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SPRING ACOUSTIC AUDIT - IMMISSION REPORT

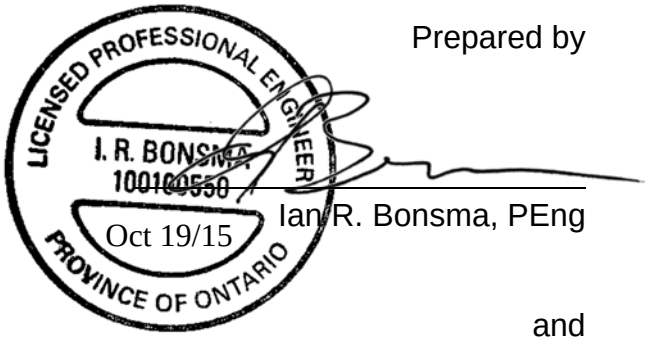
Bluewater Wind Energy Project

Municipality of Bluewater, Ontario

Prepared for:

Varna Wind, LP
390 Bay Street, Suite 1720
Toronto, ON
M5H 2Y2

Prepared by



Ian R. Bonsma, PEng

and

Brian Howe, MEng, MBA, PEng

October 19, 2015

EXECUTIVE SUMMARY

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by Varna Wind, LP to complete an acoustic immision audit of the Bluewater Wind Energy Centre ("Wind Project") in the Municipality of Bluewater. The project includes 37 General Electric GE 1.6-100 LNTE wind turbine generators, each rated at 1.6 MW. The acoustic immision audit is required as a condition of Renewable Energy Approval number 7483-94DPRF issued by the Ontario Ministry of the Environment and Climate Change. HGC Engineering has assessed the acoustic impact against the acoustic criteria of the Ontario Ministry of the Environment and Climate Change ("MOECC") and in accordance with the requirements of the MOECC's Compliance Protocol for Wind Turbine Noise. The spring measurement campaign was completed between March 5 and April 24, 2015.

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 considered receptors. 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 ("Varna Wind") to complete an Acoustic Audit – Immission of the Bluewater Wind Energy Centre. The project is located in the municipality of Bluewater, Ontario and consists of 37 General Electric GE 1.6-100 LNTE wind turbine generators, each rated at 1.6 MW and with a hub height of 80 metres.

The Audit is required as part of the Renewable Energy Approval ("REA") number 7483-94DPRF [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 order to satisfy the second of two audits required under Condition E of the REA.

2 POINTS OF RECEPTION

The Acoustic Assessment Report prepared by Aecom [2] provided sound level predictions for receptors within 2000 metres of the project wind turbine generators. The condition in the REA requires that measurements be completed at three different points of reception which are selected utilizing the following criteria:

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

Receptor locations BLW517, BLW906 and BLW780 were selected based on their downwind locations, predicted sound levels, and consultation with the land owners. The historical wind rose for the area is provided in Appendix A. The sound level predictions included in the Acoustic Assessment Report indicate sound levels of 38.3, 39.3 and 38.2 dBA at the selected receptors, respectively. A number of additional receptors were approached for use as sound level monitoring locations for the audit, however, permission for use was not granted.

Receptor BLW517, is a two storey home located on the west side of the project with the closest turbine, WTG 2, at approximately 740 metres away. Receptor location BLW906 is two storey home located on the east side of the project with several buildings for equipment and storage, a barn and a grain silo. The nearest wind turbine is WTG 23, at a distance of approximately 770 metres. BLW780 is a two storey home located centrally within the project with the closest turbine, WTG 14, at approximately 1000 metres.

The site is generally rural in nature with infrequently travelled asphalt roads (Bronson Line, Babylon Line and Goshen Line).

3 INSTRUMENTATION

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

Audio frequency sound level measurements were performed using Svantek 971 integrating sound level meters connected to their respective ½" microphones. Each microphone was set at a height of approximately 4.5 m and equipped with a 175 mm diameter windscreen to minimize wind-induced microphone self-noise. A Brüel & Kjær 2238 sound level meter was also used to measure the sound level within close proximity of a turbine.

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 pass-bys. 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, three meteorological instruments were used. An APRS weather station was deployed to collect ground weather conditions including temperature, humidity, and precipitation at BLW517. NRG anemometers and wind vanes were used to collect 10 metre height wind speed and direction at each of the three receptor locations.

The various instruments deployed by HGC Engineering are summarized in Table 1 below, and their relative locations are shown in Figure 1.

Table 1: Sound Level Measurement Instrumentation

Location	Address	Instrumentation Make and Model	Serial Number
BLW517	74517 Bronson Line	Svantek 971 Sound Level Meter	41988
		NRG#40 Anemometer connected to the APRS Weather Station	179500239663
		APRS Weather Station	A4431
BLW906	74559 Babylon Line	Svantek 971 Sound Level Meter	36827
		NRG#40 Anemometer with Campbell Scientific Data Logger	179500221341
BLW780	74291 Goshen Line	Svantek 971 Sound Level Meter	36816
		NRG#40 Anemometer with Campbell Scientific Data Logger	17900229306
WTG 14		B&K Sound Level Meter Type 2238	2039554

The Svantek sound level meters were configured to measure and document spectral (frequency-dependent) 1 minute L_{EQ} and 15 minute L_{90} sound level measurements at the receptor locations, and to also record audio files to allow for identification of dominant sources. A B&K sound level meter was also used to measure and record the L_{EQ} and L_{90} sound level at 1 minute intervals within close proximity to WTG 14.

Correct calibration of the acoustic instrumentation was verified using an acoustic calibrator manufactured by Brüel & Kjær (B&K). Calibration was carried out at the start, intermediate, and end of the measurement period.

Wind screens were used on all microphones, consistent with the requirements of MOECC technical publication NPC-103, *Procedures* [4]. Large wind screens, 175 mm in diameter, were utilized 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 these large wind screens.

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 2.

Table 2: Wind Turbine Noise Criteria [dBA]

Wind Speed (m/s) at 10 m Height	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 a receptor includes significant sound due to the relevant sound source and unrelated background sound sources (i.e., road vehicles, 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 below.

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 and without 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 (L_n) can also be measured during the monitoring campaign to aid in the analysis.

The MOECC protocol requires that at least 120 one minute intervals be measured for each wind speed when the turbines are operating and at least 60 one minute intervals be measured for each 10 metre 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 include data only during 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 10 metre wind speed 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 allowed for the identification of the dominant noise source within a given one minute interval, and a subsequent removal of those with 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 MEASUREMENTS AND RESULTS

Sound level measurements were conducted at the receptor locations between March 5 and April 24, 2015. The weather during the monitoring period varied, including several days with rain and snow. Temperatures ranged from -26 to 21° Celsius. Wind speeds at 10 metres in height ranged from 0 m/s up to 18 m/s. The prevailing wind direction during the measurement campaign was from the southwest. Figures 2a through 4b show the wind roses for the receptors during the ON and OFF conditions. Observations during the attended measurements conducted on a number of occasions throughout the measurement campaign indicated that the turbines were not tonal.

