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ASSESSMENT REPORT - **Project: 15247.03**

Armow Wind Power Project
Tonality Assessment Report – R243

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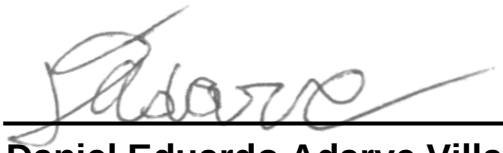
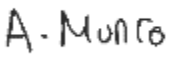
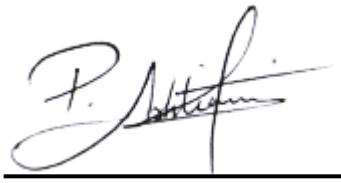


Daniel Eduardo Adarve Villanueva. B.Eng., E.I.T.



Allan Munro, B.A.Sc., P.Eng.



Payam Ashtiani, B.A.Sc., P.Eng.

07 February 2020

Revision History

Revision Number	Description	Date
1	Tonality Investigation Noise Report	07/02/2020

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Executive Summary

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow wind turbines identified in the REA as T50, T30, T88, T102, **T75** and T95. This report is specific to Turbine T75. The tonality assessment has been conducted at the worst-case receptor for turbine T73 which is the same turbine model as T75 (SWT-2.3-101 2.3MW, hub 99.5) as agreed to by the MECP and as per section 3.c of the Armow Scope of Work document dated July 26, 2019.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location R243. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4-1 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH, issued on October 9, 2013.

The tonality investigation has been completed as per the methodology outlined in Parts D 3.8.3 of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

No tone was present at R243 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T73, T75 and turbines of the same type (SWT-2.3-101 2.3MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

1 Introduction

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow wind turbines identified in the REA as T50, T30, T88, T102, **T75** and T95. This report is specific to Turbine T75 and the tonality assessment has been conducted at the worst-case receptor for turbine T73 which is the same turbine model as T75 (SWT-2.3-101 2.3MW, hub 99.5) as agreed to by the MECP and as per section 3.c of the Armow Scope of Work document dated July 26, 2019.

An alternative surrogate receptor was chosen as the closest respective receptors to turbine T75 are in the upwind direction.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location R243. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4-1 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH, issued on October 9, 2013.

The tonality investigation has been completed as per the methodology outlined in Parts D 3.8.3 of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

This report outlines the measurement methodology, results, and a comparison of the measured turbine tonal audibility to the tonal adjustment structure from ISO1996-2:2007 Annex C.

2 Noise Source Summary

Aercoustics was retained before this assessment to conduct E-Audits to verify the noise emission of turbines at the Armow Wind Power Project.

The purpose of the E-Audits was to confirm whether equipment was operating as per manufacturer's specifications and satisfies the sound power level specified in the REA Appendix B. The E-Audits reports have been prepared to facilitate submission to the MECP, in compliance with acoustic audit conditions outlined in the REA (Specifically, Section F – Wind Turbine Acoustic Audit – Emission).

Wind Turbine Generator T75 was audited utilizing International Standard IEC 61400-11 (Edition 3.0, released 2012-11), "Wind Turbine generator systems – Part 11: Acoustic Noise Measurement Techniques".

Table 1 Summary of Wind Turbine Noise Emission Audit

Turbine ID	Turbine Model	Report ID
T75	Siemens SWT-2.3-101 2.3MW, hub 99.5m	15247.00.T75.RP2

Detailed measurement reports for T75 (Report ID: 15247.00.T75.RP2) outline the apparent sound power level, measurement uncertainties and tonal audibility results.

2.1 Tonal Audibility Results from E-Audit

Results of the tonality assessment of the acoustic audit for T75 is summarised in Table 2.

Table 2 – T75 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
8	58	-2.4	-0.4	57	82	70%
8.5	58	-2.1	-0.1	27	75	36%
8.5	481	-1.1	1.2	33	75	44%
9	493	-0.3	2.0	42	45	93%
9.5	504	-0.1	2.2	31	35	89%
10	510	0.2	2.5	21	25	84%
10.5	528	0.7	3.0	108	112	96%
11	530	1.0	3.3	114	116	98%
11.5	529	1.3	3.7	82	88	93%
12	529	1.5	3.8	63	68	93%
12.5	530	1.9	4.3	44	47	94%

Table 3 presents a summary of the relevant tones for this assessment noted from the E-Audits and includes the frequency range, tonal audibilities and the corresponding turbine operational parameters during which elevated tonal audibility levels were observed.

Table 3 Summary of Relevant Tones T75

Turbine ID	Frequency Range (Hz)	Tonal Audibility (dB)	Hub Height Wind Speed Range (m/s)	Electrical Power Output Range (kW)
T75	481Hz [452Hz to 508Hz]	1.2 - 2.2	8.5 – 9.5	1316 - 1778
	530Hz [502Hz to 560Hz]	2.2 – 4.3	9.5 – 12.5	1778 – 2298

3 Tonal Assessment Details

The acoustic audit was conducted at receptor R243[1]. This location is closest to turbine T73. Turbine T74 is the same model turbine as T75 (SWT-2.3-101 2.3MW, hub 99.5m) and was chosen as the alternate surrogate turbine as the closest respective receptors to turbine T75 are in the upwind direction compared to the predominant wind direction for the Armow Wind Power Project.

Monitoring at R243 spanned the following dates, summarized in Table 4.

Table 4: Monitoring Period for Receptor R243 (DD/MM/YYY)

Location	Monitoring Start Date	Monitoring End Date
R243	19/09/2019	11/11/2019

3.1 Test Equipment

The measurement equipment used for the Tonal Assessment, both acoustic and environmental, is detailed below. Equipment specifications and measurement positions comply with MECP Compliance Protocol sections *D2 – Instrumentation* and *D3 – Measurement* Procedure, respectively. Each remote monitoring unit is comprised of the following:

- One (1) Type 1 sound level meter, with microphone and pre-amplifier mounted at a height of 4.5 meters, at least 5 meters from any large reflecting surfaces.
- One (1) primary and one (1) secondary windscreen for the microphone. The 1/3 octave band insertion loss of the secondary windscreen has been tested and was accounted for in the data analysis.
- One (1) anemometer, mounted at a height of 10 metres above ground level (“10 m AGL”).

Table 5 provides the specific model and serial numbers for the measurement equipment used during the measurement campaign.

