aercoustics

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ASSESSMENT REPORT - **Project: 13228.00**

SOUTH KENT WIND LP – 2nd Immission Audit Receptor Measurements

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Prepared for:

South Kent Wind L.P.
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12 November 2015

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Executive Summary

Aercoustics Engineering Limited ("AEL") has been retained by South Kent Wind L.P. to complete the acoustic audit outlined in the Renewable Energy Approval ("REA") for the South Kent Wind Farm ("SKWF"). SKWF operates under REA #2871-8UKGPC, issued on June 15, 2012.

This report details the second measurement campaign of the SKWF immission audit. Noise measurements were conducted between March 10, 2015 and October 4, 2015 at receptors R3306, R3330, and R3344. Acoustic and weather data was logged simultaneously for the duration of the measurement campaign.

The audit has been completed as per the methodology outlined in Part D of the "*MOE Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement*."

The turbine-only noise contribution was compared to the Ministry of Environment and Climate Change sound level limits and the facility was found to be in compliance.

1 Introduction

Aercoustics Engineering Limited ("AEL") has been retained by South Kent Wind L.P. to complete the required acoustic audit outlined in the Renewable Energy Approval ("REA") for the South Kent Wind Farm ("SKWF") [1]. SKWF operates under REA #2871-8UKGPC, issued on June 15, 2012.

The audit was completed as per the methodology outlined in Part D of the "*MOE Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement*", [2] to fulfil Section E, "*Acoustic Audit – Immission*" of the REA. This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the Ontario Ministry of Environment and Climate Change ("MOECC") sound level limits.

2 Facility Description

The SKWF utilizes 124 Siemens SWT-101 wind turbines for power generation, each having a nameplate capacity of 2.221MW, 2.126MW, 1.903MW, or 1.824MW. Each turbine has a hub height of 99.5 meters and a rotor diameter of 101 meters.

The facility operates 24 hours per day, 7 days per week.

3 Audit Details

The acoustic audit was conducted at receptors R3306, R3330, and R3344[1]. Monitoring at R3330 and R3344 spanned between March 11, 2015 and April 27, 2015. Monitoring at R3306 also began on March 11, 2015, but was continued until October 4, due to that site having lower winds compared to the other two receptors.

The following sections detail the test equipment, measurement methodology, measurement locations, and environmental conditions during the audit.

3.1 Test Equipment

The equipment, both acoustic and non-acoustic, used at each audit location for the measurement campaign is as follows.

- One (1) Type 1 sound level meter, with microphone and pre-amplifier that meet the MOECC protocol specifications outlined in Part D, Section D2.1 - Acoustic Instrumentation.

[1] Receptor IDs taken from the Noise Assessment Report by HATCH, dated May 7, 2013 [3]

- 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 programmed to sample weather data every 0.5 seconds. The anemometer was located 10m above grade, as defined by Section D3.4. Performance specifications comply with Part D, Section D.2.2 of the MOECC protocol.

The following table lists the specific model and serial numbers for the equipment used during the measurement campaign.

Table 1 Equipment Details

Location	Equipment	Serial Number
SKW R3306	B&K 2250 Sound Level Meter	3006579/3004461
	B&K 4189 Microphone	2919502/2888697
	B&K ZC 0032 Pre-amplifier	21158/20327
	Vaisala WXT 520	K0550006/K0630017
SKW R3330	B&K 2250 Sound Level Meter	2630243
	B&K 4189 Microphone	2237428
	B&K ZC 0032 Pre-amplifier	21913
	Vaisala WXT 520	J4830029
SKW R3344	B&K 2250 Sound Level Meter	3004461
	B&K 4189 Microphone	2888697
	B&K ZC 0032 Pre-amplifier	20327
	Vaisala WXT 520	K2640013

The sound level meter, microphone, and pre-amplifier were calibrated successfully before and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator with serial number 2513130.

3.2 Measurement Methodology

For the duration of the measurement campaign, acoustic and anemometer data was logged simultaneously in one-minute intervals. The measurement equipment was setup to log one minute equivalent sound levels (L_{eq}) in broadband and 1/3 octave bands between 20-20,000 Hz. The microphone was placed at a measurement height of 4.5m above grade, at least 5 meters away from any large reflecting surfaces, in direct line of sight to the nearest turbines, and as far away as practically possible from trees or other foliage. Measurement data was filtered into integer wind bins from 3 to 10 m/s. Each bin ranged from 0.5m/s below to 0.5m/s above each respective wind bin (i.e. 5 m/s data represents data between 4.5m/s and 5.5m/s).

A one-minute measurement interval was considered valid if:

- The interval occurred between 10pm – 5am
- No precipitation was detected within an hour before the interval
- The maximum measured wind speed at 10m was no more than 2m/s higher than the recorded average for that interval
- The temperature was above -10˚C
- Either all nearby turbines were on (for turbine ON measurements), or all nearby turbines were off (for ambient measurements). The list of turbines parked for ambient measurements is provided in Section 3.6.
- The measured L_{eq} was no more than 10 dB greater than the L90 value

These filters were designed to obtain measurement data of the wind farm when it is fully operational, as well as reduce the amount of contamination from transient ambient noise sources such as vehicle passbys and dog barks. These filters also are based on equipment operating limitations, and the filters prescribed in the Part D of the Protocol to eliminate noise from precipitation, as well as noise on the microphone from gusty periods where the reliability of the data is reduced.

Additional filtering of the measurement data was required for receptor R3306 due to the presence of crickets in part of the measurement campaign. The acoustic energy from the crickets chirping was present only above 4kHz but was dominating the overall level in both Turbine ON and ambient measurements. As a result, the measurements at R3306 were filtered to exclude all data above 4kHz, thus removing the effect of the crickets.

It should be noted that although the MOECC Protocol calls for data points to be excluded if the minimum wind speed at 10m is more than 2m/s less than the recorded average, this limitation was not employed on this data-set. The effect on the dataset of removing the minimum wind speed filter has been assessed at a number of locations and found to be insignificant; this study is provided in Appendix D.

3.3 Sample size requirements

In order to account for the dependence on wind speed of wind turbine noise and ambient noise, the measurement data is sorted into integer wind speed bins according to the measured wind speed. As per Section D3.8 of the MOECC protocol, at least 120 data points in each wind bin are required for Turbine ON measurements, and 60 data points for the ambient measurements.

3.4 Measurement Location

Receptors R3306, R3330, and R3344 were chosen to be representative of the worst-case impact from the facility. The receptors are located downwind from the predominant wind direction of the farm. R3306, R3330, and R3344 have a predicted impact of 39.4dBA, 39.9dBA, and 39.4dBA respectively, as per data provided in the Acoustic Assessment Report [3]. The following describes the measurement locations in relation to the above listed receptors:

- R3306: Measurement equipment was placed in an open field south-east of R3306, 594m to the nearest turbine, and 100m east of a small patch of trees

- R3330: Measurement equipment was placed in an open field just to the north-west of R3330, 666m to the nearest turbine.

- R3344: Measurement equipment was placed in an open field just to the north-west of R3344, 823m to the nearest turbine.

The following table provides a summary of the receptor location. Detailed site plans showing the receptor and audit locations are attached in Appendix A.