Data reductions, as discussed in Section 5, were applied to the measured sound levels at the three receptor locations. To confirm wind project ON and OFF conditions a number of additional items of information were reviewed/collected including electrical power production from the turbines, and audio recordings at the receptor locations.

The sound level summary for data collected at BLW517 is shown in Tables 3a and 3b below and Figures 5a and 5b.

Table 3a: Sound Level Summary for Receptor BLW517 [dBA]

	10 metre Wind Speed Bins							
L_{EQ} Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	34.8	3.7	39.4	3.2	42.4	2.6	45.0	2.6
Average Ambient (OFF) / std dev.	35.7	5.3	39.1	3.9	40.0	3.6	42.7	3.5
Wind Project Only / std dev.	N/A[1]	-	27.5[2]	3.4[2]	38.6	2.8	41.1	2.9
Criteria	40.0		40.0		40.0		43.0	
Excess	**0**		**0**		**0**		**0**	

[1] The wind project only sound level cannot be calculated, as the average ambient sound level was greater than the average operating sound level.
[2] The calculated sound level does not represent the contribution of the wind project at this location, as the average operating and ambient sound levels were essentially equivalent.

Table 3b: Summary of Valid Data Points for Receptor BLW517

Wind Project Condition	10 metre Wind Speed [m/s]			
	4	5	6	7
Operating (ON)	2595	1428	1466	573
Ambient (OFF)	479	455	143	95

Based on the data presented above and in Figures 5a and 5b, the wind energy facility is compliant with the MOECC sound level criteria at this location.

The sound level summary for data collected at BLW906 is presented in Tables 4a and 4b and Figures 6a and 6b.

Table 4a: Sound Level Summary for Receptor BLW906 [dBA]

L_{EQ} Sound Level [dBA]	10 metre Wind Speed Bins							
	4 m/s		5 m/s		6 m/s		7 m/s	
Average Operating (ON) / std dev.	39.6	3.9	41.7	3.5	44.0	3.5	47.0	2.9
Average Ambient (OFF) / std dev.	34.5	5.3	42.4	5.0	47.5	3.6	50.2	2.3
Wind Project Only / std dev.	38.0	4.4	N/A[1]	-	N/A[1]	-	N/A[1]	-
Criteria	40.0		40.0		40.0		43.0	
Excess	**0**		**0**		**0**		**0**	

[1] The wind project only sound level cannot be calculated, as the average ambient sound level was greater than the average operating sound level.

Table 4b: Summary of Valid Data Points for Receptor BLW906

Wind Project Condition	10 metre Wind Speed [m/s]			
	4	5	6	7
Operating (ON)	1730	1151	718	499
Ambient (OFF)	259	250	275	227

The sound level measurements at receptor BLW906 indicate that the wind energy facility is compliant with the MOECC sound level criteria at this location. Furthermore, the average operating sound levels for wind speeds between 5 and 7 m/s were either below or equivalent to the average ambient sound levels at this location, as shown in Table 4a.

The sound level summary for data collected at BLW780 is presented in Tables 5a and 5b and Figures 6a and 6b.

Table 5a: Sound Level Summary for Receptor BLW780 [dBA]

	10 metre Wind Speed Bins							
L_{EQ} Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	37.3	4.7	40.4	3.8	42.7	3.6	46.3	3.5
Average Ambient (OFF) / std dev.	35.7	6.1	39.4	3.8	43.1	3.8	46.2	3.0
Wind Project Only / std dev.	32.3	5.0	33.4	3.9	N/A[1]	-	32.3[2]	3.4[2]
Criteria	40.0		40.0		40.0		43.0	
Excess	**0**		**0**		**0**		**0**	

[1] The wind project only sound level cannot be calculated, as the average ambient sound level was greater than the average operating sound level.
[2] The calculated sound level does not represent the contribution of the wind project at this location, as the average operating and ambient sound levels were essentially equivalent.

Table 5b: Summary of Valid Data Points for Receptor BLW780 [dBA]

	10 metre Wind Speed [m/s]			
Wind Project Condition	**4**	**5**	**6**	**7**
Operating (ON)	2283	2531	1767	855
Ambient (OFF)	483	529	239	203

Based on the data presented above and in Figures 7a and 7b, the wind energy facility is compliant with the MOECC sound level criteria at this location. Furthermore, the average operating sound levels for wind speeds between 6 and 7 m/s were roughly equivalent to the average ambient sound levels at this location, as shown in Table 5a.

Appendix B includes a statement from Varna Wind, LP indicating the wind turbines were operating normally for the duration of the measurement campaign.

7 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.

REFERENCES

1. Ontario Ministry of the Environment Renewable Energy Approval Number 7483-94DPRF, April 22, 2013.
2. Aecom, *Bluewater Wind Energy Centre – Noise Assessment Report*, March, 2013.
3. Ontario Ministry of the Environment Publication, *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*. June 3, 2015. Retrieved from http://www.windatlas.ca/en/rose.php?field=E1&height=50&season=ANU&no=24&ni=927&nj=184.

Figure 1: Wind Turbine and Sound Level Monitor Locations
Bluewater Wind Energy Project, Bluewater, Ontario

