MARSHALL DAY Acoustics

# MT EMERALD WIND FARM
# REVISED A-WEIGHTED NOISE ASSESSMENT

Rp 002 R01 2015545ML | 30 January 2017

MARSHALL DAY Acoustics

6 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
ABN: 53 470 077 191
www.marshallday.com

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| Project: | **MT EMERALD WIND FARM** |
| Prepared for: | **RATCH-Australia Corporation Limited**<br>**Level 7, 111 Pacific Highway**<br>**North Sydney NSW 2059**<br>**AUSTRALIA** |
| Attention: | **Mr Neil Weston** |
| Report No.: | **Rp 002 R01 2015545ML** |



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## 1.0 INTRODUCTION

This report presents the results of a revised noise assessment for the proposed Mt Emerald Wind Farm that is being developed by RATCH Australia Corporation (RATCH).

The wind farm is proposed to be located between Mareeba and Atherton in Far North Queensland. RATCH has obtained a Development Permit for the construction of up to sixty-three (63) turbines at the wind farm. The Development Permit includes conditions for the control of operational noise associated with the project.

This report was commissioned by RATCH to address the requirement of condition 6 with respect to A-weighted noise limits specified in condition 4 of the Development Permit.

The revised noise assessment presented in this report is based on:

- Operational noise limits derived in accordance with the Development Permit
- Predicted noise levels for the proposed wind farm design comprising fifty-three (53) Vestas wind turbines
- A comparison of the predicted noise levels with the criteria derived in accordance with the Development Permit.

This report is to be read in conjunction with a separate report titled *Mt Emerald Wind Farm – Background Noise Monitoring*[1] dated 12 September 2016 (referred to as the *background noise report* herein). The background noise report provides details of the monitoring carried out since the Development Permit was granted and the noise limits that have been derived from the background noise data.

In addition to this revised noise assessment and the background noise report, a separate report containing a noise compliance plan is to be prepared prior to conducting operational noise measurements. This report will document detailed measurement and analysis procedures to be used to assess whether noise levels comply with the Development Permit after the wind farm commences operation. In advance of this report, an outline of the proposed compliance measurement and analysis procedures is provided in Appendix H. This will provide the framework for preparation of the compliance noise assessment report required under condition 6 (b).

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2003 *Acoustics - Description measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures*. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report. For example, sound pressure levels measured using an "A" frequency weighting are expressed as $L_A$ dB. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

Acoustic terminology used in this report is presented in Appendix A.

Throughout this report, the term receiver is used to identify locations in the vicinity of existing or approved residential locations around the proposed Mt Emerald Wind Farm at the date of the Development Permit.

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[1] Marshall Day Acoustics report reference Rp 001 R01 2015545ML dated 12 September 2016

# 2.0 PROJECT DESCRIPTION

## 2.1 Overview

A Development Permit for the proposed wind farm was originally granted in April 2015, subject to a set of conditions which were amended by the Notice of the Minister for Local Government and Planning on 18 December 2015. The operational, A-weighted noise related conditions of the Development Permit are reproduced in Appendix B and discussed in further detail subsequently in Section 3.0.

The Development Permit allows for the construction of up to sixty three (63) wind turbines and ancillary infrastructure at the development site.

The final wind farm design that is proposed to be constructed comprises a reduced layout of fifty three (53) wind turbines. The coordinates of the fifty three (53) proposed wind turbines are tabulated in Appendix C.

A total of one hundred and twenty three (123) receivers surrounding the Mt Emerald Wind Farm have been considered in this revised noise assessment. The receivers and their locations correspond to the same one hundred and twenty three (123) receivers included in the noise assessment of the wind farm during the planning approval phase[2] of the project. The coordinates of the receiver locations are also tabulated in Appendix D.

A site layout plan illustrating the turbine layout and receiver locations is provided in Appendix E.

## 2.2 Wind turbines

### 2.2.1 Overview

The wind farm is proposed to comprise two types of Vestas turbines:

- Sixteen (16) V112-3.3MW turbines and
- Thirty seven (37) V117-3.45MW turbines

Details of the two turbine types are provided in Table 1.

**Table 1: Proposed Vestas wind turbines – description**

| Detail | V112-3.3MW | V117-3.45MW |
|---|---|---|
| Rotor diameter | 112 m | 117 m |
| Hub height | 84 m | 90 m |
| Blade orientation | Upwind | Upwind |
| Blade type | Serrated trailing edge | Serrated trailing edge |
| Cut-in wind speed (hub height) | 3 m/s | 3 m/s |
| Rated power wind speed (hub height) | 13 m/s (approximately) | 13 m/s (approximately) |
| Cut-out wind speed (hub height) | 25 m/s | 25 m/s |

[2] Marshall Day Acoustics report reference Rp 001 R02 2012376ML dated 16 April 2014.

### 2.2.2 Sound power data

The noise emissions of the Vestas V112-3.3MW and V117-3.45MW are represented by the warranted sound power level data scheduled in the Engineering Procurement and Construction (EPC) contract for the supply and installation of the wind turbines. The warranted sound power levels represent the values which must be achieved by the installed turbines when tested and rated in accordance with International Electrotechnical Commission publication IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques* (IEC 61400-11).

The data scheduled in the EPC contract was sourced from the following documents:

- Vestas document titled *Performance Specification – V112-3.45 MW 50/60 Hz* (Vestas document number 0053-3710 V05 dated 6 May 2016)
- Vestas document titled *V112-3.45 MW Third octave noise emission* (Vestas document number 0055-1396_01 dated 1 March 2016)
- Vestas document titled *V117-3.45 MW Third octave noise emission* (Vestas document number DMS 0055-1397_V01)

The Vestas V112-3.3MW and V117-3.45MW are variable speed pitch-regulated turbines which are able to be operated in a variety of modes for the purposes of power regulation and noise control. An outline operating strategy has been developed for the Mt Emerald Wind Farm which involves a number of turbines operating in reduced sound modes for specific wind speeds, wind directions and time periods. Further details of the outline operating strategy for the wind farm are detailed in the following section.

The warranted sound power levels of the V112-3.3MW turbine for the proposed range of operating modes are summarised in Table 2 and illustrated on the following page in Figure 1.

**Table 2: Vestas V112-3.3MW**

| Operating Mode | dB $L_{WA}$ at hub height wind speed (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Mode LO1 [A] | 92.9 | 93.4 | 94 | 96.7 | 99.8 | 102.7 | 104.8 | 105.3 | 105.3 | 105.3 | 105.3 |
| Sound Mode 2 | 92.9 | 93.4 | 94 | 96.7 | 99.8 | 102.1 | 102.9 | 103 | 103 | 103 | 103 |
| Sound Mode 3 | 92.9 | 93.4 | 94 | 96.7 | 99.5 | 100.7 | 101 | 101 | 101 | 101 | 101 |
| Sound Mode 5 | 92.9 | 93.4 | 94 | 96.6 | 99.3 | 100 | 100 | 100 | 100 | 100 | 100 |

Note A: Load optimised mode 1 – un-curtailed noise emissions

The warranted sound power levels of the V117-3.45MW turbine for the proposed range of operating modes are summarised in Table 3 and illustrated on the following page in Figure 2.

**Table 3: V117-3.45MW**

| Operating Mode | dB $L_{WA}$ at hub height wind speed (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Sound Mode 0 [A] | 91.8 | 92.1 | 93.9 | 97.1 | 100.4 | 103.4 | 106 | 106.8 | 106.8 | 106.8 | 106.8 |
| Sound Mode 3 | 91.8 | 92.1 | 93.9 | 97.1 | 100.2 | 102 | 102.4 | 102.4 | 102.4 | 102.4 | 102.4 |
| Sound Mode 4 | 91.8 | 92.1 | 93.9 | 97 | 99.7 | 99.8 | 99.8 | 99.8 | 99.8 | 99.8 | 99.8 |

Note A: Un-curtailed noise emissions

**Figure 1: Vestas V112-3.3MW – warranted sound power levels**

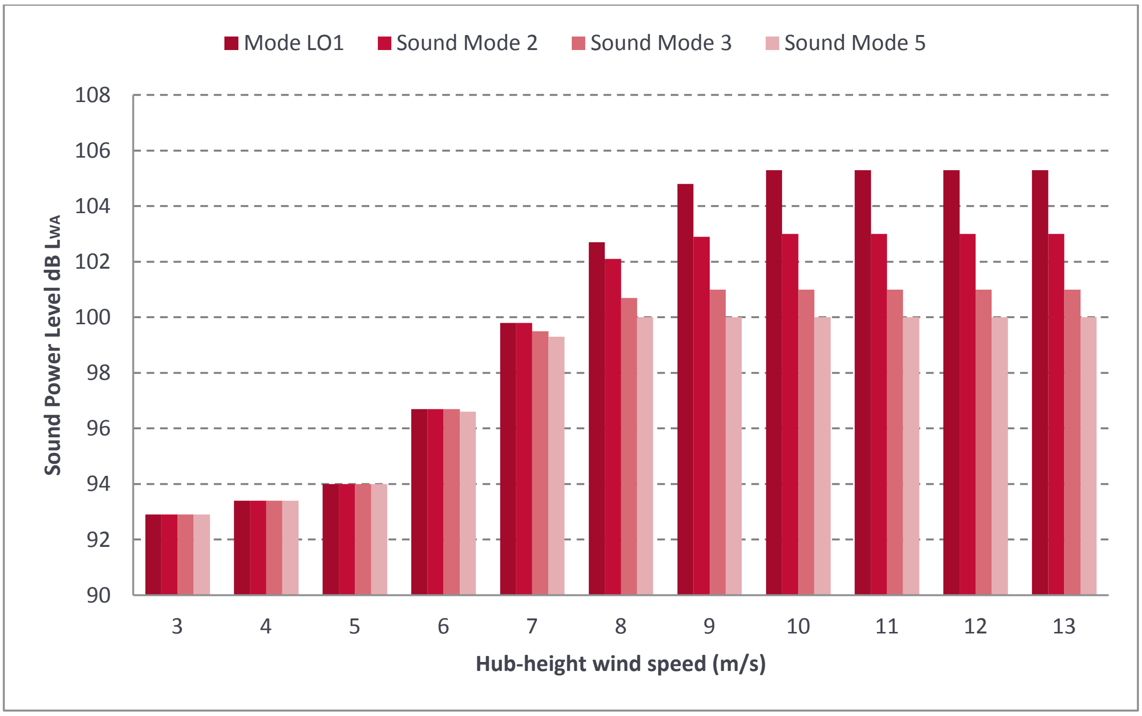
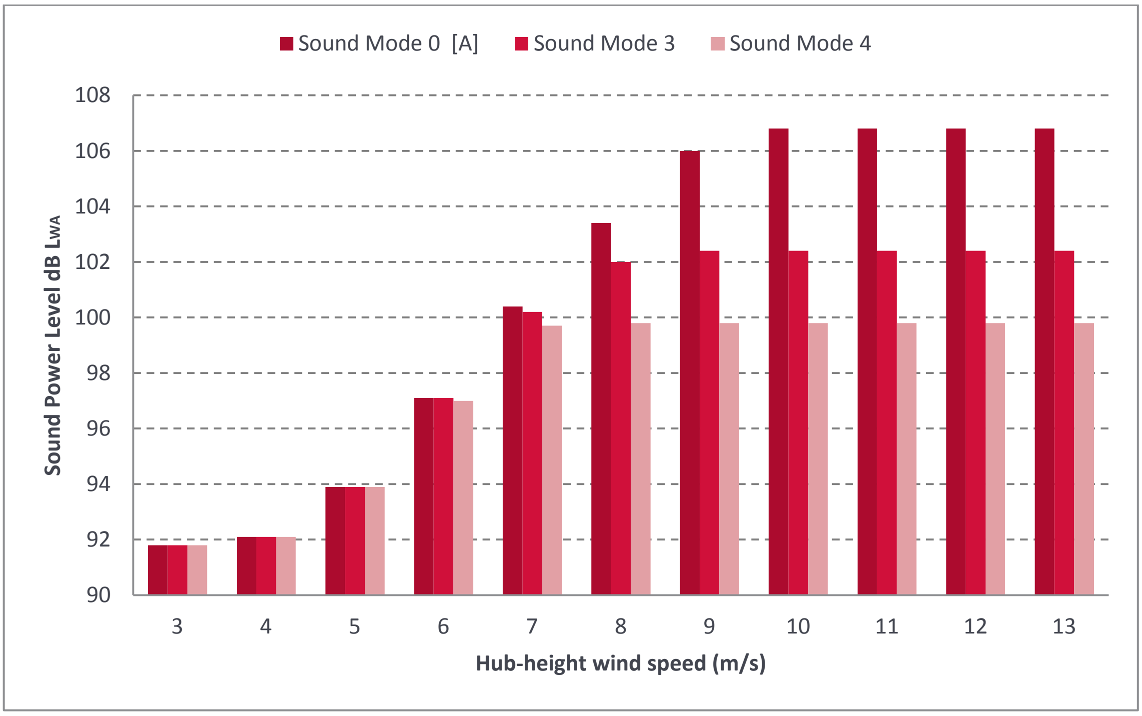



**Figure 2: Vestas V117-3.45MW – warranted sound power levels**




The sound frequency characteristics (spectra) of the wind turbines are provided in Appendix F.

The noise modelling presented in this assessment is based on the warranted sound power data detailed above, adjusted by the addition of 1.0 dB to account for typical sound power level test uncertainties.

### 2.2.3 Outline operating strategy

An outline operating strategy has been developed for the wind farm which involves selected turbines operating in reduced sound modes for certain wind speeds, wind directions and time periods. The outline operating strategy presented herein represents the latest iteration of the proposed configuration of the wind farm, designed to respond to the A-weighted noise level requirements of the Development Permit. This strategy will however be subject to ongoing development to determine the most energy efficient method of achieving compliance with the permit requirements.

