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FALL ACOUSTIC AUDIT - IMMISSION REPORT

St. Columban Wind Energy Project

St. Columban, Ontario

Prepared for:

St. Columban Energy, LP
222 – 3rd Avenue S.W.
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Prepared by

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and

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June 16, 2016

EXECUTIVE SUMMARY

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by St. Columban Energy, LP to complete an acoustic immission audit of the St. Columban Wind Energy Project. The project includes 15 Siemens wind turbine generators, rated at 2.3 MW, 2.221 MW and 2.126 MW. The acoustic immission audit is required as a condition of Renewable Energy Approval number 7042- 96FQB7 issued by the Ontario Ministry of the Environment and Climate Change ("MOECC"). HGC Engineering has assessed the acoustic impact against the acoustic criteria of the MOECC in accordance with the requirements of the MOECC's Compliance Protocol for Wind Turbine Noise. The fall measurement campaign was completed between October 9, 2015 and January 14, 2016.

The sound level measurements and analysis, as performed in accordance with the MOECC's Compliance Protocol for Wind Turbine Noise, indicate that the project meets the applicable sound level limits at the chosen receptor 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 St. Columban Energy, LP to complete an Acoustic Audit – Immission of the St. Columban Wind Energy Project. The project is located north of the town of St. Columban, Ontario and consists of 15 Siemens wind turbine generators, rated at 2.3 MW, 2.221 MW and 2.126 MW and with a hub height of 99.5 m.

The audit is required as part of the Renewable Energy Approval ("REA") number 7042-96FQB7 [1] issued for the project by the Ontario Ministry of the Environment and Climate Change ("MOECC"). Specifically, this report summarizes measurements that were conducted in the fall in order to satisfy the first of two seasonal audits required under Condition E of the REA.

2 MONITORING LOCATIONS

The Noise Assessment Report prepared by Zephyr North [2] provided sound level predictions for locations within 1500 metres of the project wind turbine generators. Condition E1 (2) in the REA requires that measurements be completed at two monitoring locations which are selected using the following criteria:

- The monitoring locations should represent the location of the greatest predicted noise impact.
- The monitoring locations should be in the direction of prevailing winds from the facility.

A number of locations were considered for use as sound level monitoring locations for the audit, as shown in Table 1.

Table 1: Potential Monitoring Locations

ID	Distance to Nearest Turbine [m]	Nearest turbine ID	Calculated Sound Pressure Level at Receptor [dBA] at Selected Wind Speed [m/s]					Wind Direction	Comments
			6	7	8	9	10		
V662	698	T3	39.9	39.9	39.9	39.9	39.9	Crosswind	Permission Not Granted
V663	760	T2	39.6	39.6	39.6	39.6	39.6	Crosswind	Permission Not Granted
R3	551	T9	39.3	39.3	39.3	39.3	39.3	Downwind	Selected Location
V659	697	T3	39.3	39.3	39.3	39.3	39.3	Crosswind	Too many large trees
V664	788	T3	39.3	39.3	39.3	39.3	39.3	Crosswind	Active farm field
V596	597	T9	39.2	39.2	39.2	39.2	39.2	Upwind	
V660	718	T3	39.2	39.2	39.2	39.2	39.2	Crosswind	Active farm field
R50	763	T3	38.9	38.9	38.9	38.9	38.9	Crosswind	Too many large trees
V658	725	T3	38.9	38.9	38.9	38.9	38.9	Upwind	
R202	555	T11	38.8	38.8	38.8	38.8	38.8	Upwind	
V680	629	T11	38.8	38.8	38.8	38.8	38.8	Upwind	
V661	836	T13	38.6	38.6	38.6	38.6	38.6	Downwind	Selected Location
R22	681	T3	38.5	38.5	38.5	38.5	38.5	Downwind	Too many large trees
R33	678	T9	38.5	38.5	38.5	38.5	38.5	Upwind	
V645	635	T8	38.5	38.5	38.5	38.5	38.5	Middle	Too many large trees
V646	660	T8	38.5	38.5	38.5	38.5	38.5	Middle	Too many large trees

The monitoring locations were selected based on their downwind location, predicted sound level, and consultation with the land owners. The annual wind rose for the area is provided in Appendix A. Photos of the selected monitoring locations can be found in Appendix B.

Monitoring location R3 is a single storey home located on the north side of the project with turbines T09 and T10 at a distance of approximately 550 meters to the south. The sound level meter was installed at a fence line on the southwest side of the residential property,

approximately 475 m from T10. The microphone was placed at a height of 4.5 m, consistent with the receptor height utilized in the Noise Assessment Report.

Monitoring location V661 is an agricultural field located centrally within the project. The closest turbine, T13 is approximately 830 meters to the southwest. The sound level meter was installed approximately 30 meters northeast of Hydro Line Road in an open area of the field, 775 m from T13.

The project area is generally rural in nature with infrequently travelled gravel and asphalt roads.

3 INSTRUMENTATION

The MOECC document, *Compliance Protocol for Wind Turbine Noise – Guidelines for Acoustic Assessment and Measurement* [3] ("Compliance Protocol") provides requirements for instrumentation for Acoustical Audits of wind energy projects. Instrumentation used for this acoustic audit satisfies the requirements of the Compliance Protocol.

Audio frequency sound levels were measured using Brüel & Kjær 2250, Svantek 977 and Norsonic N140 sound level meters, each connected to ½" microphones. The microphones were set at a height of approximately 4.5 m and equipped with 175 mm diameter windscreens to minimize wind-induced microphone self-noise.

The energy-equivalent average sound level, denoted $L_{EQ,}$ and also the L_{90} sound level, the level exceeded 90% of the time during the measurement, were recorded by the instrumentation. The L_{90} sound level is commonly used to represent the background or steady-state sound level because it minimizes transient sounds such as occasional human voices, brief animal activity, and car or train noise. 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. An APRS weather station was deployed at V661 to collect ground weather conditions including temperature, humidity, and precipitation. NRG and RM Young anemometers and wind vanes were used to collect 10 metre height wind speed and direction at the monitoring locations.

The various instruments deployed by HGC Engineering are summarized in Table 2, and their relative locations are shown in Figures 1a and 1b. Due to various instrumentation demands and calibration schedules, a number of sound level meters were utilized throughout the campaign.

Table 2: Measurement Instrumentation

Monitoring Location	Instrumentation Make and Model	Serial Number
V661	Svantek 977 sound level meter	36428
	Svantek 977 sound level meter	36493
	NRG#40 anemometer connected to a Campbell Scientific datalogger	179500229305
R3	Norsonic Nor140 sound level meter	1404511
	Norsonic Nor140 sound level meter	1405046
	Norsonic Nor140 sound level meter	1403983
	Norsonic Nor140 sound level meter	1405028
	Brüel & Kjær 2250 (Noise Sentinel)	3007161
	RM Young Wind Monitor anemometer connected to a Campbell Scientific datalogger	93557
	NRG#40 anemometer connected to a Campbell Scientific datalogger	179500229306

The sound level meters were configured to measure and document spectral (frequency-dependent) 1 minute L_{EQ} and 10 minute L_{90} sound level measurements. For identification of dominant sources, the sound level meters also recorded audio files.

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

Windscreens were used on the microphones, consistent with the requirements of MOECC technical publication NPC-103, *Procedures* [4]. A large wind screen, 175 mm in diameter, was used on each sound level monitor 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 equipment was within its annual calibration, and the calibration certificates can be found in Appendix C.

4 ASSESSMENT CRITERIA

The MOECC 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. Additionally, the Compliance Protocol document and the REA approval include the same sound level limits which are shown in Table 3.

Table 3: Wind Turbine Noise Criteria [dBA]

Wind Speed at 10 m Height [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 MOECC 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 the monitoring 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 MOECC to complete an assessment of wind energy projects is discussed in the following section.

