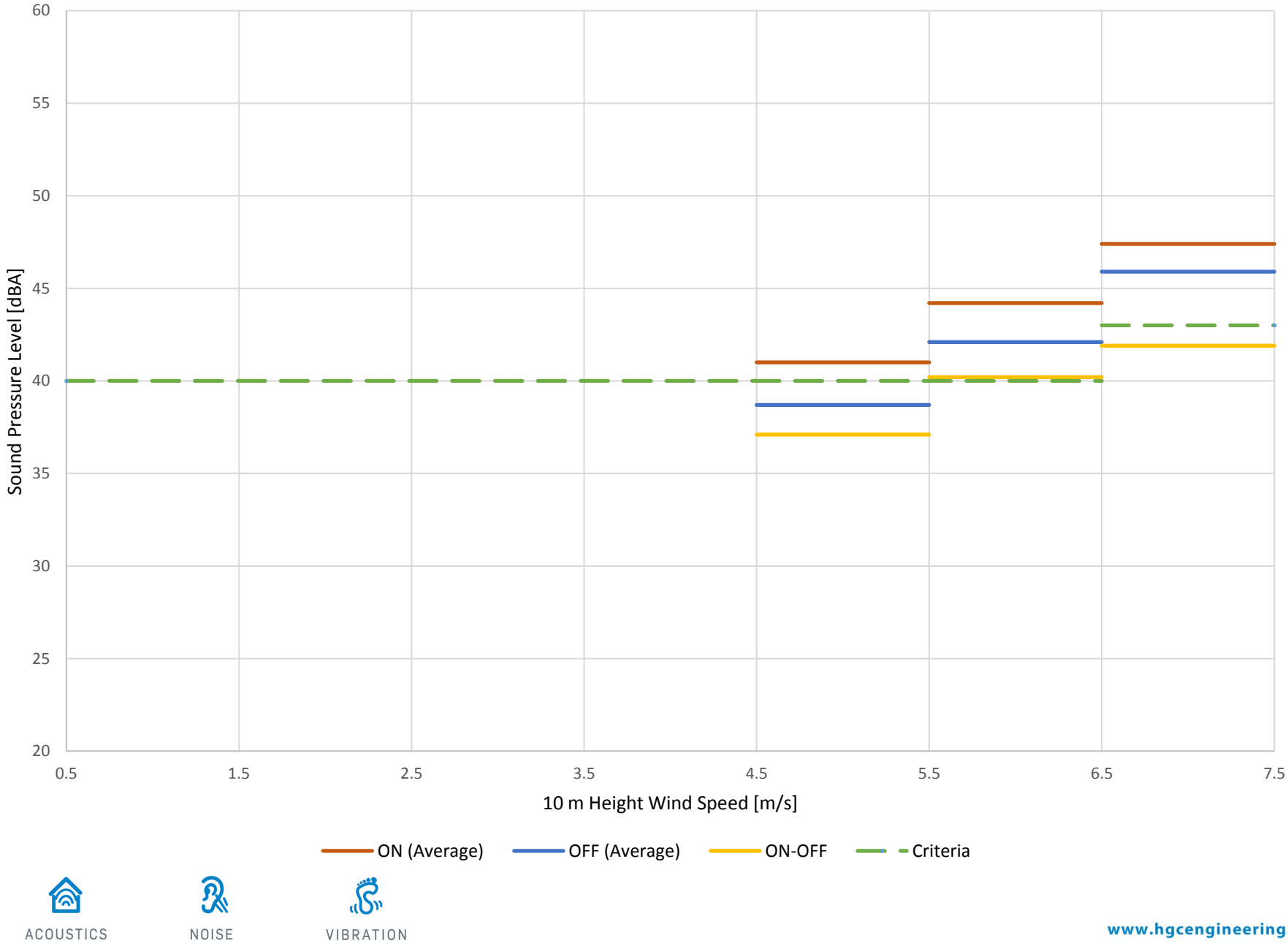


Figure 6a: Bluewater, Immission Results
Monitoring Location M1750, January 11 to February 12, 2019

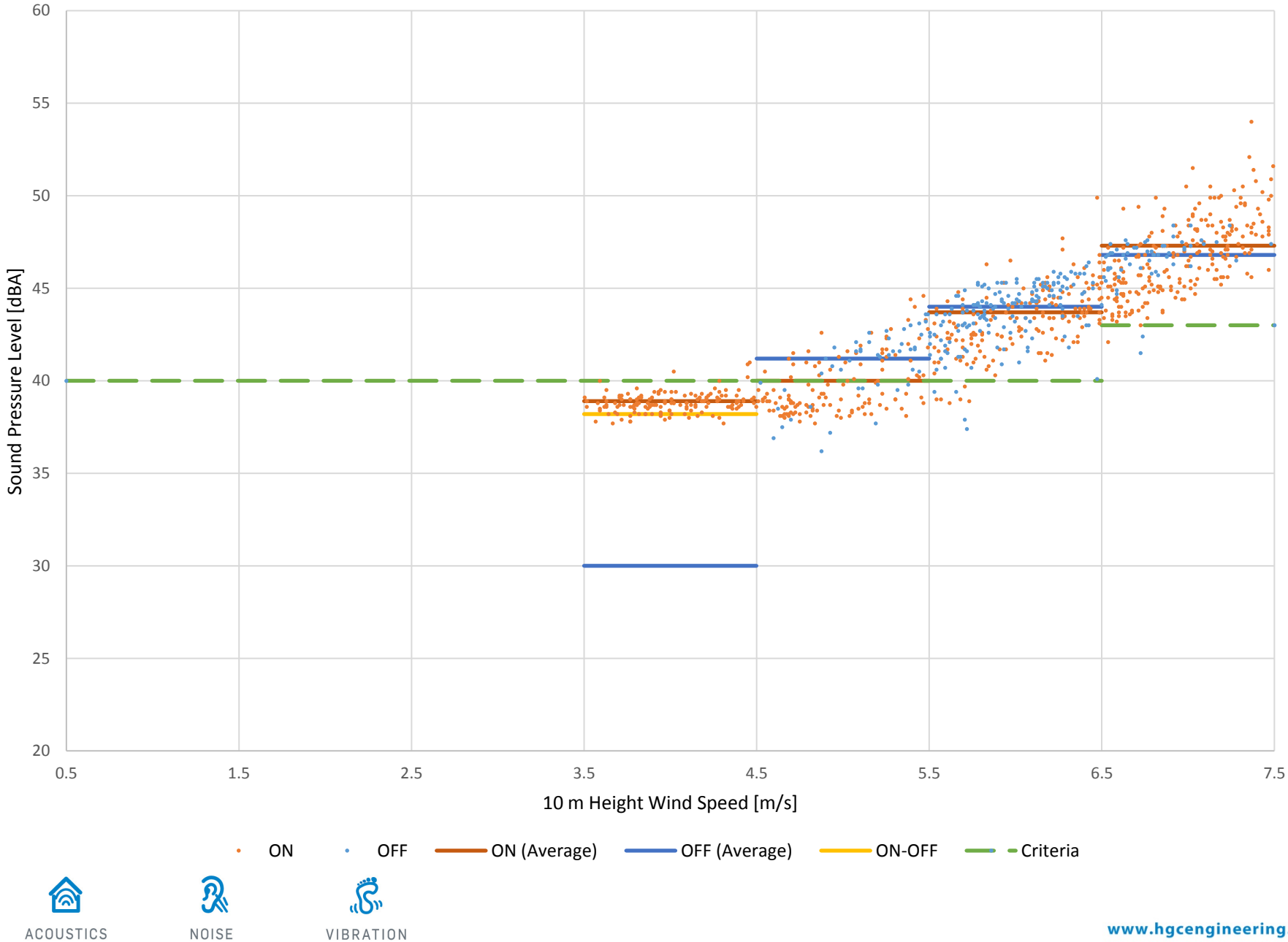


Figure 6b: Bluewater, Immission Results
Monitoring Location M1750, January 11 to February 12, 2019