[1] Receptor IDs taken from the Noise Assessment Report by A. Brunskill, D. Eaton and E.Crivella dated September 9, 2013 [3]

Table 5: Equipment Details

Location	Equipment	Make/Model	Serial Number
R243	Sound Level Meter	NI 9234	1B3CDE4
	Microphone	PCB 378B02	167979
	Pre-Amplifier	PCB 426E01	044829
	Weather Anemometer	Vaisala WXT 520	L3020298
	Signal Conditioner	PCB 480E09	33810

The measurement chain was calibrated before and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator.

3.2 Measurement Methodology

For the duration of the measurement campaign, acoustic and anemometer data was logged simultaneously in one-minute intervals. The acoustic data included A-weighted overall equivalent sound levels (LAeq), percentile statistical levels (L90), and 1/3 octave band levels between 20 Hz and 10,000 Hz. The recorded weather data included average wind direction, wind speed, temperature, relative humidity, and atmospheric pressure. The maximum wind speed for each one-minute interval was also stored.

To account for the effect of wind speed on the measured sound level, measurement intervals are sorted into integer wind bins based on the measured 10 m wind speeds. Each bin ranges from 0.5 m/s below to 0.5 m/s above each respective wind bin (i.e. 5 m/s wind bin represents all intervals with average wind speeds between 4.5 m/s and 5.5 m/s).

3.3 Data Reduction and Filtering

The data reduction procedures used on the measurement data to remove invalid data points from the assessment are detailed below. These procedures are in accordance with Section D5.2 of the Protocol and in accordance with the measurement equipment specifications.

A measurement interval is excluded if any one of the following criteria are not satisfied:

- The interval occurred between 10pm – 5am
- No precipitation was detected 60 minutes before and 60 minutes after the interval
- The ambient temperature was above -20˚C

The purpose of the filters listed above is to exclude intervals where the data quality is reduced due to extraneous events (such as vehicle pass-bys), unusable environmental conditions (such as rain), or equipment operating outside of its specifications. Intervals that pass the filtering criteria listed above are sorted into Turbine ON or Background periods based according to the conditions listed below. If neither Turbine ON or Background conditions are met, the data point is excluded.

- Turbine ON: Armow turbines must be rotating and generating power
- Background: Armow turbines must be parked and not generating power

The Protocol also requires additional criteria be met by each Turbine ON data point based on the conditions of the nearest turbine to each receptor. Specifically,

> "*Only downwind data will be considered in the analysis. With reference to the Turbine location, downwind directions are ±45 degrees from the line of sight between the Turbine and receptor/measurement location*." *{Section D5.2 (4)}*

The following additional power filter was applied to specifically assess operational conditions when the highest tonal audibility values were measured during the I-audit testing at T73.

Table 6: Power Filtering Summary

Location	Turbine	Power Output (kW)
R243	T73	≥ 1316

3.4 **Measurement Location**

Monitoring was conducted at the lot receptor R243. R243 has a predicted impact of 38.8 dBA as per level predicted from an "As Built" noise model based on the original CadnaA noise prediction model. The following table provides a summary of the receptor location. Detailed site plans showing the receptor and audit location is attached in Appendix A.

Table 7: Receptor Measurement Locations

	Audit Receptor ID Turbine ID	R243 T73
Receptor	UTM Coordinates (X,Y)	17T 460096 mE 4899622 mN
	Distance to Turbine (m)	627
	Receptor Height (m)	4.5
	Predicted Level (dBA)*	38.8
Monitor	UTM Coordinates (X,Y)	17T 460062 mE 4899638 mN
	Distance to Turbine (m)	620
	Monitor Height (m)	4.5
	Predicted Level (dBA)*	38.8

*Predicted Level from Aercoustics' acoustic mode

Flora and Fauna
Ambient contamination from flora and fauna was present to varying degrees at the measurement location. Transient contamination (dogs barking etc.) are removed by the listening tests. Insects, birds, and noise from leaves and crops rustling were present to varying degrees in the environment surrounding all receptors; this noise is present to greater degrees at high frequencies and those frequencies were excluded to minimize contamination from insect noise.

Impact of Excluded Frequencies
Analysis of the measured sound levels for R243 were limited to 1/3rd octave band frequencies below 1250 Hz and frequencies above 8000 Hz. This frequency band was excluded to minimize contamination of the acoustic measurements from steady ambient sources such as insects. The predicted impact at these frequencies is presented in Table 8.

Table 8: Predicted Impact from Facility of Excluded Frequencies

Measurement Location	Predicted Facility Immission, 2000 Hz – 4000 Hz octave bands[2]
R243	27.5 dBA

The contribution from the wind facility at these frequencies is small because high frequency sound is more efficiently absorbed by the atmosphere. The predicted facility sound impact at from frequencies excluded from the measurement data have been added back to the Turbine-Only sound level.

3.5 Sample size Reporting Requirements

As per Section D3.8.3 Tonality (tonal assessment) of the MECP protocol, at least 5 one-minute intervals are required for wind turbine noise and background noise (wind turbines parked). These intervals shall be as close as possible to the integer wind speed. In addition, the MECP has required that the five (5) one-minute measurements per wind speed bin are to include the entire assessment range of the turbine and is not limited to wind speed bins of 4-7 m/s.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by Pattern Operation Control Centre. Measurement data at receptor was filtered to include only intervals when all turbines in the immediate vicinity were operational, or, in the case of the ambient noise measurements, were not operational. The turbines included in this study were chosen such that when they are turned off, the partial impact of the remaining

[2] Contribution by octave band frequency determined using CadnaA model

Armow turbines was less than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were T10, T73.

4 Tonal Assessment Results

Acoustic and weather data measured during the Tonal Assessment are summarized in the following section.

4.1 Weather Conditions

General weather conditions measured over the course of the tonality investigation are summarized in Table 9.

Table 9: General Weather Conditions – Range of Measured Values

	10-m AGL			
	Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]
Minimum	974	0.1	37	-6
Maximum	995	18.4	91	24

4.2 Wind Direction

A Wind rose representing the recorded wind directions during the audit is reported in Appendix B. Wind direction recorded from the turbine yaw angle, and wind speeds measured from the 10-m AGL anemometer, were combined to prepare the wind rose. The wind speeds from 1-7 m/s at 10-m AGL represent the I-audit wind bins as per Section E5.5 of the Protocol.