5 METHODOLOGY

The REA requires the acoustic audit be completed in accordance with Part D of the Compliance Protocol for Wind Turbine Noise. 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 conducted with (ON) and without (OFF) the turbines operating. Simultaneously, wind speed and direction at 10 metre height are measured 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 arithmetically 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, temperature, humidity, and statistical noise indices (Ln) can also be measured during the monitoring campaign to aid in the analysis.

The MOECC protocol requires at least 120 one minute intervals be measured for each 10 metre 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 metre height wind speed between 4 and 7 m/s when the turbines are parked. 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), data outside of rainfall (no rain within an hour of the measurement interval), and the maximum wind speed measured at a 10 metre height should not differ from the average by more than 2 m/s.

The MOECC 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 International Standards Organization 1996-2 [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 turbine at those wind speeds.

6 TONALITY ASSESSMENT

Based on our site observations and measurements up close to the wind turbine generators there is the potential for tones to be generated by the wind turbines. The *Compliance Protocol for Wind Turbine Noise* requires that "if a tone is identified at any of the wind speeds, the average tonal audibility correction shall be added to the final noise contribution of the wind turbine at those speeds."

The audio recordings captured during the measurement campaign were analyzed utilizing a Larson Davis 831 (S/N 0001865) to conduct narrow band frequency analysis of the recordings. Fast Fourier Transform ("FFT") analysis was utilized to convert the recordings to frequency domain spectra with a resolution of 0.625 Hz. Tones identified in this way were analysed following ISO standard 1996-2 Annex C "*Objective Method for assessing the audibility of tones in noise – Reference method*". The MOECC *Compliance Protocol for Wind Turbine Noise* assesses tonality as per ISO 1996-2 rather than the tonality analysis included within IEC 61400-11 where a tonality determination is made within close proximity of the turbine.

As per the MOECC's Compliance Protocol, five one-minute recordings closest to each integer wind speed bin were selected for each monitoring location. Data were filtered to include points where the monitoring location was downwind of the closest turbine and the closest turbine was operating near rated electrical output. Table 4 summarizes the maximum tonal audibility (ΔLta) and the tonal adjustment (Kt) from the assessed data points for each monitoring location. The only tonal adjustment is for R3, for the 5 m/s integer wind speed bin, which is included in Table 6a.

Table 4: Summary of Tonality Assessment [dB]

Monitoring Location	10 meter Wind Speed							
	4 m/s		5 m/s		6 m/s		7 m/s	
	ΔLta	Kt	ΔLta	Kt	ΔLta	Kt	ΔLta	Kt
V661	3.7	0	< 0	0	< 0	0	< 0	0
R3	0.2	0	4.6	0.6	2.4	0	< 0	0

7 MEASUREMENTS AND RESULTS

Sound level measurements were conducted between October 9, 2015 and January 14, 2016. The weather during the monitoring period varied, including several days with rain and snow. Temperatures ranged from -10 to 15° Celsius. Wind speeds at 10 metres in height ranged from 0 m/s up to 15 m/s. The prevailing wind direction during the measurement campaign was from the southwest, consistent with the historical wind rose. Figures 2a through 3b show the wind roses for the monitoring locations during the ON and OFF conditions.

A software programming change was implemented on all turbines on December 12, 2015. The analysis herein uses sound level data for turbine operating (ON) collected between December 12, 2015 and January 14, 2016. Ambient sound level data (OFF) was collected during various project shutdowns between October 9, 2015 and January 14, 2016.

The sound level summary for data collected at location V661 is shown in Tables 5a and 5b.

Table 5a: Receptor V661 - Sound Level Summary L_{EQ} [dBA]

	10 metre Wind Speed							
Leq Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	36.5	2.7	38.1	2.9	40.3	2.9	42.9	3.1
Average Ambient (OFF) / std dev.	36.2	3.9	38.2	3.8	39.9	2.1	42.3	1.8
Wind Project Only / std dev.	24	2.9	NA	2.9	30	2.8	34	2.9
Criteria	40		40		40		43	
Excess	**0**		**0**		**0**		**0**	

Table 5b: Receptor V661 - Summary of Valid Data Points

	10 metre Wind Speed			
Wind Project Condition	**4 m/s**	**5 m/s**	**6 m/s**	**7 m/s**
Operating (ON)	994	1258	896	520
Ambient (OFF)	94	97	100	84

Based on the data presented above and in Figures 4a and 4b, the wind energy facility is compliant with the MOECC sound level criteria at monitoring location V661.

The sound level summary for data collected at location R3 is shown in Tables 6a and 6b.

Table 6a: Receptor R3 - Sound Level Summary L_{EQ} [dBA]

	10 metre Wind Speed							
Leq Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	39.8	3.4	42.3	2.4	43.9	2.5	45.6	2.3
Average Ambient (OFF) / std dev.	33.7	3.0	39.8	3.4	41.3	2.8	42.2	2.6
Wind Project Only / std dev.	39	4.1	39[1]	2.6	40	2.7	43	2.7
Criteria	40		40		40		43	
Excess	**0**		**0**		0		**0**	

[1] Includes tonal adjustment of +0.6 dBA

Table 6b: Receptor R3 - Summary of Valid Data Points

	10 metre Wind Speed			
Wind Project Condition	**4 m/s**	**5 m/s**	**6 m/s**	**7 m/s**
Operating (ON)	1607	1719	1118	508
Ambient (OFF)	432	147	192	121

The sound level monitoring location for receptor R3 is approximately 75 m closer to turbines T09 and T10 than the actual receptor location, equating to a sound level adjustment of -1 dBA to the Wind Project Only sound level (ie. 39 dBA at 6 m/s). The sound level measurements and analysis indicate that the project meets the applicable sound level limits at location R3.

Appendix C includes a statement from St. Columban Energy, LP indicating the wind turbines were operating normally from December 12, 2015 to January 14, 2016.

8 CONCLUSIONS AND RECOMMENDATIONS

The measurements and analysis, performed in accordance with the methods prescribed by the Ontario Ministry of the Environment and Climate Change in publication *Compliance Protocol for Wind Turbine Noise* indicates that the wind energy facility is operating within compliance of the MOECC's sound level criteria at the monitoring locations.

REFERENCES

1. Ontario Ministry of the Environment Renewable Energy Approval Number 7042- 96FQB7, July 2, 2013.
2. Zephyr North, *Noise Assessment Report, St. Columban Wind Project*, January, 2013.
3. Ontario Ministry of the Environment, *Compliance Protocol for Wind Turbine Noise Guideline for Acoustic Assessment and Measurement*.
4. Ontario Ministry of the Environment Publication, NPC-103, *Procedures.*
5. Ontario Ministry of the Environment Publication, *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*, October 2008.
6. International Standards Organization 1996-2, *Acoustics – Description, assessment and measurement of environmental noise – Part 2: Determination of environmental noise levels*, 2007.
7. Environment Canada, *Wind Atlas*. August 20, 2015. Retrieved from http://www.windatlas.ca/en/rose.php?field=EU&height=80&season=ANU&no=24&ni=930&nj=189

Figure 1a: Monitoring Location V661

Figure 1b: Monitoring Location R3

Figure 2a: Wind Direction - Monitoring Location V661
10 m Height Wind Speeds 4-7 m/s
ON Condition, December 12, 2015 to January 14, 2016