Figure 2a: Wind Direction - Bronson Line, Receptor BLW517

10 m Height, Wind Speeds 4-7 m/s

ON Condition, March 5 to April 24, 2015

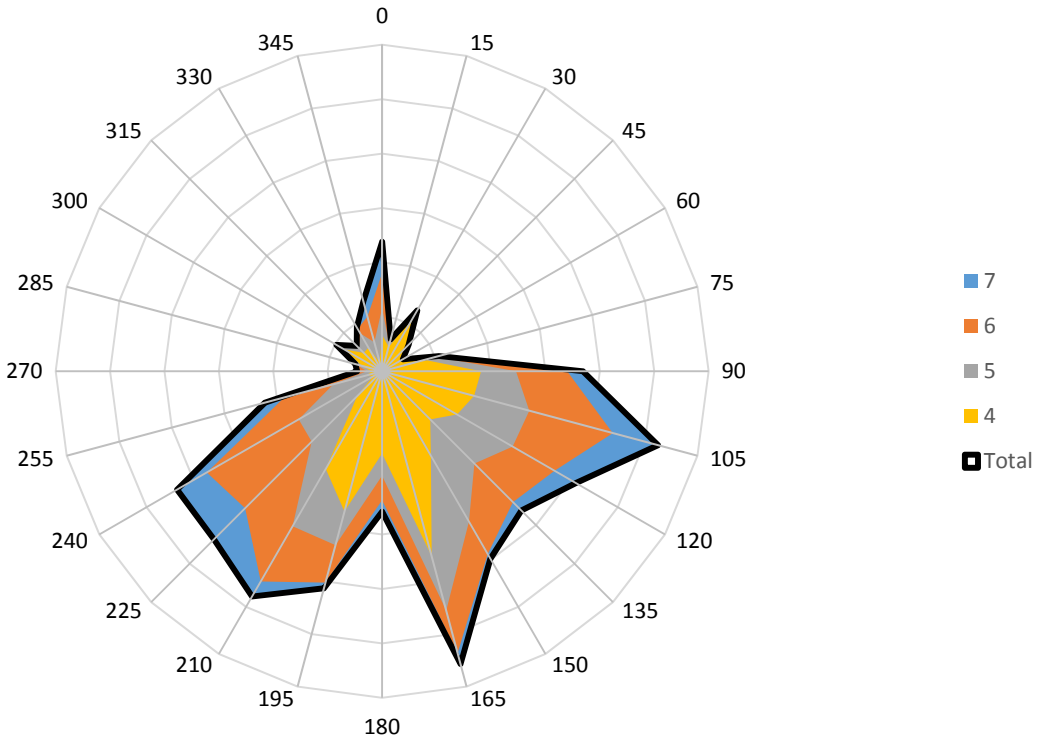


Figure 2b: Wind Direction - Bronson Line, Receptor BLW517

10 m Height, Wind Speeds 4-7 m/s

OFF Condition, March 5 to April 24, 2015

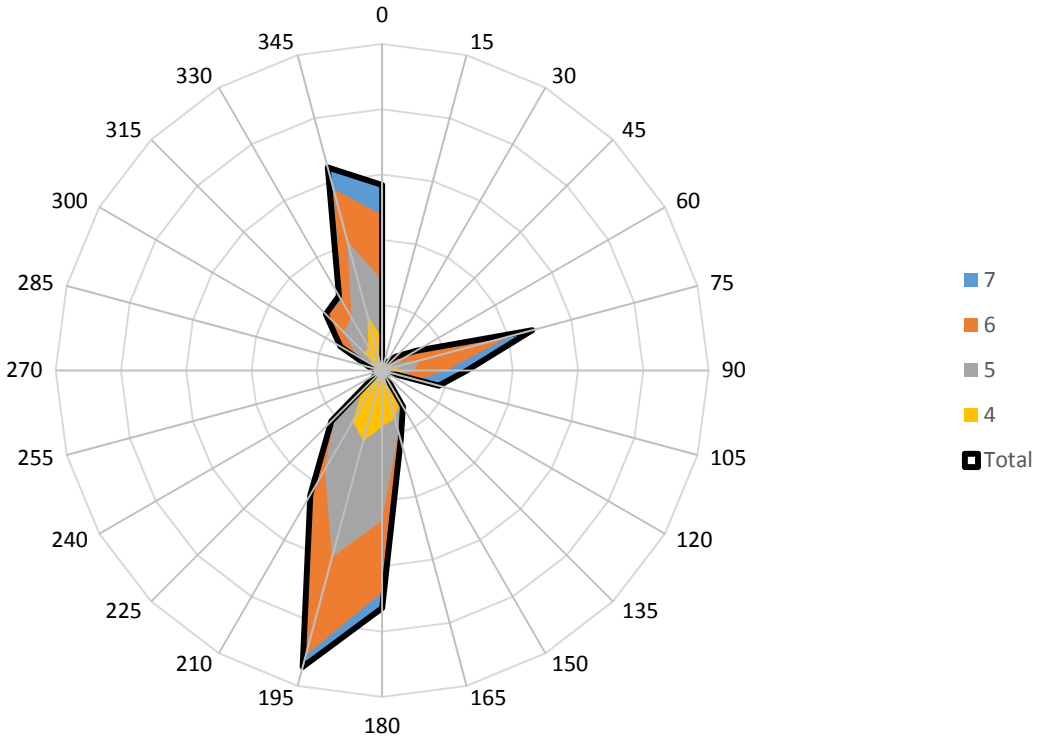


Figure 3a: Wind Direction - Babylon Line, Receptor BLW906

10 m Height, Wind Speeds 4-7 m/s

ON Condition, March 5 to April 24, 2015

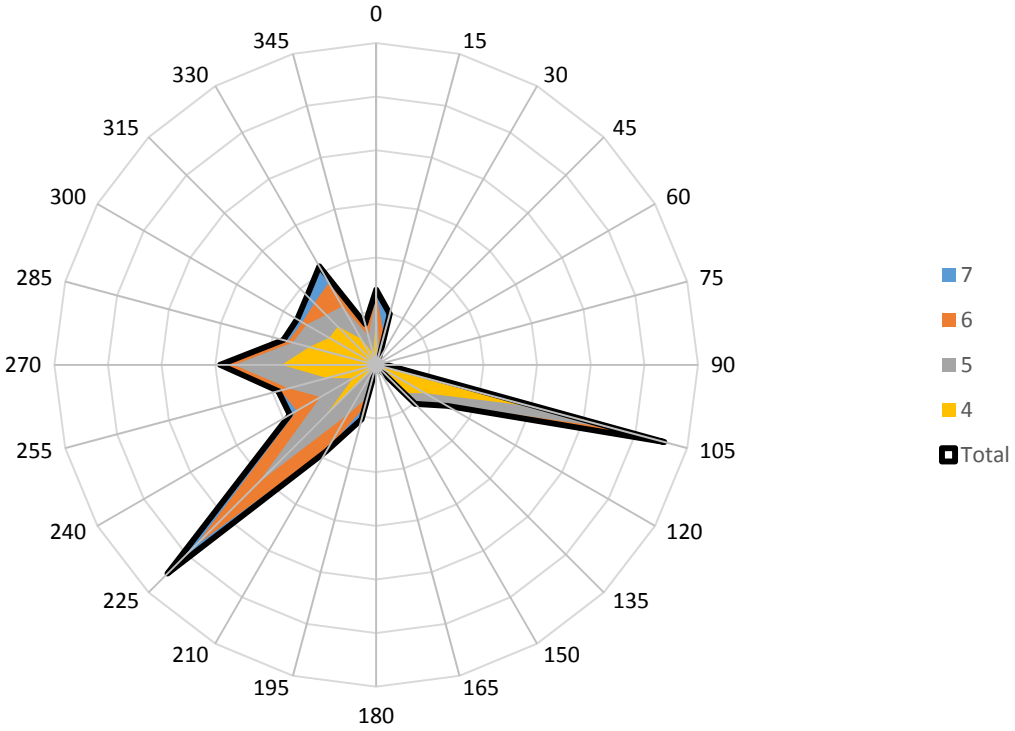


Figure 3b: Wind Direction - Bronson Line, Receptor BLW906