4.3 Measured Sound Levels

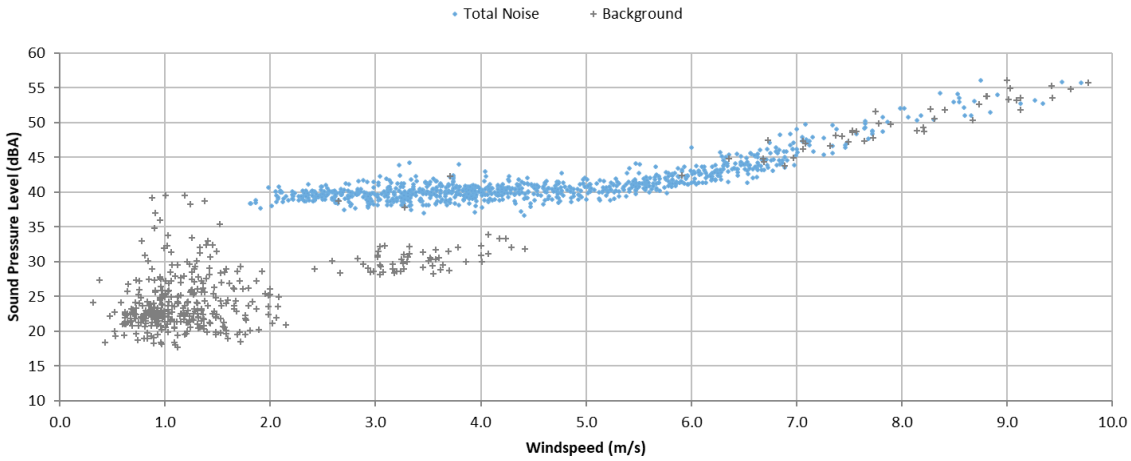
Table 10 details the sound levels measured at the receptor when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). The Turbine ON and Turbine OFF sound level presented are filtered as per the filters detailed in Section 3.3.

Table 10: R243 Sound levels measured for Turbine ON and OFF (Downwind – T73)

I-Audit Wind Bins (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
1	0	-	-	289	27.0	3.9
2	65	39.5	0.7	56	25.5	3.4
3	204	39.9	1.1	33	31.3	2.4
4	220	40.2	1.1	24	32.9	2.8
5	136	40.6	1.0	0	-	-
6	151	42.6	1.2	2	43.8	1.7
7	83	45.7	1.8	12	46.6	1.5

The following figure presents the scatter plot showing each valid 1-minute interval measured sound levels at R243 when all the nearby turbines were ON (Turbine ON + Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON and Turbine OFF sound level presented was using the filter outlined in section 3.3.

Figure 1: R243 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind – T73)



4.4 **Measured Tonality**

The tonal assessment has been completed using ISO/PAS 20065:2016 (Acoustic-Objective method for assessing the audibility of tones in noise-Engineering Method) and the tonal penalty structure taken from ISO 1996-2:2007 Annex C. Namely, Section 5.1 of the compliance protocol states:

> *If a tonal assessment … indicates a tonal audibility value that exceeds 4 dB, the Ministry will require that a tonal penalty be applied at all Receptors in accordance with the penalties described in Annex C of ISO 1996-2, Reference [2]*

The tonality analysis results of the Emission audit measurements for T75 were used as a basis for tones at receptors which were likely to have been generated by the closest turbine rather than an external source.

Tonality analysis was completed based on 1-minute narrow band spectra, ranging from 20 Hz to 3000 Hz with a frequency resolution of 2 Hz.

Narrowband data was acquired and calculated for each 1-minute interval used in the immission analysis and binned by wind speed. The mean tonal audibility of spectra in each wind bin was then evaluated to determine if a tonal adjustment would be applicable.

For a given spectra if the Tonal audibility is greater than 0dB then a tone is present. For all Spectra in which no tone is found, a tonal audibility of -10 dB is applied (as specified in Section 5.3.9 in ISO/PAS 20065:2016). The Mean Tonal Audibility values reported represent the energy average of all data points with an identified tone that falls within the same frequency of origin with the inclusion of data points with unidentified tones (i.e. -10 dB). A sample tone plot is provided in Appendix D.

4.4.1 Tonal Assessment – 10m wind speed

The presence of tones in the I-audit data binned by 10m wind speed was determined.

Tonal assessment summary table is provided in Table 11 and Table 12.

Table 11: Tonality Summary – R243 – 480 Hz [452Hz to 508Hz]

10m Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
1	0	0	0%	-	-
2	65	3	5%	-8.2	0
3	204	0	0%	-10.0	0
4	220	0	0%	-10.0	0
5	136	0	0%	-10.0	0
6	151	0	0%	-10.0	0
7	83	0	0%	-10.0	0

Table 12: Tonality Summary – R243 – 530 Hz [502Hz to 560Hz]

10m Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
1	0	0	0%	-	-
2	65	6	9%	-7.0	0
3	204	3	1%	-9.3	0
4	220	2	1%	-9.6	0
5	136	1	1%	-9.6	0
6	151	1	1%	-9.7	0
7	83	0	0%	-10.0	0

Relevant tones from T73 (480 Hz and 530 Hz) were found to be present at receptor R243. No tonal adjustment was found to be applicable at receptor R243 at any 10m wind speed bin

4.4.2 Tonal Assessment - hub-height wind speed

The presence of tones in the I-audit data as a function of hub height wind speeds was also determined. The tonal analysis covered the same hub height wind speed range as the sound power level measurement of the E-audit test for Turbine T75. The turbine electrical power filter was removed, and all spectra were sorted into half-integer hub height wind speed bins using the methodology for the E-audit (IEC 61400-11 Ed 3.0) adapted for I-audit measurements. The results of this analysis provide the mean tonal audibility over the entire assessment range of the turbine (8m/s to 12.5m/s).

Table 13 Tonality Assessment at each half-integer hub-height wind speed 480 Hz [452 to 508Hz]

Hub Height Wind Bin (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Turbine Power Output (kW)
8	186	0	0%	-10.0	1196
8.5	132	0	0%	-10.0	1437
9	151	2	1%	-9.4	1677
9.5	122	1	1%	-9.6	1876
10	103	0	0%	-10.0	2075
10.5	90	0	0%	-10.0	2163
11	78	0	0%	-10.0	2251
11.5	43	0	0%	-10.0	2272
12	22	0	0%	-10.0	2293
12.5	16	0	0%	-10.0	2296

Table 14 Tonality Assessment at each half-integer hub-height wind speed 530 [502Hz to 560Hz]

Hub Height Wind Bin (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Turbine Power Output (kW)
8	186	0	0%	-10.0	1196
8.5	132	0	0%	-10.0	1437
9	151	0	0%	-10.0	1677
9.5	122	4	3%	-8.7	1876
10	103	3	3%	-8.7	2075
10.5	90	3	3%	-8.6	2163
11	78	1	1%	-9.4	2251
11.5	43	0	0%	-10.0	2272
12	22	0	0%	-10.0	2293
12.5	16	0	0%	-10.0	2296

Similar to the tonal assessment binned by 10m wind speed, relevant tones from T73 (480 Hz and 530 Hz) were found to be present at receptor R243 for some hub-height wind bins, however the tonal presence and mean audibility was relatively low compared to measurements at the E-audit location.