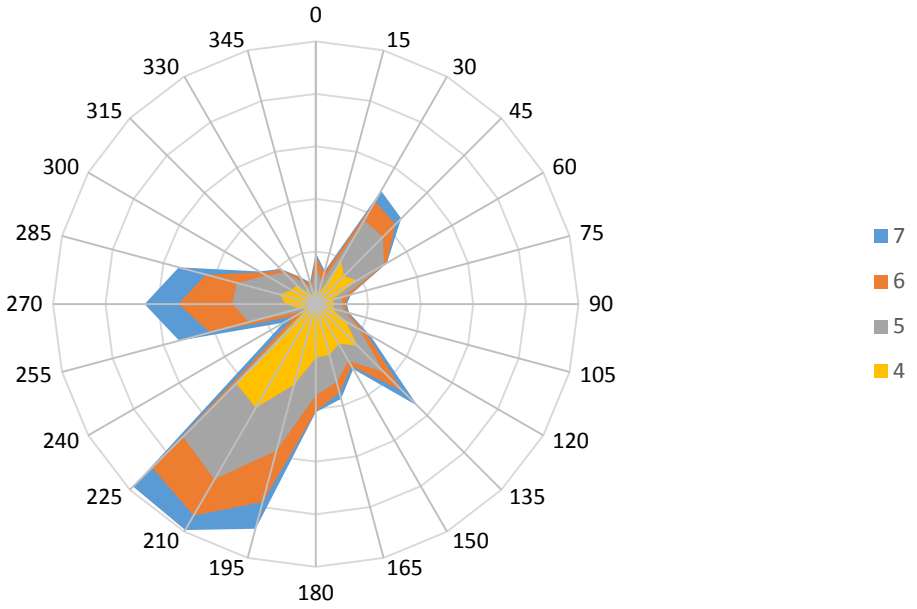


Figure 2b: Wind Direction - Monitoring Location V661
10 m Height, Wind Speeds 4-7 m/s
OFF Condition, October 9, 2015 to January 14, 2016

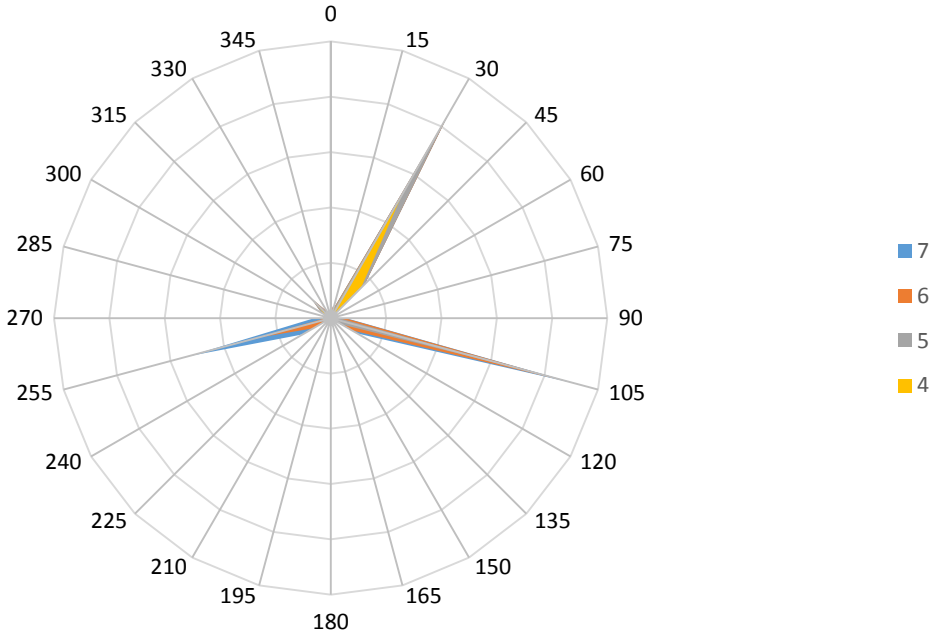


Figure 3a: Wind Direction - Monitoring Location R3
10 m Height, Wind Speeds 4-7 m/s
ON Condition, December 12, 2015 to January 14, 2016

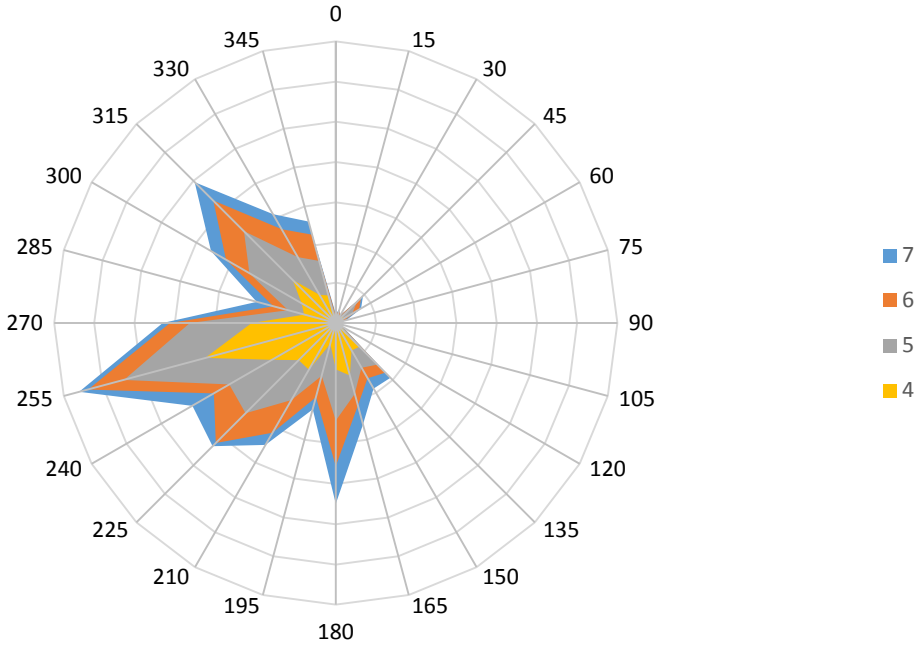


Figure 3b: Wind Direction - Monitoring Location R3
10 m Height, Wind Speeds 4-7 m/s
OFF Condition, October 9, 2015 to January 14, 2016

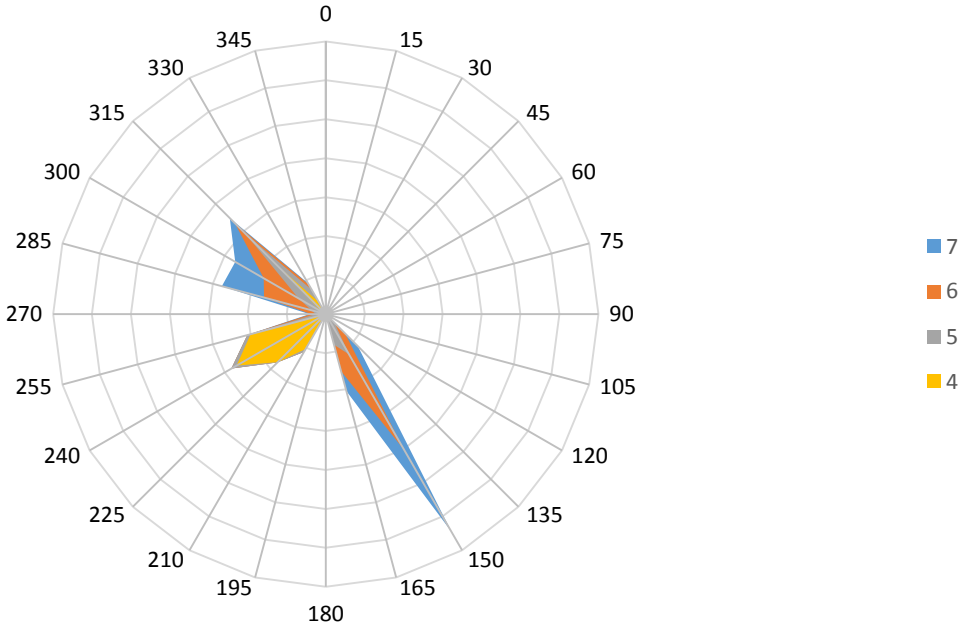


Figure 4a: St Columban Wind Project, Fall Immission Results
Monitoring Location V661, October 9, 2015 to January 14, 2016