10 m Height, Wind Speeds 4-7 m/s

OFF Condition, March 5 to April 24, 2015

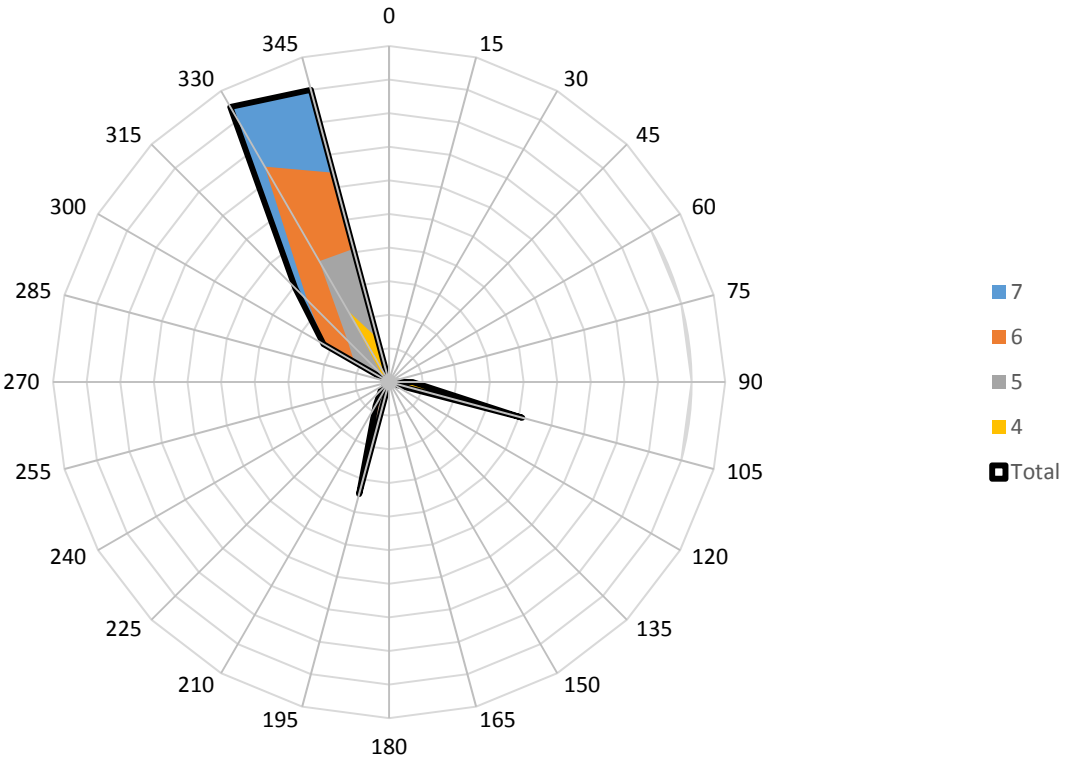


Figure 4a: Wind Direction - Goshen Line, Receptor BLW780

10 m Height, Wind Speeds 4-7 m/s

ON Condition, March 5 to April 24, 2015

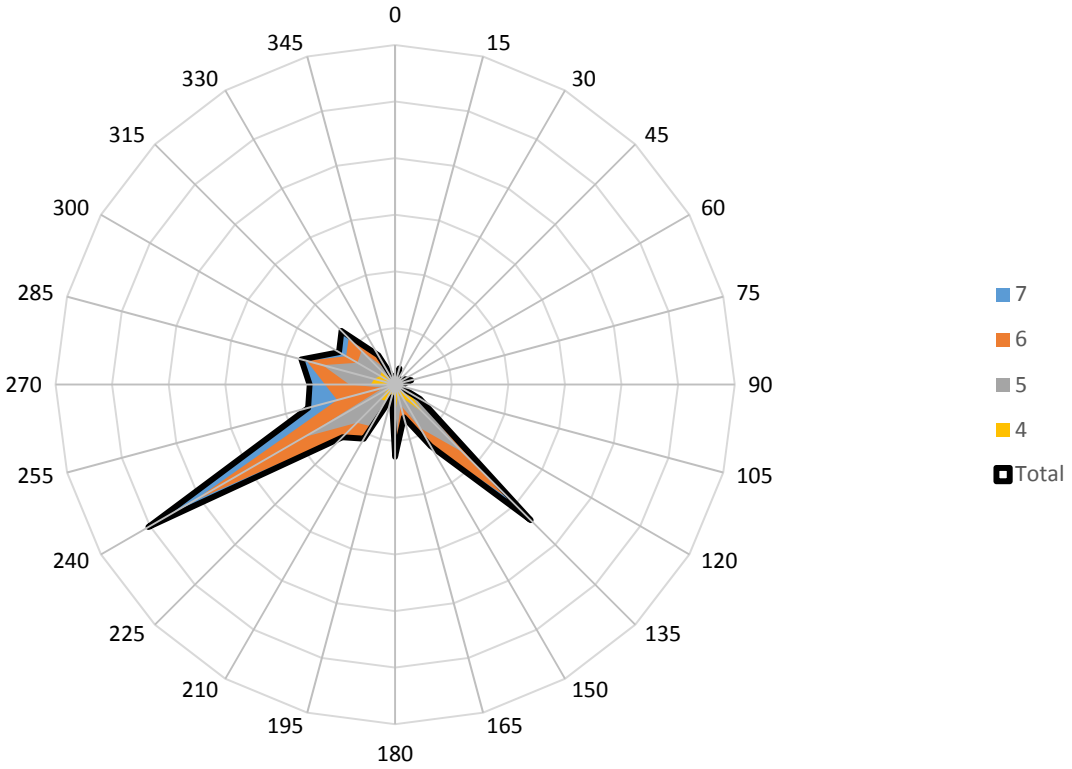


Figure 4b: Wind Direction - Goshen Line, Receptor BLW780

10 m Height, Wind Speeds 4-7 m/s

OFF Condition, March 5 to April 24, 2015

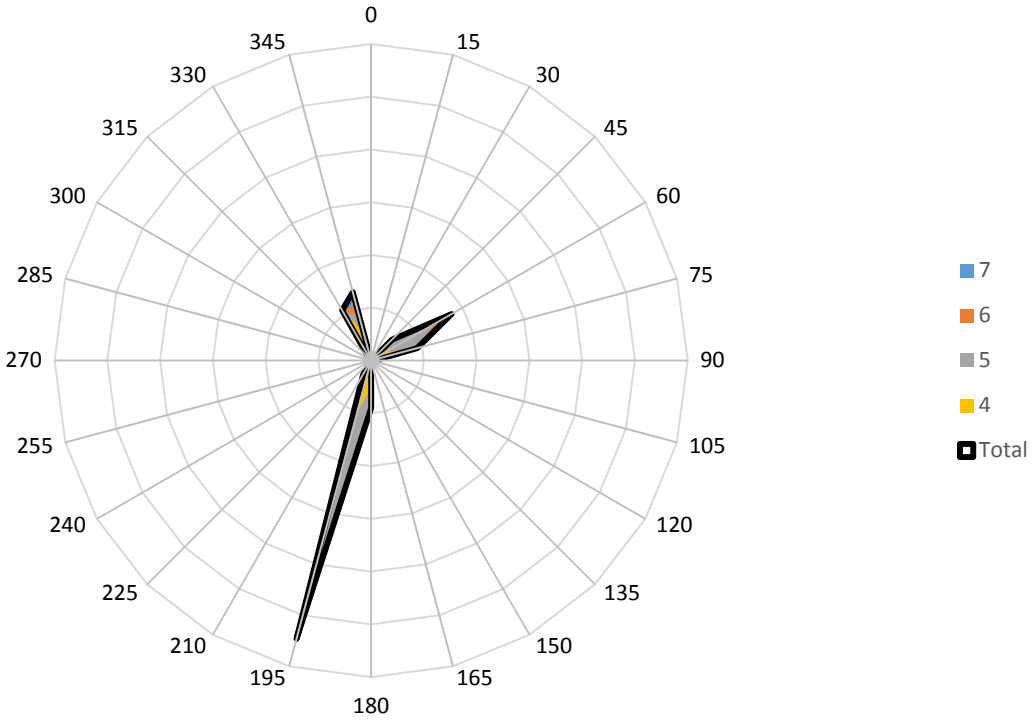


Figure 5a: Bluewater Wind Energy Center, Spring Acoustic Audit Results
Bronson Line, Receptor BLW517, March 5 to April 24, 2015