Table 2 Receptor Measurement Locations

	Audit Receptor ID Nearest Turbine ID	R3306 P108	R3330 P108	R3344 P036
Receptor	UTM Coordinates (X,Y)	17T 416061mE 4691837mN	17T 416509mE 4691369mN	17T 416804mE 4691109mN
	Distance to Nearest Turbine	618 m	689 m	854 m
	Predicted Level dBA*	39.4	39.9	39.4
Monitor	UTM Coordinates (X,Y)	17T 416115mE 4691783mN	17T 416482mE 4691390mN	17T 416744mE 4691122mN
	Distance to Nearest Turbine	594 m	666 m	823 m

* Predicted level from Noise Assessment Report for South Kent Wind Project – HATCH [3]

3.5 Weather Conditions

Ambient conditions encountered over the measurement campaign were as follows:

- Ambient Humidity: 36% to 95%
- Ambient Temperature: -11˚C to 27˚C
- 10m Wind Speed: 0 m/s to 15 m/s

Historically, the predominant wind direction is from the south-west for this site. The wind direction varied over the course of the audit campaign. Wind roses have been provided in Appendix B that show the measured 10m wind direction at each receptor averaged for all Turbine ON measurements. Wind directions shown on the wind roses indicate the direction the wind is coming from.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by SKWF. Measurement data at each 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 turbines was less than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were T29, T30, T31, T34, T35, T36, T41, T42, T108, T109, T120, T135, and T155.

4 Sound Level Limits

The purpose of the sound measurements was to confirm whether the sound emitted by the wind facility is in compliance with the MOECC allowable sound level limits. The MOECC sound level limits for wind turbines vary with wind speed defined at a 10m height. The details of the sound level limits are presented in Table 3 below.

Table 3 MOECC Sound Level Limits for Wind turbines

Wind speed at 10m height [m/s]	MOECC Sound level limit [dBA]
≤ 4	40
5	40
6	40
7	43
8	45
9	49

5 Audit Results

The following tables detail the sound levels measured at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF).

Table 4 R3306 Sound levels measured for Turbine ON and OFF

	Wind speed at 10m height [m/s]	3	4	5	6	7
Turbine ON	Number of Samples	7366	4725	2531	954	383
	LAeq [dBA]	40	40	42	44	47
	Std Dev [dBA]	4.7	3.2	2.6	2.0	1.7
Turbine OFF	Number of Samples	141	364	600	350	71
	LAeq [dBA]	38	37	38	42	46
	Std Dev [dBA]	4.6	3.5	3.4	2.8	2.1
Turbine ONLY		32	36	37	39	38

Table 5 R3330 Sound levels measured for Turbine ON and OFF

	Wind speed at 10m height [m/s]	3	4	5	6	7
Turbine ON	Number of Samples	1709	1548	1212	605	290
	LAeq [dBA]	38	39	41	43	46
	Std Dev [dBA]	2.8	3.0	2.2	1.5	1.6
Turbine OFF	Number of Samples	185	269	121	144	134
	LAeq [dBA]	35	37	38	43	46
	Std Dev [dBA]	3.0	1.7	1.9	1.4	1.4
Turbine ONLY		36	33	37	n/a**	n/a**

** Measured Turbine OFF level greater than measured Turbine ON level

Table 6 R3344 Sound levels measured for Turbine ON and OFF

	Wind speed at 10m height [m/s]	3	4	5	6	7
Turbine ON	Number of Samples	2255	1976	1148	510	288
	LAeq [dBA]	37	38	40	43	47
	Std Dev [dBA]	3.8	3.3	2.3	1.7	1.9
Turbine OFF	Number of Samples	391	328	93	122	132
	LAeq [dBA]	34	35	38	43	47
	Std Dev [dBA]	2.3	1.6	1.9	2.1	1.5
Turbine ONLY		35	35	37	31	37

The following figures are the plots of the measured sound levels at all three receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Note that all plots include the 95% confidence interval as a dashed line above and below the average value.