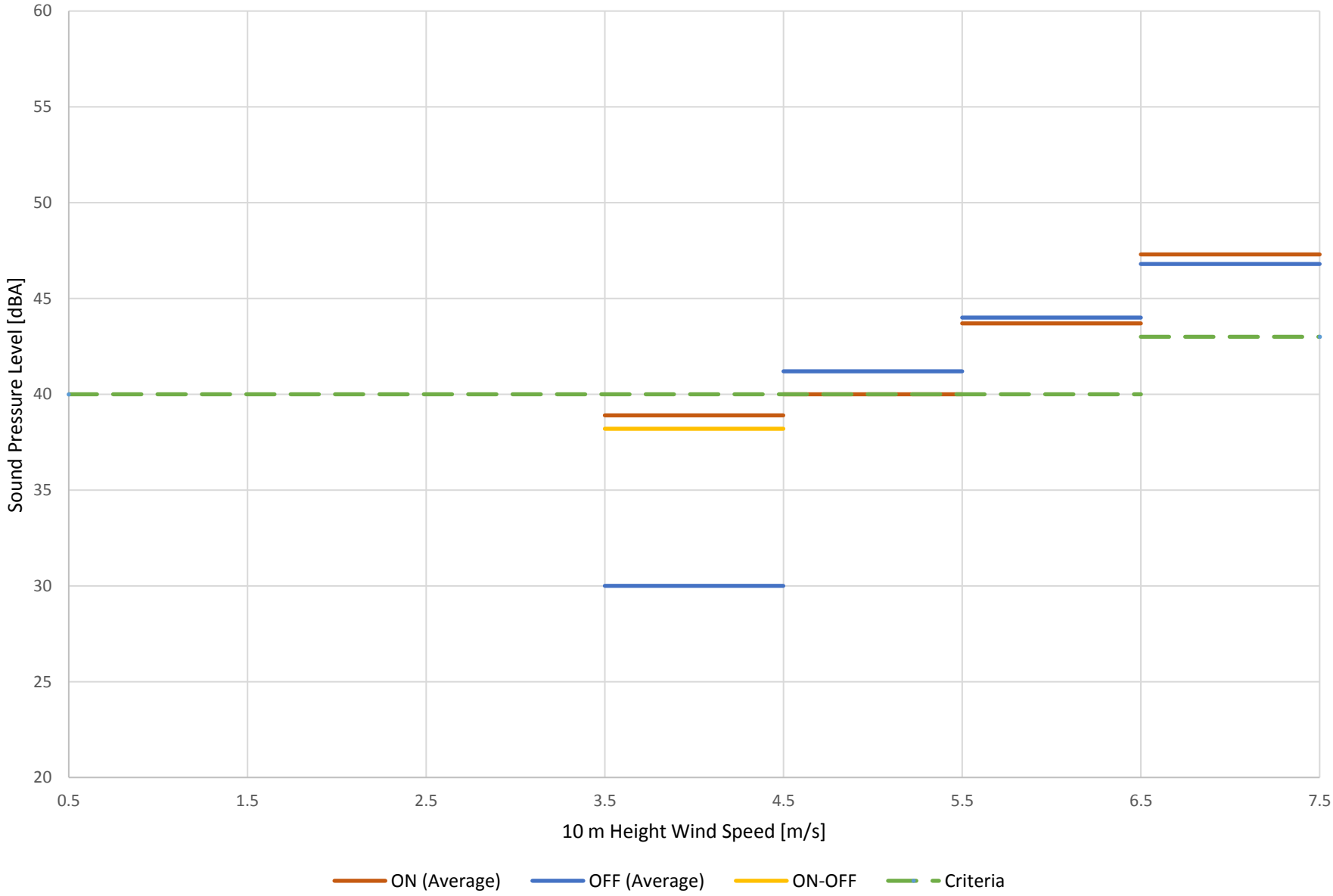


Figure 7a: Bluewater, Immission Results
Monitoring Location M1769, January 11 to April 1, 2019

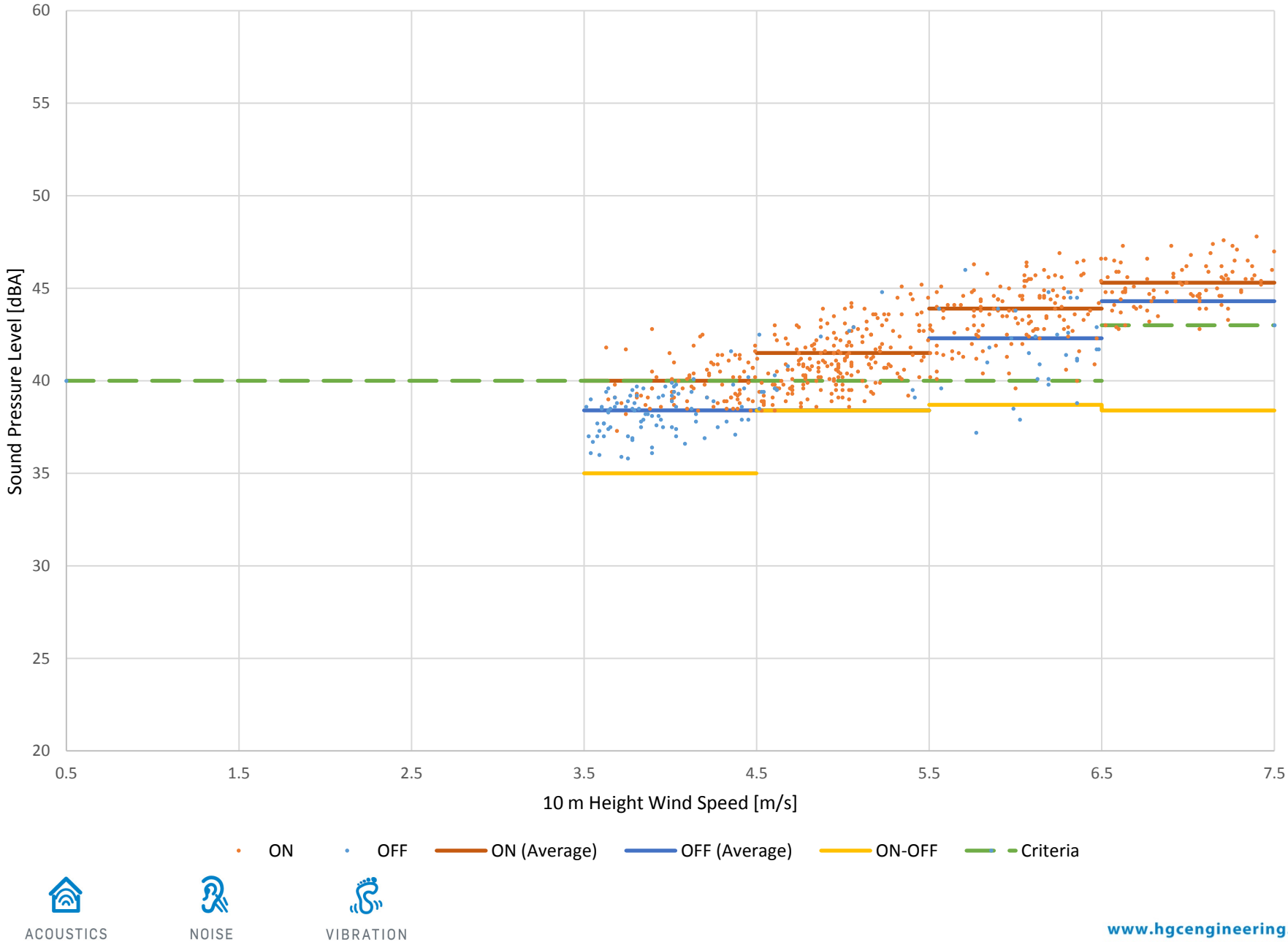
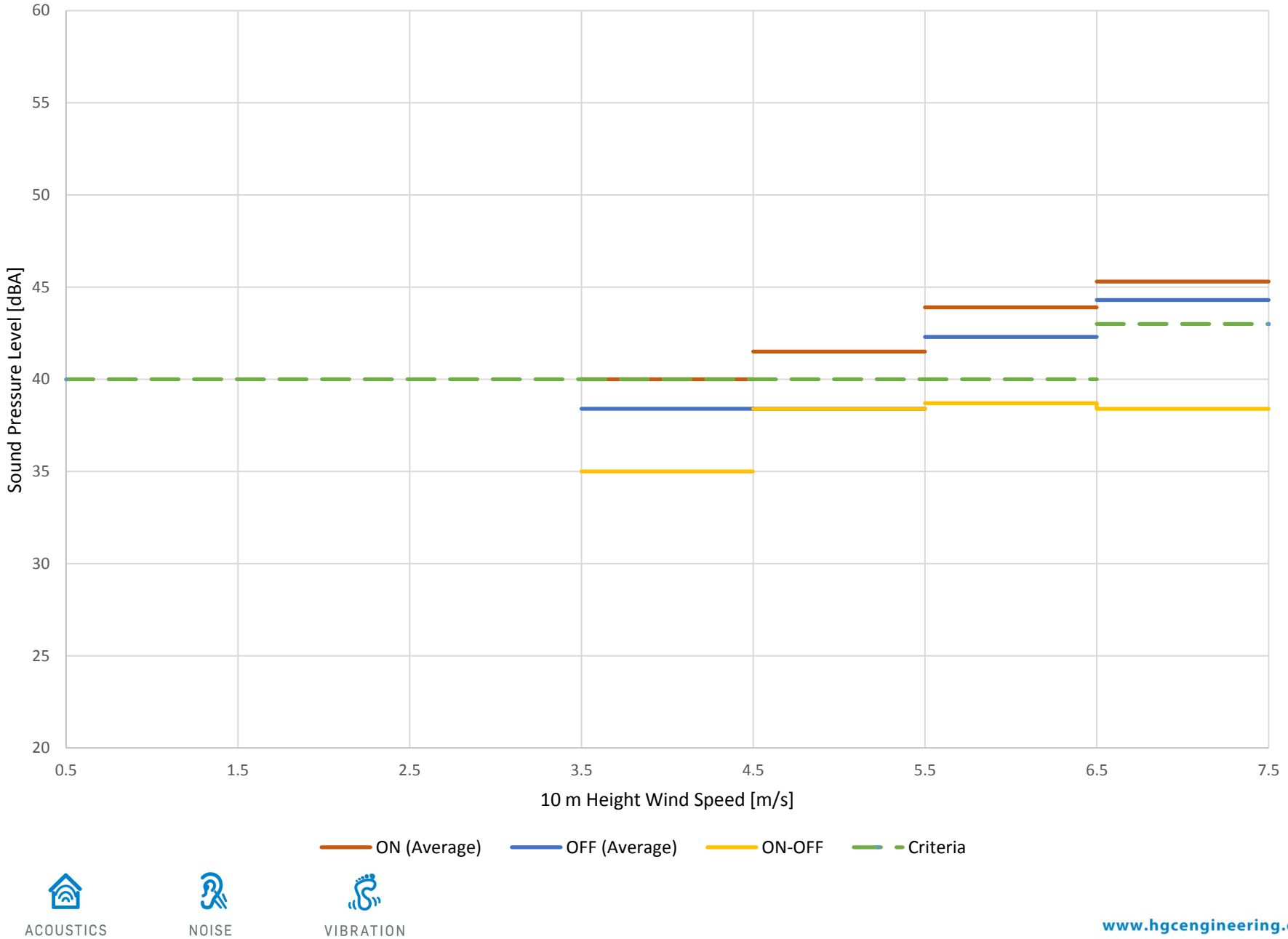