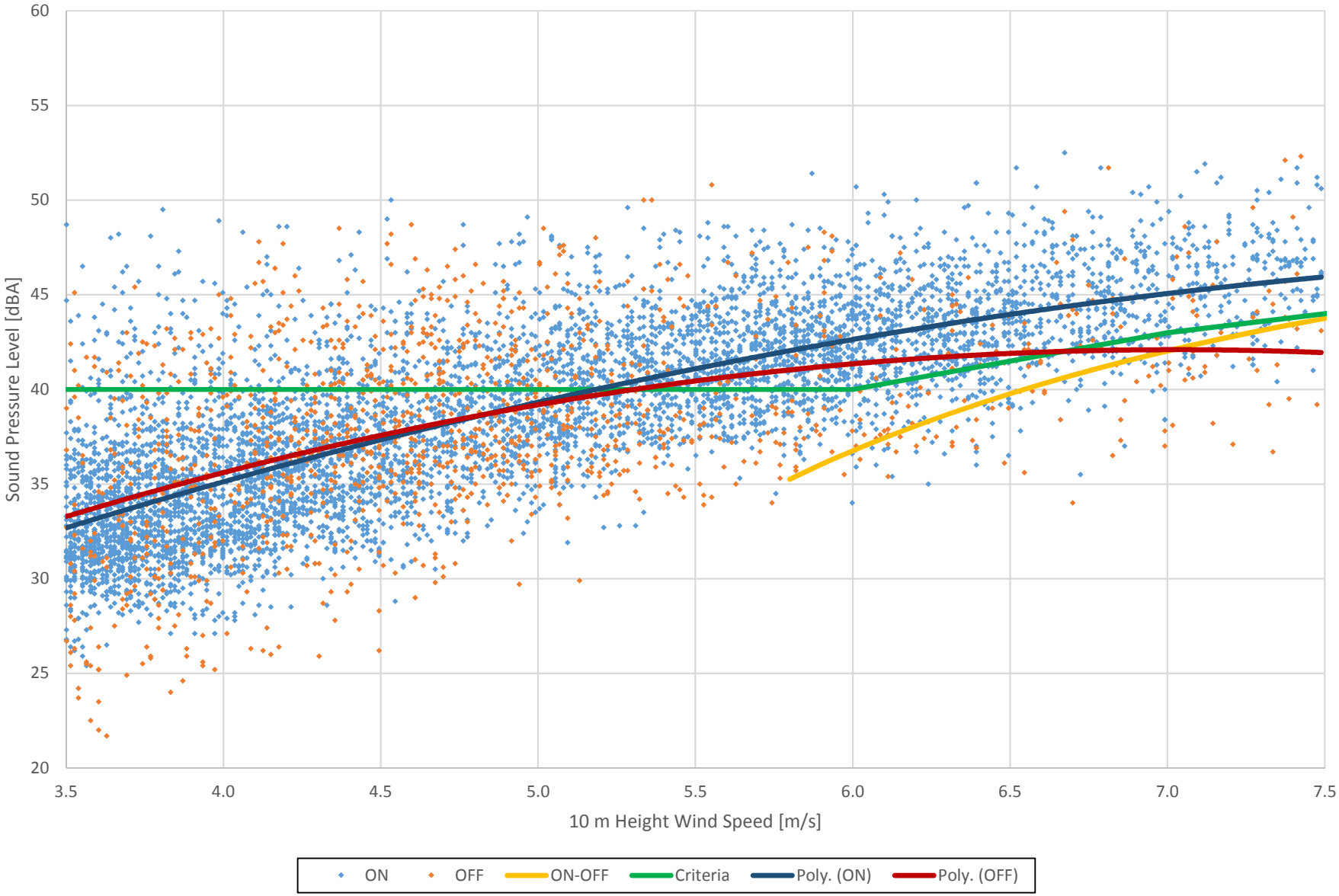


Figure 5b: Bluewater Wind Energy Center, Spring Acoustic Audit Results
Bronson Line, Receptor BLW517, March 5 to April 24, 2015