A summary of the outline operating strategy is provided in Table 4.

**Table 4: Outline operating strategy – curtailment summary**

| Period | Turbine type | Curtailment for specific wind speeds and directions |
|---|---|---|
| Day<br>0600 - 2200 hours | V112-3.3MW | Five (5) turbines operating in sound mode 2 |
| | V117-3.45MW | No curtailment |
| Night<br>2200 - 0600 hours | V112-3.3MW | Twelve (12) turbines operating in sound mode 5 |
| | V117-3.45MW | Twenty-one (21) turbines operating in sound mode 4 |

The daytime outline operating strategy comprises a group of turbines to the west of the wind farm operating in reduced sound modes for wind directions ranging from west-northwest to east-southeast (clockwise). The reduced modes are used for the control of noise levels at receivers to the west and southwest of the site.

The night-time outline operating strategy comprises two broad groups of turbines:

- West group: ten (10) turbines along the west side of the wind farm operating in reduced sound modes for wind directions ranging from northwest to the south-southeast (clockwise). The reduced modes are used for the control of noise levels to the west and southwest of the site
- Northeast group: twenty-three (23) turbines along the northeast side of the wind farm, including turbines at the north and south of the wind farm, operating in reduced sound modes for wind directions ranging from the east to the north-northeast (clockwise). The reduced modes are used for the control of noise levels at receivers to the north, northeast and east of the site.

Full details of the turbines, wind speeds and directions associated with the outline operating strategy are tabulated in Appendix G.

The location of the turbines associated with the currently proposed daytime operating strategy are illustrated in Figure 3and those associated with the currently north-eastern and western night-time operating strategies are illustrated in Figure 4 and Figure 5 respectively.

**Figure 3: Site layout indicating the reduced sound mode turbines associated with the daytime outline operating strategy**

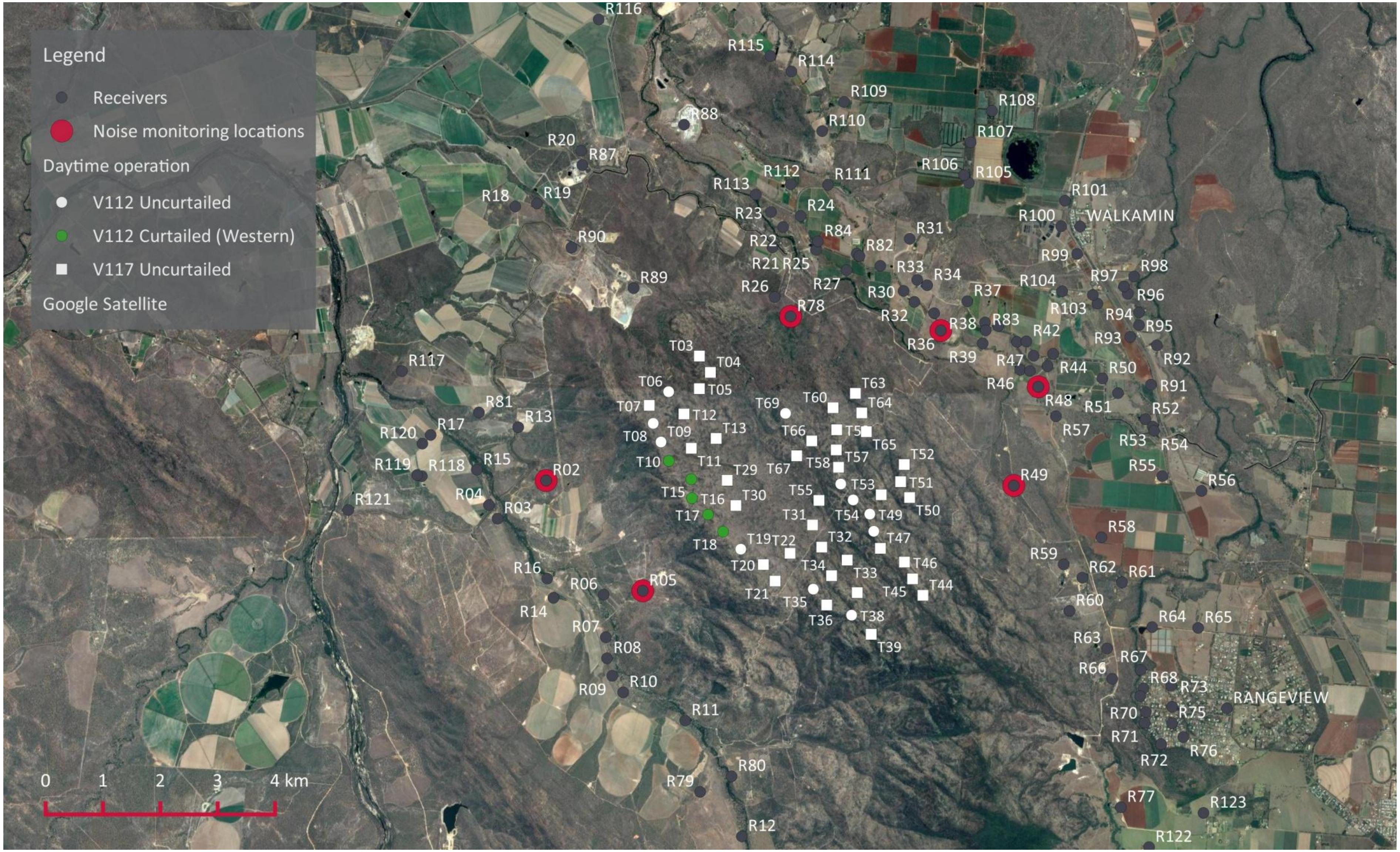


**Figure 4: Site layout indicating the northeast group reduced sound mode turbines associated with the night-time outline operating strategy**

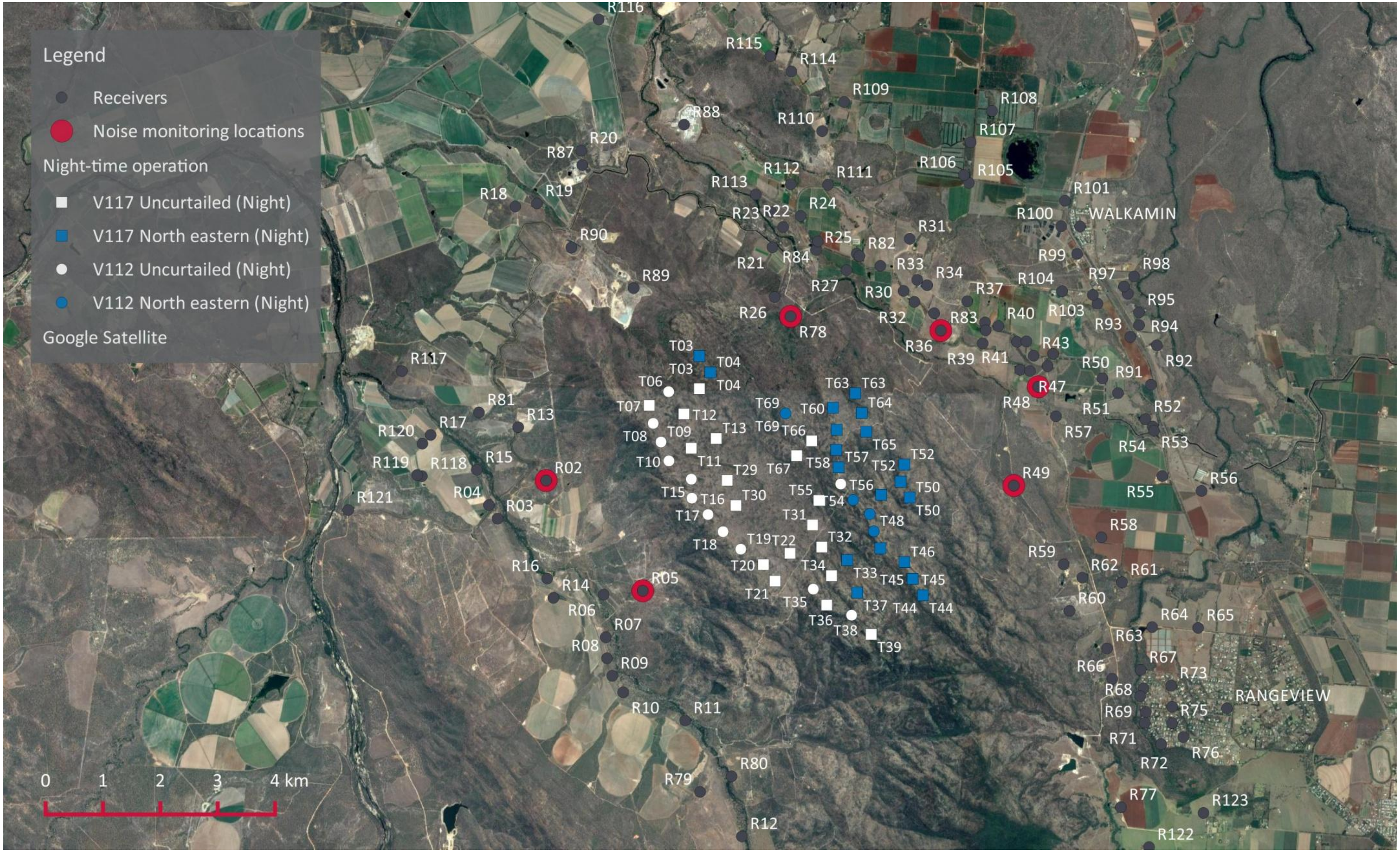
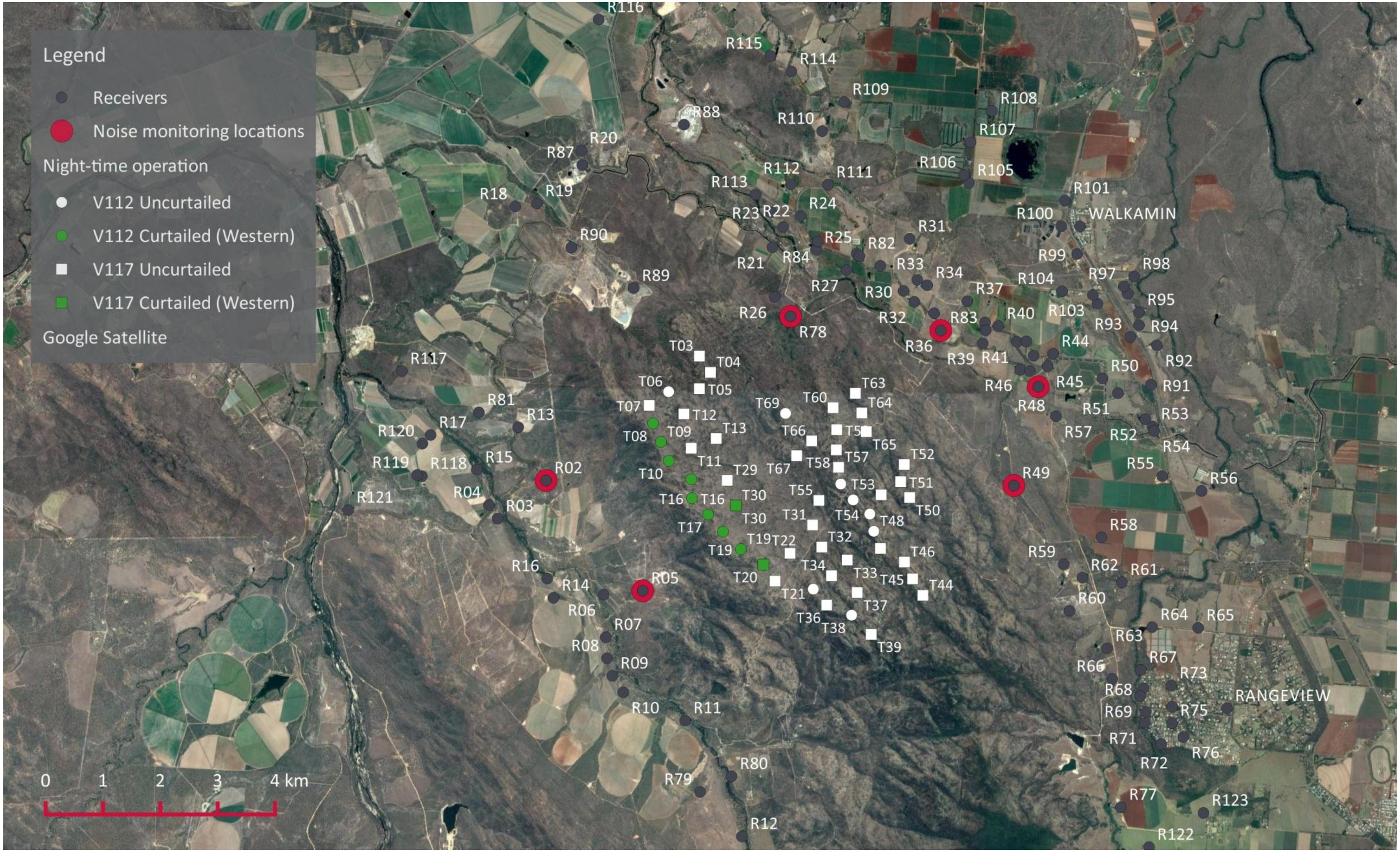


**Figure 5: Site layout indicating the west group reduced sound mode turbines associated with the night-time outline operating strategy**



### 2.2.4 Tonality

Adjustments for tonality have not been applied to the predictions presented in this report.

The EPC contract for the supply of the turbines includes requirements for the control of tonal noise emissions.

Specifically, the turbine supplier warrants a tonal audibility of 2 dB at receiver locations, when measured in accordance with IEC 61400-11, and rated in accordance with ISO 1996-2:2007. The EPC contract subsequently stipulates tonal penalties which are to apply to the measured noise levels if the supplier fails to achieve the warranted tonal audibility level.