Figure 7b: Bluewater, Immission Results
Monitoring Location M1769, January 11 to April 1, 2019



APPENDIX A:
MONITORING LOCATION SELECTION

Figure A1: Annual Wind Rose [8]

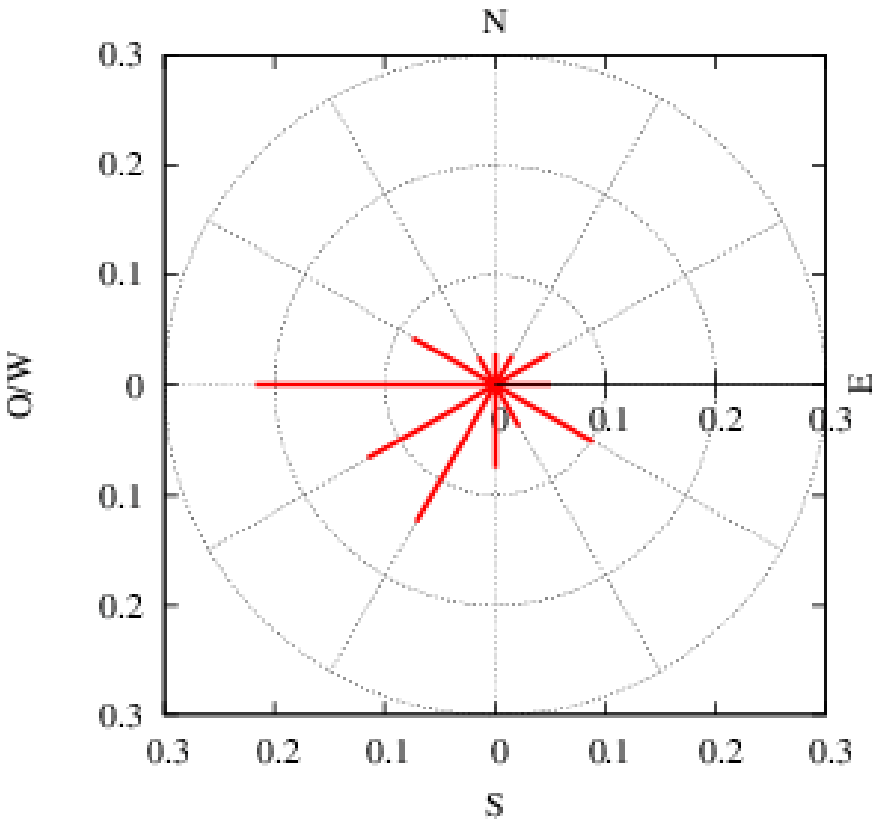


Table A1: Receptor Location Selection

ID	Type	Receptor Height [m]	Distance to nearest turbine [m]	Nearest turbine ID	Calculated Sound Pressure Level at Receptor [dBA]		Suitable Audit Receptor	Comments
					ENIA [2]	HGC Acoustic Model*		
BLW930	PR	7.5	439	WTG29	42.9	42.8	N	Participating, not prevailing wind direction
BLW194	NP	4.5	-	Zurich	-	-	N	Zurich Wind project dominant
BLW509	PR	4.5	539	WTG01	39.7	39.7	N	Participating
BLW1070	PR	4.5	535	WTG35	39.8	39.6	N	Participating, Permission not granted, Minimal space for equipment.
BLW770	PR	4.5	656	WTG25	39.8	39.5	N	Participating, not prevailing wind direction
BLW1749	VPR	4.5	539	WTG28	39.1	38.9	N	Participating vacant lot
BLW1750	VNP	4.5	563	WTG28	38.8	38.6	Y	Selected Receptor
M1750	Monitoring Location	4.5	556	WTG28	-	38.7	-	Selected Monitoring Location
BLW1767	VPR	4.5	715	WTG22	38.7	38.6	N	Participating vacant lot, logistics of crops in field
BLW1517	NP	7.5	787	WTG24	39.2	38.5	N	Not prevailing wind direction. Trees, transformer dominant.
BLW1535	NP	4.5	700	WTG25	39.1	38.5	N	Not prevailing wind direction
BLW1539	PR	4.5	801	WTG27	38.7	38.5	N	Participating, not prevailing wind direction
BLW1756	VPR	4.5	705	WTG25	39.1	38.5	N	Participating, not prevailing wind direction
BLW1768	VPR	4.5	747	WTG22	38.7	38.5	N	Participating vacant lot
BLW1769	VPR	4.5	690	WTG38	38.6	38.5	Y	Selected Receptor
M1769	Monitoring Location	4.5	729	WTG38	-	38.2	-	Selected Monitoring Location
BLW793	NP	7.5	709	WTG24	39	38.5	N	Not prevailing wind direction
BLW883	PR	7.5	715	WTG38	38.8	38.5	N	Participating, interference (barns, fans, etc.)
BLW1536	NP	4.5	835	WTG26	38.7	38.4	Y	Selected Receptor
M1536	Monitoring Location	4.5	826	WTG16	-	38.2	-	Selected Monitoring Location
BLW511	NP	4.5	687	WTG12	38.4	38.4	N	Not prevailing wind direction
BLW767	NP	4.5	822	WTG25	38.8	38.4	N	Not prevailing wind direction
BLW768	NP	4.5	853	WTG25	38.8	38.4	N	Not prevailing wind direction
BLW769	NP	4.5	851	WTG26	38.8	38.4	N	Not prevailing wind direction
BLW790	NP	4.5	696	WTG24	38.3	38.4	N	Not prevailing wind direction
BLW902	PR	7.5	740	WTG23	39.6	38.4	N	Participating receptor

*Sound level predicted by acoustic model prepared by HGC Engineering, with turbines T20, T39, T40 and T41 removed (alternate turbines not constructed).