Figure 1 R3306 Measured Turbine ON levels

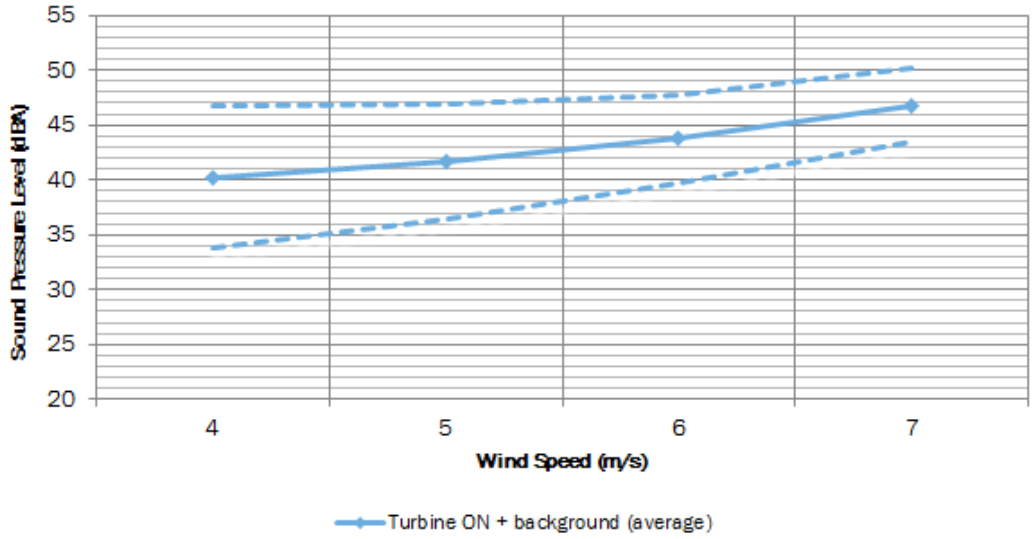


Figure 2 R3306 Measured Turbine OFF (Background) levels

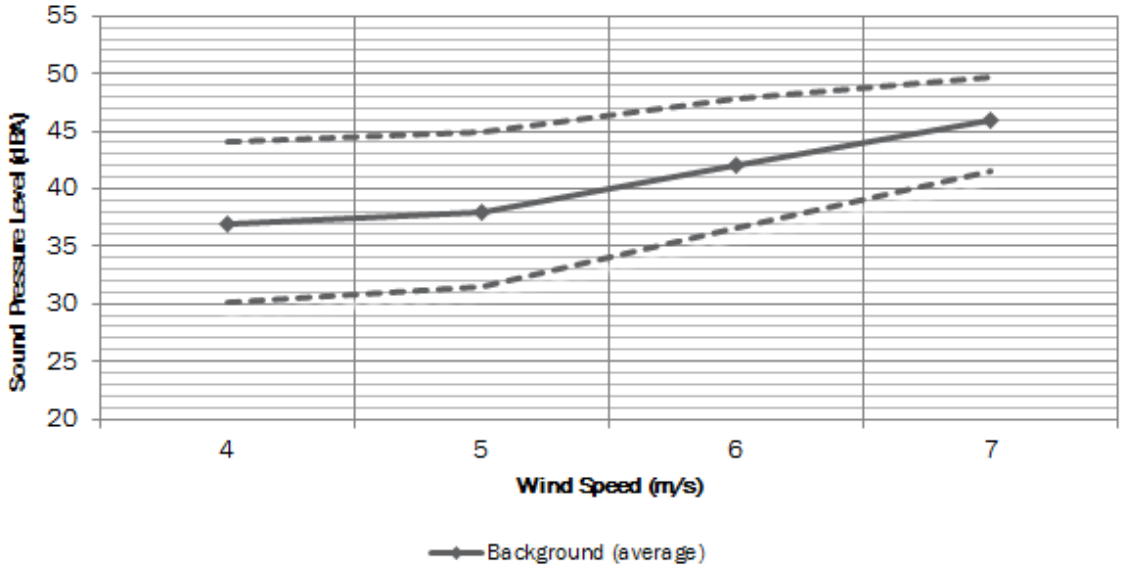


Figure 3 R3330 Measured Turbine ON levels

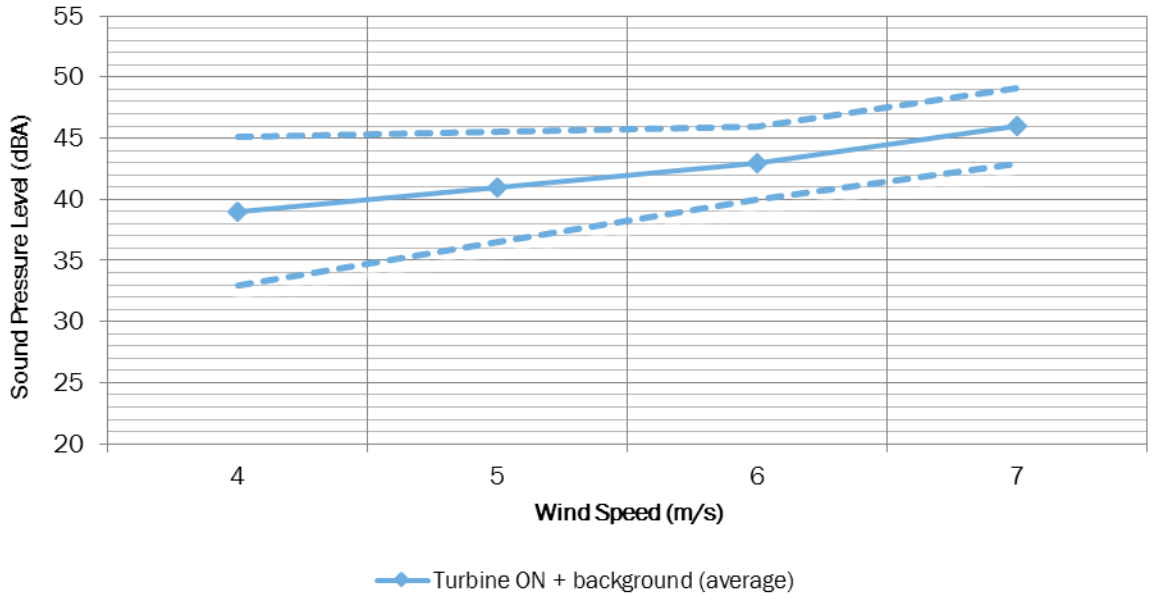


Figure 4 R3330 Measured Turbine OFF (Background) levels

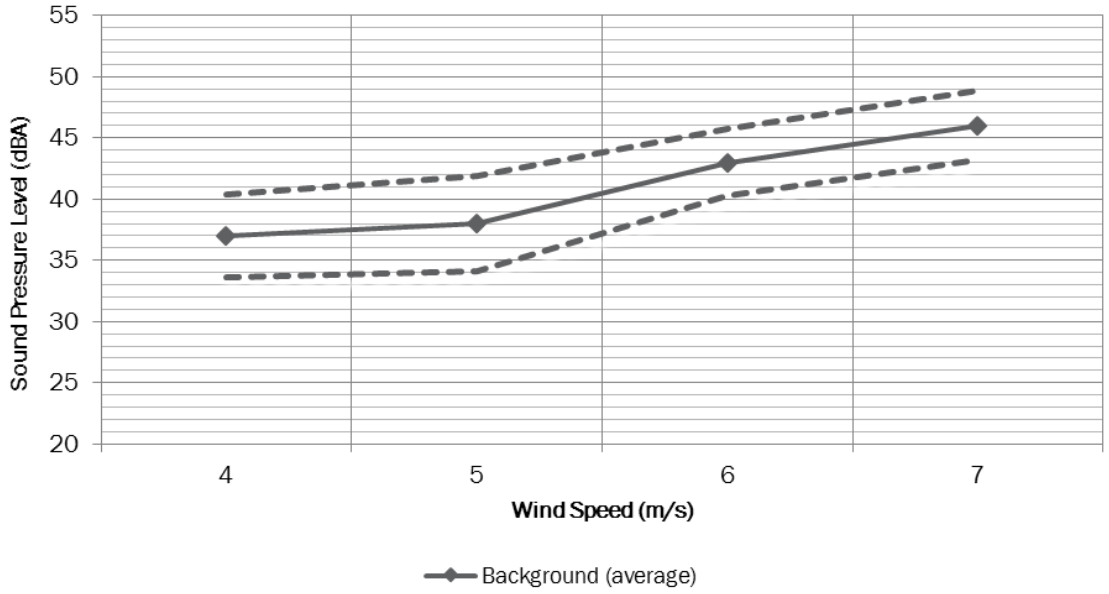


Figure 5 R3344 Measured Turbine ON levels

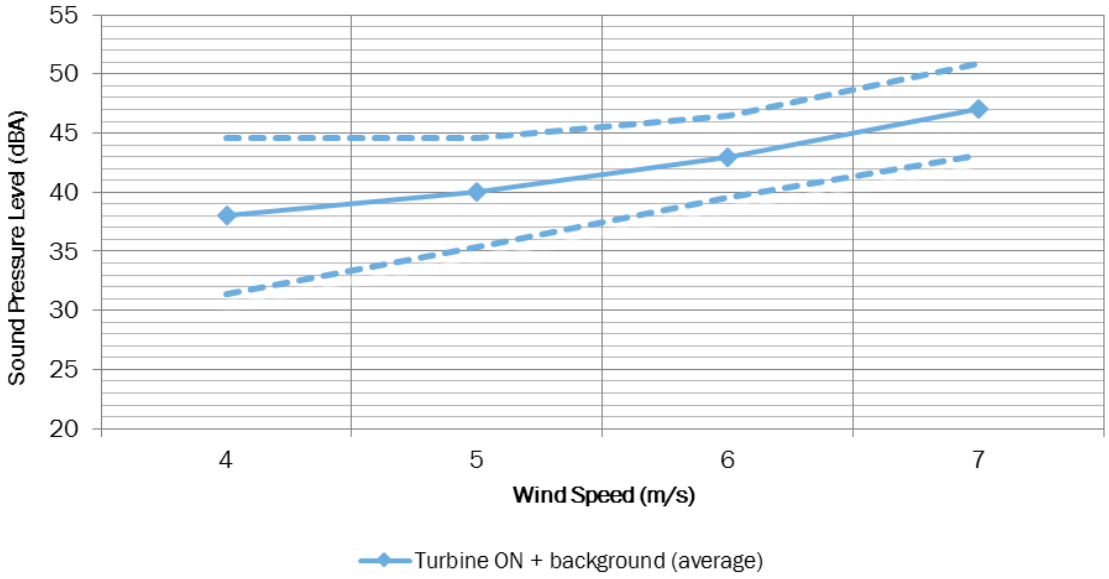
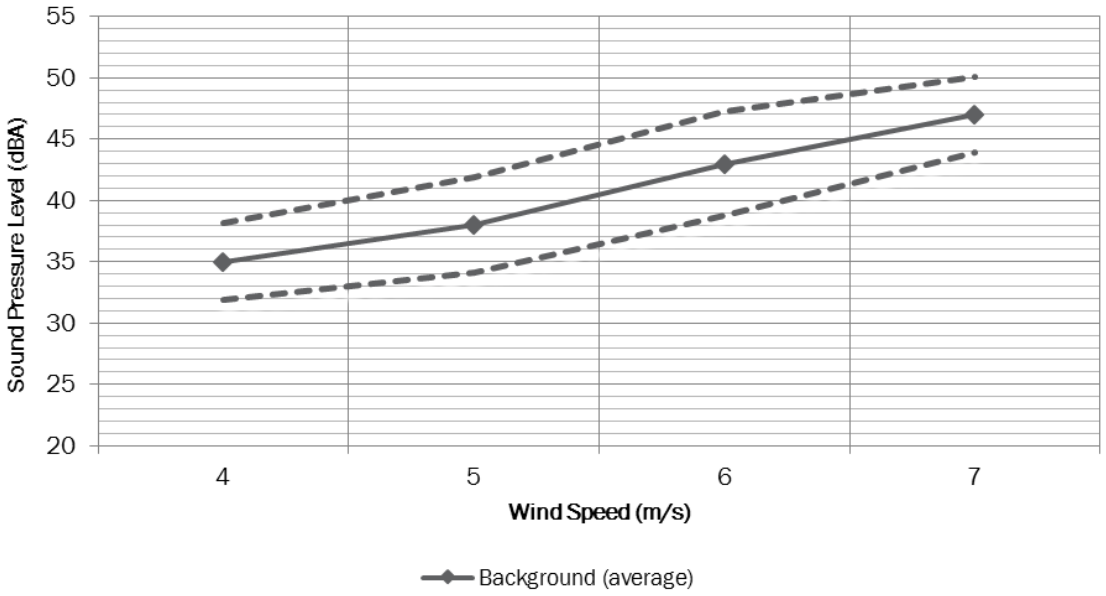