Tonality related data for the proposed Vestas V112-3.3MW and V117-3.45MW turbines is also contained in the technical documents referenced in the EPC contract. This additional data is expressed in a different form to the receiver guarantee, as it relates to tonality at sound power test locations in close proximity to the turbines when rated in accordance with IEC-61400-11. The additional data is however consistent with the warranted audibility level being achieved at the receiver locations.

In terms of considering tonality in the present assessment, the ISO 1996-2:2007 rating procedure referred to in the EPC contract is also referenced in the assessment standard stipulated in the Development Permit for the Mt Emerald Wind Farm (discussed in the following section).

The ISO 1996-2:2007 tonality assessment procedure stipulates that adjustments for tonality are not applicable when the tonal audibility is less than 4 dB (see section C.2.4 of ISO 1996-2:2007). Accordingly, compliance with the receptor warranted tonal audibility specified in the EPC contract means that adjustments for tonality would not be applicable to the noise of the wind farm.

On the basis of the above, adjustments for tonality do not need to be applied to the predictions presented in this report.

### 2.2.5 Impulsivity and amplitude modulation

Adjustments for impulsivity and amplitude modulation have not been applied to the predictions presented in this report.

Impulsivity is not a characteristic that is normally associated with a correctly functioning wind turbine. For this reason, manufacturer's noise emission data for wind turbines does not include information relating to impulsivity, and the noise associated with the Mt Emerald Wind Farm is not expected to be characterised by impulsivity.

Amplitude modulation is a normal feature of a correctly functioning wind turbine, and is defined as the rise and fall in broadband noise level corresponding with the rotation of the turbine's blades. This characteristic is typically most evident in close proximity to a wind turbine. International research has however demonstrated that atypical levels of amplitude modulation can occur at some sites, and for the sites where it has been reported, its occurrence is infrequent. Importantly, the factors that give rise to the occurrence of atypical amplitude modulation are dependent on complex interactions between the turbines and site-specific atmospheric conditions. Accordingly, noise emission data for wind turbines does not include data relating to amplitude modulation. However, the limited occurrence of the effect documented in international reports, combined with the absence of substantive evidence of the effect occurring at Australian sites, indicates that atypical amplitude modulation is unlikely to be a characteristic of the Mt Emerald Wind Farm.

Based on the above, adjustments for impulsivity and amplitude modulation are not considered to be warranted.

## 3.0 ASSESSMENT CRITERIA

### 3.1 Development Permit

Schedule 1 of the Development Permit for the Mt Emerald Wind Farm includes conditions of Approval which establish operational noise requirements for the project.

Full details of the relevant conditions are reproduced in Appendix B and are briefly summarised below in Table 5.

**Table 5: Development Permit – summary of A-weighted operational noise assessment requirements**

| Condition | Summary Requirement |
|---|---|
| 4 | Establishes allowable A-weighted noise levels for day and night operation, based on a combination of fixed value limits and allowable margins above background noise levels |
| 6(a) | Establishes a requirement for a revised noise assessment report to be prepared prior to construction, demonstrating that the proposed wind farm can meet the noise levels specified in condition 4 |
| 6(b) | Establishes a requirement for monitoring operational noise compliance and preparing an operational noise compliance report within 12 months of completion of construction. |

The Development Permit refers to Australian Standard AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* (AS 4959:2010) as the applicable guidance to be followed for:

- The measurement and analysis of background noise levels; and
- The measurement, rating and assessment of operational wind farm noise levels, including the assessment of any Special Audible Characteristics (SACs) associated with the sound of the wind farm.

This report addresses the requirement of condition 6(a) with respect to condition 4, by documenting a revised noise assessment which demonstrates that the proposed wind farm and outline operating strategy is predicted to achieve compliance with the criteria established by condition 4 of the Development Permit.

An outline of the proposed compliance measurement and analysis procedures is provided in Appendix H.

### 3.2 Noise limits

The limits which apply to the A-weighted noise level that is solely attributable to the operation of the wind farm are summarised in Table 6.

**Table 6: Development Permit – summary of noise limits**

| Period | Metric | Development Permit requirement |
|---|---|---|
| Day<br>(0600-2200 hrs) | A-weighted noise levels | $L_{Aeq} \leq 37$ dB or background $L_{A90}$ + 5dB, whichever is higher |
| Night<br>(0600-2200 hrs) | A-weighted noise levels | $L_{Aeq} \leq 35$ dB or background $L_{A90}$ + 5dB, whichever is higher |

Noise monitoring was carried out in the vicinity of the Mt Emerald Wind Farm in May and June 2016 to establish an updated representation of background noise levels which could be used to:

- Determine operational noise limits in accordance with the Development Permit
- Assist the identification of background noise dominated periods during any future compliance surveys for the wind farm.

The monitoring was carried out at a total of six (6) existing and potential residential locations surrounding the wind farm. The results of the background monitoring, and the noise limits derived in accordance with the Development Permit, are documented in detail in a separate background noise report[3]. Specifically, the background noise report addresses the requirement of condition 4 of the Development Permit that background noise measurements are conducted in accordance with AS 4959:2010.

The derived noise limits are presented subsequently in Section 4.0 of this report as part of the assessment of compliance.

A consolidated tabular summary of the derived limits, based on tabulated background noise levels in the background noise report, is also provided in Appendix I below.

[3] Marshall Day Acoustics report reference Rp 001 R01 2015545ML dated 12 September 2016

# 4.0 NOISE PREDICTION METHODOLOGY

## 4.1 Overview

Operational wind farm noise levels have been predicted on the basis of:

- The sound emissions of the Vestas turbines as outlined in Section 2.2
- A 3D digital model of the site and the surrounding environment
- International standards used for the calculation of environmental sound propagation, with input settings and adjustments specifically suited to wind farm noise assessment.

The outline operating strategy for the wind farm includes the use of reduced sound modes for certain wind turbines for particular wind speeds and wind directions in order to achieve compliance with the noise criteria. As a result, noise levels at each receiver location will vary with wind direction due to:

- Changes in the noise emissions of the turbines (i.e. selected turbines operating in different modes for different wind directions); and
- Changes in the way noise propagates (e.g. differences between downwind, crosswind and upwind noise propagation).

It is therefore necessary to include an account of the change in noise levels with wind direction as part of the noise modelling. For this purpose, two levels of noise modelling have been carried out to verify compliance with the noise limits at surrounding receiver locations:

- Downwind noise modelling of key operating scenarios for all receiver locations
- Directional noise propagation modelling at key receiver locations around the wind farm

The downwind modelling only accounts for changes in noise levels with wind direction which occur as a result of the changes to the operating scenarios of the turbines. This involves modelling several operating scenarios corresponding to the conditions in which the different groups of turbines, defined in Section 2.2.3, operate in reduced sound modes for particular wind directions. The noise predictions for each of these scenarios is based on propagation calculations which assumes that each receiver is simultaneously downwind of every turbine (i.e. no account of the change in propagation for different wind directions). The primary purpose of this modelling is to demonstrate the wind farm complies with the criteria at relevant downwind receptor locations, utilising the same prediction method used during the planning stage of the project.

The directional noise propagation modelling that is subsequently carried out takes account of the combined wind direction effects related to both the noise emissions of the turbines and changes to the noise propagation conditions. The primary purpose of this modelling is to verify that the wind farm remains compliant for other wind directions when turbines are not utilising reduced sound modes.

The following subsections describe the procedures used for the downwind noise modelling and directional noise propagation modelling.

## 4.2 Downwind conditions

The noise prediction method for downwind conditions is summarised in Table 7 below. This method is consistent with the procedures used to calculate operational noise levels during the planning stage of the project.

This method has been shown to provide a reliable method of predicting the level of noise expected in practice. This finding is supported by comparisons of wind farm noise predictions with noise compliance monitoring results obtained using measurement and analysis procedures that are routinely use for wind farm developments in Australia. These procedures are representative of those which are proposed to be adopted for the Mt Emerald Wind Farm (an outline of the proposed methodology is presented in Appendix H).

**Table 7: Downwind prediction methodology**

| Detail | Description |
|---|---|
| Software | Proprietary noise modelling software SoundPLAN version 7.4 (current release) |
| Method | International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2).<br><br>Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (UK Institute of Acoustics guidance).<br><br>The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation.<br><br>Specific details of adjustments are noted below. Further discussion of the prediction method is provided in Appendix F. |
| Source characterisation | Each wind turbine is modelled as an incoherent point source of sound. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each.<br><br>Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine (84 – 90 m AGL according to turbine type).<br><br>Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine (140 – 148.5 m AGL). Further discussion of terrain screening effects is provided below. |
| Terrain data | A digital model of the terrain for the site and surrounding areas was provided by RATCH in October 2012 comprising the following data sourced from aerial survey of the site (LIDAR):<br>• Project area: 1 m interval contours<br>• Surrounding environs: 5 m interval contours |
| Terrain effects | Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F.<br>• Valley effects: + 3dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground was flat.<br>• Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. |

| Detail | Description |
|---|---|
| Ground conditions | Ground factor of G = 0.5 on the basis of the UK good practice guide and research outlined in Appendix F.<br>The ground around the site corresponds to acoustically soft conditions (G=1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations ground porosity and provide a cautious representation of ground effects. |
| Atmospheric conditions | Temperature 10 $^0$C and relative humidity 70 %<br>These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance.<br>The calculations are based on sound speed profiles[4] which increase the propagation of sound from each turbine to each receiver location, whether as a result thermal inversions or wind directed toward each calculation point. |
| Receiver heights | 1.5 m AGL<br>This corresponds to the height that the compliance monitoring would be undertaken, and is consistent with the modelling undertaken during the planning stage of the project. Further discussion of the choice in calculation receiver height is provided in Appendix J. |

## 4.3 Directional modelling

The noise prediction method outlined in Section 4.2 for modelling downwind conditions is based on the assumption that sound from the wind farm propagates equally in all directions. In practice, sound propagation will vary with wind direction.

The outline operating strategy of the Mt Emerald Wind Farm involves selected turbines utilising reduced sound modes for wind directions which correspond to the nearest receiver locations being downwind of the turbine.

In order to verify that the wind farm remains compliant for other wind directions when the turbines are not utilising reduced sound modes, directional modelling has been carried out using the UK Institute of Acoustics guidance on the change in sound propagation with wind direction.

The guidance includes methods for sites characterised by flat or complex landscapes. In recognition of the terrain profile around the Mt Emerald Wind Farm, the method for complex landscapes has been factored into the modelling.

The method is based on downwind propagation conditions occurring over a very broad range wind directions. Specifically, a wind direction within a range of ± 80 degrees of a wind blowing directly from a wind turbine to a receiver location is considered to result in downwind sound propagation conditions. During cross wind conditions, marginal reductions in sound level are then factored into the calculation. For wind directions ranging from cross wind to upwind, the further reductions are progressively factored into the calculation until a minimum level is reached when the wind is blowing directly from a receiver to a turbine.

The UK Institute of Acoustics guidance on directional analysis has not yet been incorporated into standard proprietary noise modelling software tools. Accordingly, implementing the method involves extensive processing of the downwind noise predictions generated from the modelling described in Section 4.2.

[4] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

This process is used to calculate the noise level in 5 degree wind direction increments. For each 5 degree wind direction increment, the angle between the wind direction and a line drawn from a turbine to a receiver is determined for each turbine and receiver pairing. For each assessed receiver, the angle is calculated for each of the 53 turbines, for each 5 degree wind sectors. The angle is then used to determine the directional adjustment according to the UK institute of Acoustics guidance, for each turbine and assessed receiver. The adjusted turbine contributions are then summed to determine the total wind farm noise level for each 5 degree wide sector.

The results are then plotted on a chart to illustrate the variation in noise level with wind direction, and to verify that that the proposed operated strategy will satisfy the requirements of the Development Permit across all wind speeds and directions.

The analysis was carried out for a representative group of receiver locations positioned in different directions from the wind farm. For each receiver location, the analysis is repeated for wind speeds ranging from 8 m /s to 13 m/s inclusive.

Full details of the UK Institute of Acoustics guidance on propagation directivity and its implementation for the Mt Emerald Wind are provided in Appendix J.

## 5.0 ASSESSMENT

This section of the report presents the predicted A-weighted noise levels at surrounding receiver locations, and an assessment of their compliance with the applicable noise limits. Results are provided for both the downwind and directional noise modelling.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

### 5.1 Predicted noise levels – Downwind modelling

Downwind noise modelling was separately carried out for the following four (4) operating scenarios:

- Day period – west group curtailed
- Day period – no curtailment
- Night period – west group curtailed
- Night period – northeast group curtailed.

For each of these operating scenarios, relevant downwind receiver locations were identified for inclusion in the scenario on the basis of a relatively wide range of wind directions. For example, the northeast group included receiver locations to the northwest around to the southeast of the wind farm. A schedule designating each receiver's assignment to an operating scenario is provided with the predicted noise levels presented in Appendix K.

The receiver locations where operational wind farm noise levels are predicted to be higher than 37 dB $L_{Aeq}$ during the day are listed in Table 8, along with the daytime predicted noise level corresponding to a hub height wind speed of 13 m/s when the wind farm's noise emissions are highest.

The daytime predicted noise level at all other receiver locations is equal to or below 37 dB $L_{Aeq}$. The results for these receiver locations are tabulated for the range of assessable wind speeds in Appendix K.