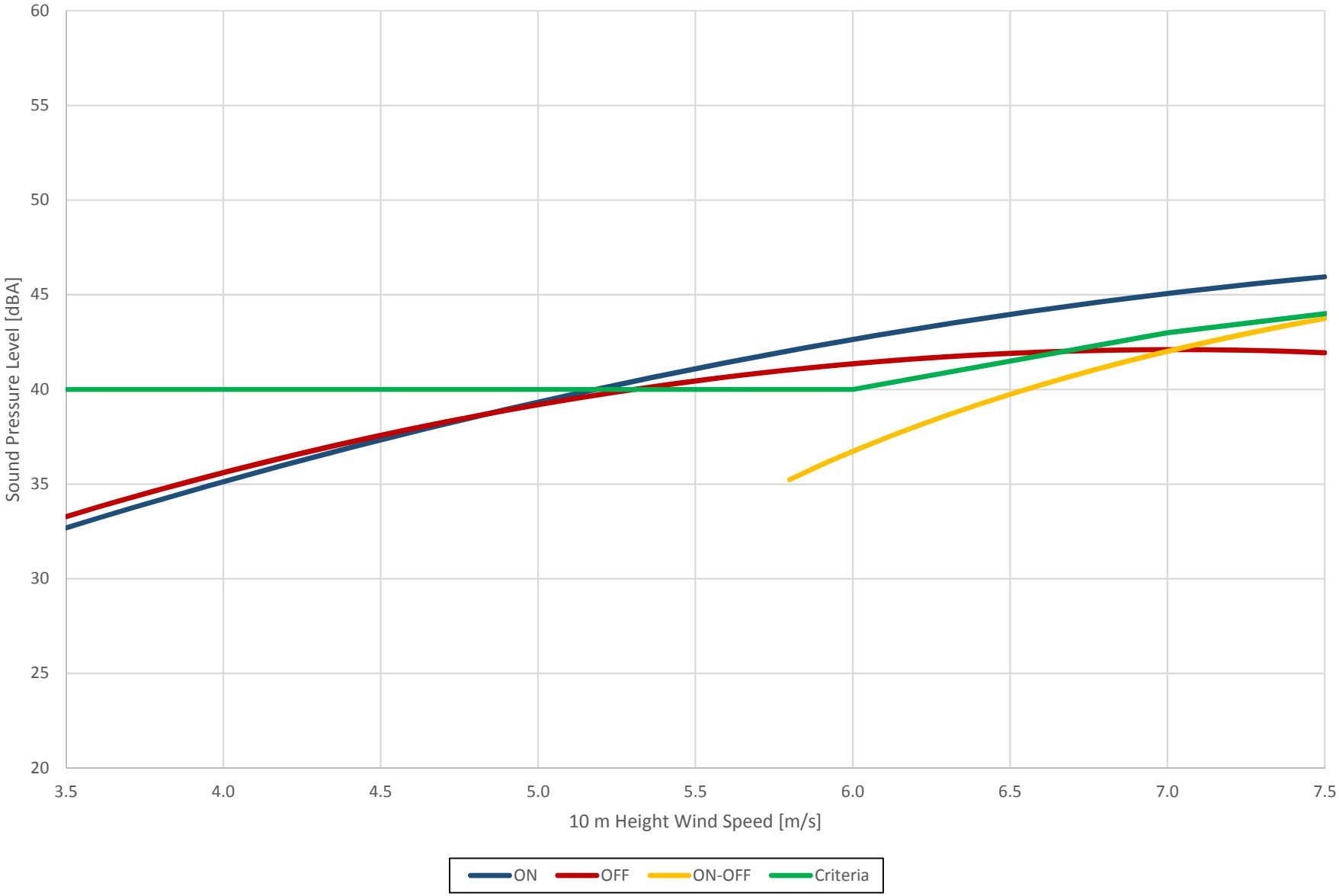


Figure 6a: Bluewater Wind Energy Centre, Spring Acoustic Audit Results
Babylon Line, Receptor BLW906, March 5 to April 24, 2015

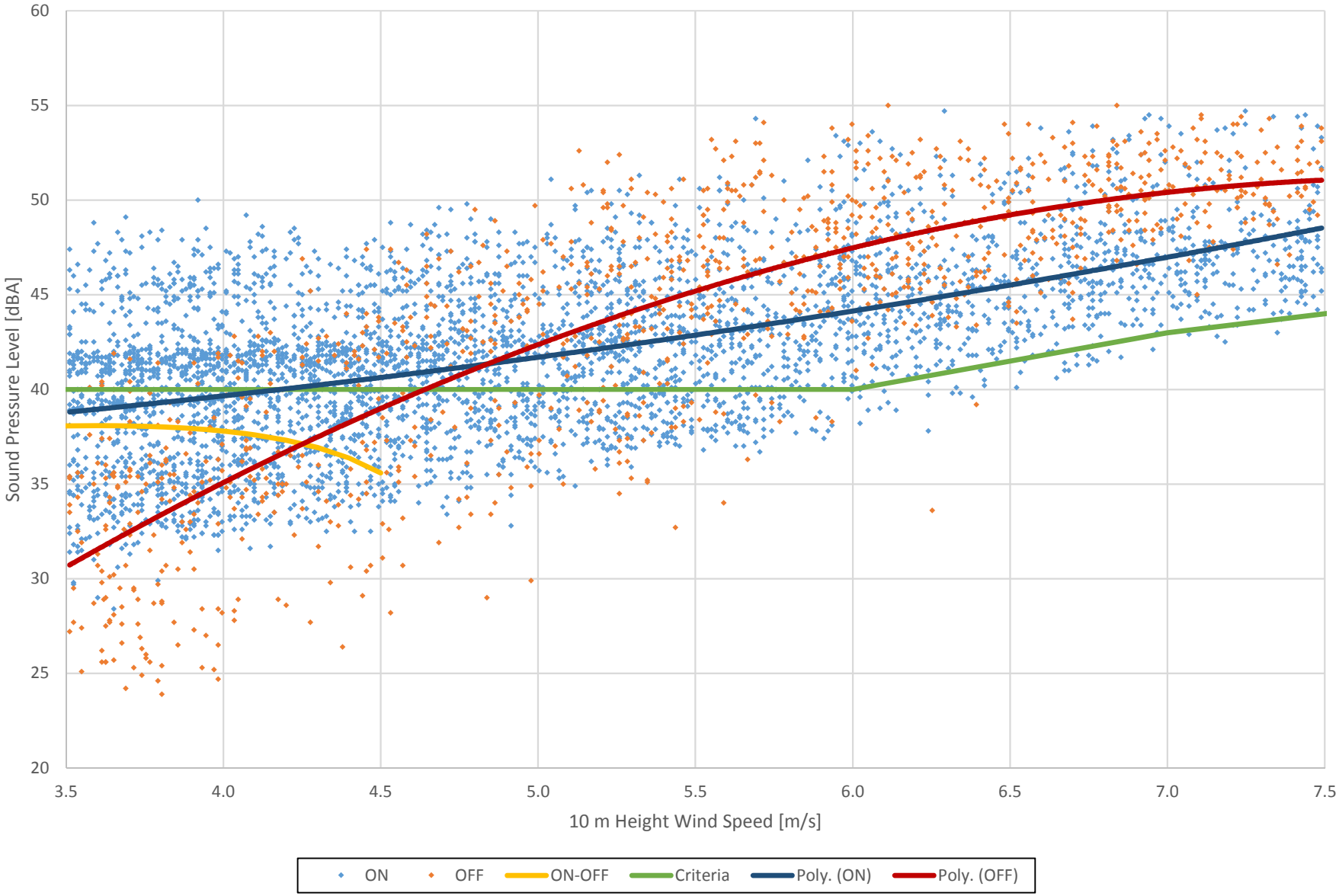


Figure 6b: Bluewater Wind Energy Centre, Spring Acoustic Audit Results
Babylon Line, Receptor BLW906, March 5 to April 24, 2015