Figure 6 R3344 Measured Turbine OFF (Background) levels



6 Discussion

6.1 Overall Sound Level

The turbine-only component of the sound level was derived from a logarithmic subtraction of the ambient noise from that of the sound level measured with the turbines operating. The resulting sound level can be attributed to the turbines. It should be noted that all values in Table 7 have been rounded to the nearest integer. Calculated Turbine ONLY levels listed were calculated based on unrounded Turbine ON and Turbine OFF values.

There were some instances, at higher wind speeds, where the measured ambient level was higher than the average measured level when all turbines were operating. This indicates that local ambient noise sources, rather than the turbines, are driving the overall sound level at that receptor. In these instances, it is known that the Turbine ONLY contribution to the receptor sound level is at least 3dB less than the Turbine ON level (which includes ambient sources). This is a very conservative assessment; in reality, the Turbine ONLY level is expected to be much lower.

Table 7 Assessment Table

Measurement Location	Wind speed at 10m height [m/s]	3	4	5	6	7
R3306	Turbine ON LAeq [dBA]	40	40	42	44	47
	Turbine OFF LAeq [dBA]	38	37	38	42	46
	Calculated Turbine ONLY LAeq [dBA]	36	37	39	38	40†
R3330	Turbine ON LAeq [dBA]	38	39	41	43	46
	Turbine OFF LAeq [dBA]	35	37	38	43	46
	Calculated Turbine ONLY LAeq [dBA]	36	33	37	<40*	<43*
R3344	Turbine ON LAeq [dBA]	37	38	40	43	47
	Turbine OFF LAeq [dBA]	34	35	38	43	47
	Calculated Turbine ONLY LAeq [dBA]	35	35	37	31†	37†
MOECC Limit		40	40	40	40	43

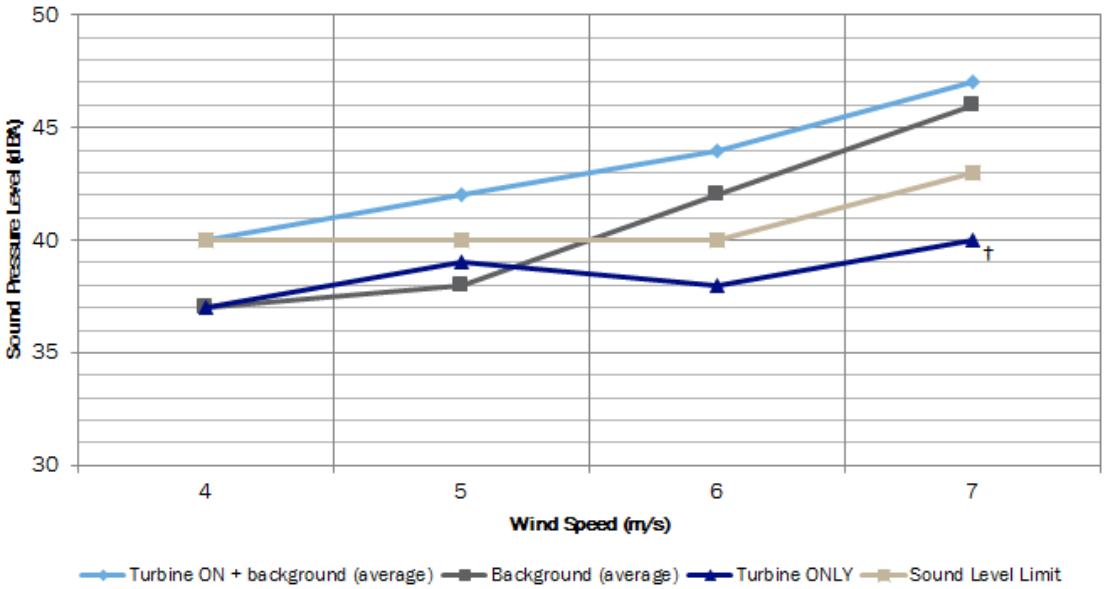
*Ambient (Turbine OFF) level higher than the Turbine ON level. Turbine ONLY component calculated by subtracting 3dB from the measured Turbine ON level

†Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB the measured Turbine ON level.

Each monitoring rig used for the audit was placed in a location representative of the noise level at its corresponding receptor. The data from

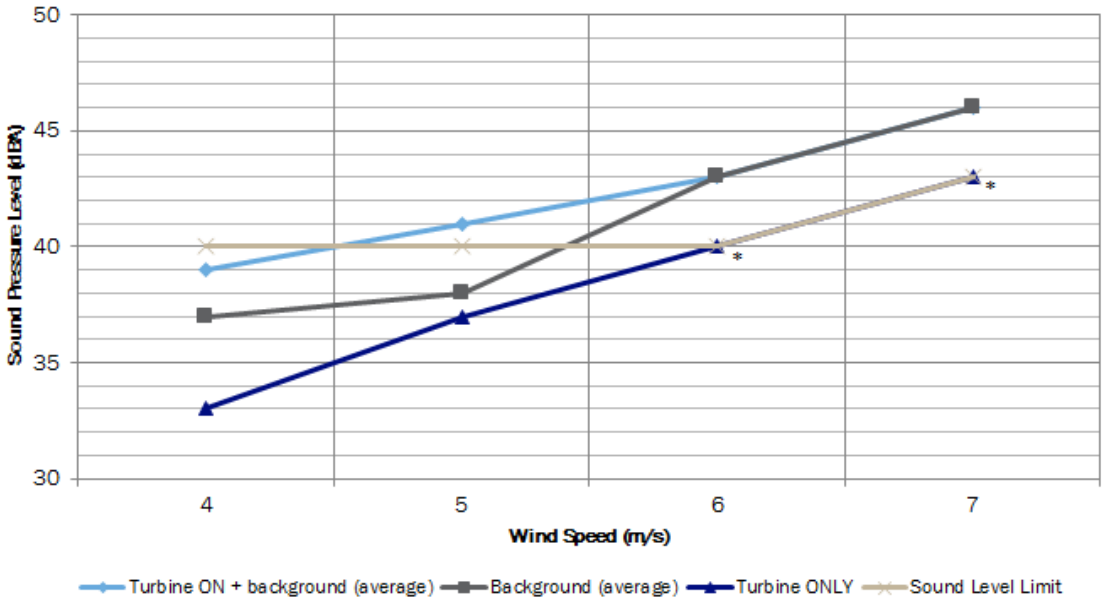
Table 7 is plotted in Figure 7, Figure 8, and Figure 9.