APPENDIX B:
MONITORING LOCATION PHOTOS

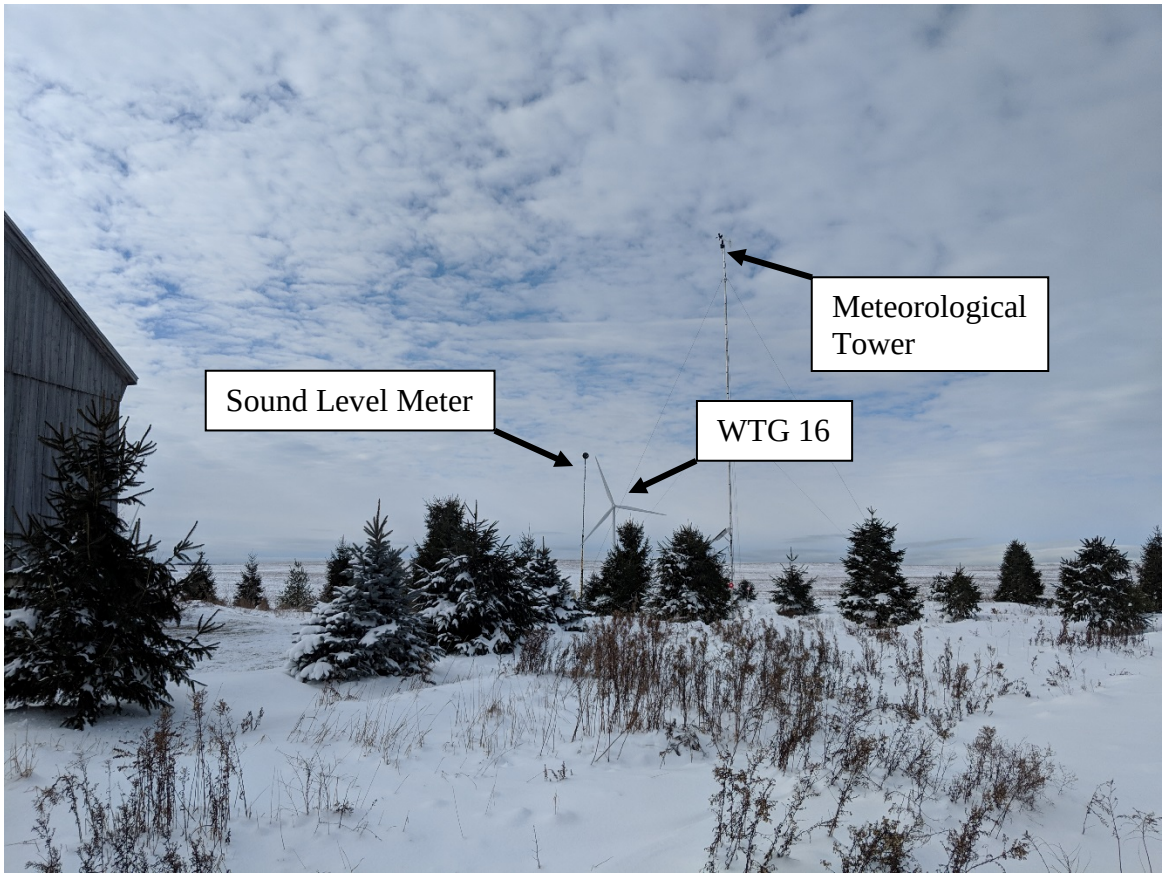


Photo of Meteorological Tower and Sound Level Meter at Location M1536 (looking west)

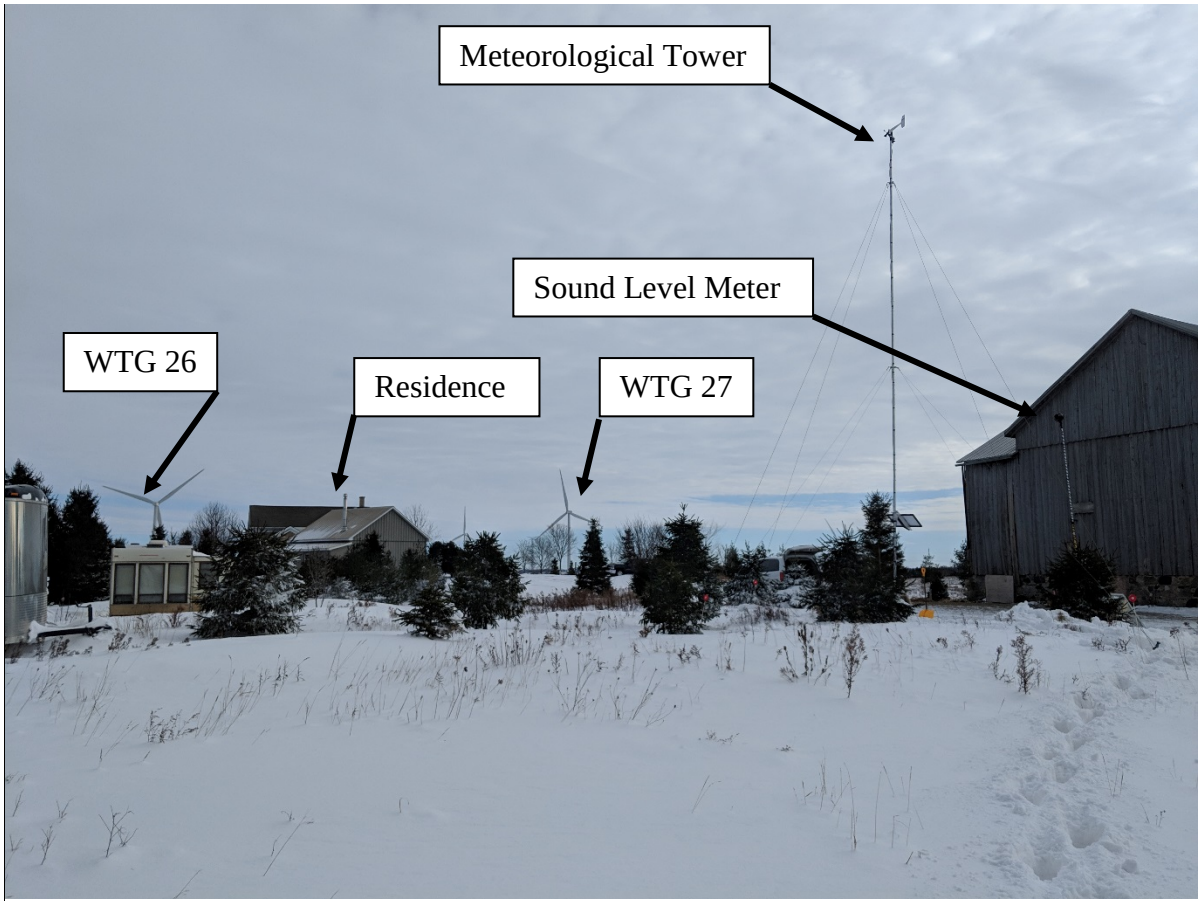


Photo of Meteorological Tower and Sound Level Meter at Location M1536 (looking east)