**Table 8: Daytime predicted A-weighted noise levels dB $L_{Aeq}$ at a hub height wind speed of 13 m/s**

| Receiver Location | Operating Scenario | Predicted noise level dB $L_{Aeq}$ |
|---|---|---|
| R05 | West group curtailed | 38.0 |
| R30 | No turbines curtailed | 37.5 |
| R32 | No turbines curtailed | 37.8 |
| R35 | No turbines curtailed | 37.9 |
| R36 | No turbines curtailed | 38.2 |
| R39 | No turbines curtailed | 37.2 |
| R49 | No turbines curtailed | 39.4 |
| R78 | No turbines curtailed | 37.2 |

The receiver locations where operational wind farm noise levels are predicted to be higher than 35 dB $L_{Aeq}$ during the night are listed in Table 9, along with the night-time predicted noise level corresponding to a hub height wind speed of 13 m/s when the wind farm's noise emissions are highest.

The night-time predicted noise level at all other receiver locations is below 35 dB $L_{Aeq}$. The results for these receiver locations are tabulated for the range of assessable wind speeds in Appendix K.

**Table 9: Night-time predicted A-weighted noise levels dB $L_{Aeq}$ at a hub height wind speed of 13 m/s**

| Receiver Location | Operating Scenario | Predicted noise level dB $L_{Aeq}$ |
|---|---|---|
| R02 | Western group curtailed | 36.4 |
| R05 | Western group curtailed | 36.7 |
| R06 | Western group curtailed | 35.5 |
| R35 | Northeast group curtailed | 35.1 |
| R36 | Northeast group curtailed | 35.1 |
| R49 | Northeast group curtailed | 36.5 |
| R78 | Northeast group curtailed | 35.7 |

The receiver locations identified in Table 8 and Table 9 are assessed in further detail in the following subsections.

### 5.1.1 Compliance assessment – Day

Using the eight (8) receiver locations presented in Table 8 where predicted noise levels are greater than 37 dB $L_{Aeq}$, this section presents an assessment of compliance with the applicable A-weighted noise limits across the range of assessable wind speeds.

The results presented in Table 10 to Table 16 below demonstrate compliance with the applicable daytime noise limits at all assessable wind speeds at all receiver locations. The proposed wind farm is therefore predicted to comply with the daytime noise requirements of condition 4 of the Development Permit.

The predicted noise levels at all other receiver locations are below the minimum value of the limits which apply to the Mt Emerald Wind Farm (as shown in Appendix K).

**Table 10: Receiver R05 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| Limit | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 38.5 | 40.7 |
| Predicted level | 26.1 | 26.0 | 26.5 | 29.1 | 32.1 | 35.0 | 36.7 | 36.9 | 36.8 | 37.9 | 38.0 |
| Compliance margin | 10.9 | 11.0 | 10.5 | 7.9 | 4.9 | 2.0 | 0.3 | 0.1 | 0.2 | 0.6 | 2.7 |

**Table 11: Receiver R30 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| Limit [A] | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| Predicted level | 23.9 | 23.8 | 25.0 | 27.9 | 31.1 | 34.0 | 36.4 | 37.1 | 37.1 | 37.3 | 37.5 |
| Compliance margin | 13.1 | 13.2 | 12.0 | 9.1 | 6.8 | 5.0 | 3.7 | 3.8 | 4.4 | 4.3 | 4.1 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 12: Receiver R32 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| Limit [A] | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| Predicted level | 24.1 | 24.0 | 25.3 | 28.3 | 31.4 | 34.4 | 36.8 | 37.5 | 37.5 | 37.7 | 37.8 |
| Compliance margin | 12.9 | 13.0 | 11.7 | 8.7 | 6.5 | 4.6 | 3.3 | 3.4 | 4.0 | 3.9 | 3.8 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 13: Receiver R35 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit [A] | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| Predicted level | 24.1 | 24.1 | 25.3 | 28.3 | 31.5 | 34.4 | 36.9 | 37.6 | 37.6 | 37.8 | 37.9 |
| Compliance margin | 12.9 | 12.9 | 11.7 | 8.7 | 6.4 | 4.6 | 3.2 | 3.3 | 3.9 | 3.8 | 3.7 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 14: Receiver R36 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit [A] | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| Predicted level | 24.4 | 24.4 | 25.7 | 28.7 | 31.8 | 34.8 | 37.2 | 37.9 | 37.9 | 38.1 | 38.2 |
| Compliance margin | 12.6 | 12.6 | 11.3 | 8.3 | 6.1 | 4.2 | 2.9 | 3.0 | 3.6 | 3.5 | 3.4 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 15: Receiver R39 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit [A] | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| Predicted level | 23.6 | 23.5 | 24.7 | 27.7 | 30.8 | 33.8 | 36.2 | 36.9 | 36.9 | 37.1 | 37.2 |
| Compliance margin | 13.4 | 13.5 | 12.3 | 9.3 | 7.1 | 5.2 | 3.9 | 4.0 | 4.6 | 4.5 | 4.4 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 16: Receiver R49 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.6 | 38.8 | 39.7 | 40.4 | 40.6 | 40.6 |
| Predicted level | 25.6 | 25.6 | 26.9 | 29.9 | 33.0 | 36.0 | 38.5 | 39.2 | 39.2 | 39.3 | 39.4 |
| Compliance margin | 11.4 | 11.4 | 10.1 | 7.1 | 4.0 | 1.6 | 0.3 | 0.5 | 1.2 | 1.3 | 1.2 |

**Table 17: Receiver R78 – Daytime Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 37 | 37 | 37 | 37 | 37 | 37.3 | 38.8 | 40 | 40.5 | 40.5 | 40.5 |
| Predicted level | 23.8 | 23.9 | 24.9 | 27.8 | 30.9 | 33.9 | 36.3 | 36.9 | 36.9 | 37.1 | 37.2 |
| Compliance margin | 13.2 | 13.1 | 12.1 | 9.2 | 6.1 | 3.4 | 2.5 | 3.1 | 3.6 | 3.4 | 3.3 |

### 5.1.2 Compliance assessment – Night

Using the seven (7) receiver locations presented in Table 9 where predicted noise levels are greater than 35 dB $L_{Aeq}$, this section presents an assessment of compliance with the applicable A-weighted noise limits across the range of assessable wind speeds.

The results presented in Table 18 to Table 24 demonstrate compliance with the applicable limits at all assessable wind speeds at all receiver locations. The proposed wind farm is therefore predicted to comply with the night-time noise requirements of condition 4 of the Development Permit.

The predicted noise levels at all other receiver locations are below the minimum value of the limits which apply to the Mt Emerald Wind Farm (as shown in Appendix K).

**Table 18: Receiver R02 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 36.8 | 39.9 |
| Predicted level | 24.8 | 24.7 | 25.2 | 27.8 | 30.8 | 33.6 | 33.9 | 34.5 | 34.6 | 36.2 | 36.4 |
| Compliance margin | 10.2 | 10.3 | 9.8 | 7.2 | 4.2 | 1.4 | 1.1 | 0.5 | 0.4 | 0.6 | 3.5 |

**Table 19: Receiver R05 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.4 | 38.0 | 41.4 |
| Predicted level | 26.1 | 26.0 | 26.5 | 29.1 | 32.1 | 34.9 | 34.6 | 35.0 | 35.2 | 36.6 | 36.7 |
| Compliance margin | 8.9 | 9.0 | 8.5 | 5.9 | 2.9 | 0.1 | 0.4 | 0.0 | 0.2 | 1.4 | 4.7 |

**Table 20: Receiver R06 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit [A] | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.4 | 38.0 | 41.4 |
| Predicted level | 24.6 | 24.5 | 24.9 | 27.5 | 30.5 | 33.2 | 33.4 | 33.9 | 34.0 | 35.3 | 35.5 |
| Compliance margin | 10.4 | 10.5 | 10.1 | 7.5 | 4.5 | 1.8 | 1.6 | 1.1 | 1.4 | 2.7 | 5.9 |

Note A: Applicable limit derived from representative background noise monitoring at R05

**Table 21: Receiver R35 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit [A] | 35.0 | 35.0 | 35.0 | 35.0 | 35.2 | 35.6 | 36.0 | 36.5 | 37.0 | 37.5 | 38.1 |
| Predicted level | 24.1 | 24.1 | 25.3 | 28.3 | 31.5 | 34.0 | 32.9 | 33.1 | 33.2 | 33.5 | 35.1 |
| Compliance margin | 10.9 | 10.9 | 9.7 | 6.7 | 3.7 | 1.6 | 3.1 | 3.4 | 3.8 | 4.0 | 3.0 |

Note A: Applicable limit derived from representative background noise monitoring at R36

**Table 22: Receiver R36 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 35.0 | 35.0 | 35.0 | 35.0 | 35.2 | 35.6 | 36.0 | 36.5 | 37.0 | 37.5 | 38.1 |
| Predicted level | 24.4 | 24.4 | 25.7 | 28.7 | 31.8 | 34.3 | 33.0 | 33.3 | 33.3 | 33.7 | 35.1 |
| Compliance margin | 10.6 | 10.6 | 9.3 | 6.3 | 3.4 | 1.3 | 3.0 | 3.2 | 3.7 | 3.8 | 3.0 |

**Table 23: Receiver R49 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.3 | 36.5 |
| Predicted level | 25.6 | 25.6 | 26.9 | 29.9 | 33.0 | 34.8 | 34.3 | 34.6 | 34.7 | 34.9 | 36.5 |
| Compliance margin | 9.4 | 9.4 | 8.1 | 5.1 | 2.0 | 0.2 | 0.7 | 0.4 | 0.3 | 0.4 | 0.0 |

**Table 24: Receivers R78 – Night-time Compliance Assessment (dB $L_{Aeq}$)**

| Description | Hub height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Limit | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.6 | 37.1 | 38.7 |
| Predicted level | 23.8 | 23.9 | 24.9 | 27.8 | 30.9 | 33.8 | 33.9 | 34.0 | 34.1 | 35.0 | 35.7 |
| Compliance margin | 11.2 | 11.1 | 10.1 | 7.2 | 4.1 | 1.2 | 1.1 | 1.0 | 1.5 | 2.1 | 3.0 |

## 5.2 Predicted noise levels – Directional modelling

The directional noise modelling has been carried out for the following five (5) receivers that have been selected as being representative of neighbouring locations around the find farm:

- R02
- R05
- R36
- R49
- R78

The location of these representative receivers is illustrated in Figure 6 on the following page.

Full results for each of the representative receivers are provided in Appendix L and demonstrate that the predicted noise levels remain compliant with the noise criteria for all wind directions at all wind speeds.

However, as an indication of the assessment that has been carried out, Figure 7 and Figure 8 on the following pages demonstrate the results of the directional noise modelling for receiver R05 and R49 respectively. Each chart illustrates:

- the noise limit: green dashed line
- the predicted noise level without curtailment: the red line; and
- the predicted noise level with the outline operating strategy: the blue line

The data is provided in 5 degree wind direction increment.

In both cases, the predicted noise level for the outline operating strategy (the blue line) remains within the noise limit (the green line ) for all wind directions, confirming that compliance is achieved in all wind directions. In particular, the predicted noise levels for R05 remain well below the noise limit, even for the northeast wind direction (45 degrees) within which the receiver is directly downwind of the wind farm.

The result for R05 illustrates that the outline operating strategy is a conservative approach that demonstrates how the wind farm is able to achieve compliance with the specific noise criteria. It also illustrates that there is potential “excess curtailment” that may not ultimately be required in order to maintain compliance, and hence the operating strategy of the wind farm will be subject to ongoing refinement in order to determine the most energy efficient method of achieving compliance with the Development Permit noise requirements.

**Figure 6: Representative receivers for directional noise modelling**

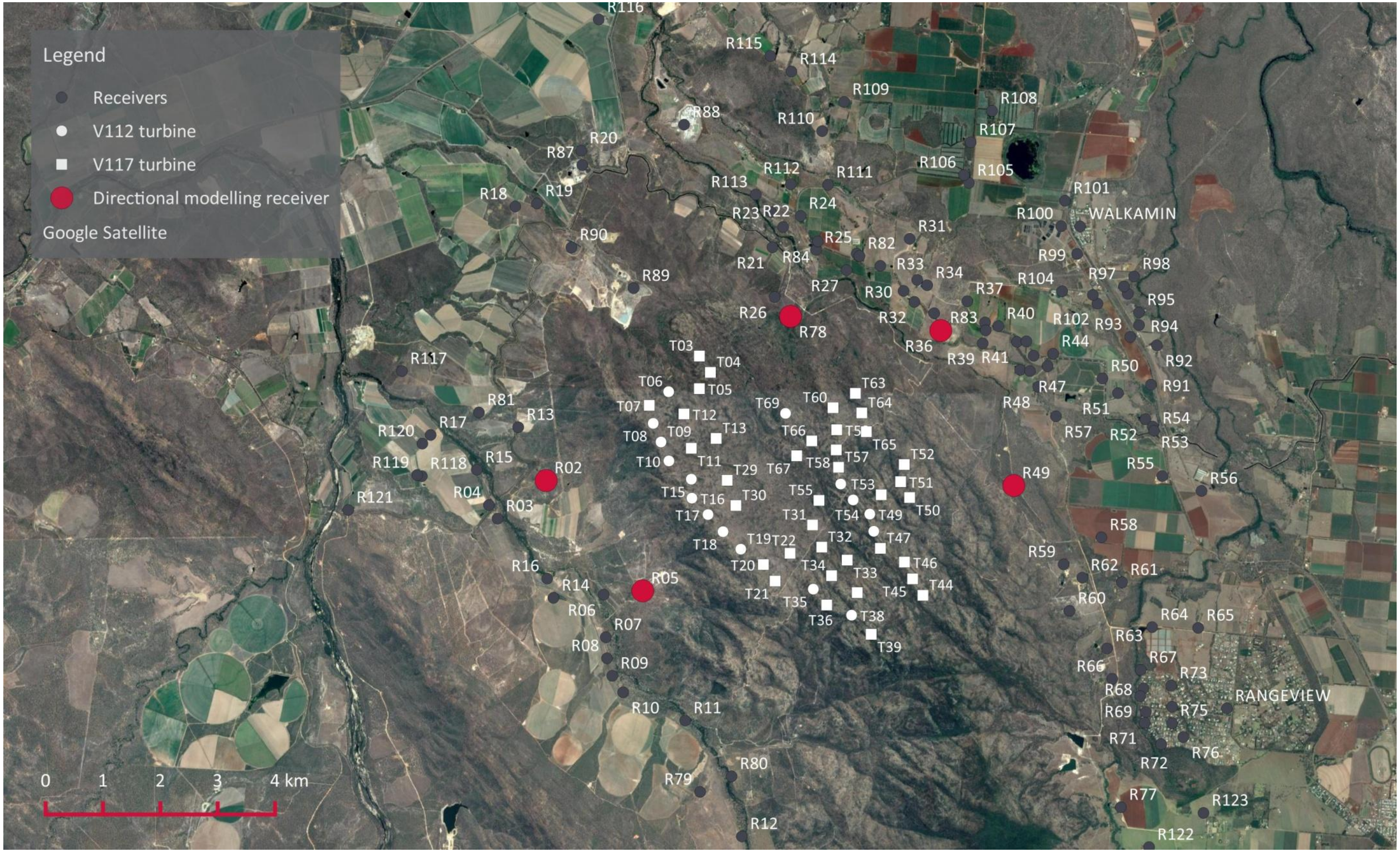


Figure 7: Receiver R05 predicted directional noise levels (dB $L_{Aeq}$) at a hub-height wind speed of 13 m/s