5 Assessment of Compliance

As per Section D5.6 of the Protocol, if a tone is identified at any of the wind speed bins, the average tonal audibility correction shall be added to the final noise contribution of the wind turbine at those wind speed bins.

No tone was present at R243 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T73, T75 and turbines of the same type (SWT-2.3-101 2.3MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

References

[1] V. Schroter, “Renewable Energy Approval #4544-9B7MYH”, Ontario Ministry of the Environment, Toronto, ON, October 9, 2013.

[2] Ministry of the Environment and Climate Change, *“Compliance Protocol for Wind Turbine Noise”*, Ontario Ministry of the Environment, Toronto, ON, April 21, 2017.

[3] A. Brunskill, D. Eaton and E.Crivella , “Armow Wind Farm, Ontario Noise Impact Assessment ”, GL Garrad Hassan, 9 September 2013.

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Appendix A
Location Details

Legend

- Armow Turbines
- R243

N

Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 10, 2020
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assesment R243

Appendix A.1

Site Plan Overview

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Legend

- Armow Turbines
- R243
- Bruce County Road 15
- Side Road 10

N

Project ID:	15247.03
Drawn by:	DEA
Reveiwed by:	AM
Date:	January 10, 2020
Revision:	1
Scale:	As Indicated

Armow Wind Power Project
Tonal Assessment R243

Appendix A.2

Measurement Locations

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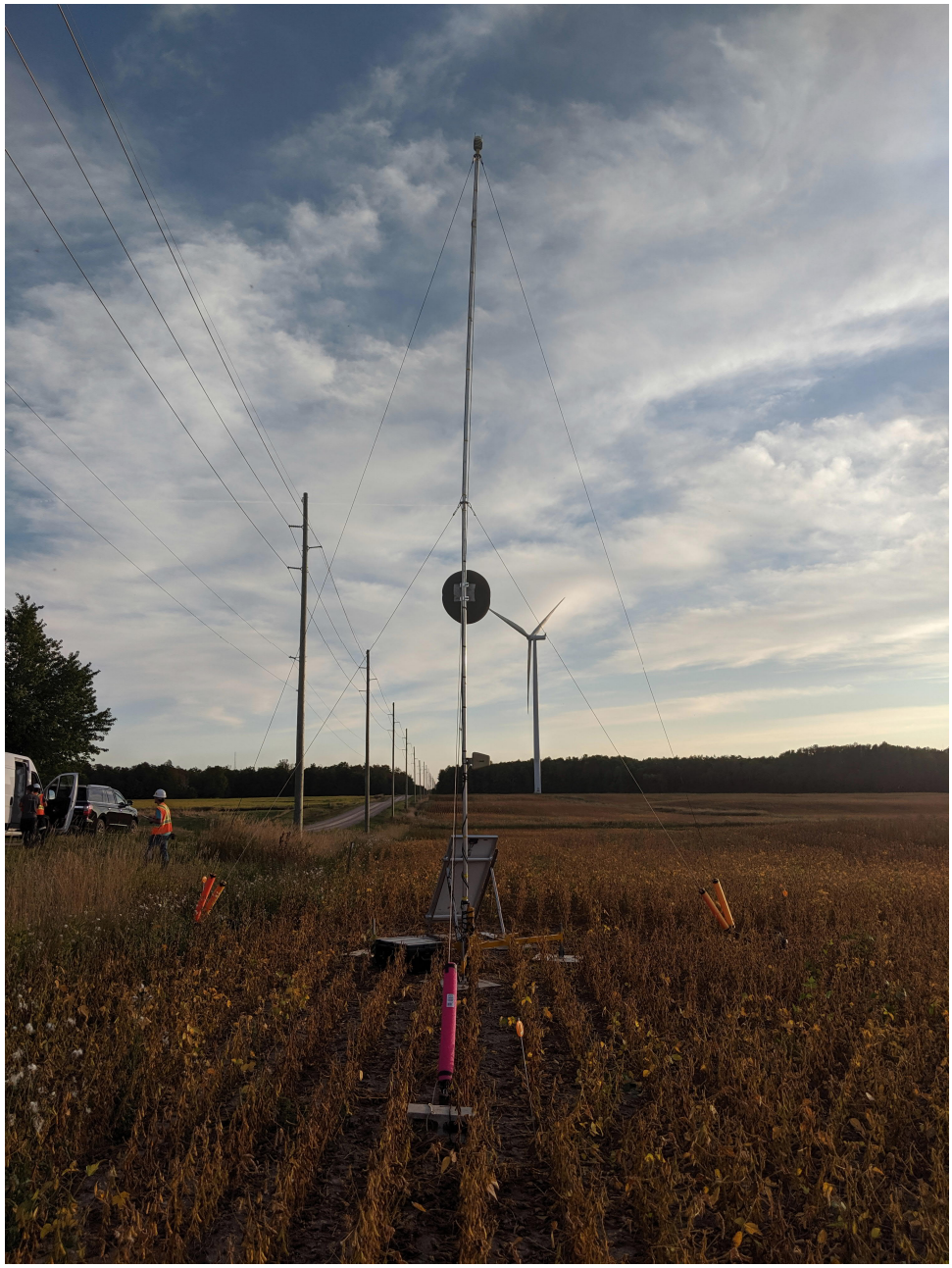

Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 10, 2020
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R243