Figure 7 R3306 Turbine Levels compared to MOECC Limits



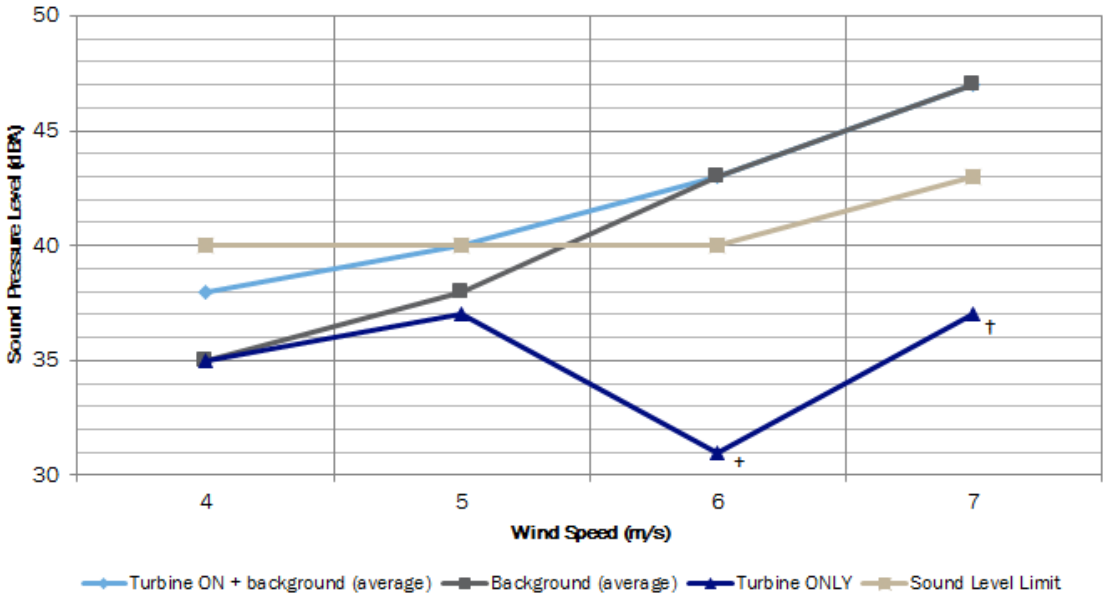
†Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB the measured Turbine ON level.

Figure 8 R3330 Turbine Levels compared to MOECC Limits



*Ambient (Turbine OFF) level higher than the Turbine ON level. Turbine ONLY component calculated by subtracting 3dB from the measured Turbine ON level

Figure 9 R3344 Turbine Levels compared to MOECC Limits



†Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB the measured Turbine ON level.

6.2 Tonality

Our site observations qualitatively indicate no presence of distinctly audible tones at the measurement location. The noise from the wind turbines was subjectively assessed not to be tonal.

7 Assessment of Compliance

Based on the calculated turbine-only component indicated in

Table 7 and Figures 7-9, the South Kent Wind Farm is compliant with MOECC limits at all receptors.

8 Conclusion

Aercoustics Engineering Limited has completed the acoustic audit outlined in the Renewable Energy Approval for the South Kent Wind Farm. The audit was completed as per the methodology outlined in Part D of the "*MOE Compliance Protocol for Wind Turbine Noise*." The measured levels were compared to the MOECC limits, and the facility was determined to be in compliance at all receptors.

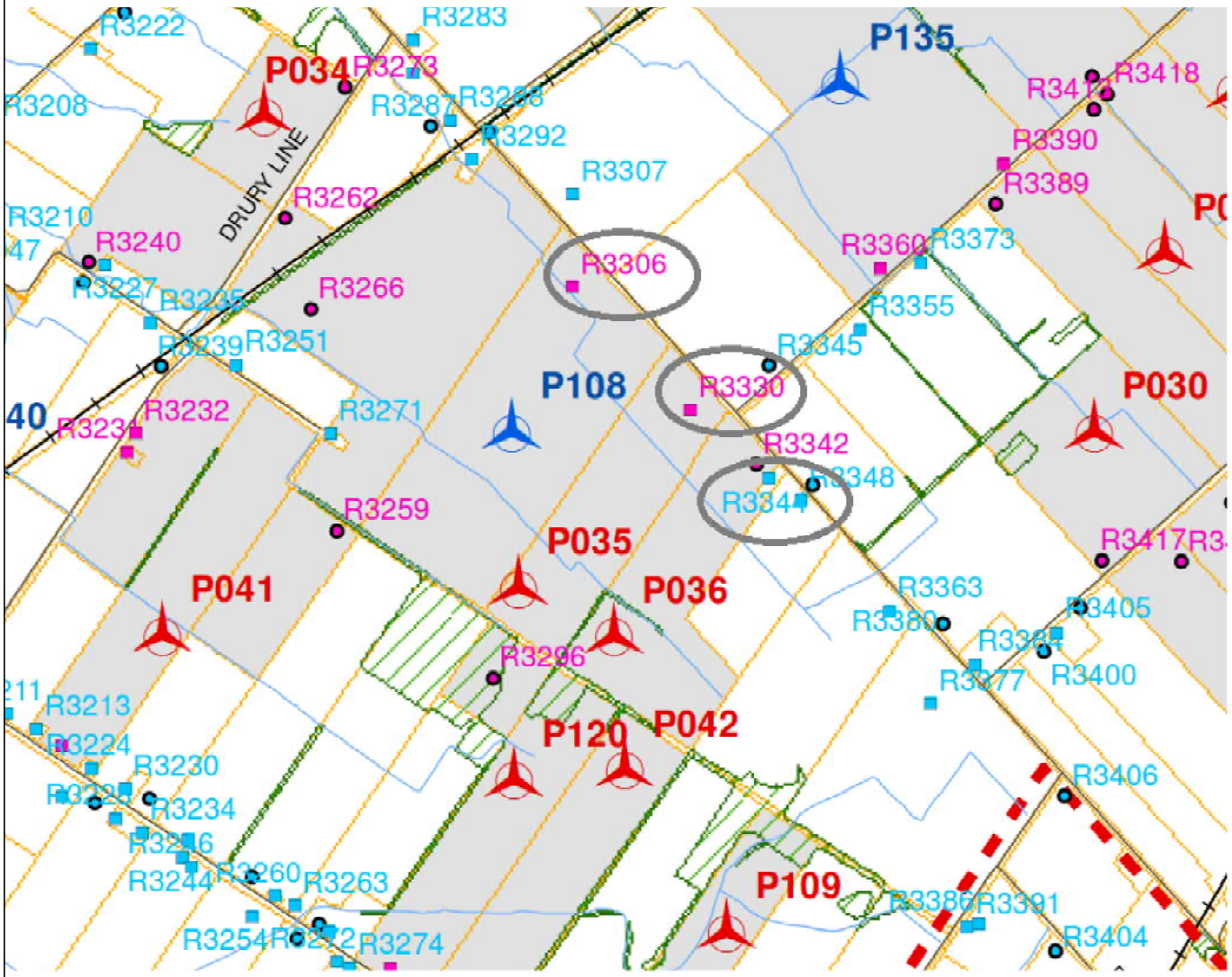
9 References

[1] V. Schroter, "Renewable Energy Approval #2871-8UKGPC", Ontario Ministry of the Environment, Toronto, ON, June 15, 2012

[2] Ministry of the Environment, "Compliance Protocol for Wind Turbine Noise – Guideline for Acoustic Assessment and Measurement", Ontario Ministry of the Environment, Toronto, ON.