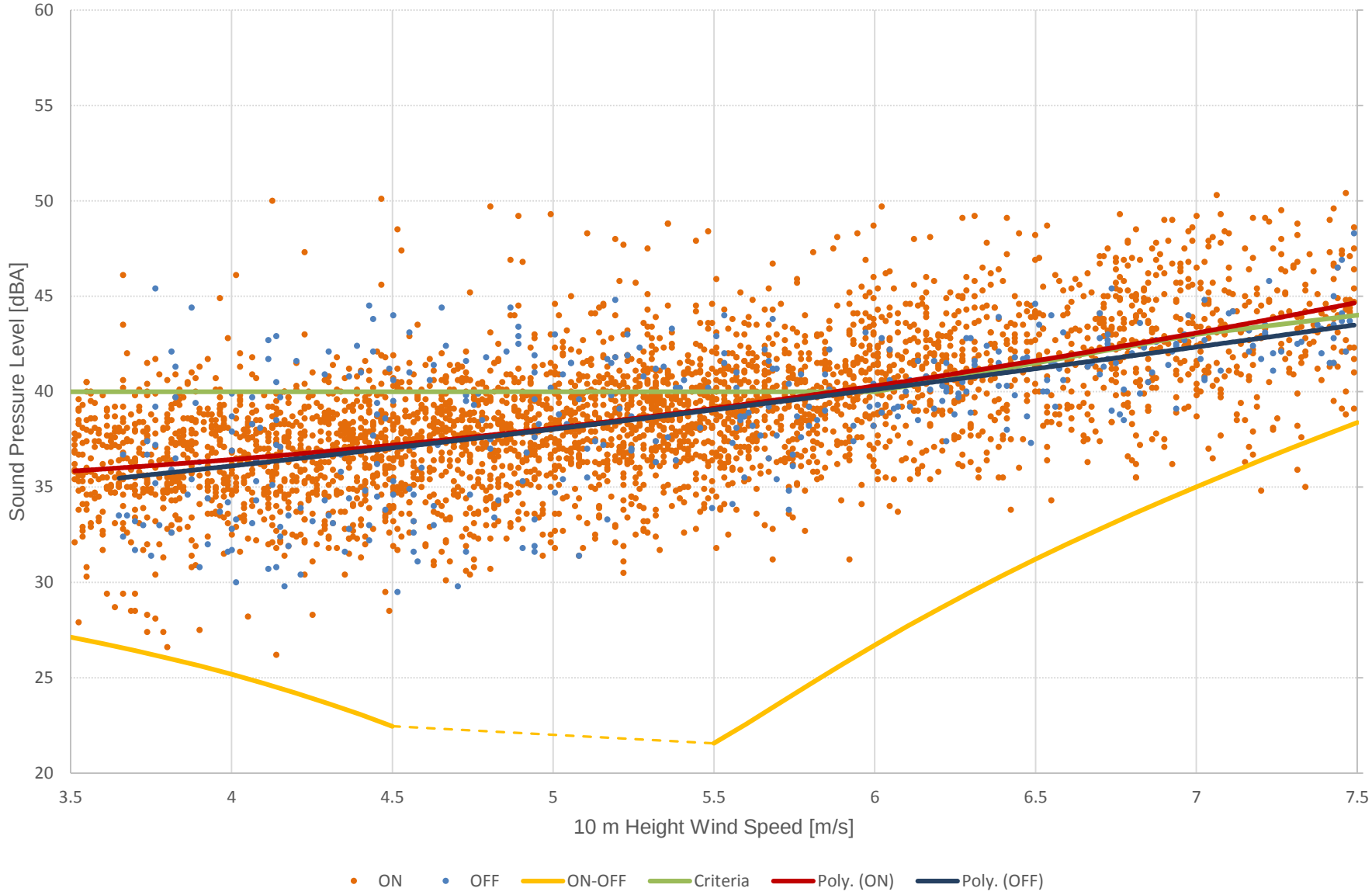


Figure 4b: St Columban Wind Project, Fall Immission Results
Monitoring Location V661, October 9, 2015 to January 14, 2016

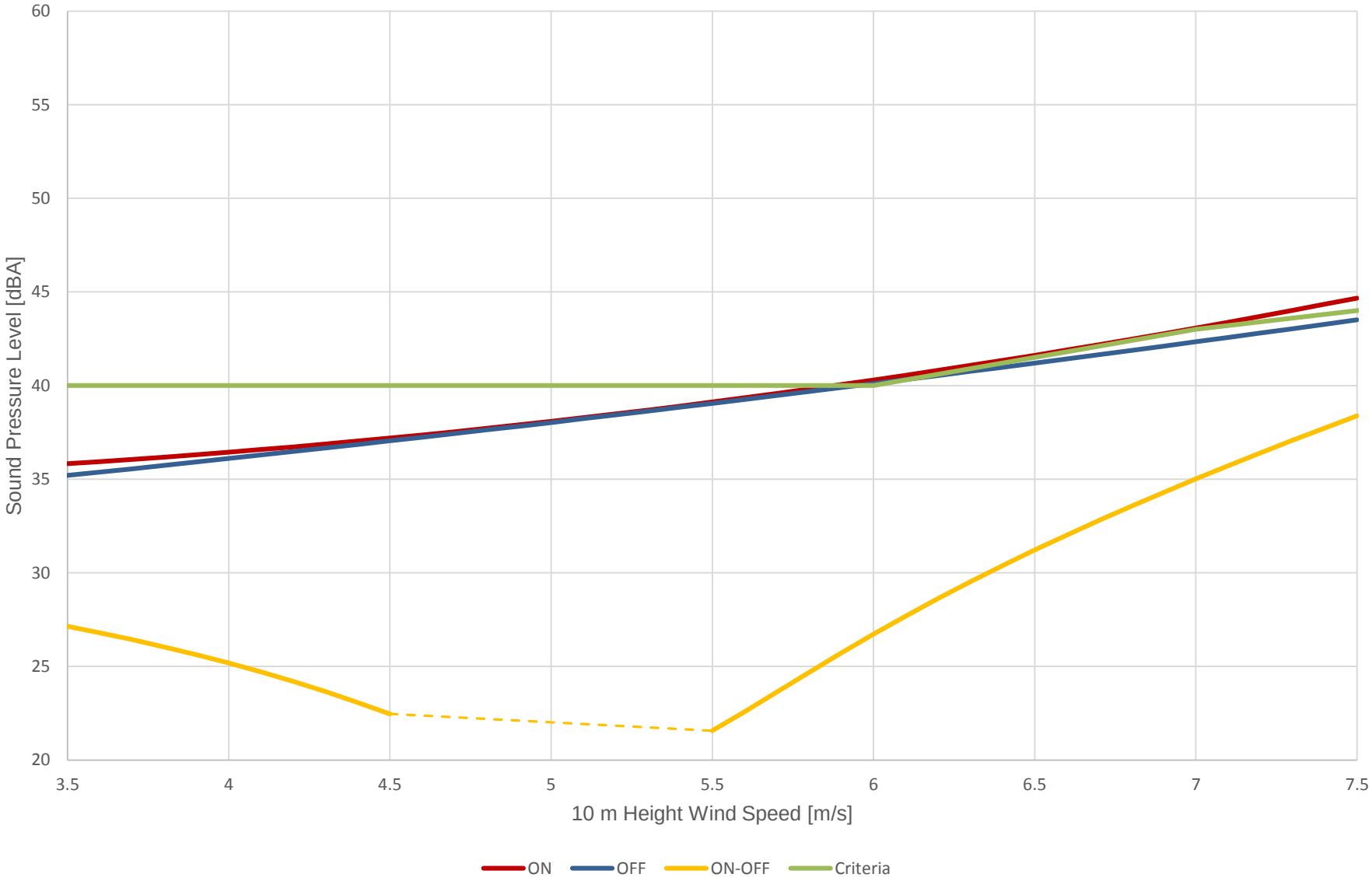


Figure 5a: St Columban Wind Project, Fall Immission Results
Monitoring Location R3, October 9, 2015 to January 14, 2016