Appendix A.3

Site photo

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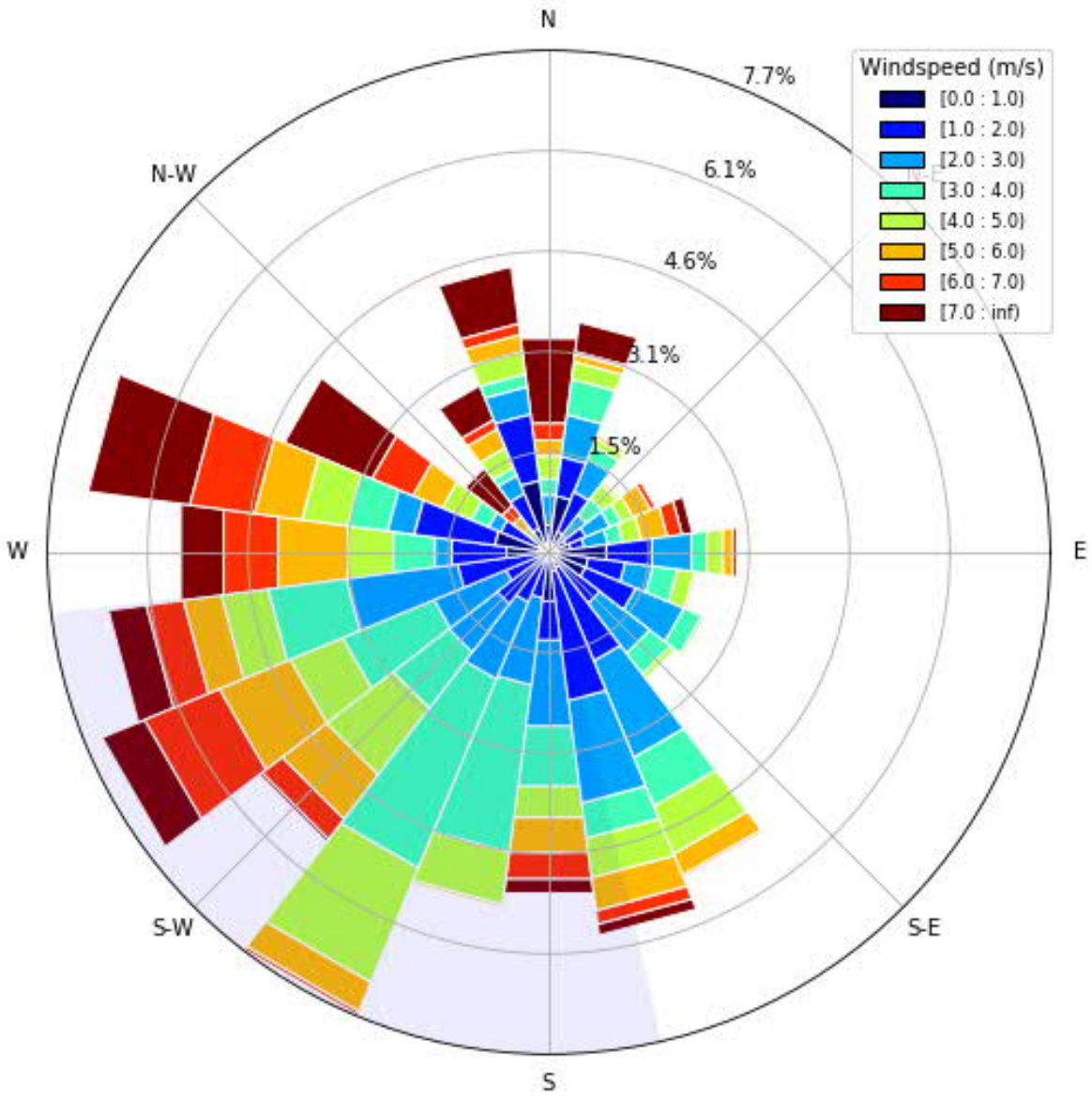
Appendix B
Wind Roses



Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 10, 2020
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R243

Appendix B.1

Supplementary Wind Rose
based on All Data

aercoustics

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix C
Calibration Certificates

Calibration Certificates –

Details are disclosed in the table below regarding the calibration of the equipment used for the Phase 2 I-Audit campaign at monitor location R243. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
R243	Data Acquisition Card	NI 9234	1B3CDE4	2019-07-22
	Signal Conditioner	PCB 480E09	33810	2019-06-28
	Microphone	PCB 377B02	167979	2019-08-19
	Pre-Amplifier	PCB 426E01	044829	2019-08-19
	Weather Anemometer	Vaisala WXT 536	L3020298	2019-05-24

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	158486
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	126903	P. Order :	2019.08.12C
Asset # :	00909		

Cal. status : Received in spec's, no adjustment made.
Preamp System with Mic 377B02 s/n 167977

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 Quality System system complies with the requirements of ISO-9001-2015 and is registered under certificate CA96/269, 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 : Aug 19, 2019 By : Petro Onasko

Cal. Due : Aug 19, 2021

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

Standards used : J-216 J-324 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 800-668-7440 Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: 378B02	Approved by: JR	Feb-16	Ver 1.0

Calibration Report for Certificate : 158486

Make			Model	Serial	Asset		
PCB Piezotronics			378B02	126903	00909		
PCB Piezotronics			426E01	044829	00909		
PCB Piezotronics			377B02	167977	00909		

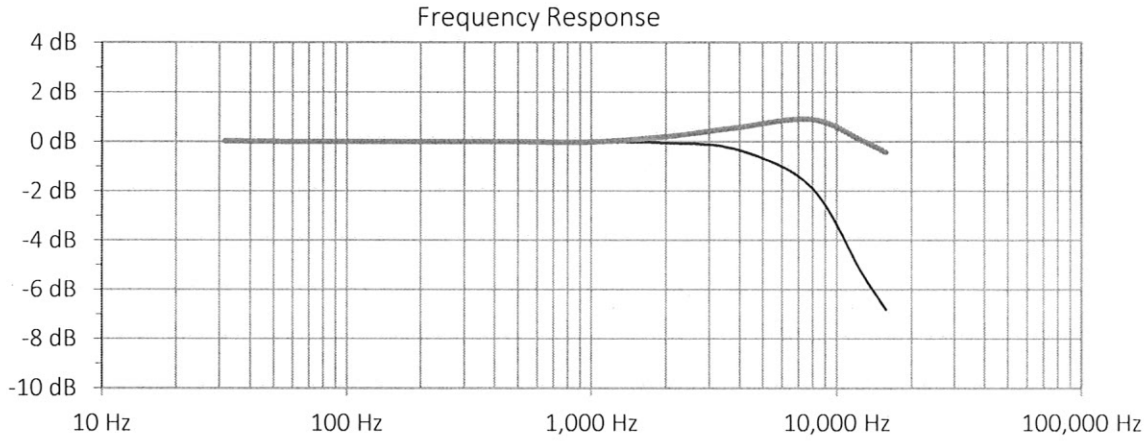
Sensitivity at 250 Hz

Specs Nom	Unit		Min	Reading	Max		In/Out
50	mV/Pa		39.72	42.76	62.94		In
-26.02	dB re 1V/Pa		-28.02	-27.38	-24.02		In
0	dB re 50mV/Pa		-2	-1.36	2		In