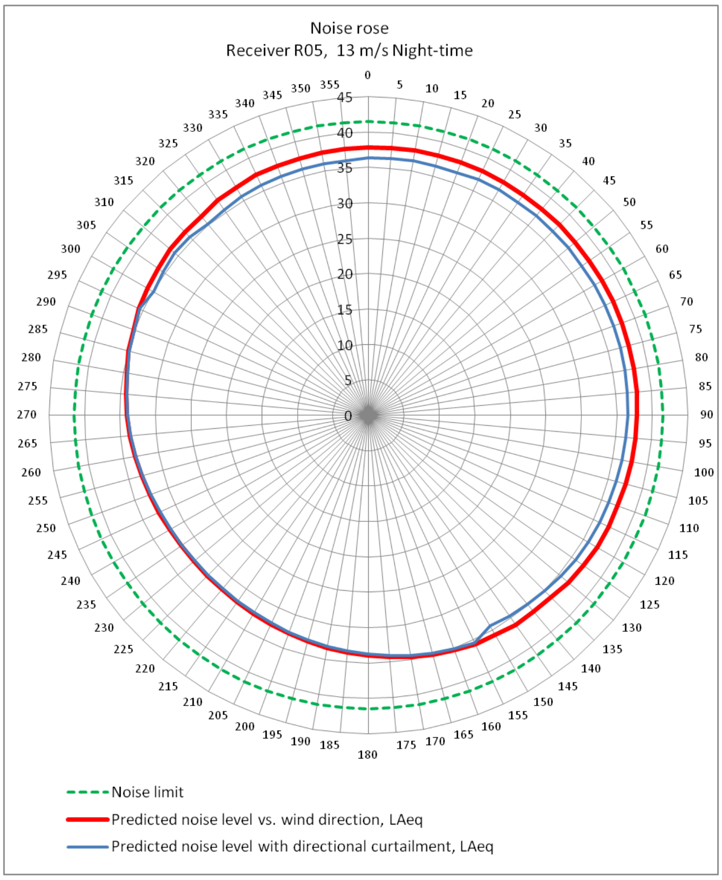
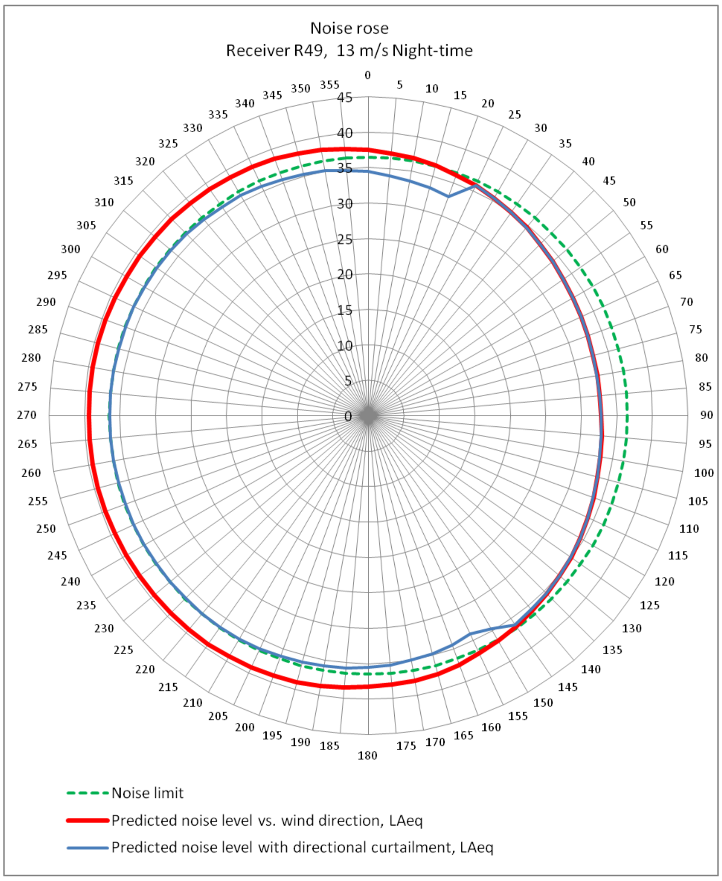



Figure 8: Receiver R49 predicted directional noise levels (dB $L_{Aeq}$) at a hub-height wind speed of 13 m/s



## 6.0 SUMMARY

This report presents the results of updated noise predictions prepared for the proposed Mt Emerald Wind Farm that is being developed by RATCH Australia Corporation (RATCH).

The predictions have been undertaken on the basis of the proposed layout design comprising:

- Sixteen (16) Vestas V112-3.3MW turbines; and
- Thirty seven (37) Vestas V117-3.45MW turbines

The data provided for the two Vestas turbines supports that adjustments for tonality related Special Audible Characteristics are not considered applicable to the noise modelling.

To address the operational noise requirements of the Development Permit, an outline operating strategy has been developed which involves a number of turbines operating in reduced sound modes for specific wind speeds, wind directions and time periods.

The results of the noise predictions demonstrate that the predicted noise levels for the proposed turbine configuration and outline operating strategy achieve compliance with the day and night A-weighted noise level requirements established by Condition 4 of the Development Permit.

It also demonstrates that the outline operating strategy is a conservative approach with potential "excess curtailment" that may not ultimately be required in order to maintain compliance, and hence there is opportunity for further refinement to determine the most energy efficient method of achieving compliance with the Development Permit noise requirements.

In accordance with condition 6 of the Development Permit, compliance monitoring will be required to demonstrate that measured operational noise levels associated with the Mt Emerald Wind Farm achieve the noise criteria. Details of the noise compliance monitoring strategy will be documented in detail for review and agreement with the authority in advance of conducting the monitoring. In preparation, an outline of the proposed monitoring strategy has been provided for reference purposes.

## APPENDIX A GLOSSARY OF TERMINOLOGY

| | |
|---|---|
| **dB** | Decibel. The unit of sound level. |
| **$L_W$** | The sound power level. The level of total sound power radiated by a sound source. |
| **$L_{WA}$** | The "A" weighted sound power level. |
| **$L_{eq}$** | Continuous or semi-continuous noise levels are described in terms of the equivalent continuous sound level ($L_{eq}$). This is the constant sound level over a stated time period which is equivalent in total sound energy to the time-varying sound level measured over the same time period. This is commonly referred to as the average noise level. |
| **$L_{Aeq}$** | The "A" weighted equivalent continuous sound level. |
| **Octave Band** | A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound. |
| **$L_{A90}$** | The noise level exceeded for 90 % of the measurement period, measured in A-weighted decibels. This is commonly referred to as the background noise level. |

## APPENDIX B DEVELOPMENT PERMIT – A-WEIGHTED OPERATIONAL NOISE REQUIREMENTS

The following excerpts concerning A-weighted operational wind turbine noise have been reproduced from *Schedule 1: Conditions of Approval* of the Development Permit, as amended by the notice of the Minister for Local Government and Planning dated 18 December 2015.

| | |
|---|---|
| *4. The wind farm development must be designed and operated to ensure that:*<br>*(a) The outdoor night-time (10pm to 6am) equivalent noise level ($L_{Aeq,10\ minutes}$) at existing and approved sensitive land uses at the date of this approval, does not exceed the higher of:*<br>*(i) 35dB(A); or*<br>*(ii) The background noise level ($L_{A90}$) plus 5dB(A);*<br>*and*<br>*(b) The outdoor day-time equivalent noise level ($L_{Aeq,10\ minutes}$) at existing and approved sensitive land uses at the date of this approval, does not exceed the higher of:*<br>*(i) 37dB(A); or*<br>*(ii) The background noise level ($L_{A90}$) plus 5dB(A)*<br>*(c) The equivalent noise levels ($L_{Aeq}$) are to be assessed at all existing and approved sensitive land uses at the date of this approval for all integer hub height wind speeds from cut-in to rated power of the wind turbine generator.*<br>*(d) Measurements of background noise operational noise from wind turbine generators for the operation shall be in accordance with Australian Standard AS4959-2010 Acoustics – Measurement, prediction and assessment of noise from wind turbine generators (AS4959-2010) at any existing and approved sensitive land uses at the date of this approval. If an alternative standard or guideline to AS4959-2010 is to be followed for the assessment of Special Audible Characteristics, then reasons for the selection of the alternative are to be provided.* | *Prior to commencement of use and then to be maintained.* |

| | | | |
|---|---|---|---|
| *6.* | *(a)* | *Submit to the chief executive administering the SPA a revised noise assessment report, certified by a suitably qualified acoustic consultant, demonstrating that the proposed wind farm can meet the noise levels specified in conditions 4 and 5 of this approval. The report is to:*<br><br>*i. Model the acoustic impacts of the wind farm based on the revised Turbine Location and Development Footprint Plan submitted in accordance with condition of this approval.*<br><br>*The noise modelling should take into account the varied topography between the turbine locations and existing and approved sensitive land use receptors at the date of this approval and any impacts that may have on predicted noise levels, and include an assessment of Special Audible Characteristics including tonality, impulsivity and amplitude modulation.*<br><br>*ii. Identify any design specifications or operational restrictions that may be necessary to ensure compliance with the noise levels specified in conditions 4 and 5, such as turbine types or limitations on hours of operation of specific turbines.* | *(a) Prior to the commencement of site / operational / building work* |
| | *(b)* | *Submit to the chief executive administering the SPA a compliance noise assessment report, by a suitably qualified acoustic consultant, demonstrating that the proposed wind farm meets the noise levels specified in conditions 4 and 5 of this approval. The report is to:*<br><br>*i. Measure the acoustic impacts of the wind farm based on the final Turbine Location and Development Footprint Plan submitted in accordance with condition 2 of this approval.*<br><br>*The noise measurements should take into account the turbine locations and any existing and approved sensitive land use receptors at the date of this approval; and include an assessment of Special Audible Characteristics including tonality, impulsivity and amplitude modulation. Assessment of Special Audible Characteristics should be carried out using an appropriate international standard or guideline. Reasons for the selection of the standard or guideline are to be provided with the noise assessment report. The assessment should determine whether Special Audible Characteristics are excessive and require an adverse character adjustment (adj) to specific measurement period.* | *(c) Within twelve (12) months of the completion of construction and then to be maintained* |

## APPENDIX C TURBINE COORDINATES – MGA 94 ZONE 55

The following table sets out the coordinates of the proposed fifty-three (53) turbine layout (data supplied by Vestas 2 August 2016). The layout comprises sixteen (16) Vestas V112-3.3MW and thirty seven (37) Vestas V117-3.3MW turbines.