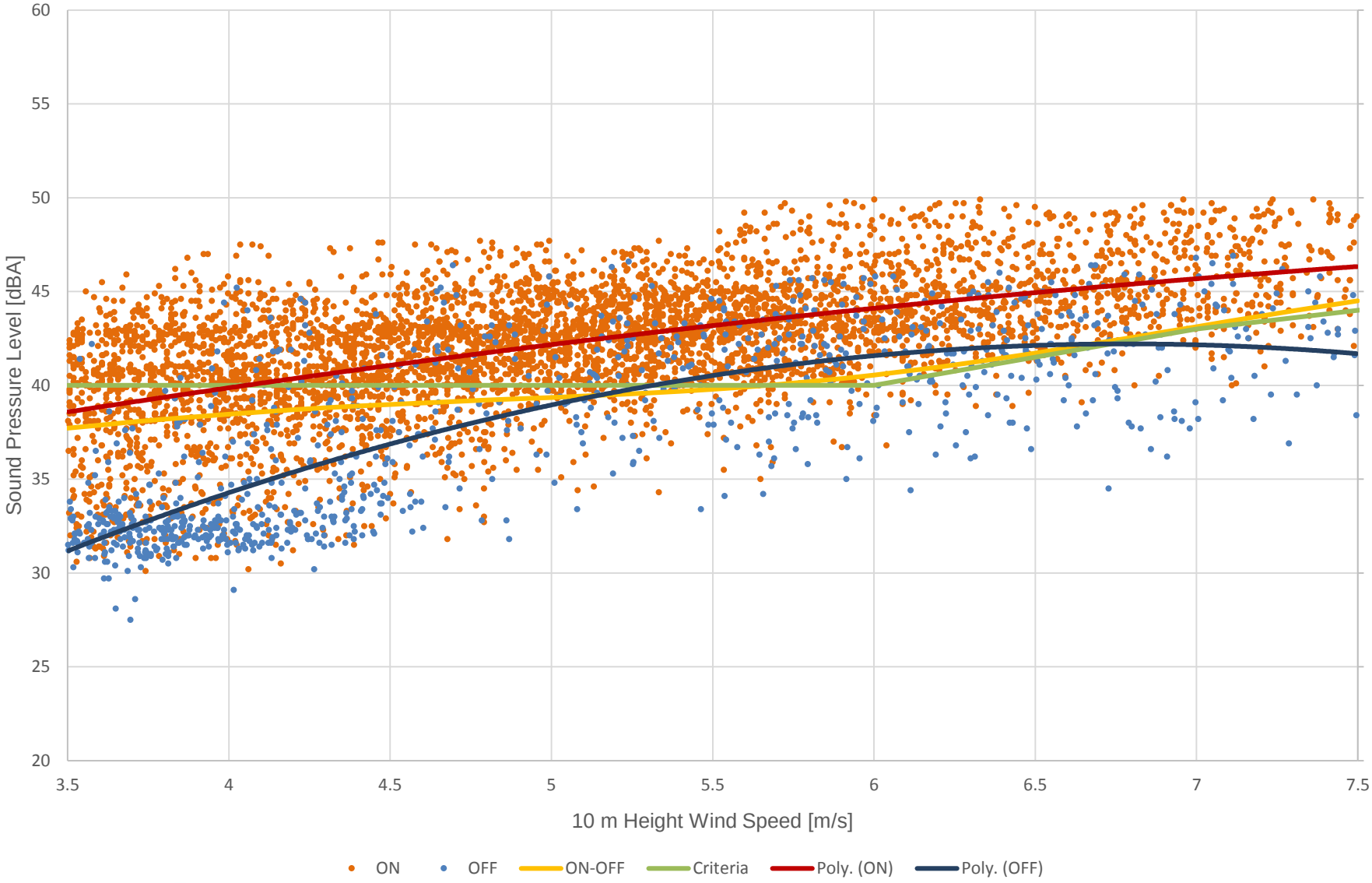
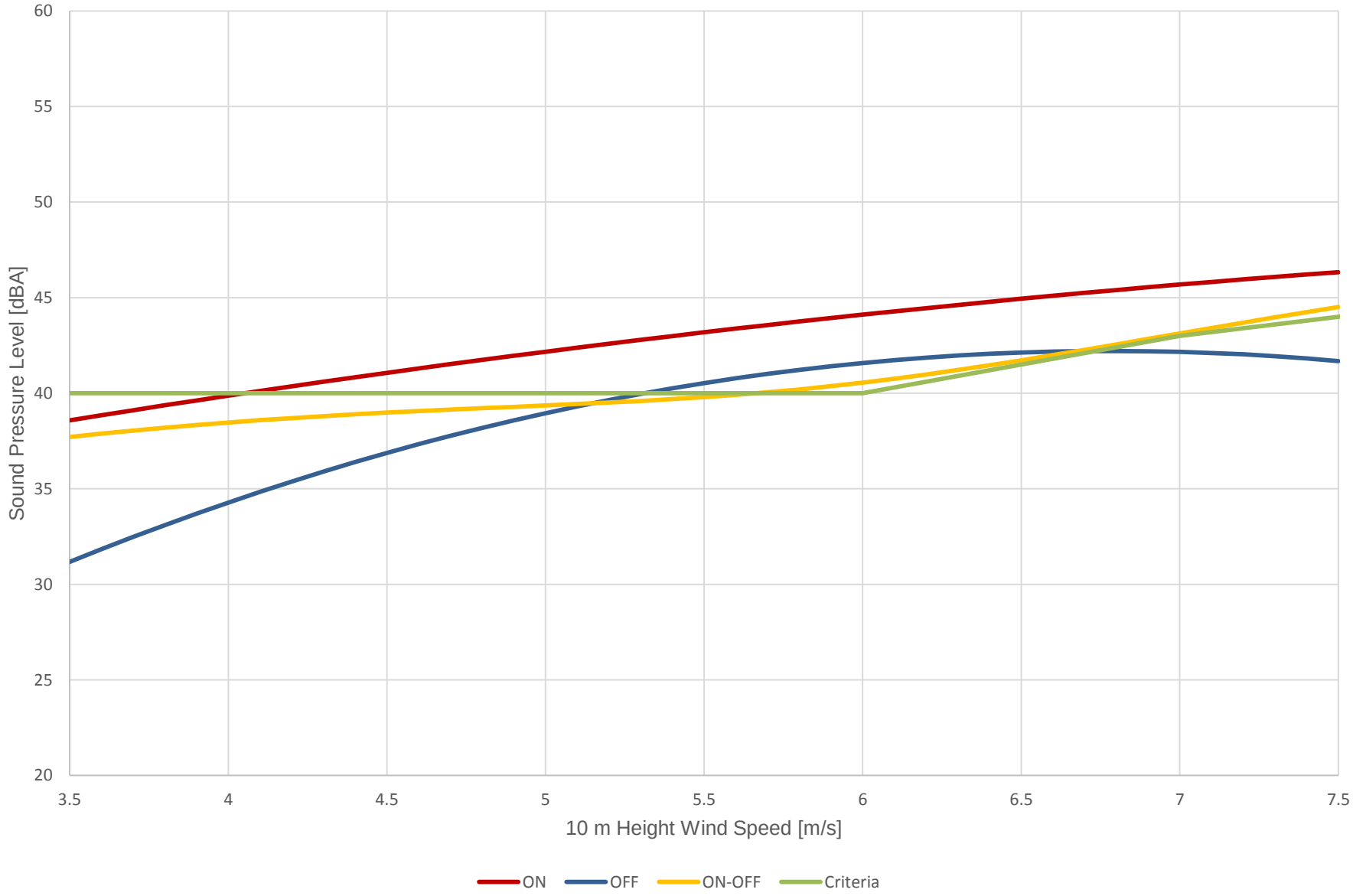
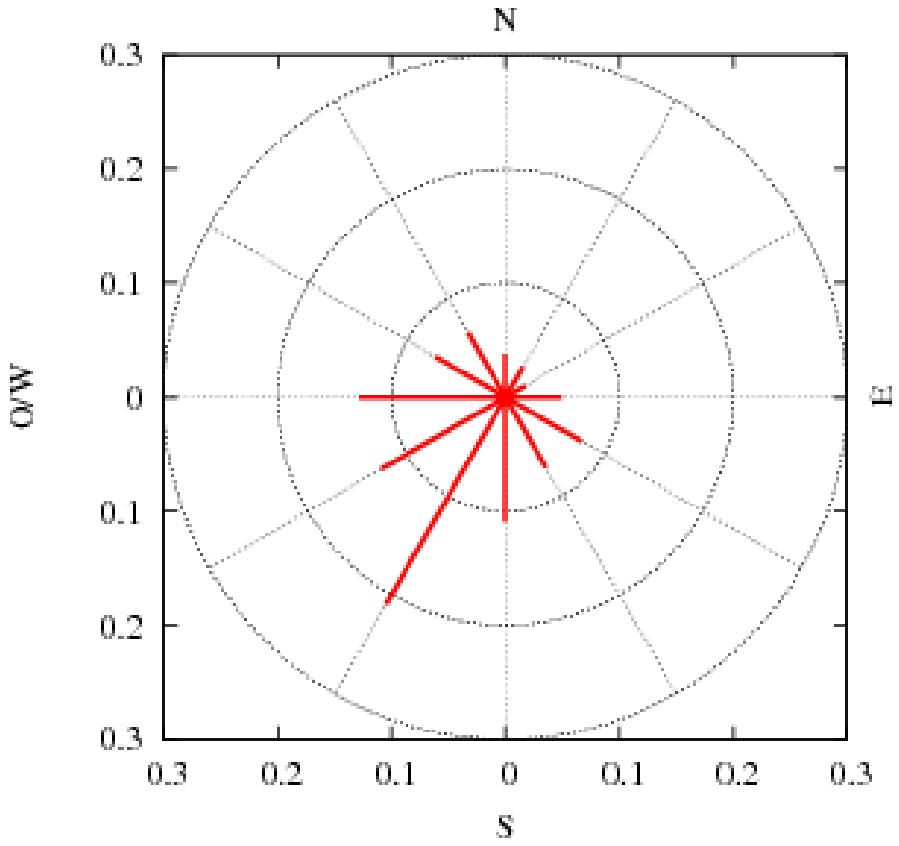