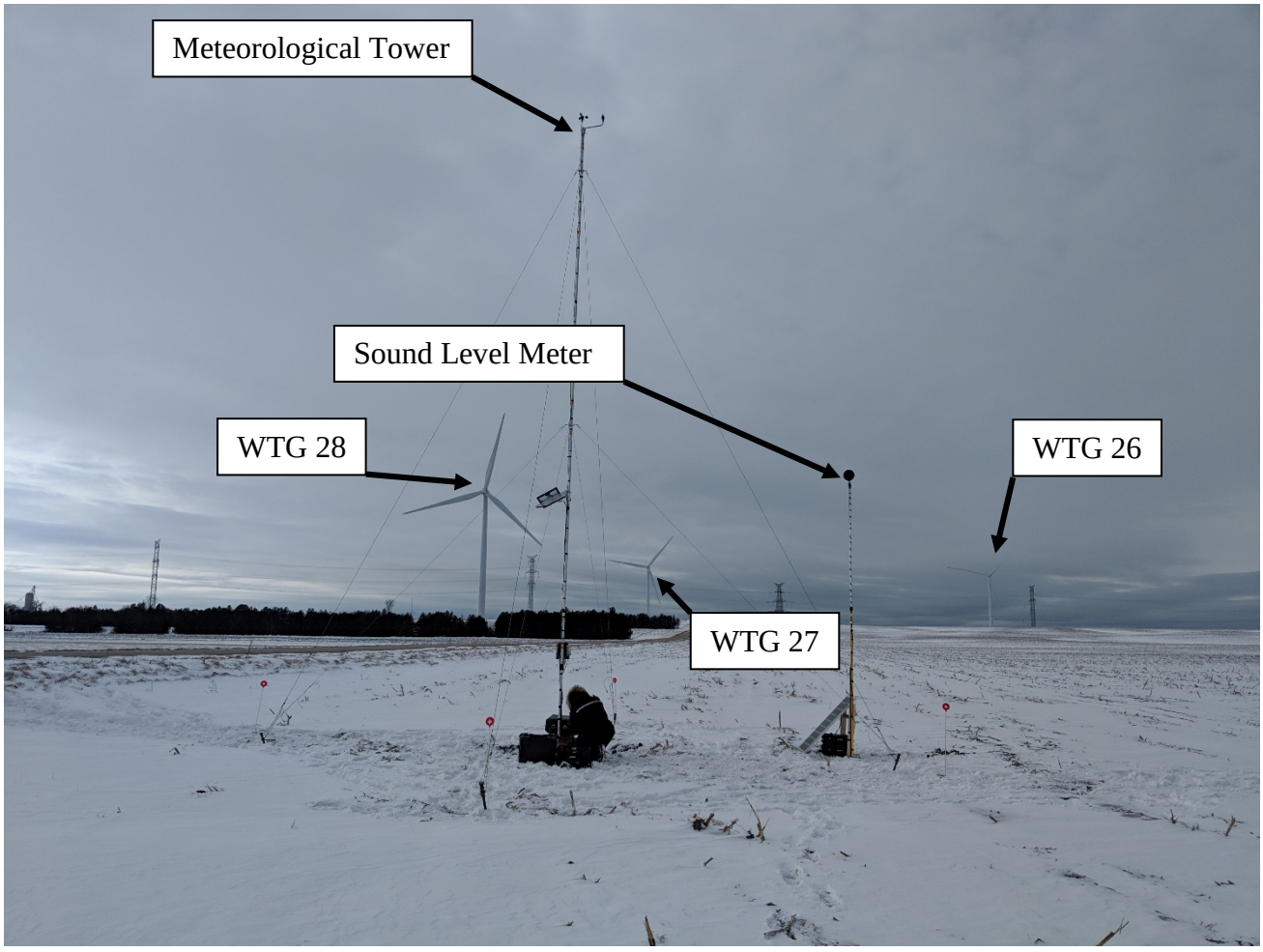


Photo of Meteorological Tower and Sound Level Meter at Location M1750 (looking west)

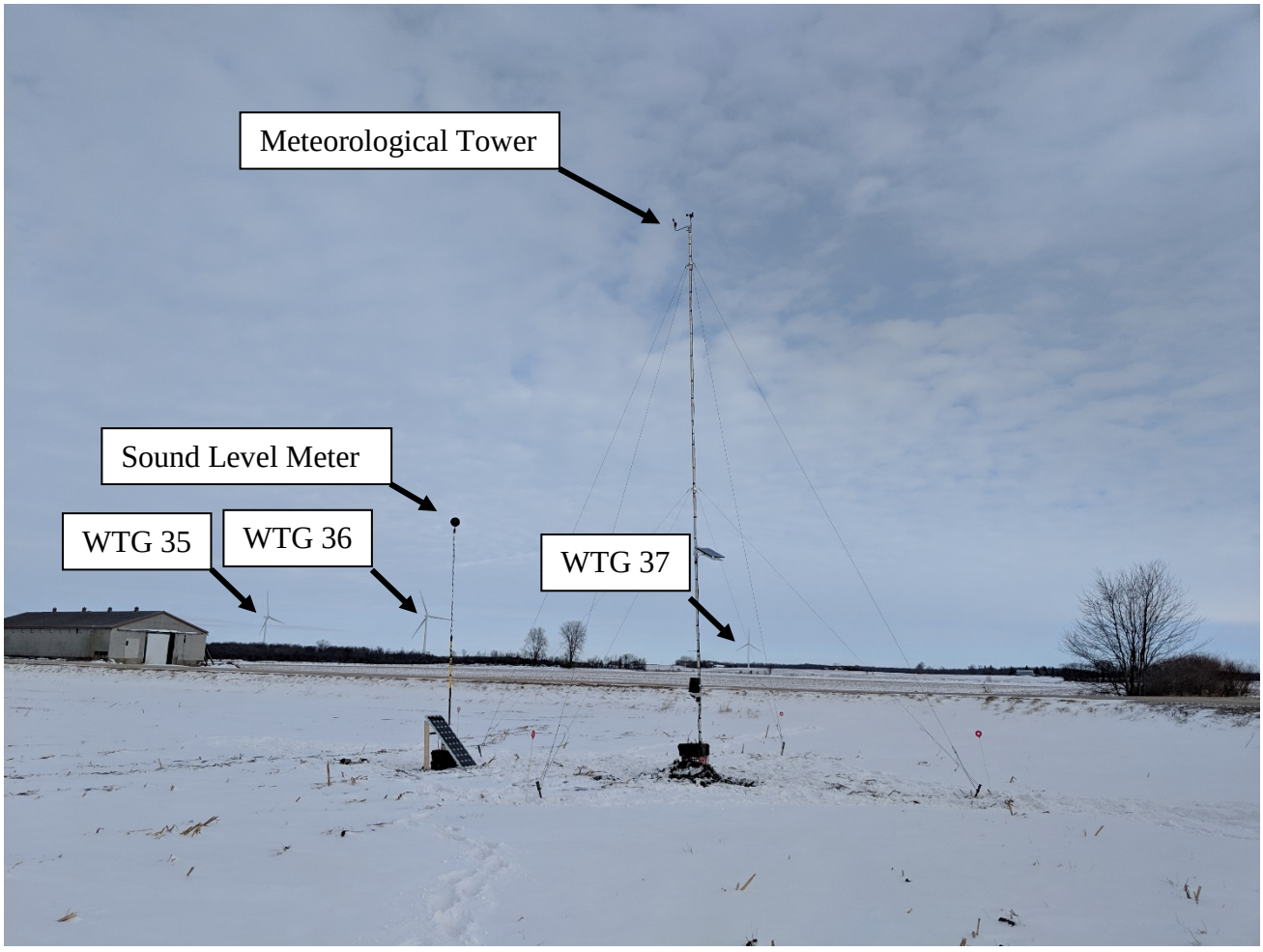


Photo of Meteorological Tower and Sound Level Meter at Location M1750 (looking east)