**Table 25: Proposed turbine coordinates**

| WTG | WTG Type | Hub Height [m] | Easting [m] | Northing [m] |
|---|---|---|---|---|
| T06 | V112 -3.3MW | 84 | 325535 | 8102589 |
| T08 | V112 -3.3MW | 84 | 325266 | 8102037 |
| T09 | V112 -3.3MW | 84 | 325402 | 8101713 |
| T10 | V112 -3.3MW | 84 | 325539 | 8101383 |
| T15 | V112 -3.3MW | 84 | 325931 | 8101065 |
| T16 | V112 -3.3MW | 84 | 325941 | 8100734 |
| T17 | V112 -3.3MW | 84 | 326222 | 8100448 |
| T18 | V112 -3.3MW | 84 | 326484 | 8100150 |
| T19 | V112 -3.3MW | 84 | 326793 | 8099845 |
| T35 | V112 -3.3MW | 84 | 328058 | 8099149 |
| T38 | V112 -3.3MW | 84 | 328726 | 8098695 |
| T48 | V112 -3.3MW | 84 | 329113 | 8100157 |
| T49 | V112 -3.3MW | 84 | 329043 | 8100457 |
| T54 | V112 -3.3MW | 84 | 328753 | 8100703 |
| T56 | V112 -3.3MW | 84 | 328537 | 8100981 |
| T69 | V112 -3.3MW | 84 | 327574 | 8102211 |
| T03 | V117 -3.45MW | 90 | 326071 | 8103211 |
| T04 | V117 -3.45MW | 90 | 326263 | 8102926 |
| T05 | V117 -3.45MW | 90 | 326071 | 8102642 |
| T07 | V117 -3.45MW | 90 | 325197 | 8102351 |
| T11 | V117 -3.45MW | 90 | 325930 | 8101603 |
| T12 | V117 -3.45MW | 90 | 325803 | 8102201 |
| T13 | V117 -3.45MW | 90 | 326364 | 8101775 |
| T20 | V117 -3.45MW | 90 | 327187 | 8099577 |
| T21 | V117 -3.45MW | 90 | 327392 | 8099290 |
| T22 | V117 -3.45MW | 90 | 327652 | 8099773 |
| T29 | V117 -3.45MW | 90 | 326556 | 8101046 |
| T30 | V117 -3.45MW | 90 | 326708 | 8100606 |
| T31 | V117 -3.45MW | 90 | 328045 | 8100267 |
| T32 | V117 -3.45MW | 90 | 328206 | 8099881 |
| T33 | V117 -3.45MW | 90 | 328648 | 8099655 |
| T34 | V117 -3.45MW | 90 | 328376 | 8099384 |

| WTG | WTG Type | Hub Height [m] | Easting [m] | Northing [m] |
|---|---|---|---|---|
| T36 | V117 -3.45MW | 90 | 328292 | 8098872 |
| T37 | V117 -3.45MW | 90 | 328824 | 8099088 |
| T39 | V117 -3.45MW | 90 | 329067 | 8098362 |
| T44 | V117 -3.45MW | 90 | 329970 | 8099041 |
| T45 | V117 -3.45MW | 90 | 329790 | 8099328 |
| T46 | V117 -3.45MW | 90 | 329648 | 8099620 |
| T47 | V117 -3.45MW | 90 | 329228 | 8099859 |
| T50 | V117 -3.45MW | 90 | 329738 | 8100745 |
| T51 | V117 -3.45MW | 90 | 329581 | 8101021 |
| T52 | V117 -3.45MW | 90 | 329644 | 8101320 |
| T53 | V117 -3.45MW | 90 | 329242 | 8100793 |
| T55 | V117 -3.45MW | 90 | 328157 | 8100695 |
| T57 | V117 -3.45MW | 90 | 328498 | 8101272 |
| T58 | V117 -3.45MW | 90 | 328458 | 8101575 |
| T59 | V117 -3.45MW | 90 | 328466 | 8101926 |
| T60 | V117 -3.45MW | 90 | 328402 | 8102310 |
| T63 | V117 -3.45MW | 90 | 328792 | 8102560 |
| T64 | V117 -3.45MW | 90 | 328903 | 8102219 |
| T65 | V117 -3.45MW | 90 | 328983 | 8101892 |
| T66 | V117 -3.45MW | 90 | 328031 | 8101732 |
| T67 | V117 -3.45MW | 90 | 327768 | 8101472 |

## APPENDIX D RECEIVER LOCATIONS – MGA 94 ZONE 55

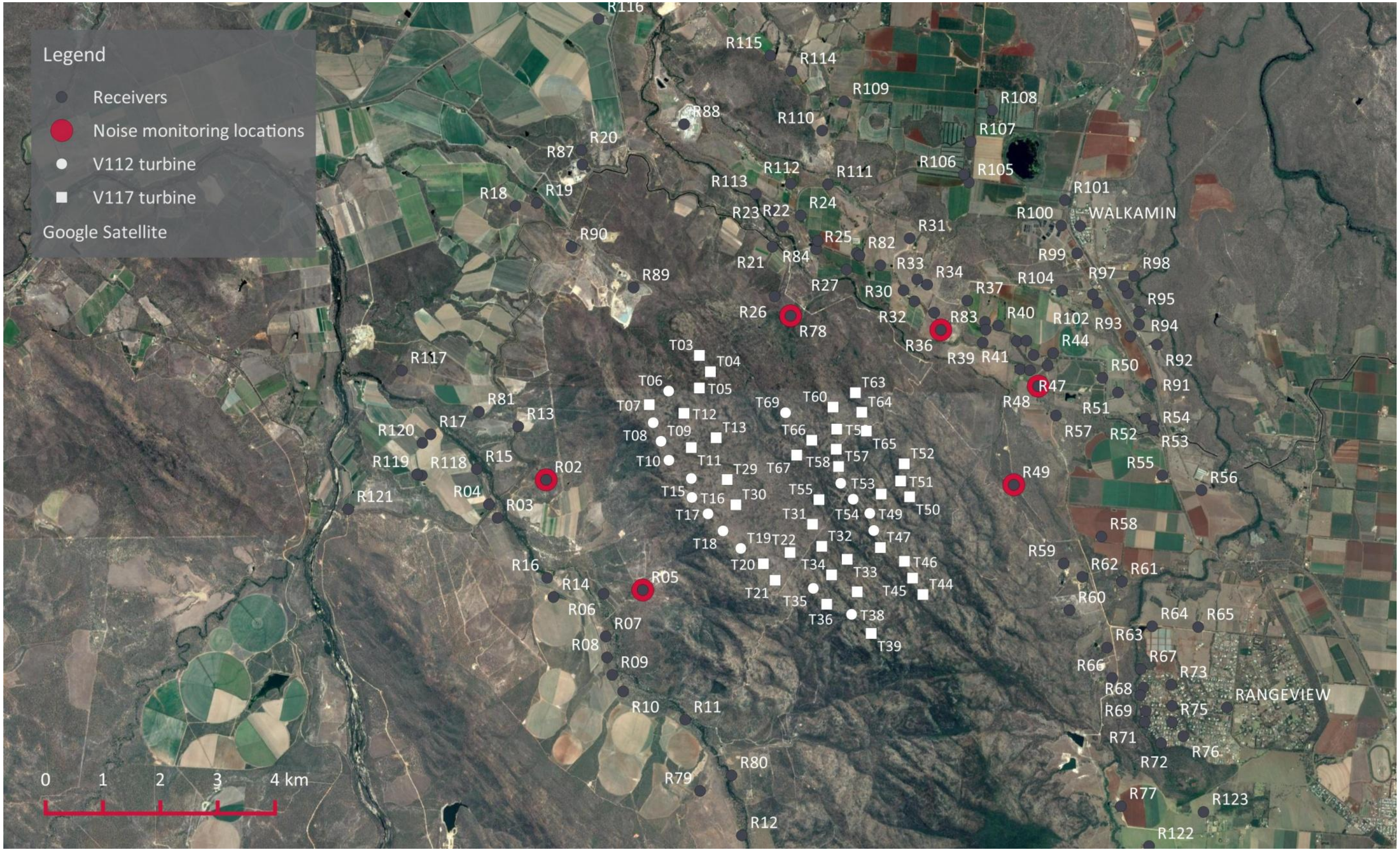
The following table sets out the one-hundred and twenty three (123) receiver locations considered in the revised assessment (coordinates originally received from RATCH 22 October 2012, and subsequently confirmed by RATCH on 23 November 2015 as being applicable to the revised noise assessment during the survey planning (received from RATCH 23 November 2015). These coordinates correspond to the same receiver locations considering during the planning and development approval stage of the project.

**Table 26: Receiver locations**

| Receiver | Easting | Northing | Receiver | Easting | Northing |
|---|---|---|---|---|---|
| R01 | 327108 | 8094240 | R63 | 333180 | 8098115 |
| R02 | 323399 | 8101041 | R64 | 333966 | 8098486 |
| R03 | 322551 | 8100377 | R65 | 334769 | 8098473 |
| R04 | 322401 | 8100614 | R66 | 333273 | 8097584 |
| R05 | 325084 | 8099119 | R67 | 333769 | 8097741 |
| R06 | 324402 | 8099053 | R68 | 333818 | 8097418 |
| R07 | 324438 | 8098311 | R69 | 333759 | 8097284 |
| R08 | 324461 | 8097943 | R70 | 333858 | 8097008 |
| R09 | 324552 | 8097638 | R71 | 333837 | 8096819 |
| R10 | 324741 | 8097351 | R72 | 334122 | 8096447 |
| R11 | 325824 | 8096858 | R73 | 334300 | 8097467 |
| R12 | 326812 | 8094840 | R74 | 334315 | 8097097 |
| R13 | 322913 | 8101970 | R75 | 334312 | 8096814 |
| R14 | 323526 | 8098996 | R76 | 334510 | 8096570 |
| R15 | 322190 | 8101228 | R77 | 333420 | 8095349 |
| R16 | 323417 | 8099332 | R78 | 327662 | 8103902 |
| R17 | 321385 | 8101835 | R79 | 326084 | 8095615 |
| R18 | 322861 | 8105817 | R80 | 326633 | 8095887 |
| R19 | 323237 | 8105869 | R81 | 322227 | 8102228 |
| R20 | 324011 | 8106789 | R82 | 328862 | 8104954 |
| R21 | 327346 | 8105105 | R83 | 331064 | 8103659 |
| R22 | 327532 | 8105458 | R84 | 328138 | 8105207 |
| R23 | 327320 | 8105720 | R87 | 324029 | 8106539 |
| R24 | 327836 | 8105651 | R88 | 325804 | 8107243 |
| R25 | 328105 | 8105059 | R89 | 324925 | 8104393 |
| R26 | 327385 | 8104239 | R90 | 323839 | 8105103 |
| R27 | 328640 | 8104706 | R91 | 333946 | 8102712 |
| R28 | 328814 | 8104996 | R92 | 334049 | 8103397 |
| R29 | 329227 | 8104783 | R93 | 333585 | 8103544 |
| R30 | 329632 | 8104345 | R94 | 333738 | 8103749 |
| R31 | 329738 | 8105254 | R95 | 333737 | 8103972 |

| Receiver | Easting | Northing | Receiver | Easting | Northing |
|---|---|---|---|---|---|
| R32 | 329821 | 8104154 | R96 | 333543 | 8104296 |
| R33 | 329870 | 8104536 | R97 | 333476 | 8104424 |
| R34 | 330044 | 8104444 | R98 | 333652 | 8104597 |
| R35 | 330166 | 8103957 | R99 | 332659 | 8104989 |
| R36 | 330281 | 8103655 | R100 | 332380 | 8105473 |
| R37 | 330744 | 8104165 | R101 | 332447 | 8105917 |
| R38 | 331053 | 8103796 | R102 | 333013 | 8104126 |
| R39 | 331012 | 8103431 | R103 | 332934 | 8104276 |
| R40 | 331286 | 8103732 | R104 | 332397 | 8104339 |
| R41 | 331610 | 8103457 | R105 | 330771 | 8106228 |
| R42 | 331773 | 8103467 | R106 | 330687 | 8106366 |
| R43 | 331900 | 8103216 | R107 | 330802 | 8106936 |
| R44 | 332241 | 8103249 | R108 | 331175 | 8107484 |
| R45 | 332142 | 8103035 | R109 | 328594 | 8107639 |
| R46 | 331667 | 8102969 | R110 | 328212 | 8107130 |
| R47 | 331836 | 8102949 | R111 | 328314 | 8106195 |
| R48 | 331981 | 8102675 | R112 | 327666 | 8106205 |
| R49 | 331555 | 8100953 | R113 | 327055 | 8106025 |
| R50 | 333099 | 8102820 | R114 | 327675 | 8108169 |
| R51 | 333372 | 8102564 | R115 | 327309 | 8108440 |
| R52 | 333849 | 8102111 | R116 | 324316 | 8109076 |
| R53 | 333977 | 8101981 | R117 | 320884 | 8102947 |
| R54 | 334001 | 8101907 | R118 | 321231 | 8101117 |
| R55 | 334143 | 8101119 | R119 | 321148 | 8101136 |
| R56 | 334828 | 8100860 | R120 | 321240 | 8101684 |
| R57 | 332290 | 8102160 | R121 | 319947 | 8100527 |
| R58 | 333082 | 8100051 | R122 | 333913 | 8094653 |
| R59 | 332424 | 8099580 | R123 | 334862 | 8095248 |
| R60 | 332526 | 8098770 | RANGEVIEW | 335269 | 8097070 |
| R61 | 333441 | 8099268 | WALKAMIN | 332711 | 8105470 |
| R62 | 332750 | 8099348 | | | |

## APPENDIX E SITE LAYOUT PLAN


Legend
Receivers
Noise monitoring locations
V112 turbine
V117 turbine
Google Satellite
0 1 2 3 4 km
WALKAMIN
RANGEVIEW
R116
R115
R114
R109
R108
R88
R110
R107
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R87
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R90
R25
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R104
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R37
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R26
R78
R32
R83
R40
R102
R93
R94
R36
R39
R41
R44
R117
R50
R92
R47
R91
R81
R48
R51
R13
R17
R54
R120
R57
R52
R53
R119
R118
R15
R55
R02
R49
R56
R121
R04
R03
R58
R59
R16
R62
R61
R14
R05
R60
R06
R07
R64
R65
R63
R08
R67
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R73
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R68
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R77
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R122
T03
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T69

## APPENDIX F WIND TURBINE SOUND EMISSIONS – FREQUENCY SPECTRUM DATA

### F1 Vestas V112 3.3MW sound power levels

This section presents tabulated sound power level data for the uncurtailed mode of operation (Vestas designation - load optimised mode 1) and the relevant curtailments modes (Vestas designation – sound optimised modes 2, 3 and 5).