Figure 5b: St Columban Wind Project, Fall Immission Results
Monitoring Location R3, October 9, 2015 to January 14, 2016



APPENDIX A:
HISTORICAL WIND ROSE

Figure A1: Annual Wind Rose [7]



APPENDIX B:

MONITORING LOCATION PHOTOS

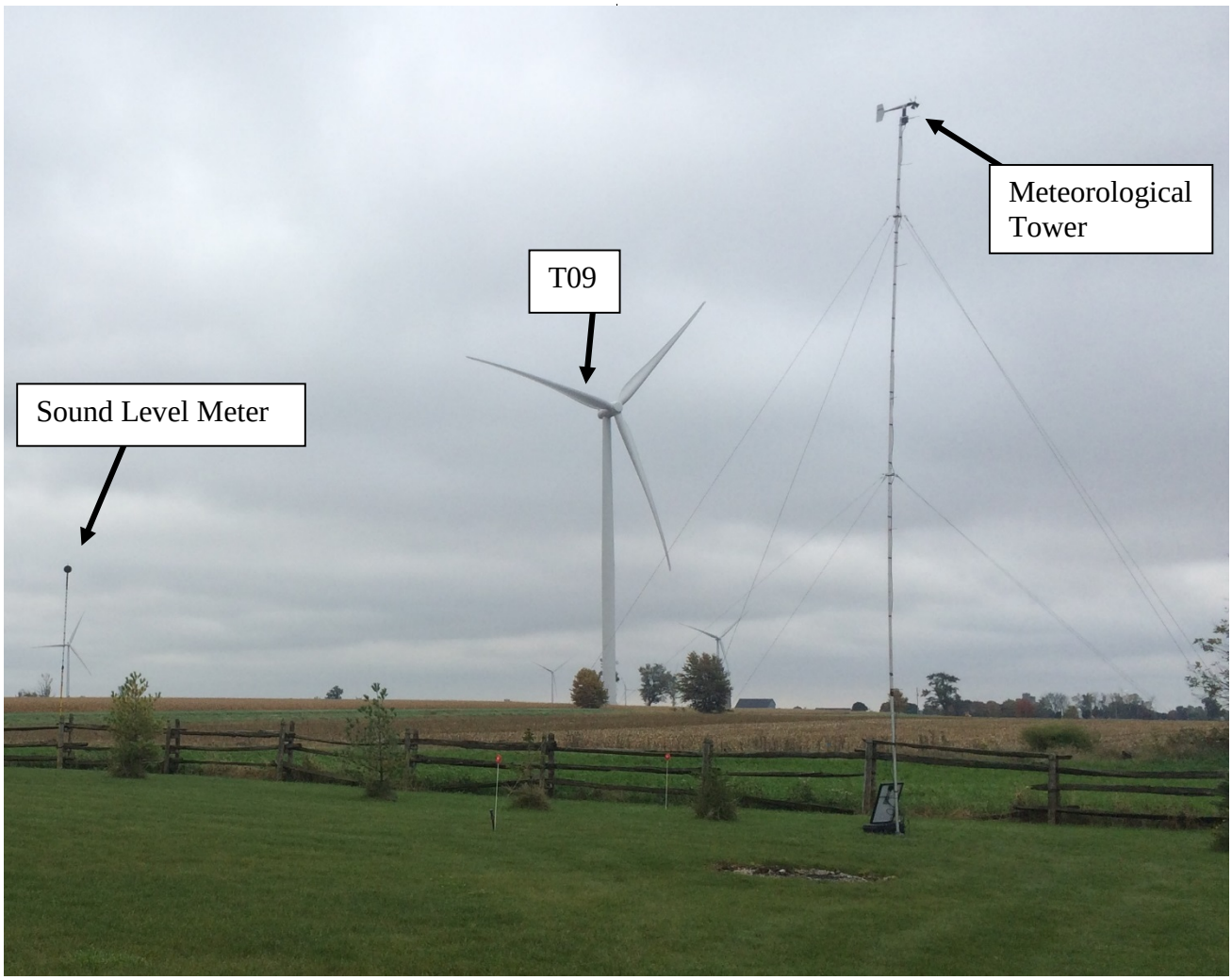


Photo of Instrumentation at Receptor R3

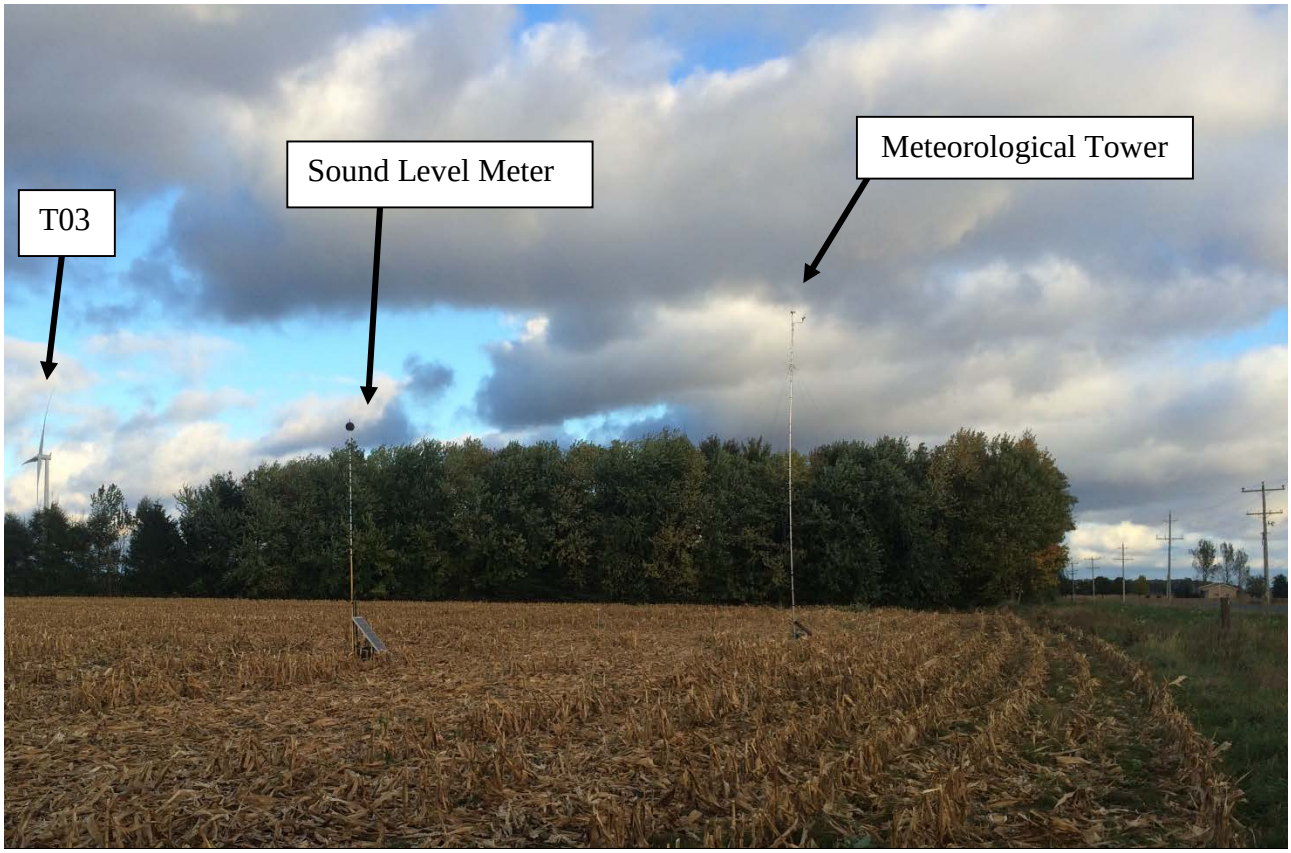


Photo of Instrumentation at Receptor V661

APPENDIX C:

CALIBRATION CERTIFICATES

CERTIFICATE of CALIBRATION

Make : Svantek

Model : SVAN977

Descr. : Sound Level Meter Type 1

Serial # : 36439

Asset # : SV977-4

Reference # : 140991

Customer : HGC Engineering
Mississauga, ON

P. Order :

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 : Sep 24, 2015

Cal. Due : Sep 24, 2016

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: navair @ navair.com

CERTIFICATE of CALIBRATION

Make : Svantek

Model : SVAN977

Descr. : Sound Level Meter Type 1

Serial # : 36428

Asset # : SV977-3

Reference # : 140992

Customer : HGC Engineering
Mississauga, ON

P. Order :

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 : Sep 24, 2015

Cal. Due : Sep 24, 2016

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: navair @ navair.com

CERTIFICATE of CALIBRATION

Make : Norsonic

Model : NOR140

Descr. : SLM Type 1

Serial # : 1404511

Asset # : N140-3

Reference # : 138346

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richardson

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

23 FEB 2015

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 : Feb 18, 2015

By : T. Beilin

Cal. Due : Feb 18, 2016

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: navair @ navair.com

CERTIFICATE of CALIBRATION

Make :	Norsonic	Reference # :	138351
Model :	NOR140	Customer :	HGC Engineering Mississauga, ON
Descr. :	SLM Type 1		
Serial # :	1403983	P. Order :	Sean Richardson
Asset # :	N140-4		

Cal. status : Received in spec's, no adjustment made. 23 FEB 2015

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 : Feb 18, 2015 By : T. Beilin

Cal. Due : Feb 18, 2016

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: navair @ navair.com

CERTIFICATE of CALIBRATION

Make : Norsonic

Model : NOR140

Descr. : Sound Level Meter Type 1

Serial # : 1405028

Asset # : N140-5

Reference # : 142149

Customer : HGC Engineering
Mississauga, ON

P. Order :

Cal. status : Received in spec's, no adjustment made. 14 Dec 2015

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 07, 2015