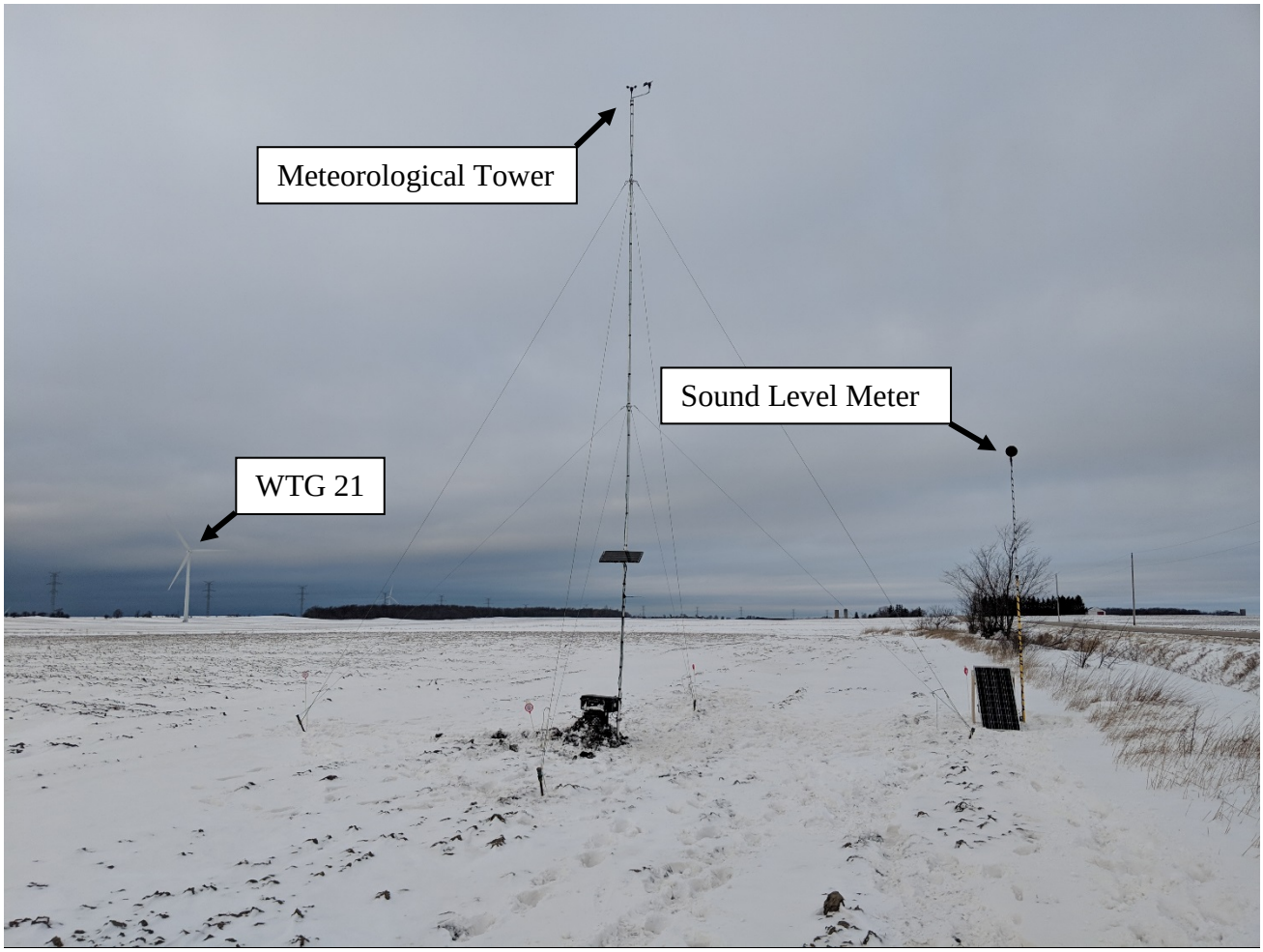


Photo of Meteorological Tower and Sound Level Meter at Location M1769 (looking north)

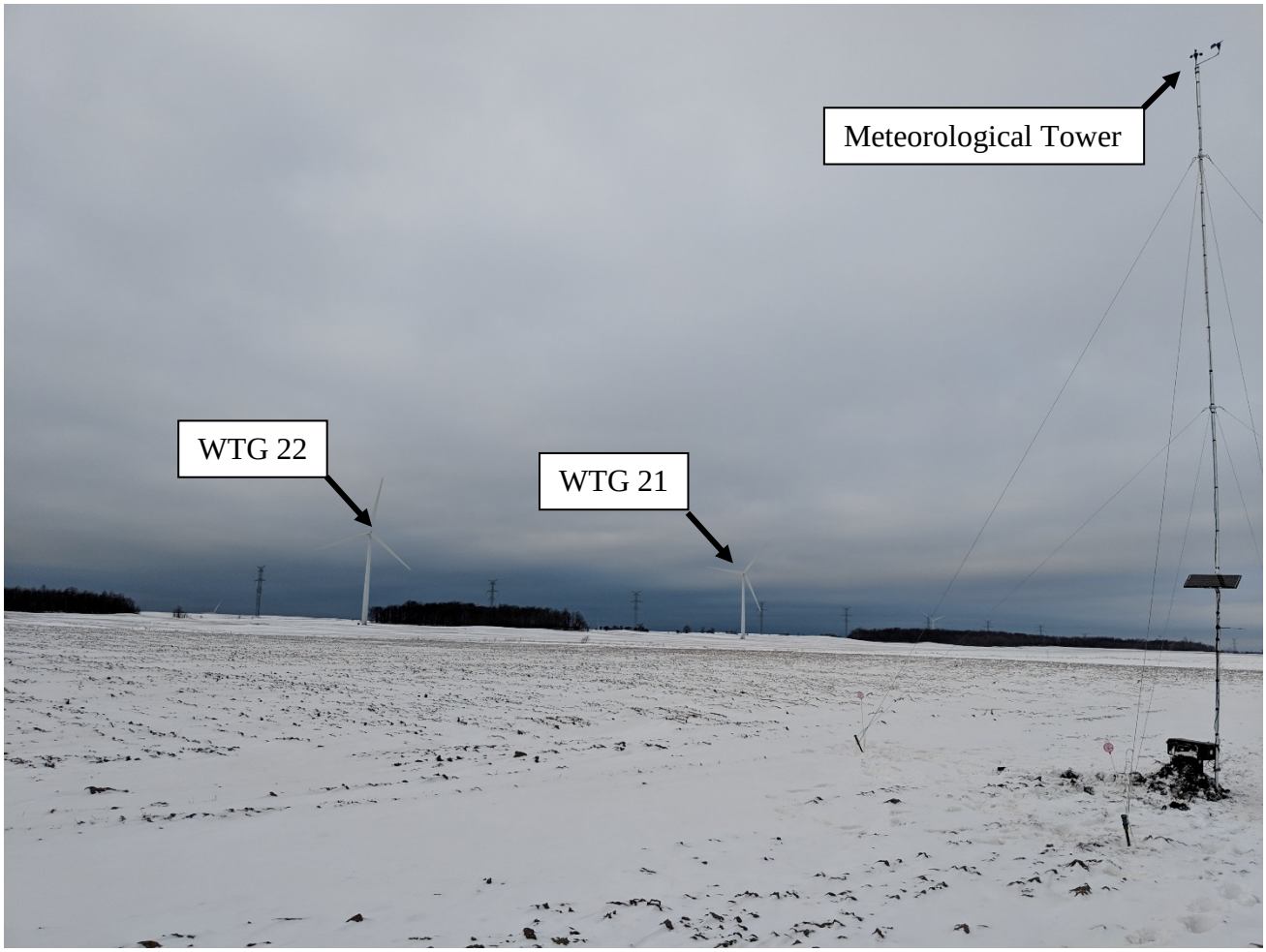


Photo of Meteorological Tower at Location M1769 (looking northwest)