**Table 27: V112 3.3MW sound power levels – load optimised mode 1 – uncurtailed sound emissions**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 60.6 | 72.1 | 81.6 | 84.2 | 87.3 | 86.2 | 84.5 | 82.9 | 79.7 | 68.0 |
| 4 | 60.3 | 69.7 | 80.1 | 83.8 | 88.2 | 87.2 | 85.1 | 83.5 | 80.3 | 67.8 |
| 5 | 59.9 | 67.0 | 78.4 | 83.3 | 89.0 | 88.3 | 85.6 | 84.1 | 80.9 | 67.8 |
| 6 | 60.7 | 68.2 | 79.8 | 85.6 | 91.1 | 91.3 | 89.1 | 87.2 | 83.5 | 69.2 |
| 7 | 61.9 | 70.4 | 81.9 | 88.7 | 93.4 | 94.6 | 92.9 | 90.7 | 86.4 | 71.2 |
| 8 | 63.1 | 72.4 | 83.8 | 92.0 | 95.6 | 97.5 | 96.4 | 93.8 | 89.0 | 73.3 |
| 9 | 63.6 | 72.8 | 84.5 | 94.4 | 97.2 | 99.6 | 98.7 | 95.9 | 90.7 | 74.8 |
| 10 | 63.7 | 71.7 | 83.9 | 94.8 | 97.8 | 100.3 | 99.2 | 96.5 | 91.2 | 75.3 |
| 11 | 64.0 | 72.4 | 84.4 | 94.9 | 97.8 | 100.2 | 99.2 | 96.5 | 91.3 | 75.3 |
| 12 | 64.6 | 75.1 | 86.2 | 95.2 | 97.5 | 100.0 | 99.3 | 96.6 | 91.3 | 75.1 |
| 13 | 65.4 | 77.7 | 88.0 | 95.6 | 97.4 | 99.7 | 99.4 | 96.7 | 91.3 | 75.1 |

**Table 28: V112 3.3MW sound power levels – sound optimised mode 2**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 60.6 | 72.1 | 81.6 | 84.2 | 87.3 | 86.2 | 84.5 | 82.9 | 79.7 | 68.0 |
| 4 | 60.3 | 69.7 | 80.1 | 83.8 | 88.2 | 87.2 | 85.1 | 83.5 | 80.3 | 67.8 |
| 5 | 59.9 | 67.1 | 78.5 | 83.4 | 89.0 | 88.3 | 85.7 | 84.1 | 80.9 | 67.8 |
| 6 | 60.7 | 68.2 | 79.8 | 85.6 | 91.1 | 91.3 | 89.1 | 87.2 | 83.5 | 69.2 |
| 7 | 61.9 | 70.4 | 81.9 | 88.7 | 93.4 | 94.6 | 92.9 | 90.7 | 86.4 | 71.2 |
| 8 | 62.5 | 71.3 | 83.0 | 91.2 | 95.1 | 96.9 | 95.6 | 93.1 | 88.3 | 72.7 |
| 9 | 62.3 | 70.8 | 82.7 | 92.2 | 95.6 | 97.8 | 96.6 | 94.0 | 89.0 | 73.2 |
| 10 | 62.0 | 70.0 | 82.1 | 92.3 | 95.7 | 98.0 | 96.7 | 94.1 | 89.0 | 73.3 |
| 11 | 62.2 | 71.1 | 82.9 | 92.5 | 95.7 | 97.9 | 96.8 | 94.2 | 89.1 | 73.2 |
| 12 | 62.5 | 73.2 | 84.2 | 92.9 | 95.3 | 97.7 | 97.0 | 94.3 | 89.0 | 72.9 |
| 13 | 62.9 | 75.3 | 85.7 | 93.2 | 95.0 | 97.3 | 97.1 | 94.4 | 89.0 | 72.8 |

**Table 29: V112 3.3MW sound power levels – sound optimised mode 3**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 60.6 | 72.1 | 81.6 | 84.2 | 87.3 | 86.2 | 84.5 | 82.9 | 79.7 | 68.0 |
| 4 | 60.3 | 69.7 | 80.1 | 83.8 | 88.2 | 87.2 | 85.1 | 83.5 | 80.3 | 67.8 |
| 5 | 59.9 | 67.1 | 78.5 | 83.4 | 89.0 | 88.3 | 85.7 | 84.1 | 80.9 | 67.8 |
| 6 | 60.7 | 68.2 | 79.8 | 85.6 | 91.1 | 91.3 | 89.1 | 87.2 | 83.5 | 69.2 |
| 7 | 61.8 | 69.9 | 81.5 | 88.3 | 93.3 | 94.3 | 92.6 | 90.3 | 86.1 | 71.0 |
| 8 | 62.1 | 69.9 | 81.8 | 89.5 | 94.3 | 95.6 | 93.9 | 91.6 | 87.2 | 72.0 |
| 9 | 62.1 | 69.3 | 81.5 | 89.6 | 94.6 | 96.0 | 94.2 | 91.9 | 87.4 | 72.3 |
| 10 | 62.1 | 69.3 | 81.5 | 89.6 | 94.5 | 95.9 | 94.2 | 91.8 | 87.4 | 72.2 |
| 11 | 62.4 | 70.5 | 82.3 | 89.9 | 94.5 | 95.9 | 94.3 | 91.9 | 87.5 | 72.2 |
| 12 | 62.7 | 72.5 | 83.6 | 90.3 | 94.2 | 95.7 | 94.4 | 92.1 | 87.5 | 72.1 |
| 13 | 63.1 | 74.6 | 85.0 | 90.8 | 93.9 | 95.4 | 94.6 | 92.2 | 87.5 | 72.0 |

**Table 30: V112 3.3MW sound power levels – sound optimised mode 5**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 60.6 | 72.1 | 81.6 | 84.2 | 87.3 | 86.2 | 84.5 | 82.9 | 79.7 | 68.0 |
| 4 | 60.3 | 69.7 | 80.1 | 83.8 | 88.2 | 87.2 | 85.1 | 83.5 | 80.3 | 67.8 |
| 5 | 59.9 | 67.1 | 78.5 | 83.4 | 89.0 | 88.3 | 85.7 | 84.1 | 80.9 | 67.8 |
| 6 | 60.6 | 68.1 | 79.7 | 85.4 | 91.0 | 91.2 | 89.0 | 87.1 | 83.4 | 69.1 |
| 7 | 61.6 | 69.3 | 81.1 | 88.0 | 93.1 | 94.2 | 92.3 | 90.0 | 85.9 | 70.9 |
| 8 | 61.6 | 67.9 | 80.3 | 88.4 | 93.9 | 95.0 | 92.9 | 90.7 | 86.6 | 71.6 |
| 9 | 62.1 | 69.8 | 81.6 | 88.7 | 93.8 | 94.9 | 93.1 | 90.8 | 86.6 | 71.6 |
| 10 | 63.0 | 73.2 | 83.9 | 89.4 | 93.5 | 94.5 | 93.1 | 90.9 | 86.6 | 71.5 |
| 11 | 63.6 | 75.6 | 85.6 | 90.0 | 93.3 | 94.2 | 93.3 | 91.0 | 86.7 | 71.7 |
| 12 | 63.9 | 77.3 | 86.6 | 90.3 | 93.0 | 93.9 | 93.4 | 91.1 | 86.6 | 71.6 |
| 13 | 64.0 | 78.4 | 87.3 | 90.6 | 92.7 | 93.7 | 93.5 | 91.1 | 86.6 | 71.6 |

## F2 Vestas V117 3.45MW sound power levels

This section presents tabulated sound power level data for the uncurtailed mode of operation (Vestas designation – sound mode 0) and the relevant curtailments modes (Vestas designation – sound optimised modes 3 and 4).

**Table 31: V117 3.45MW sound power levels – sound optimised mode 0 – uncurtailed noise emissions**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 42.6 | 59.7 | 75.6 | 82.1 | 85.6 | 84.3 | 82.3 | 84.5 | 83.3 | 75.1 |
| 4 | 41.4 | 58.2 | 74.6 | 82.1 | 86.2 | 85.0 | 82.7 | 84.5 | 83.0 | 74.0 |
| 5 | 44.5 | 60.5 | 75.9 | 83.7 | 87.8 | 87.2 | 85.3 | 86.2 | 84.1 | 74.5 |
| 6 | 50.6 | 65.6 | 79.2 | 86.8 | 90.6 | 90.6 | 89.5 | 89.4 | 86.8 | 76.7 |
| 7 | 56.1 | 70.2 | 82.4 | 89.9 | 93.4 | 94.0 | 93.5 | 92.6 | 89.4 | 78.9 |
| 8 | 61.2 | 74.7 | 85.4 | 92.8 | 96.1 | 97.1 | 97.2 | 95.6 | 92.0 | 81.2 |
| 9 | 65.2 | 77.9 | 87.8 | 95.3 | 98.3 | 99.8 | 100.3 | 98.0 | 94.1 | 82.8 |
| 10 | 65.9 | 78.6 | 88.2 | 95.9 | 99.0 | 100.7 | 101.2 | 98.6 | 94.6 | 83.2 |
| 11 | 66.5 | 79.3 | 88.8 | 96.0 | 98.9 | 100.5 | 101.1 | 98.8 | 94.8 | 83.7 |
| 12 | 67.7 | 80.7 | 89.8 | 96.3 | 98.8 | 100.3 | 101.0 | 99.1 | 95.4 | 84.7 |
| 13 | 68.4 | 81.6 | 90.5 | 96.5 | 98.6 | 100.0 | 100.9 | 99.2 | 95.7 | 85.4 |

**Table 32: V117 3.45MW sound power levels – sound optimised mode 3**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 42.6 | 59.7 | 75.6 | 82.1 | 85.6 | 84.3 | 82.3 | 84.5 | 83.3 | 75.1 |
| 4 | 41.5 | 58.3 | 74.7 | 82.1 | 86.2 | 85.0 | 82.7 | 84.5 | 83.0 | 74.1 |
| 5 | 44.5 | 60.5 | 75.9 | 83.7 | 87.8 | 87.2 | 85.3 | 86.2 | 84.1 | 74.5 |
| 6 | 50.6 | 65.6 | 79.2 | 86.8 | 90.6 | 90.6 | 89.5 | 89.4 | 86.8 | 76.7 |
| 7 | 55.6 | 69.8 | 82.0 | 89.7 | 93.3 | 93.8 | 93.3 | 92.4 | 89.2 | 78.7 |
| 8 | 58.0 | 71.6 | 83.4 | 91.3 | 95.0 | 95.8 | 95.5 | 94.0 | 90.6 | 79.6 |
| 9 | 58.0 | 71.5 | 83.4 | 91.6 | 95.5 | 96.4 | 96.0 | 94.3 | 90.8 | 79.6 |
| 10 | 58.6 | 72.3 | 83.9 | 91.8 | 95.3 | 96.1 | 95.9 | 94.4 | 91.0 | 80.1 |
| 11 | 59.9 | 73.8 | 84.9 | 92.0 | 95.2 | 95.9 | 95.9 | 94.7 | 91.5 | 81.0 |
| 12 | 61.2 | 75.1 | 85.7 | 92.2 | 94.9 | 95.6 | 95.9 | 94.9 | 91.8 | 81.7 |
| 13 | 62.0 | 76.1 | 86.3 | 92.3 | 94.7 | 95.4 | 95.8 | 95.0 | 92.0 | 82.3 |

**Table 33: V117 3.45MW sound power levels – sound optimised mode 4**

| Hub Height Wind Speed | Octave Band Centre Frequency Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 16 | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 3 | 42.6 | 59.7 | 75.6 | 82.1 | 85.6 | 84.3 | 82.3 | 84.5 | 83.3 | 75.1 |
| 4 | 41.5 | 58.3 | 74.7 | 82.1 | 86.2 | 85.0 | 82.7 | 84.5 | 83.0 | 74.1 |
| 5 | 44.5 | 60.5 | 75.9 | 83.7 | 87.8 | 87.2 | 85.3 | 86.2 | 84.1 | 74.5 |
| 6 | 50.4 | 65.4 | 79.0 | 86.7 | 90.5 | 90.5 | 89.4 | 89.3 | 86.6 | 76.5 |
| 7 | 54.5 | 68.8 | 81.4 | 89.2 | 92.9 | 93.3 | 92.7 | 91.9 | 88.8 | 78.2 |
| 8 | 55.8 | 70.2 | 82.4 | 89.5 | 92.9 | 93.2 | 92.7 | 92.2 | 89.3 | 79.1 |
| 9 | 57.1 | 71.8 | 83.5 | 89.8 | 92.6 | 92.8 | 92.7 | 92.5 | 89.9 | 80.4 |
| 10 | 57.9 | 72.7 | 84.2 | 90.0 | 92.5 | 92.6 | 92.6 | 92.6 | 90.2 | 81.1 |
| 11 | 58.3 | 73.4 | 84.5 | 90.1 | 92.3 | 92.4 | 92.4 | 92.7 | 90.3 | 81.6 |
| 12 | 58.7 | 73.9 | 85.0 | 90.1 | 92.2 | 92.1 | 92.3 | 92.7 | 90.5 | 82.1 |
| 13 | 59.0 | 74.4 | 85.3 | 90.2 | 92.1 | 92.0 | 92.3 | 92.8 | 90.7 | 82.5 |

## APPENDIX G OUTLINE OPERATING STRATEGY

**Table 34: Turbine curtailment during daytime hours (0600 – 2200 hrs)**

| Turbine | Turbine type | Operating Mode | Wind Speed Range (m/s) | Wind Direction Range [A] (°) |
|---|---|---|---|---|
| T10 | V112-3.3MW | sound mode 2 | 10 to 11 | 300 to 120 |
| T15 | V112-3.3MW | sound mode 2 | 11 | 300 to 120 |
| T16 | V112-3.3MW | sound mode 2 | 10 to 11 | 300 to 120 |
| T17 | V112-3.3MW | sound mode 2 | 9 to 11 | 300 to 120 |
| T18 | V112-3.3MW | sound mode 2 | 9 to 11 | 320 to 120 |