By : T. Beilin

Cal. Due : Dec 07, 2016

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: navair @ navair.com

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP®
NVLAP Lab Code: 200625-0

Calibration Certificate No.33290

Instrument: **Sound Level Meter**
Model: **140**
Manufacturer: **Norsonic**
Serial number: **1405046**
Tested with: **Microphone 1225 s/n 142437**
Preamplifier 1209 s/n 14553
Type (class): **1**
Customer: **Scantek, Inc.**
Tel/Fax: **410-290-7726 / 410-290-9167**

Date Calibrated: **2/20/2015** *Cal Due:* **2/20/2016**

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes X No
Calibration service: __ Basic X Standard
Address: **6430 Dobbin Road, Suite C, Columbia, MD 21045**

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., Rev. 6/22/2012
SLM & Dosimeters – Acoustical Tests, Scantek Inc., Rev. 7/6/2011

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Oct 7, 2014	Scantek, Inc./ NVLAP	Oct 7, 2015
DS-360-SRS	Function Generator	33584	Sep 30, 2013	ACR Env./ A2LA	Sep 30, 2015
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Oct 1, 2014	ACR Env. / A2LA	Oct 1, 2015
HM30-Thommen	Meteo Station	1040170/39633	Oct 3, 2014	ACR Env./ A2LA	Oct 3, 2015
PC Program 1019 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
1251-Norsonic	Calibrator	30878	Nov 10, 2014	Scantek, Inc./ NVLAP	Nov 10, 2015

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
24.1	101.37	30.6

Calibrated by:	Lydon Dawkins	**Authorized signatory:**	Mariana Buzduga
Signature	Lydon Dawkins	Signature	
Date	2/20/2015	Date	2/20/2015

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 ANEMOMETER

Certificate number: 14.US1.00888 **Date of issue:** January 22, 2014

Type: NRG #40C **Serial number:** 179500229305

Manufacturer: Renewable NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA

Client: Renewable NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA

Anemometer received: January 17, 2014 **Anemometer calibrated:** January 22, 2014

Calibrated by: tjl **Calibration procedure:** IEC 61400-12-1:2005(E) Annex F

Certificate prepared by: Software Revision 3 **Approved by:** Calibration engineer, rds

Calibration equation obtained: v [m/s] = 0.75290 · f [Hz] + 0.38793

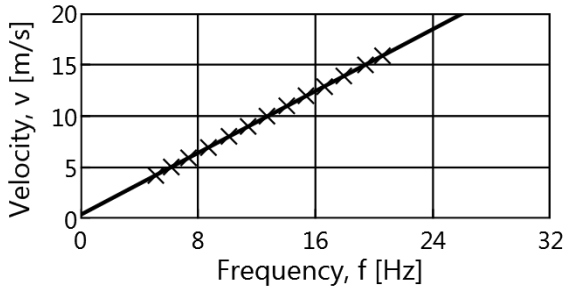
Standard uncertainty, slope: 0.00203 **Standard uncertainty, offset:** 0.05378

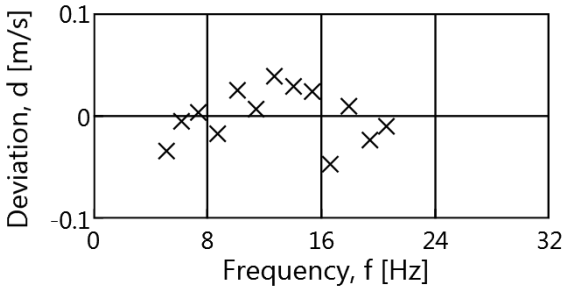
Covariance: -0.0000298 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999977