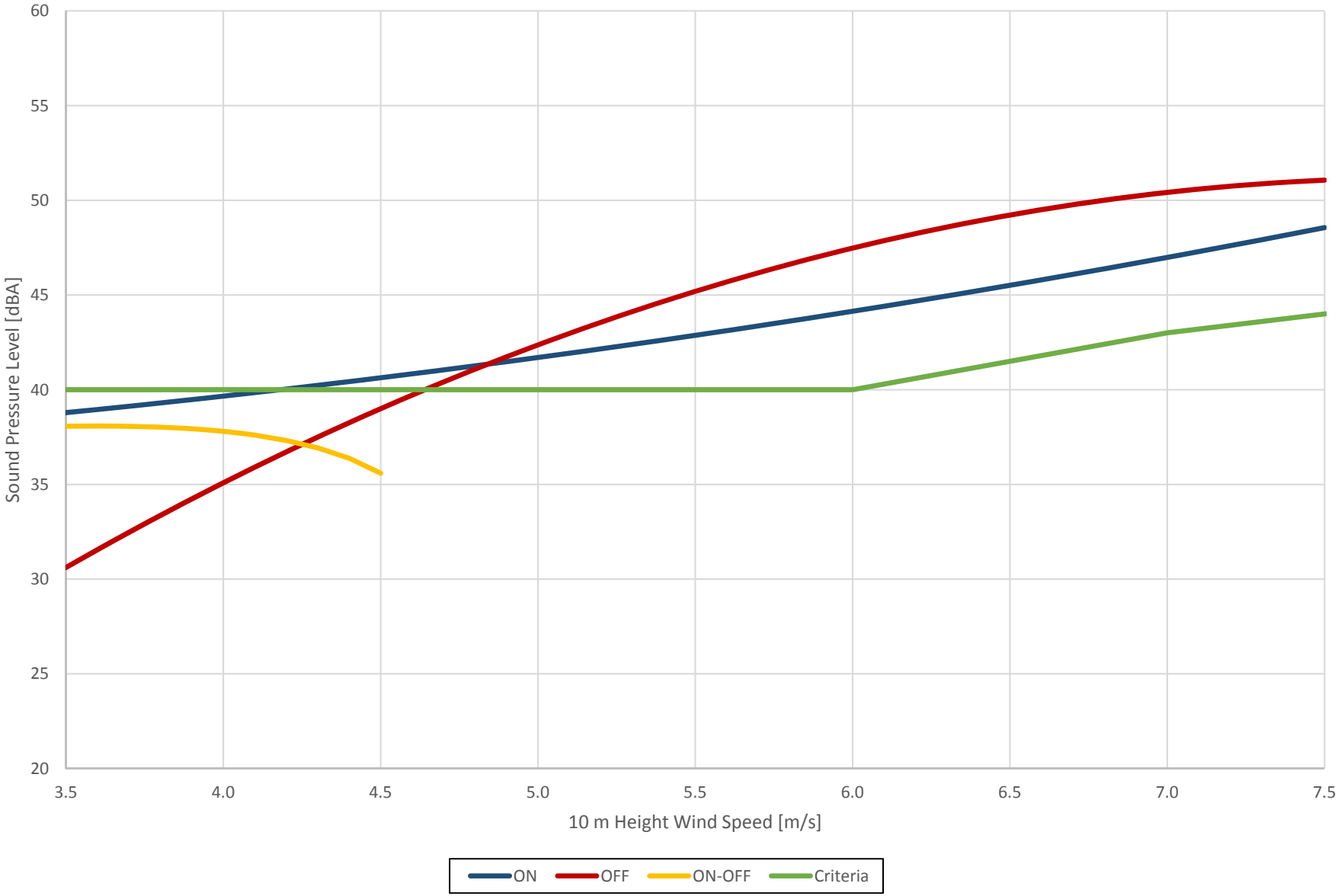


Figure 7a: Bluewater Wind Energy Centre, Spring Acoustic Audit Results
Goshen Line, Receptor BLW780, March 5 to April 24, 2015