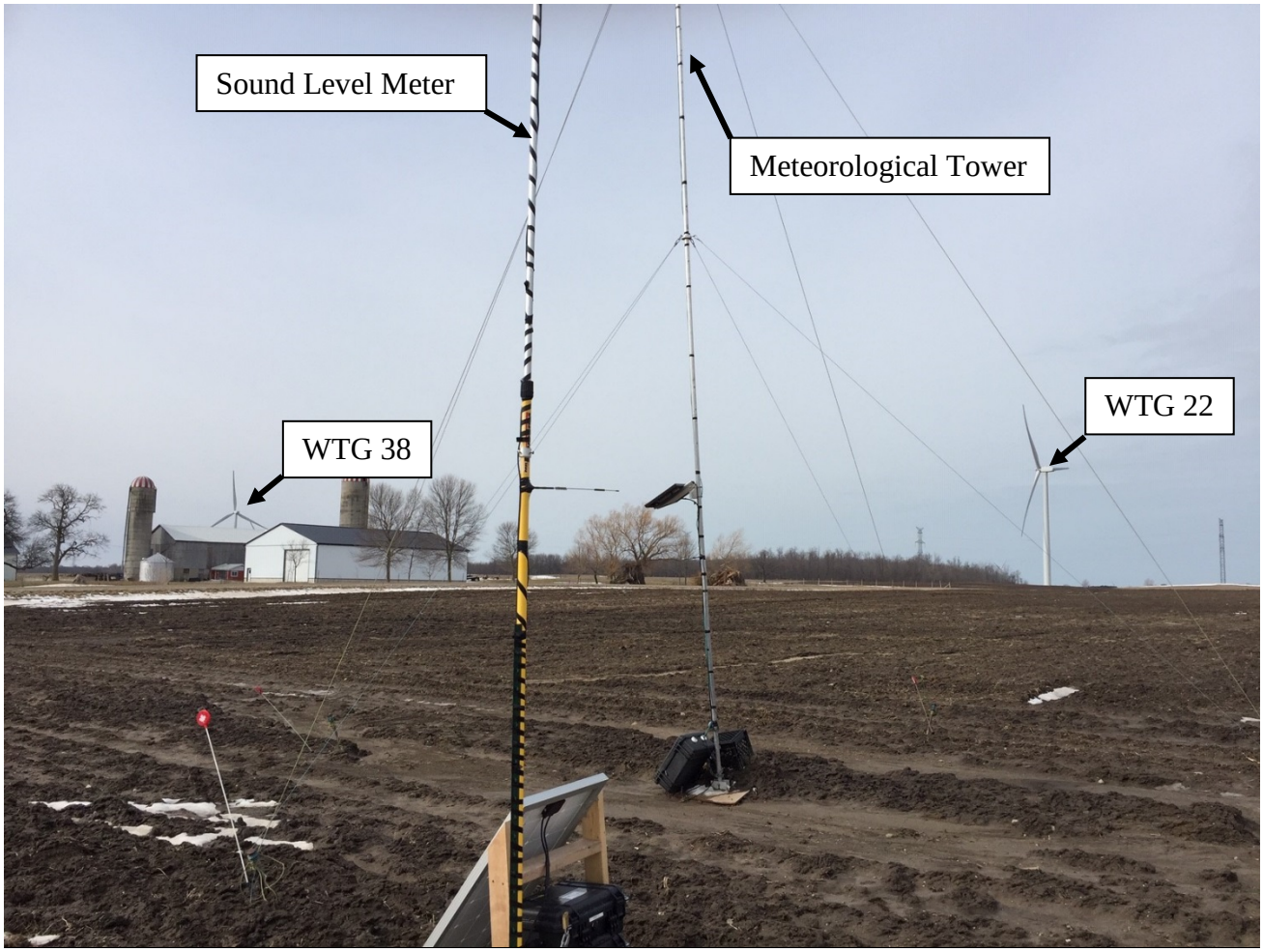


Photo of Meteorological Tower and Sound Level Meter at Location M1769 (looking southwest)

APPENDIX C:
CALIBRATION CERTIFICATES

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

NRG 4
116
24 Nov 2018

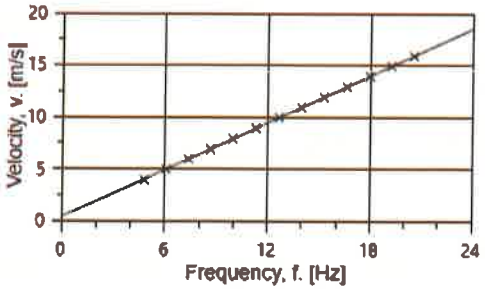
Certificate number: 18.US1.05910 **Date of issue:** November 27, 2018
Type: NRG 40C Anemometer **Serial number:** 179500235190
Manufacturer: NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA
Client: HGC Engineering, 2000 Argentia Road, Plaza One, Suite 203, Mississauga, ON L5N 1P7, Canada
Anemometer received: November 19, 2018 **Anemometer calibrated:** November 26, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

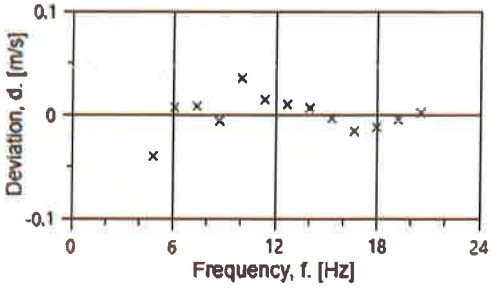
Eric Jeffcott

Calibration equation obtained: v [m/s] = 0.75518 · f [Hz] + 0.38133

Standard uncertainty, slope: 0.00137 **Standard uncertainty, offset:** 0.03692
Covariance: -0.0000136 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999990
Absolute maximum deviation: -0.040 m/s at 3.961 m/s
Barometric pressure: 999.0 hPa **Relative humidity:** 22.6%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.28	20.4	25.6	3.961	4.7929	-0.040	0.023
4	14.60	20.4	25.6	4.967	6.0639	0.007	0.026
6	21.05	20.4	25.6	5.965	7.3830	0.008	0.030
8	28.53	20.5	25.6	6.944	8.6979	-0.006	0.034
10	37.49	20.5	25.6	7.961	9.9905	0.035	0.038
12	47.48	20.5	25.6	8.959	11.3389	0.014	0.042
13-last	58.66	20.4	25.6	9.958	12.6688	0.010	0.046
11	71.04	20.4	25.6	10.959	13.9983	0.006	0.051
9	84.43	20.4	25.6	11.947	15.3204	-0.004	0.055
7	99.01	20.4	25.6	12.938	16.6474	-0.015	0.059
5	114.87	20.4	25.6	13.936	17.9652	-0.012	0.063
3	131.33	20.4	25.6	14.901	19.2323	-0.005	0.067
1-first	149.62	20.3	25.6	15.904	20.5518	0.002	0.072





ilac-MRA
ANAB ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY
AC-1746
SOH Wind Engineering LLC measnet USA

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

NRG 10
NG
29 Nov 2018

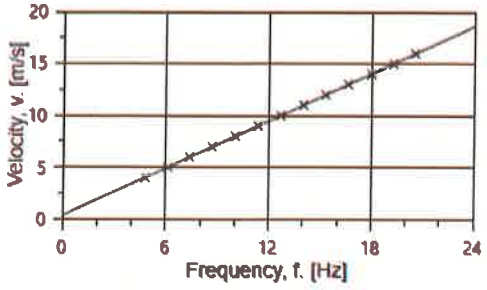
Certificate number: 18.US2.11451 **Date of issue:** November 27, 2018
Type: NRG 40C Anemometer **Serial number:** 179500239925
Manufacturer: NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA
Client: HGC Engineering, 2000 Argentia Road, Plaza One, Suite 203, Mississauga, ON L5N 1P7, Canada
Anemometer received: November 19, 2018 **Anemometer calibrated:** November 26, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