Absolute maximum deviation: 0.047 m/s at 12.859 m/s

Barometric pressure: 1005.6 hPa **Relative humidity:** 10.7%

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	10.56	22.8	25.1	4.226	5.1430	-0.034	0.045
4	15.06	22.8	25.1	5.047	6.1945	-0.005	0.038
6	20.88	22.8	25.1	5.942	7.3723	0.004	0.033
8	28.49	22.8	25.1	6.941	8.7262	-0.017	0.029
10	38.14	22.8	25.1	8.031	10.1183	0.025	0.027
12	47.84	22.7	25.1	8.994	11.4221	0.007	0.026
13-last	59.04	22.7	25.1	9.992	12.7048	0.039	0.025
11	71.48	22.7	25.1	10.995	14.0500	0.029	0.025
9	84.80	22.8	25.1	11.976	15.3598	0.024	0.025
7	97.75	22.8	25.1	12.859	16.6258	-0.047	0.025
5	114.19	22.8	25.1	13.898	17.9316	0.010	0.026
3	132.59	22.8	25.1	14.977	19.4079	-0.023	0.027
1-first	148.71	22.7	25.1	15.860	20.5634	-0.010	0.028





AC-1746

Standard: ISO/IEC 17025

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 ANEMOMETER

Certificate number: 14.US2.00924 **Date of issue:** January 22, 2014

Type: NRG #40C **Serial number:** 179500229306

Manufacturer: Renewable NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA

Client: Renewable NRG Systems Inc, 110 Riggs Road, Hinesburg, VT 05461, USA

Anemometer received: January 17, 2014 **Anemometer calibrated:** January 22, 2014

Calibrated by: tjl **Calibration procedure:** IEC 61400-12-1:2005(E) Annex F

Certificate prepared by: Software Revision 3 **Approved by:** Calibration engineer, rds

Calibration equation obtained: v [m/s] = 0.75608 · f [Hz] + 0.38135

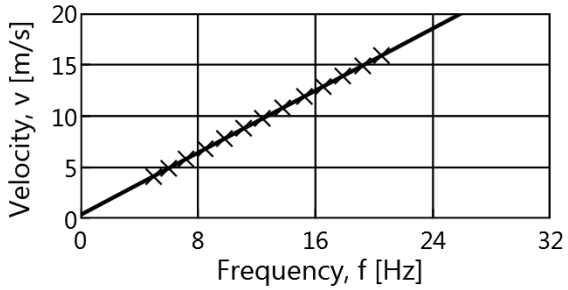
Standard uncertainty, slope: 0.00170 **Standard uncertainty, offset:** 0.04547

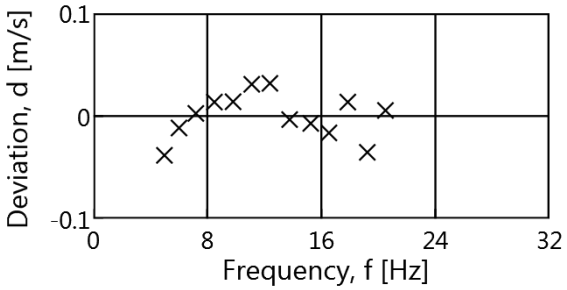
Covariance: -0.0000208 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999984

Absolute maximum deviation: 0.038 m/s at 4.118 m/s

Barometric pressure: 1004.9 hPa **Relative humidity:** 9.7%

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	10.03	22.4	25.2	4.118	4.9921	-0.038	0.047
4	14.32	22.4	25.2	4.920	6.0180	-0.012	0.039
6	20.08	22.4	25.2	5.825	7.1967	0.003	0.034
8	27.52	22.4	25.2	6.820	8.4973	0.014	0.030
10	36.13	22.4	25.1	7.814	9.8120	0.014	0.027
12	46.02	22.4	25.1	8.819	11.1186	0.031	0.026
13-last	56.60	22.4	25.1	9.781	12.3897	0.032	0.025
11	68.92	22.4	25.1	10.793	13.7745	-0.003	0.025
9	83.90	22.4	25.2	11.909	15.2554	-0.007	0.025
7	97.89	22.4	25.2	12.864	16.5309	-0.016	0.026
5	114.23	22.4	25.2	13.897	17.8579	0.014	0.027
3	130.93	22.4	25.2	14.878	19.2204	-0.035	0.028
1-first	149.21	22.4	25.1	15.882	20.4944	0.005	0.029





AC-1746

Standard: ISO/IEC 17025

Certificate of Calibration

Equipment:

Model:	05305-10
Model Description:	RMY Wind Monitor
Serial No:	93557
RMA No:	23287

	Before Service		After Service	
Vane Condition	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Propeller Condition	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Propeller Shaft Alignment	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Vane Balance	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Flange Bearing Check	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Vertical Bearing Check	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Potentiometer Resistance	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Coil Resistance	☒ Pass	☐ Fail	☒ Pass	☐ Fail
Wind Speed Signal Check	☒ Pass	☐ Fail	☒ Pass	☐ Fail

WIND SPEED SIGNAL CHECK		
Wind Speed (RPM)	**Before Service (RPM)**	**After Service (RPM)**
1000	1000	1000
2000	2000	2000
3000	3000	3000
4000	4000	4000
5000	5000	5000
6000	6000	6000
7000	7000	7000
8000	8000	8000
9000	9000	9000
10000	10000	10000
	☒ Pass ☐ Fail	☒ Pass ☐ Fail

Based on Report option requested by the client, some fields are intentionally left blank.

CAMPBELL SCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

WIND DIRECTION SIGNAL CHECK		
COMPASS DIRECTION (Degree)	**SENSOR READINGS**	
	Before Service (±3°)	**After Service (±3°)**
0°	0°	0°
30°	29°	30°
60°	60°	61°
90°	91°	91°
120°	121°	120°
150°	151°	150°
180°	180°	179°
210°	210°	209°
240°	239°	238°
270°	268°	268°
300°	298°	299°
330°	328°	329°
355°	354°	354°
	☒ **Pass** ☐ **Fail**	☒ **Pass** ☐ **Fail**

MECHANICAL DEADBAND		
COMPASS DIRECTION		
	Before Service	**After Service**
MAX°[1] (Start)	357°	357°
MIN°[2] (End)	0°	359°
Deadband Width[3] ($5°_{MAX}$)	3°	2°
	☒ **Pass** ☐ **Fail**	☒ **Pass** ☐ **Fail**

1. **Max** is the result just before the deadband resistance measures an open circuit or 1MΩ.
2. **Min** is the result of when the sensor first reads 0Ω.
3. **Deadband Width** is difference between **MAX** & **MIN**.

General Comments: _____

Calibration Date: January 10, 2014 **It is recommended that the sensor be recalibrated every year.**

Calibration by: _____
Reuben Bute

Based on Report option requested by the client, some fields are intentionally left blank.

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11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

APPENDIX D:

STATEMENT OF OPERATION

St. Columban Energy LP

SUITE 900, LIVINGSTON PLACE - SOUTH TOWER
222-3RD AVENUE SW
CALGARY, ALBERTA T2P 0B4
MAIN: (866) 944-6401
(403) 296-0140
FAX: (403) 444-6784

ST. COLUMBAN ENERGY LP

June 15, 2016

Re: Statement of Operation
St. Columban Wind Energy Project, St. Columban, Ontario

To Whom it May Concern,

This letter is to confirm that the wind turbine generators at the St. Columban Wind Energy Project were functioning in their standard operational mode during the post-construction acoustic audit, conducted between December 12, 2015 and January 14, 2016.

Yours Truly,

David Hayles
Operations Coordinator
St. Columban Wind Farms
35 Main St South
Grand Valley, Ontario
L9W 5S8

Ph: 519 216 5856

Email: dhayles@vereseninc.com