Ambient Conditions: Static Pressure 99.5 kPa
Temperature 24.4°C
Rel.Humidity 52.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.02	0.02	
63.1	0.00	-0.01	
125.9	0.00	0.00	
251.3	**0.00**	**0.00**	ref
502.5	-0.01	-0.01	
1005.1	-0.04	-0.02	
1978.7	-0.05	0.19	
3957.5	-0.34	0.57	
7914.9	-1.85	0.89	
12663	-5.33	0.04	
15830	-6.82	-0.44	



Compliant Calibration Certificate

Template Revision: Feb2018

Certificate Number:	6095133.1	**OE Number:**	21719015
Date Printed:	23-JUL-2019	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Rd No 1100 ONTARIO MISSISSAUGA, L4Y 1M4 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1B3CDE4		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	22-JUL-2019	**Recommended Calibration Due:**	22-JUL-2020
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	4.6.2.0
Lab Technician:	Rachel McKinnon	**Driver Info:**	NI-DAQmx:17.6.0
Temperature:	23.0° C	**Humidity:**	45.4% RH

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1B3CDE4
DATE 22-JUL-2019
DUE 22-JUL-2020
ni.com/calibration

The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments.

As Left The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TUR (Test Uncertainty Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TUR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TUR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact **NI Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com**

Ted Talley
Technical Manager

National Instruments Calibration Services Austin
Building A
11500 N MoPac Expwy
AUSTIN, TX 78759-3504
USA
Tel: (800) 531-5066

NATIONAL INSTRUMENTS™

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	157715
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00033810	P. Order :	2019.06.26C
Asset # :	00753		

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 Quality System system complies with the requirements of ISO-9001-2015 and is registered under certificate CA96/269, 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 : Jun 28, 2019 By : Petro Onasko

Cal. Due : Jun 28, 2021

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

Standards used : J-255 J-301 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com
Phone : 800-668-7440 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: 480E09	Approved by: J. Raposo	Jun-19	Ver 2.0

Calibration Report for Certificate : 157715

Make	Model	Serial №	Asset	Cal by
PCB Piezotronics	480E09	00033810	00753	PO

Test	Setting	Input	Min	Reading	Max	In/Out

Excitation Voltage

• 1			25 Vdc	25.8 Vdc	29 Vdc		In

Constant Current Excitation

• 1			2.0 mA	2.92 mA	3.2 mA		In

Voltage Gain Accuracy at 1 kHz

• 1	1.000 V		0.98	1.00	1.02		In
• 10	0.100 V		9.80	10.00	10.20		In
• 100	0.010 V		98.0	99.9	102.0		In

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 SONIC ANEMOMETER

Certificate number: 19.US2.04905 **Date of issue:** May 24, 2019

Type: Vaisala Weather Transmitter, WXT520 **Serial number:** L3020298

Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland

Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

Anemometer received: May 21, 2019 **Anemometer calibrated:** May 24, 2019

Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F

Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.03051 · U [m/s] + -0.00738

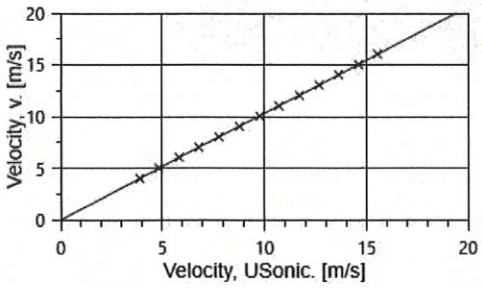
Standard uncertainty, slope: 0.00168 **Standard uncertainty, offset:** -2.43950

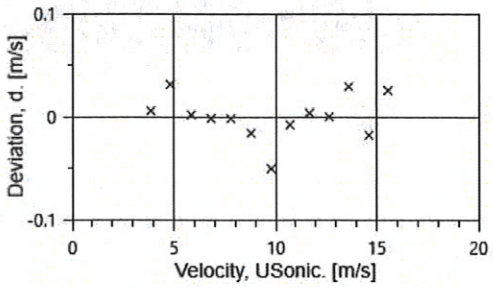
Covariance: -0.0000292 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999984

Absolute maximum deviation: -0.050 m/s at 10.027 m/s

Barometric pressure: 999.4 hPa **Relative humidity:** 38.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, U. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.32	24.1	28.3	3.997	3.8800	0.006	0.023
4	14.59	24.1	28.3	5.002	4.8310	0.031	0.026
6	21.16	24.1	28.3	6.023	5.8500	0.002	0.030
8	28.71	24.1	28.3	7.015	6.8167	-0.002	0.034
10	37.51	24.1	28.3	8.018	7.7900	-0.002	0.038
12	47.58	24.0	28.3	9.031	8.7867	-0.016	0.043
13-last	58.66	24.0	28.3	10.027	9.7862	-0.050	0.047
11	70.85	24.0	28.3	11.021	10.7100	-0.008	0.051
9	84.58	24.0	28.3	12.043	11.6900	0.003	0.056
7	99.14	24.1	28.3	13.039	12.6600	0.000	0.060
5	115.22	24.1	28.3	14.057	13.6200	0.029	0.064
3	131.77	24.1	28.3	15.034	14.6133	-0.018	0.069
1-first	150.07	24.1	28.3	16.046	15.5533	0.025	0.073





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.0035
13924	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
Njord2-PC	PC dedicated to data acquisition

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

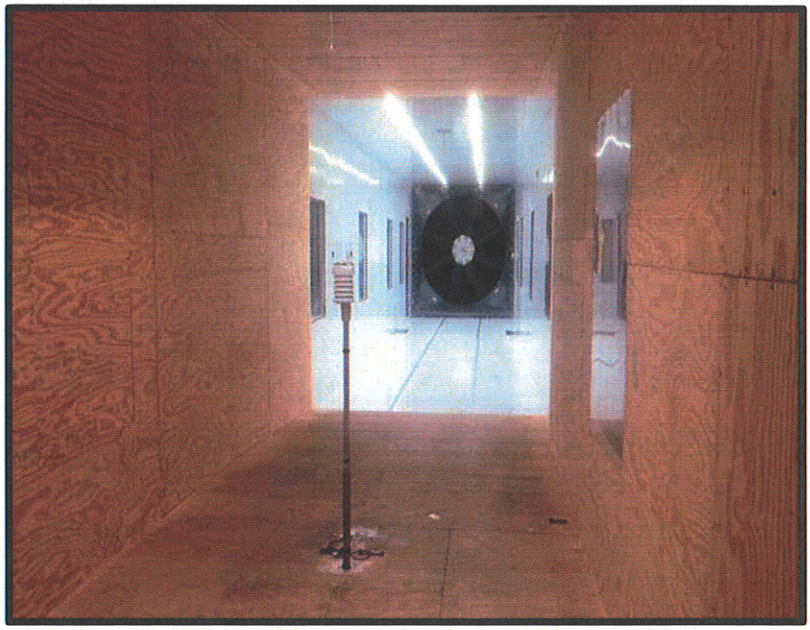


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was positioned at the 90° orientation during calibration.