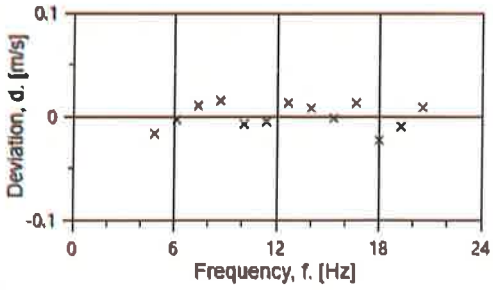
Eric Jeffcoat

Calibration equation obtained: $v\,[m/s] = 0.76148 \cdot f\,[Hz] + 0.31441$

Standard uncertainty, slope: 0.00095 **Standard uncertainty, offset:** 0.03119
Covariance: -0.0000066 $(m/s)^2/Hz$ **Coefficient of correlation:** $\rho = 0.999995$
Absolute maximum deviation: -0.023 m/s at 13.990 m/s
Barometric pressure: 999.2 hPa **Relative humidity:** 21.0%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.41	20.2	25.6	3.985	4.8423	-0.017	0.023
4	14.67	20.3	25.6	4.977	6.1278	-0.003	0.026
6	21.15	20.3	25.6	5.977	7.4228	0.010	0.030
8	28.85	20.3	25.6	6.980	8.7346	0.015	0.034
10	37.78	20.3	25.6	7.988	10.0870	-0.007	0.039
12	47.88	20.3	25.6	8.993	11.4038	-0.005	0.043
13-last	59.05	20.3	25.6	9.987	12.6859	0.013	0.047
11	71.67	20.3	25.6	11.003	14.0265	0.008	0.051
9	85.04	20.3	25.6	11.986	15.3298	-0.002	0.056
7	100.03	20.3	25.6	12.999	16.6413	0.013	0.060
5	115.85	20.3	25.6	13.990	17.9894	-0.023	0.064
3	132.92	20.3	25.6	14.985	19.2785	-0.010	0.069
1-first	151.07	20.2	25.6	15.974	20.5539	0.008	0.073





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Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

RMY
30 Jan 2018
MG

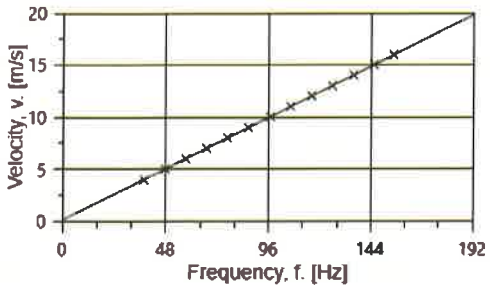
Certificate number: 18.US2.00841 **Date of issue:** January 25, 2018
Type: R.M.Young 05305-10 **Serial number:** WM93557-Prop76170
Manufacturer: R.M. Young Company, 2801 Aero-park drive, Traverse City, Michigan 49686, USA
Client: HGC Engineering, 2000 Argentia Road, Plaza One, Suite 203, Mississauga, ON L5N 1P7, Canada
Anemometer received: January 23, 2018 **Anemometer calibrated:** January 23, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

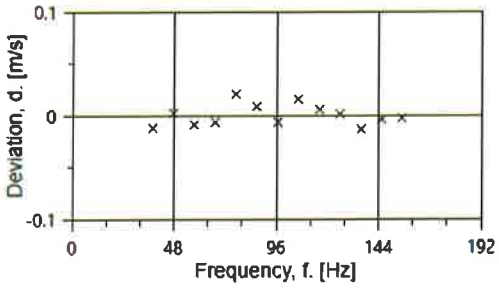
Eric Jeffcott

Calibration equation obtained: $v\,[m/s] = 0.10277 \cdot f\,[Hz] + 0.08044$

Standard uncertainty, slope: 0.00080 **Standard uncertainty, offset:** 0.10600
Covariance: -0.0000007 $(m/s)^2/Hz$ **Coefficient of correlation:** $\rho = 0.999996$
Absolute maximum deviation: 0.021 m/s at 8.021 m/s
Barometric pressure: 988.9 hPa **Relative humidity:** 17.8%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, *v*. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.26	21.7	26.4	3.984	38.1027	-0.012	0.024
4	14.52	21.8	26.4	4.990	47.7473	0.002	0.025
6	20.93	21.8	26.3	5.992	57.6056	-0.009	0.027
8	28.55	21.8	26.3	6.997	67.3670	-0.006	0.030
10	37.51	21.8	26.3	8.021	77.0696	0.021	0.033
12	47.32	21.8	26.3	9.009	86.7989	0.009	0.036
13-last	58.39	21.8	26.3	10.008	96.6688	-0.007	0.039
11	70.69	21.8	26.3	11.012	106.2195	0.016	0.042
9	84.36	21.8	26.3	12.030	116.2194	0.006	0.045
7	98.69	21.8	26.3	13.012	125.8231	0.001	0.048
5	114.63	21.8	26.3	14.023	135.7972	-0.013	0.051
3	131.50	21.7	26.4	15.018	145.3970	-0.004	0.054
1-first	149.19	21.6	26.4	15.994	154.8828	-0.003	0.057





AC-1746

CERTIFICATE of CALIBRATION

Make : Norsonic

Model : NOR140

Descr. : Sound Level Meter Type 1

Serial # : 1403362

Asset # : N-140-2

Reference # : 154932

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richardson

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Dec 21, 2018

Cal. Due : Dec 21, 2019

By : T. Beilin

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

CERTIFICATE of CALIBRATION

Make : Svantek

Model : SVAN977

Descr. : Sound Level Meter Type 1

Serial # : 36426

Asset # : SV977-2

Reference # : 155091

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richardson

NG 17 Jan 2019

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jan 15, 2019

Cal. Due : Jan 15, 2020

By : T. Beilin

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

CERTIFICATE of CALIBRATION

Make : Svantek

Model : SVAN977

Descr. : Sound Level Meter Type 1

Serial # : 36428

Asset # : SV977-3

Reference # : 154925

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richardson NG
19 Dec 2018

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Dec 19, 2018

Cal. Due : Dec 19, 2019

By : T. Beilin

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

CERTIFICATE of CALIBRATION

Make :	Svantek	Reference # :	154926
Model :	SVAN977	Customer :	HGC Engineering Mississauga, ON
Descr. :	Sound Level Meter Type 1		
Serial # :	45420	P. Order :	Sean Richardson
Asset # :	SV977-8		

Cal. status : Received in spec's, no adjustment made.

MG
19 Dec 2018

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Dec 19, 2018 By : T. Beilin

Cal. Due : Dec 19, 2019

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com

Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

APPENDIX D:
TONALITY ANALYSIS

Table D1 - Summary of Tonality Assessment, M1536

Range of Frequencies [Hz]	10 m Height Wind Speed Bin	Tone Count	Data Count	Tone Presence	Tonal Audibility [dB]	Tonal Penalty [dB]
All	5	No Relevant Tones*				**0**
	6	No Relevant Tones*				**0**
	7	No Relevant Tones*				**0**

* Tonal Presence < 20% or Tonal Audibility < -3.0 dB - No tones reported.

Table D2 - Summary of Tonality Assessment, M1750

Range of Frequencies [Hz]	10 m Height Wind Speed Bin	Tone Count	Data Count	Tone Presence	Tonal Audibility [dB]	Tonal Penalty [dB]
618.2 - 647.5	5	76	129	59%	-2.8	**0**
All Others	4	No Relevant Tones*				**0**
	5	No Relevant Tones*				**0**
	6	No Relevant Tones*				**0**
	7	No Relevant Tones*				**0**

* Tonal Presence < 20% or Tonal Audibility < -3.0 dB - No tones reported.

Table D3 - Summary of Tonality Assessment, M1769

Range of Frequencies [Hz]	10 m Height Wind Speed Bin	Tone Count	Data Count	Tone Presence	Tonal Audibility [dB]	Tonal Penalty [dB]
615.2 - 634.3	4	31	87	36%	-0.6	**0**
	5	69	207	33%	-1.2	**0**
All Others	4	No Relevant Tones*				**0**
	5	No Relevant Tones*				**0**
	6	No Relevant Tones*				**0**

* Tonal Presence < 20% or Tonal Audibility < -3.0 dB - No tones reported.

APPENDIX E:

STATEMENT OF OPERATION

Varna Wind, LP

Date April 23 2019

Re: Statement of Operation
Bluewater Wind Energy Centre
Bluewater, Ontario

To whom it may concern,

This letter is to confirm that the wind turbine generators at the Bluewater Wind Energy Project were operating normally during the post-construction acoustic audit, conducted between January 11 and April 1, 2019. Additionally, this letter confirms that the relevant turbines were parked for ambient (OFF) condition measurements.

Yours Truly,

Michael Blackmore
Wind Site Manager
NextEra Energy Canada Operating Services Inc.
(the operator of the Bluewater Project and authorized signatory of Varna Wind, LP)