[3] D. McIntosh and M. Choy, "Noise Assessment Report for South Kent Wind Project" HATCH, Niagara Falls, ON, Rev. 7, May 7, 2013.

APPENDIX A – LOCATION DETAILS



N

LEGEND

- RAIL
- ROAD
- EXISTING TRANSMISSION LINE
- INTERMITTENT WATERCOURSE
- WATERCOURSE
- PARCEL
- MUNICIPAL BOUNDARY
- WATERBODY
- SIGNIFICANT WETLAND
- WOODED AREA

PROJECT COMPONENTS

- POINT OF RECEPTION - EXISTING - NON PARTICIPATING
- POINT OF RECEPTION - EXISTING - PARTICIPATING
- POINT OF RECEPTION - VACANT - NON PARTICIPATING
- POINT OF RECEPTION - VACANT - PARTICIPATING
- PROJECT AREA (PROJECT AREA INDICATED SHOWS PERIMETER ONLY AND NOT SPECIFIC LANDS USED FOR THE PROJECT)
- PARTICIPATING PARCEL (OWNER WITH INFRASTRUCTURE)
- SOUTH KENT SWT-2.3-101, MAX. POWER 1824 KW
- SOUTH KENT SWT-2.3-101, MAX. POWER 1903 KW
- SOUTH KENT SWT-2.3-101, MAX. POWER 2126 KW
- SOUTH KENT SWT-2.3-101, MAX. POWER 2221 KW