Certificate number: 19.US2.04905

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 SONIC ANEMOMETER

Certificate number: 19.US2.04907 **Date of issue:** May 24, 2019

Type: Vaisala Weather Transmitter, WXT520 **Serial number:** L0910580

Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland

Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

Anemometer received: May 21, 2019 **Anemometer calibrated:** May 24, 2019

Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F

Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.02845 · U [m/s] + 0.02288

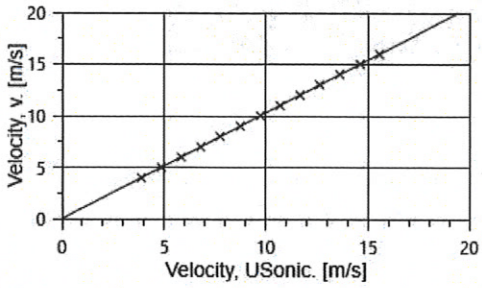
Standard uncertainty, slope: 0.00117 **Standard uncertainty, offset:** 0.54498

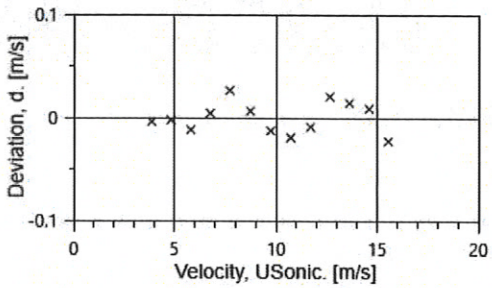
Covariance: -0.0000140 $(m/s)^2/m/s$ **Coefficient of correlation:** $\rho = 0.999993$

Absolute maximum deviation: 0.026 m/s at 8.020 m/s

Barometric pressure: 1000.2 hPa **Relative humidity:** 38.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, U. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.33	24.1	28.3	3.999	3.8700	-0.004	0.023
4	14.65	24.1	28.3	5.010	4.8517	-0.002	0.026
6	21.06	24.1	28.3	6.007	5.8300	-0.012	0.030
8	28.70	24.1	28.3	7.012	6.7914	0.004	0.034
10	37.54	24.1	28.3	8.020	7.7500	0.026	0.038
12	47.55	24.1	28.3	9.025	8.7467	0.006	0.043
13-last	58.80	24.0	28.3	10.036	9.7483	-0.013	0.047
11	70.91	24.1	28.3	11.022	10.7133	-0.019	0.051
9	84.45	24.1	28.3	12.030	11.6833	-0.009	0.056
7	99.22	24.1	28.3	13.040	12.6367	0.021	0.060
5	115.14	24.1	28.3	14.048	13.6233	0.014	0.064
3	132.27	24.1	28.3	15.057	14.6100	0.009	0.069
1-first	149.48	24.0	28.3	16.006	15.5633	-0.023	0.073





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.0035
13924	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
Njord2-PC	PC dedicated to data acquisition

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

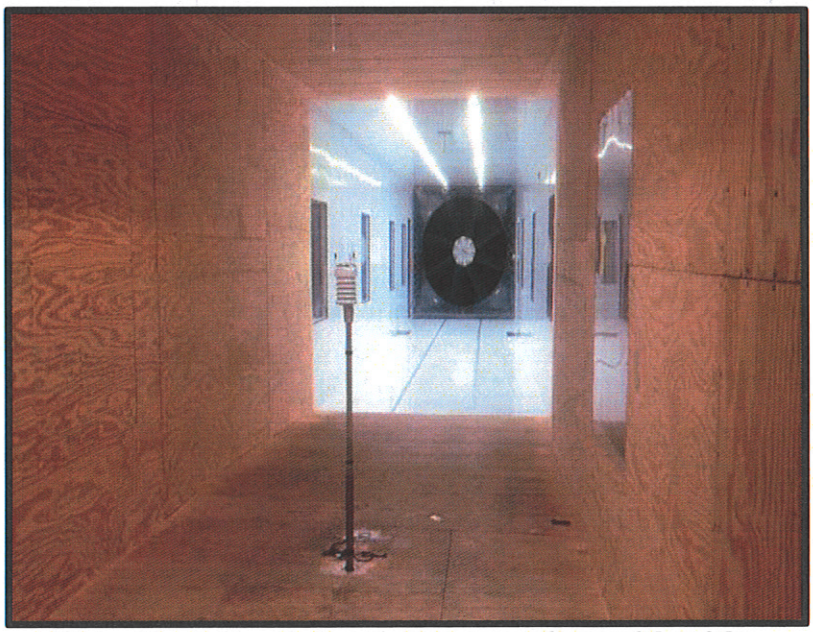


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was positioned at the 90° orientation during calibration.