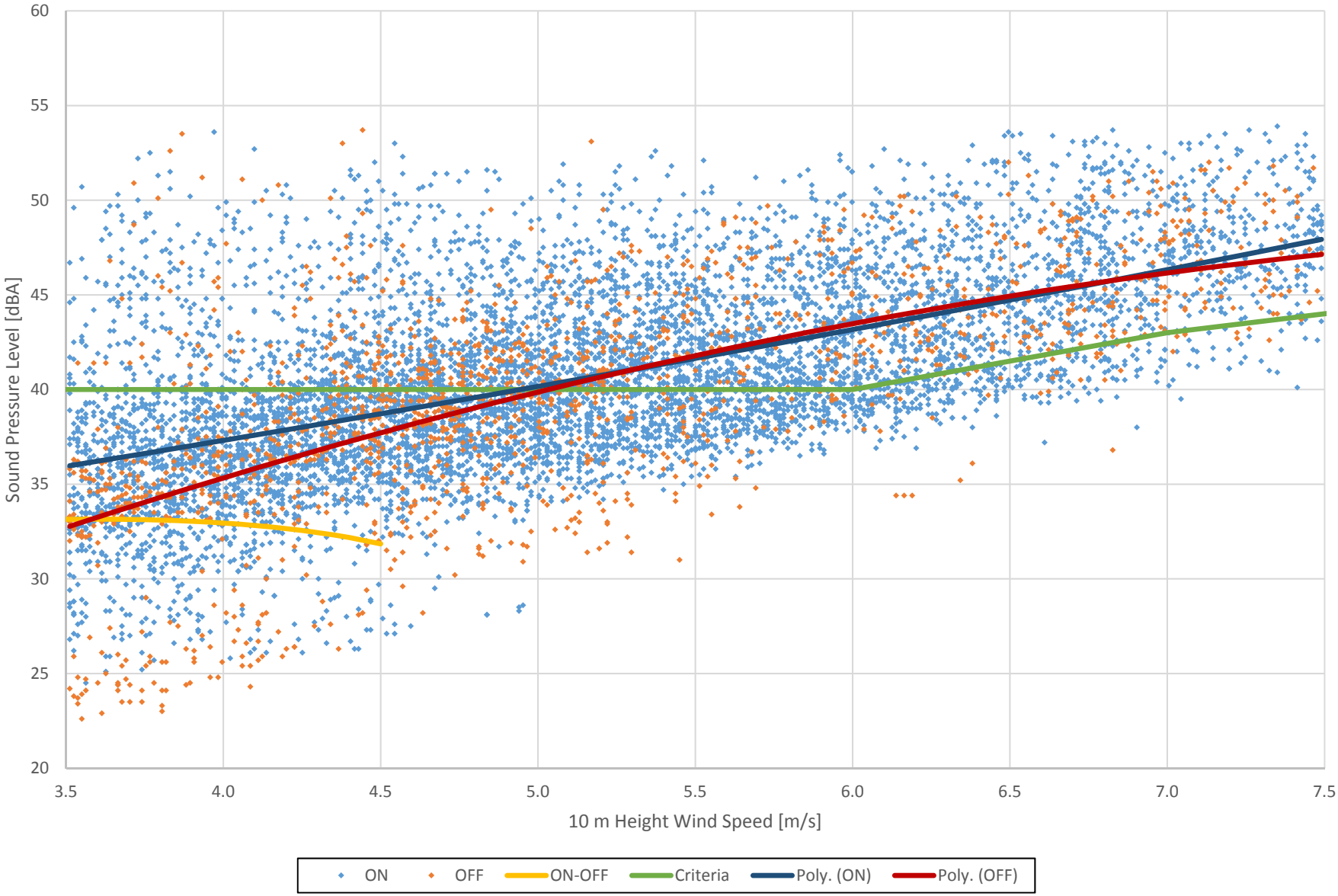
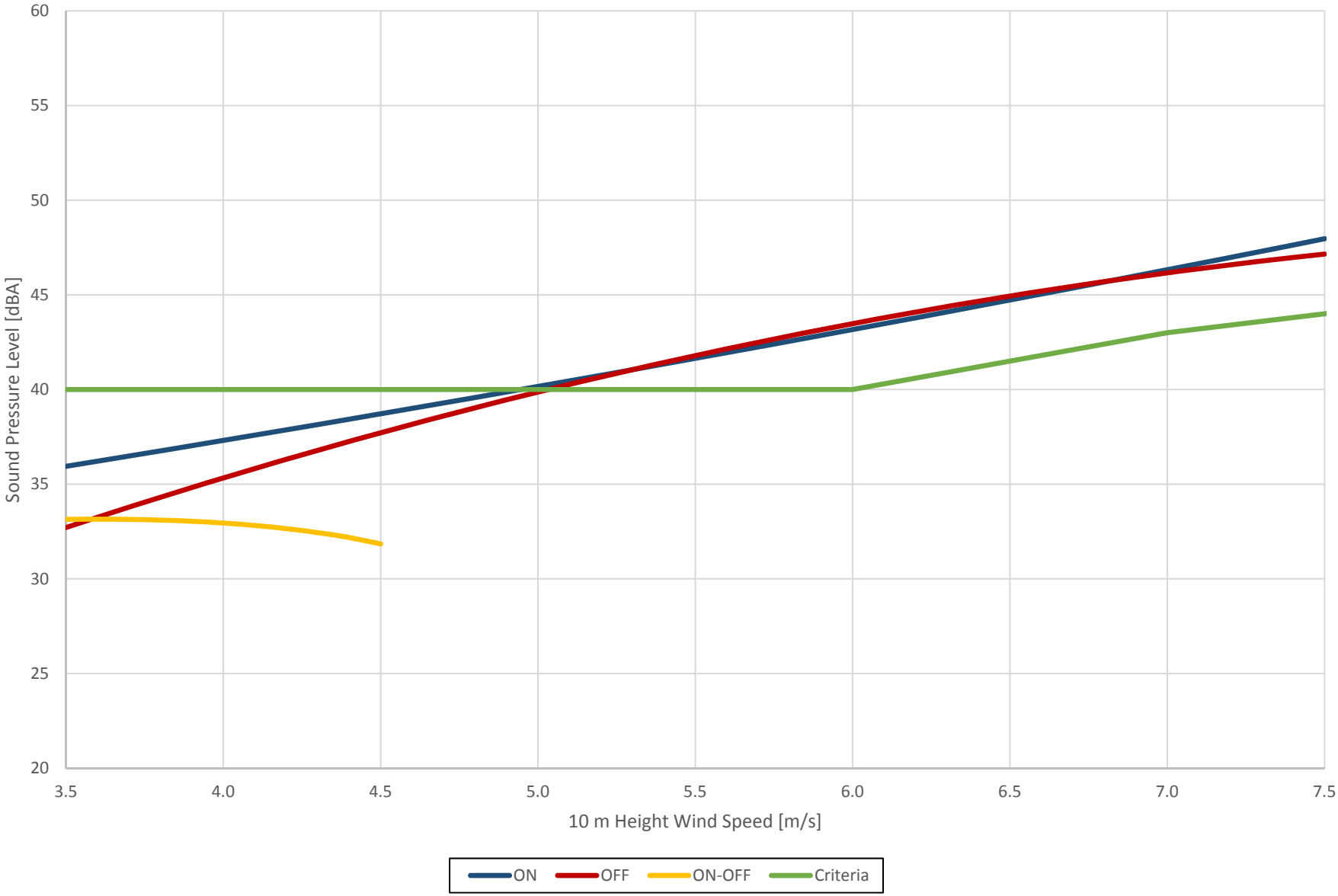
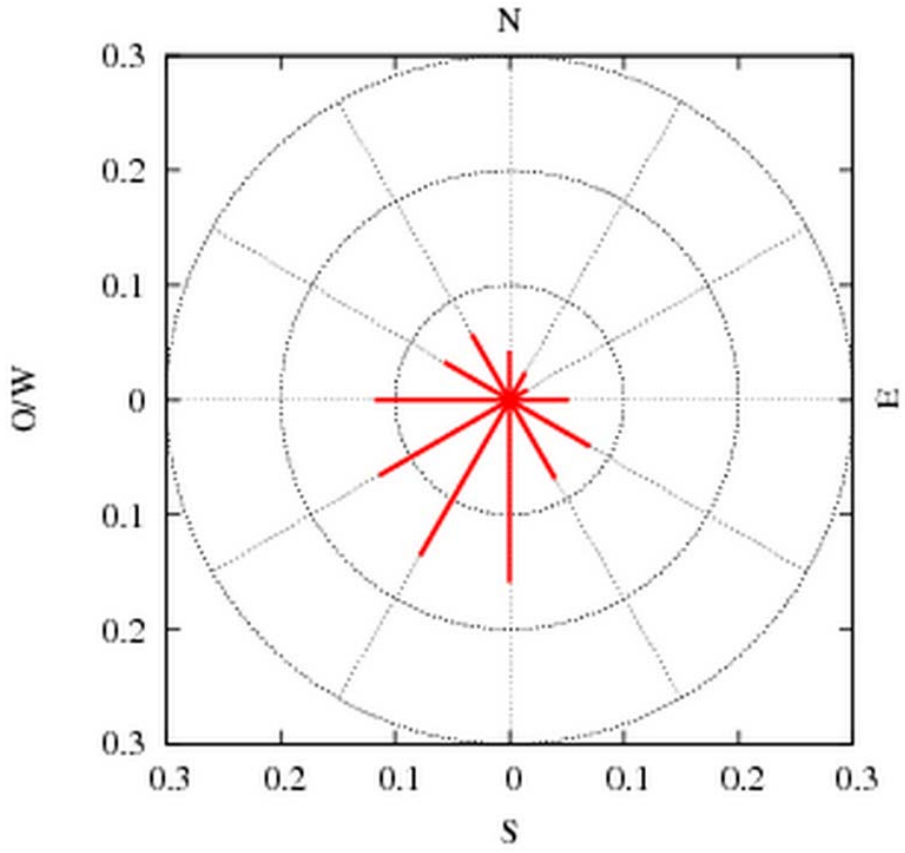


Figure 7b: Bluewater Wind Energy Centre, Spring Acoustic Audit Results
Goshen Line, Receptor BLW780, March 5 to April 24, 2015



APPENDIX A:
HISTORICAL WIND ROSE

Figure A1: Annual Wind Rose [7]



APPENDIX B:

STATEMENT OF OPERATION

Date June 10, 2015

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

To whom it may concern,

This letter is to confirm that the wind turbine generators at the Varna Wind Energy Centre were functioning in their standard operational mode during the post-construction acoustic audit, conducted between March 5 and April 24, 2015.

Yours Truly,

Doug McIntosh, Regional Wind Site Manager