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Project ID: 13228.00

Scale: NTS
Drawn by: DH
Reviewed by: RJ
Date: June 26, 2015
Revision: 1

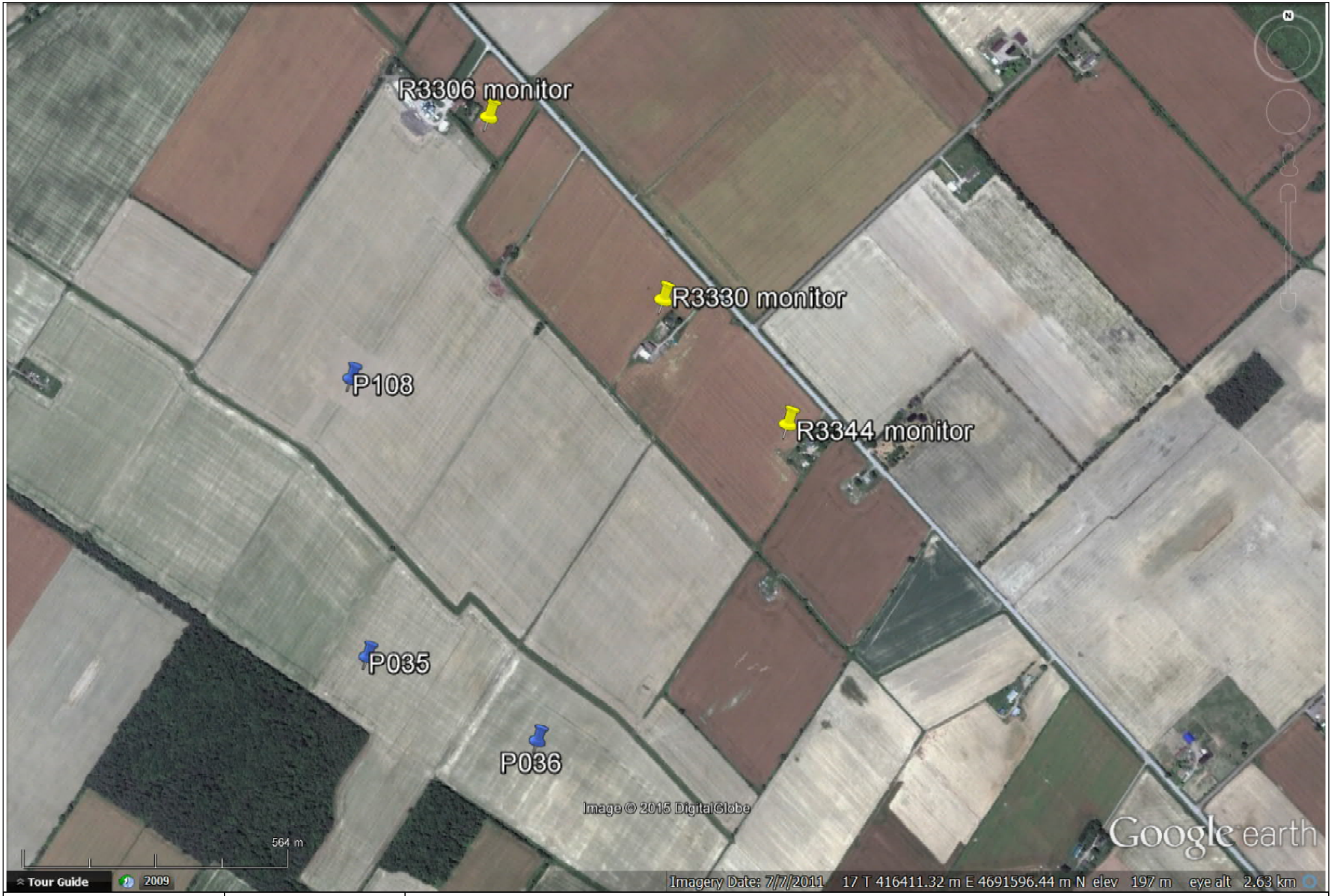
Project Name

South Kent Wind Farm - 2nd Acoustic Immission Audit

Figure Title

Site Plan

Figure A.1



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Revision: 1

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Figure Title

Monitor Locations

Figure A.2

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Figure Title

Measurement Location 1 - Receptor R3306

Figure A.3

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Revision: 1

Project Name

South Kent Wind Farm - 2nd Acoustic Immission Audit

Figure Title

Measurement Location 2 - Receptor R3330

Figure A.4

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Revision: 1

Project Name

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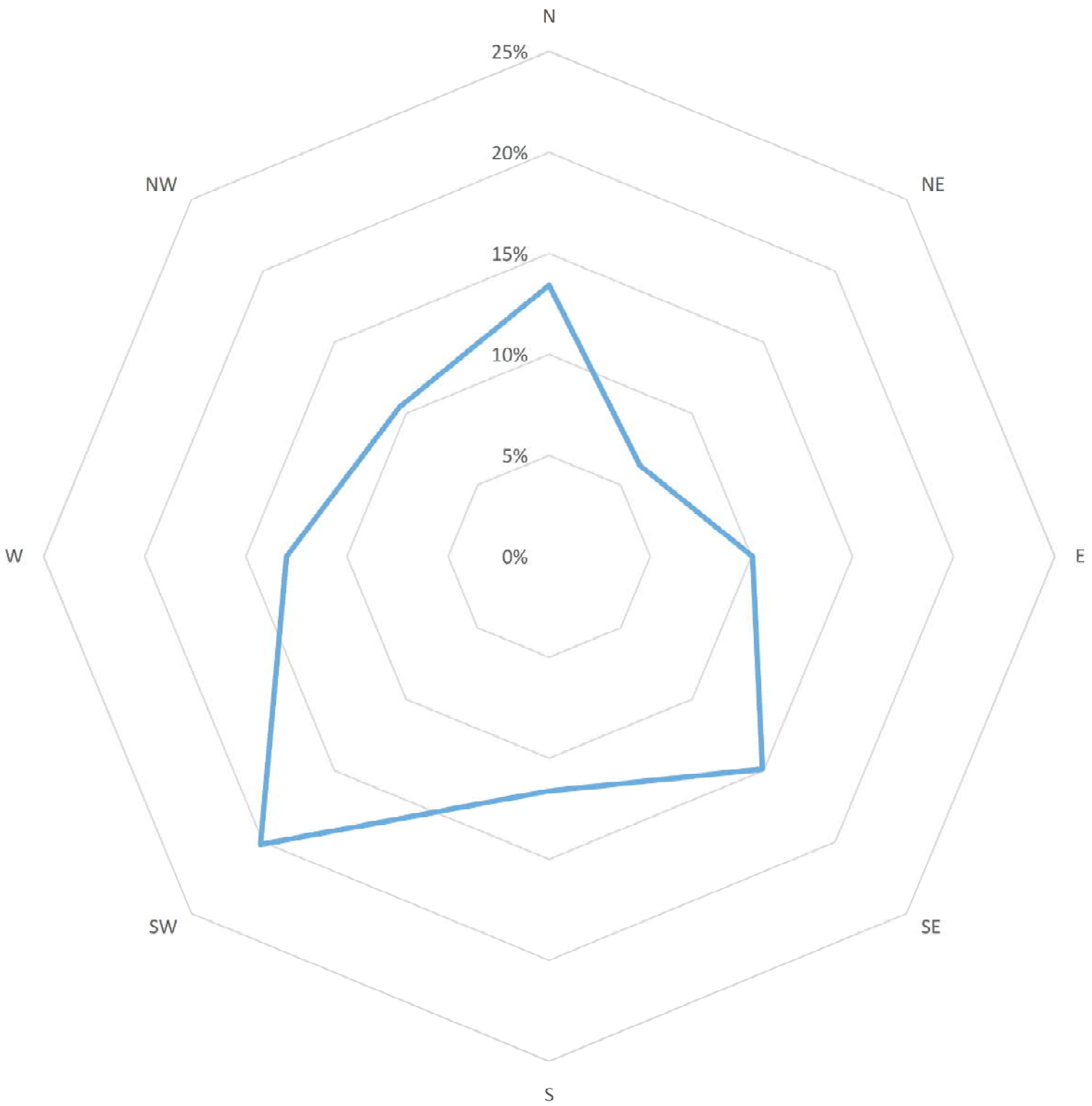
Figure Title