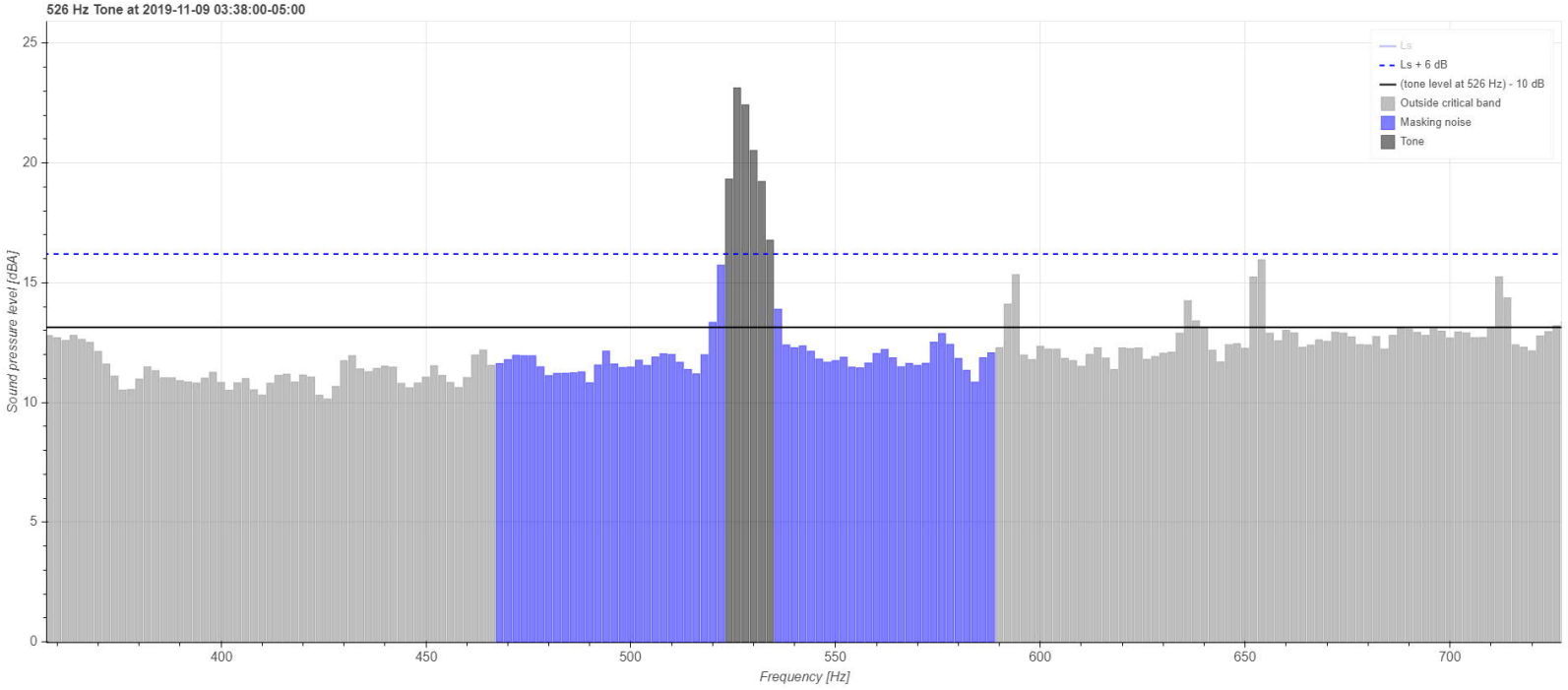
Certificate number: 19.US2.04907

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix D
Sample Tone Plot



Timestamp (America/Toronto)	Center Frequency (Hz)	Decisive Audibility (dB)	Level at Tone Line (dB)	Critical Bandwidth: Lower bound (Hz)	Critical Bandwidth: Upper bound (Hz)	Ls - Mean Masking Noise Level (dB)	LT - Tone Level (dB)	LG - Critical Band Masking Noise Level (dB)	Masking Index	Audibility (dB)
2019-11-09 03:38:00-05:00	526	1.1	23.1	468	588	10.2	26.8	27.9	-2.3	1.1

Project ID: 15247.03
Drawn by: DEA
Reveiwed by: AM
Date: January 10, 2020
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment R243

Appendix D

Sample Tone Plot - R243 - Turbine ON 4m/s

aercoustics

aercoustics

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1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix E
AWPP Scope of Work

SP Armow Wind Ontario LP
2050 Derry Road Wst, 2nd Floor
Mississauga, Ontario L5N 0B0
Canada

July 26, 2019

BY EMAIL

Director
Ministry of the Environment, Conservation and Parks
Owen Sound District Office
101 17th St., 3rd Floor
Owen Sound, ON N4K 0A5
John.S.Ritchie@ontario.ca

Dear Mr. Ritchie:

SP Armow Wind Ontario GP Inc. ("Armow") v. Ontario (Environment, Conservation and Parks)
ERT File No. 19-051

We are writing with respect to Director's Order No. 2868-B8VRY4-1 dated June 19, 2019 (the "Order"), the Director's letter of June 27, 2019 and Armow's appeal of the Order to the Environmental Review Tribunal ("ERT"). Given the extremely complex technical nature of the Order, please find below the scope of work that Armow will conduct to comply with the Order:

1) With respect to Work Ordered Items Nos. 1, 2, 3 and 4 as set out in the Order, all work has been completed and no further action is required.

2) With respect to Work Ordered Item No. 5, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant conduct a RAM I-Audit, in accordance with The Compliance Protocol for Wind Turbine Noise published April 2017 (the "2017 Compliance Protocol") regarding equipment set-up requirements, with measurement of tonality to be undertaken in accordance with ISO 1996-2:2017 for the following:
   a) the wind turbines identified in the REA as T68 and T80; and
   b) the location of a worst-case noise receptor.

   Monitoring locations for both T68 and T80 may be moved southward if remaining within same line-of-sight for T68 and distance correction factor is used (the more conservative of: 20 log rule or CADNA prediction). Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

3) With respect to Work Ordered Item No. 6, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant complete tonality measurements in accordance with ISO 1996-2:2017 (and 2017 Compliance Protocol regarding equipment set-up requirements) for each of the six (6) wind turbines identified in the REA as T50, T30, T88, T102, T75 and T95 and in accordance with the following turbine-specific requirements:

a) T95 will be addressed through a receptor in the crosswind direction, or other receptor that is located at similar distance downwind from a turbine of the same model;
b) T50 and T102 will be addressed through separate respective receptors in the downwind direction (prior measurements conducted at receptor IDs V556 and R215 may be used to fulfil tonality assessments, provided data meets the requirement of: "At least five (5) one-minute measurements per wind speed bin over entire assessment range of the turbine and not limited to wind speed bins of 4-7 m/s as per Compliance Protocol"); and
c) T30, T88, T75 will be addressed through alternative surrogate receptors, as the closest respective receptors are in the upwind direction (taking into account the following factors: same turbine model type, extent to which permission for site access is provided/withheld, and minimization of noise source contamination).

Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

4) Completion of Work Ordered Item No. 7, as set out in the Order.

5) Completion of Work Ordered Item No. 8, as set out in the Order, by submitting a noise abatement action plan prepared in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

This letter describes the whole scope of work that Armow proposes to complete in satisfaction of the Order. Please confirm the foregoing will allow for compliance with the Order. If such confirmation is received, Armow will proceed to withdraw its ERT appeal and implement this scope of work.

Yours truly,

SP Armow Wind Ontario LP,
by its general partner
SP Armow Wind Ontario GP Inc.

Per: _____
Name: Frank Davis
Title: Authorized Signatory

Per: _____
Name: Jae Young Ahn
Title: Authorized Signatory