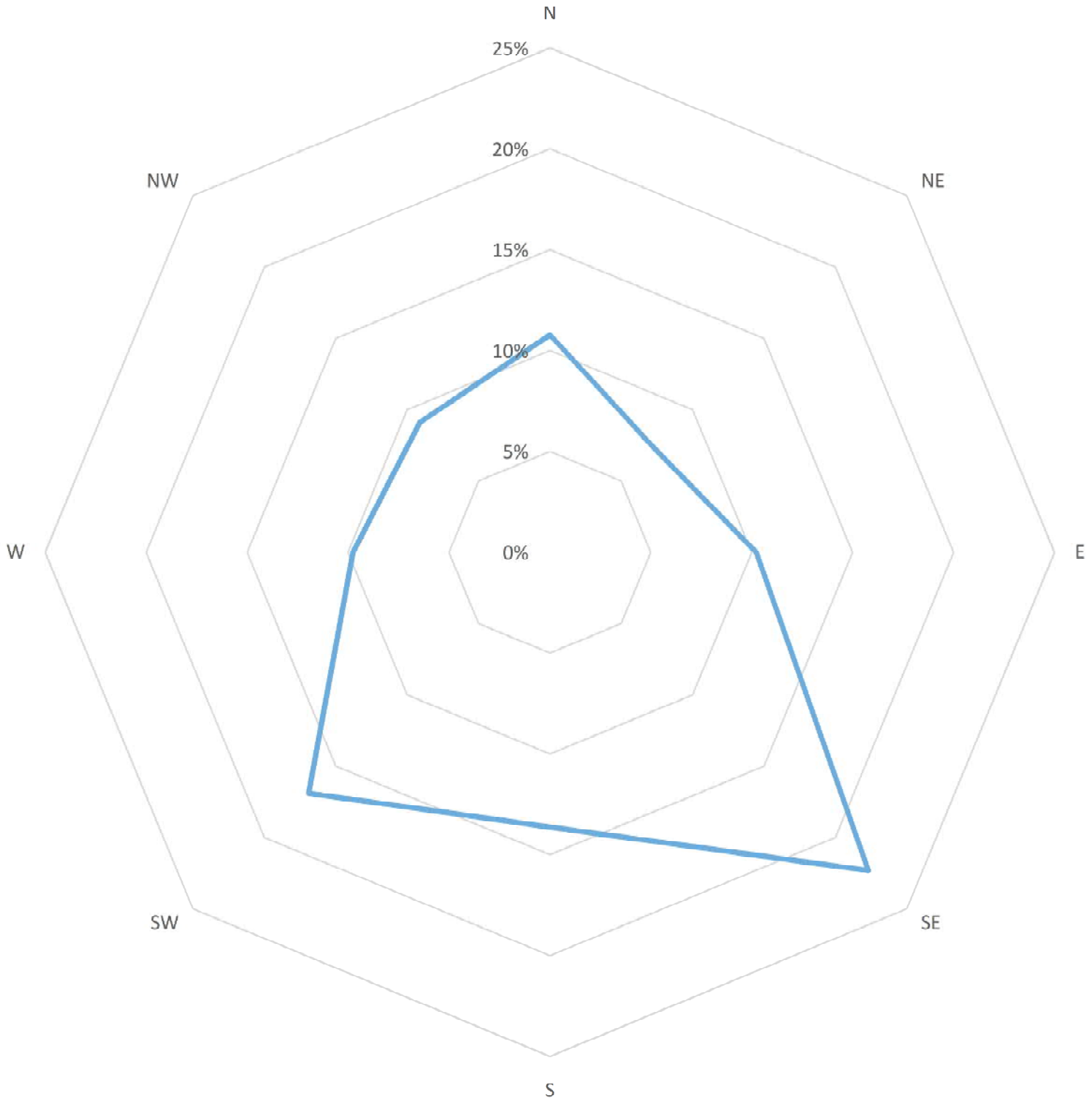
Measurement Location 3 - Receptor R3344

Figure A.5

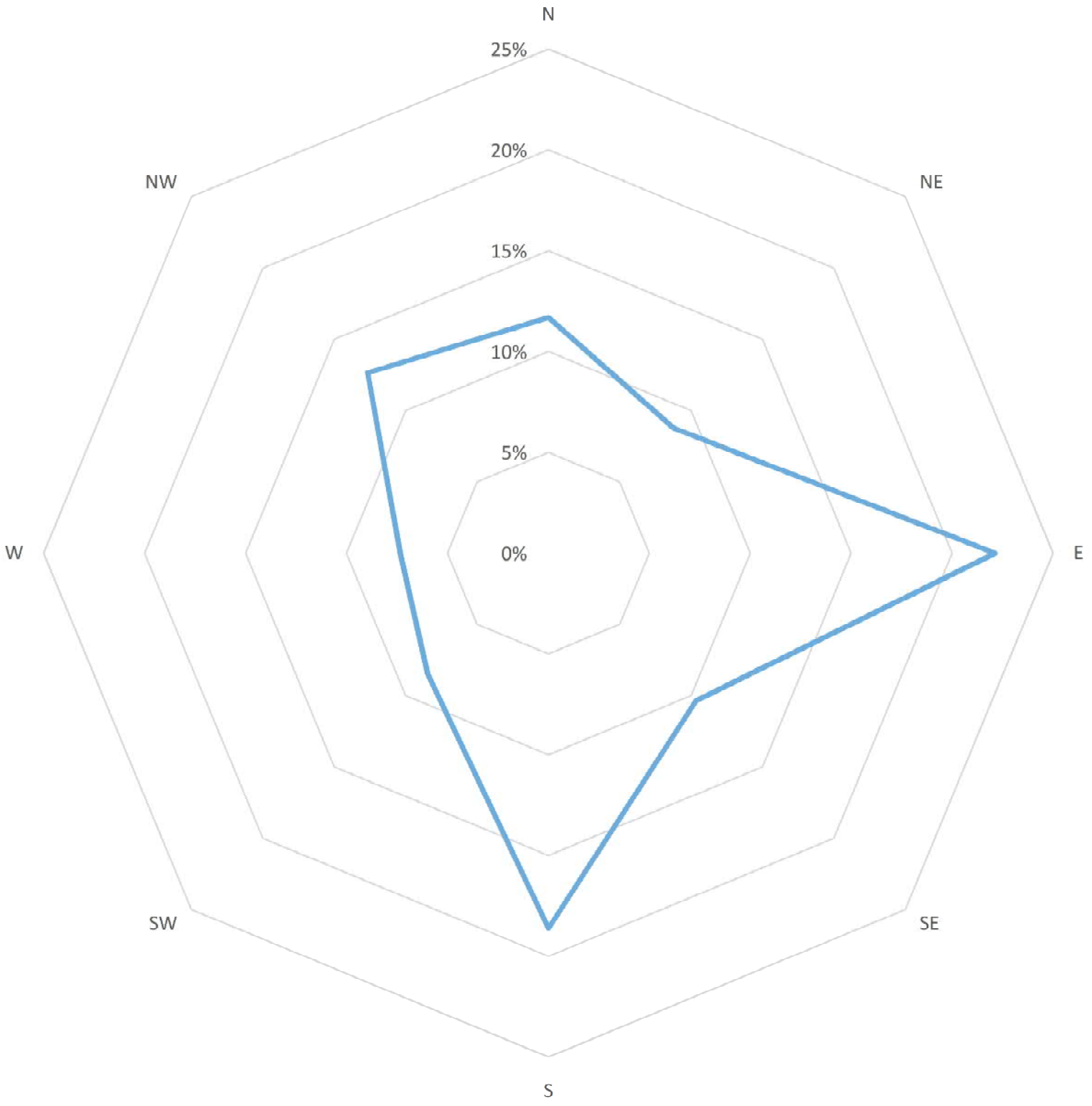
APPENDIX B – WIND ROSE



aercoustics	Project ID: 13228.00 Scale: NTS Drawn by: DH Reviewed by: PA Date: October 30, 2015 Revision: 1	**Project Name** South Kent Wind Farm - 2nd Acoustic Immission Audit	
		Figure Title Wind Rose - R3306	**Figure B.1**



aercoustics	Project ID: 13228.00 Scale: NTS Drawn by: DH Reviewed by: PA Date: October 30, 2015 Revision: 1	**Project Name** South Kent Wind Farm - 2nd Acoustic Immission Audit	
		Figure Title Wind Rose - R3330	**Figure B.2**



aercoustics	Project ID: 13228.00 Scale: NTS Drawn by: DH Reviewed by: PA Date: October 30, 2015 Revision: 1	**Project Name** South Kent Wind Farm - 2nd Acoustic Immission Audit	
		Figure Title Wind Rose - R3344	**Figure B.3**

APPENDIX C – TURBINE OPERATION DATA STAEMENT FROM OPERATOR

South Kent Wind LP
2050 Derry Rd. West 2nd Floor
Mississauga, Ontario L5N 0B9
www.southkentwind.ca

November 6th, 2015

Ministry of the Environment and Climate Change
620-4510 Rhodes Dr.
Windsor, ON
N8W 5K5

Subject:
South Kent Wind **Renewable Energy Approval Number 2871-8UKGPC; Condition – Receptor audit immission part 2 of 2**

To whom it may concern

Please accept this letter as confirmation that all turbines tested during the summer 2015 acoustic measurement campaign conducted by Aercoustics Engineering Ltd. from March 10th through October 4th, 2015 were operating as normal for the duration of the campaign.

Sincerely,

Paul Dawson
Facility Manager

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Merlin, ON N0P 1W0
C 289-380-3854
F 519-689-7956
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APPENDIX D – WIND GUSTING ANALYSIS

aercoustics

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aercoustics.com

Wind Gusting Analysis Summary

The purpose of this document is to provide supporting information for wind turbine receptor audits in which the wind speed gusting filter deviates from that prescribed by the Ministry of the Environment and Climate Change (MOECC). The Compliance Protocol for Wind Turbine Noise requires that the maximum and minimum wind speeds be within 2 m/s of the average wind speed in a measurement interval (1-minute average). Any intervals that do not meet this requirement would be excluded from the analysis. Aercoustics examined the possibility of changing this filtering to only exclude intervals where the maximum wind speed is more than 2 m/s above the average without filtering based on minimum wind speed.

Aercoustics reviewed 11 different data sets representing measurements from 3 different wind farms and 10 different receptor locations. Each data set was filtered using both the prescribed and the modified methods for wind speed gusting. The resulting sound pressure levels for Turbine On and Background measurements were computed for each wind bin. The change in number of valid data points and the change in measured sound pressure level were calculated. The increase in number of data points and change in sound pressure from the prescribed filtering method to the proposed method were averaged across the 11 data sets. The mean values by wind speed are presented in Table 1 below.

Table 1: Results

Wind Bins	Turbine ON		Background	
	Difference (pts)	Difference (dB)	Difference (pts)	Difference (dB)
3	2%	0.0	3%	0.0
4	6%	0.1	7%	0.0
5	10%	0.1	9%	0.1
6	11%	0.1	13%	0.1
7	21%	0.1	25%	0.1

These results clearly show that the proposed modification of the wind speed gusting filter increases the number of data points in all wind bins, with a more pronounced effect at high wind speeds. The over 20% increase in data points in the 7 m/s wind bins is significant as these wind speeds are typically the most difficult to measure and can considerably increase the time required to complete an audit. There are negligible increases in the measured sound levels, which occur during both Turbine On and Background measurements.