Note A: clockwise from start to end of range

**Table 35: Turbine curtailment during night-time hours (2200 – 0600 hrs)**

| Turbine | Turbine type | Operating Mode | Wind Speed Range (m/s) | Wind Direction Range [A] (°) |
|---|---|---|---|---|
| T03 | V117-3.45MW | sound mode 4 | 9 to 25 | 180 to 360 |
| T04 | V117-3.45MW | sound mode 4 | 10 to 25 | 180 to 360 |
| T08 | V112-3.3MW | sound mode 5 | 9 to 11 | 300 to 160 |
| T09 | V112-3.3MW | sound mode 5 | 9 to 11 | 300 to 160 |
| T10 | V112-3.3MW | sound mode 5 | 9 to 11 | 300 to 160 |
| T15 | V112-3.3MW | sound mode 5 | 9 to 11 | 300 to 150 |
| T16 | V112-3.3MW | sound mode 5 | 9 to 25 | 300 to 150 |
| T17 | V112-3.3MW | sound mode 5 | 9 to 25 | 295 to 150 |
| T18 | V112-3.3MW | sound mode 5 | 9 to 25 | 320 to 150 |
| T19 | V112-3.3MW | sound mode 5 | 8 to 25 | 320 to 150 |
| T20 | V117-3.45MW | sound mode 4 | 9 to 11 | 320 to 150 |
| T30 | V117-3.45MW | sound mode 4 | 9 to 11 | 320 to 150 |
| T33 | V117-3.45MW | sound mode 4 | 9 to 12 | 160 to 20 |
| T37 | V117-3.45MW | sound mode 4 | 9 to 12 | 160 to 20 |
| T44 | V117-3.45MW | sound mode 4 | 8 to 25 | 140 to 20 |
| T45 | V117-3.45MW | sound mode 4 | 9 to 25 | 150 to 20 |
| T46 | V117-3.45MW | sound mode 4 | 8 to 25 | 150 to 20 |
| T47 | V117-3.45MW | sound mode 4 | 9 to 25 | 150 to 20 |
| T48 | V112-3.3MW | sound mode 5 | 9 to 12 | 150 to 20 |
| T49 | V112-3.3MW | sound mode 5 | 9 to 12 | 150 to 20 |
| T50 | V117-3.45MW | sound mode 4 | 8 to 25 | 135 to 30 |
| T51 | V117-3.45MW | sound mode 4 | 8 to 25 | 155 to 20 |

| Turbine | Turbine type | Operating Mode | Wind Speed Range (m/s) | Wind Direction Range [A] (°) |
|---|---|---|---|---|
| T52 | V117-3.45MW | sound mode 4 | 8 to 25 | 155 to 30 |
| T53 | V117-3.45MW | sound mode 4 | 8 to 25 | 140 to 20 |
| T54 | V112-3.3MW | sound mode 5 | 9 to 12 | 140 to 20 |
| T57 | V117-3.45MW | sound mode 4 | 9 to 12 | 100 to 20 |
| T58 | V117-3.45MW | sound mode 4 | 9 to 12 | 100 to 20 |
| T59 | V117-3.45MW | sound mode 4 | 9 to 12 | 100 to 20 |
| T60 | V117-3.45MW | sound mode 4 | 9 to 25 | 100 to 20 |
| T63 | V117-3.45MW | sound mode 4 | 9 to 25 | 155 to 20 |
| T64 | V117-3.45MW | sound mode 4 | 9 to 25 | 155 to 20 |
| T65 | V117-3.45MW | sound mode 4 | 9 to 25 | 155 to 20 |
| T69 | V112-3.3MW | sound mode 5 | 9 to 11 | 100 to 20 |

Note A: clockwise from start to end of range

## APPENDIX H OUTLINE NOISE COMPLIANCE TESTING PLAN

A formal Noise Compliance and Testing Plan (NCTP) report is to be prepared in advance of operational noise compliance measurements which will specify detailed measurement and analysis procedures to be used to determine whether noise levels comply with the Development Permit after the wind farm commences operation. The NCTP will be submitted for review by the relevant authority prior to commencement of the testing. In advance of this report, an outline of the proposed compliance measurement and analysis procedures has been prepared. Key elements of the proposed methodology are summarised in

**Table 36: Key element s of proposed measurement and analysis procedures**

| Item | Description |
|---|---|
| Measurements | In accordance with the Development Permit *measurements of operational noise from wind turbine generators for the operation shall be in accordance with Australian Standard AS4959-2010 Acoustics – Measurement, prediction and assessment of noise from wind turbine generators (AS4959-2010).*<br><br>AS 4959 specifies measurement two broad types of measurement procedures, based on either unattended measurements or attended measurements.<br><br>In order to assess noise levels across the wide range of operating conditions associated with the proposed Mt Emerald Wind Farm, the unattended measurement methodology is proposed to be adopted for the compliance testing.<br><br>Consistent with AS 4959 guidance, the objective of the measurements will be to obtain noise level data under downwind conditions. |
| Measurement locations | The measurements are proposed to be carried out at minimum of six (6) locations corresponding to the background noise monitoring locations used to derive the noise limits applicable to the wind farm. In recognition of the low noise limits which apply to the wind farm, and the practical difficulties that will be associated with measuring wind farm noise at these levels, additional monitoring locations may comprise intermediate locations between the wind farm and receiver locations. |
| Measurement duration | Noise measurements are proposed to occur for a minimum of four (4) weeks. Longer periods may be required to obtain data for all relevant wind speeds and directions. |
| Analysis | The analysis is proposed to be carried out on the basis of the statistical procedures of AS 4959, and consistent with accepted analysis procedures applied to wind farm projects throughout Australia. These procedures broadly include:<br><br>• Adoption of the $L_{A90}$ measurement parameter as a representation of the equivalent noise level $L_{Aeq}$. This is consistent with the assessment standard referenced during the planning stage of the project, and the procedures adopted in other Australian jurisdictions which utilise the $L_{Aeq}$ metric as the relevant assessment parameter.<br><br>• Regression analysis of the measured data according to the statistical procedures defined in AS 4959<br><br>• Limited corrections for background noise based on the data measured for the purpose of deriving background noise criteria |
| Special audible characteristics | An assessment of special audible characteristics is proposed to be undertaken using a combination of periodic attended observations and automated analysis of recorded audio data. The attended observations would be used to determine if the sound of the wind farm includes characteristics which require further objective analysis. Objective analysis would be used to determine whether any adjustments should be applied to account for special audible characteristics such as tonality, impulsivity and amplitude modulation. The analysis would be carried out for data obtained during attended observations, and automated processing of logged audio records during the surveys. Objective analysis would generally be carried out in accordance with ISO 1996-2, as referenced in AS 4959. |

## APPENDIX I TABULATED A-WEIGHTED NOISE LIMITS

**Table 37: Daytime receiver limits**

| Background monitoring location | Noise Limit @ corrected wind speed (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R02 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.4 | 38.1 | 38.6 | 39.0 | 39.1 | 39.1 |
| R05 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 38.5 | 40.7 |
| R36 | 37.0 | 37.0 | 37.0 | 37.0 | 37.9 | 39.0 | 40.1 | 40.9 | 41.5 | 41.6 | 41.6 |
| R48 | 37.0 | 37.0 | 38.2 | 39.6 | 40.9 | 42.1 | 43.1 | 43.8 | 44.3 | 44.4 | 44.4 |
| R49 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.6 | 38.8 | 39.7 | 40.4 | 40.6 | 40.6 |
| R78 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.3 | 38.8 | 40.0 | 40.5 | 40.5 | 40.5 |

**Table 38: Night-time receiver noise limits**

| Background monitoring location | Noise Limit @ corrected wind speed (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R02 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 36.8 | 39.9 |
| R05 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.4 | 38.0 | 41.4 |
| R36 | 35.0 | 35.0 | 35.0 | 35.0 | 35.2 | 35.6 | 36.0 | 36.5 | 37.0 | 37.5 | 38.1 |
| R48 | 35.0 | 35.0 | 35.1 | 35.3 | 35.5 | 35.7 | 35.9 | 36.3 | 36.8 | 37.6 | 38.8 |
| R49 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.3 | 36.5 |
| R78 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.6 | 37.1 | 38.7 |

**Table 39: Receiver locations represented by the background noise monitoring**

| Receiver | Representative monitoring location [A] | Approximate distance to representative monitoring location (m) |
|---|---|---|
| R06 | R05 | 720 |
| R26 | R78 | 456 |
| R30 | R36 | 988 |
| R32 | R36 | 725 |
| R33 | R36 | 1037 |
| R34 | R36 | 872 |
| R35 | R36 | 343 |
| R37 | R36 | 742 |
| R38 | R36 | 824 |
| R39 | R36 | 794 |
| R40 | R36 | 1062 |
| R41 | R48 | 907 |
| R42 | R48 | 859 |
| R43 | R48 | 568 |
| R44 | R48 | 664 |
| R45 | R48 | 418 |
| R46 | R48 | 460 |
| R47 | R48 | 325 |
| R57 | R49 | 1200 |
| R83 | R36 | 815 |

Note A: As detailed in Marshall Day Acoustics report titled Mt Emerald Wind Farm – Background Noise Monitoring reference Rp 001 R01 2015545ML, background noise monitoring was carried out in 2016 at receiver locations R02, R05, R36, R48, R49 and R78.

# APPENDIX J NOISE PREDICTION MODEL

## J1 Downwind conditions

Operational wind farm noise levels are predicted using a three-dimensional noise model generated in SoundPLAN® version 7.4 software. Specifically, predictions have been carried out using the SoundPLAN implementation of ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors Part 2: General method of calculation* (ISO 9613-2) to calculate noise propagation from the wind farm to each receiver location.

The use of this method is supported by international research publications and Marshall Day Acoustics own measurement studies.

The standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of +/-45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion. In this respect, it is noted that at the wind speeds relevant to noise levels from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to the ISO 9613-2, the noise levels of each turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence
- Air absorption
- Reflecting obstacles
- Screening
- Vegetation
- Ground reflections

The octave band attenuation factors are then applied to the sound power level data to determine the corresponding octave band and total calculated noise level at relevant receiver locations.

Calculating the attenuation factors for each effect requires a relevant description of the environment into which the sound propagation such as the physical dimensions of the environment, atmospheric conditions and the characteristics of the ground between the source and the receiver.

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination.

A number of Australian and international studies support the assignment of a ground factor of G=0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point. This ground factor of G=0.5 is adopted in combination with several cautious assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 degrees and relative humidity of 70 % (conditions which give rise to low atmospheric absorption). The studies demonstrate that applying the ISO 9613-2 prediction methodology in this way provides a reliable representation of the upper noise levels expected in practice.

The following specific adjustments have been made:

- In instances where the ground terrain provides marginal or partial acoustic screening, the barrier effect should be limited to not more than 2 dB
- Screening attenuation calculated on the basis of the source being located at the tip height of the turbine (in contrast to hub height in non-adjusted ISO 9613-2 predictions)
- In instances where the ground falls away significantly between the source and receiver, such as valleys, an adjustment of 3 dB should be added to the calculated sound pressure level. A terrain profile in which the ground falls away significantly is defined as one where the mean sound propagation height is at least 50 % greater than would occur over flat ground.

In support of the use of ISO 9613-2 and the choice of G=0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G=0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- NZS 6808:2010 refers to ISO 9613-2 as an appropriate prediction methodology for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of G=0.5
- In 1998, a comprehensive study, part funded by the European Commission, Development of a Wind Farm Noise Propagation Prediction Model[5] found that the ISO 9613-2 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613-2 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment, including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2 method as the appropriate standard and specifically designated G=0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (UK Institute of Acoustics guidance). It is noted that these publication specifically refer to predictions made at receiver heights of 4m in the interest of representing 2-storey dwellings which are more common in the UK. Predictions in Australia are generally based on a lower prediction height of 1.5m which tends to result in higher ground attenuation factors, however conversely, predictions in Australia do not generally incorporate a -2dB factor (as applied in the UK) to represent the relationship between $L_{Aeq}$ and $L_{A90}$ noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G=0.5 in the context of Australian prediction methodologies.
- A range of comparative measurement and prediction studies[6, 7, 8] for wind farms in which Marshall Day Acoustics' staff have been involved have provided further support for the use of ISO 9613-2 and G=0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

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[5] Bass, Bullmore and Sloth - *Development of a wind farm noise propagation prediction model*; Contract JOR3-CT95-0051, Final Report, January 1996 to May 1998.

[6] Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

[7] Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

The key findings of these studies demonstrated the suitability of the ISO 9613-2 method to predict the propagation of wind turbine noise for:

- The types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30 m maximum source heights original considered in ISO 9613-2
- The types of environments in which wind farms are typically developed, and the range of atmospheric conditions and wind speeds typically observed around wind farm sites. Importantly, this supports the extended scope of application to wind speeds in excess of 5m/s.

## J2 Directional noise modelling

The noise prediction methods commonly used in Australia do not enable the change in noise level with wind direction to be reliably predicted:

- ISO 9613-2 is one of the most common methods for calculating noise propagation from wind farms, but primarily relates to noise levels under atmospheric conditions which enhance sound propagation
- CONCAWE is another engineering method which is used in Australia for general noise predictions. It enables predictions for varied weather conditions and directions but is generally regarded as unsuitable for wind turbine noise prediction. Specifically, it is an empirical method which was developed for ground based sources associated with petroleum refineries, and the method tends to overestimate both downwind noise levels and the difference between downwind and neutral propagation conditions (e.g. cross-wind directions)
- Nord 2000 and IMAGINE are alternative European methods which combine empirical and theoretical methods for predicting environmental noise propagation. They are the most advanced and recent engineering prediction methods and enable noise predictions for varied weather conditions and directions. Industry adoption of these methods for wind farm noise prediction is limited and, to our knowledge, they have not been trialled in Australia.

In the absence of a ratified method for predicting wind direction effects on received noise levels, a cautious assessment has been made on the basis of a simplified set of definitions for downwind, crosswind and upwind conditions as described in the following subsections. The basis of the method is to apply adjustments to calculated downwind noise levels determined in accordance with ISO 9613-2, with the adjustments being determined according to the wind direction category (i.e. downwind, crosswind or upwind) and the distance between each receiver and turbine pairing.

The definitions and wind direction effects applied in this assessment are consistent with the recommendations of the UK Institute of Acoustics guidance. The general guidance on wind direction contained in the UK Institute of Acoustics guidance was reviewed as part of a research paper[9] which considered more advanced analytical methods of modelling the effects of atmospheric conditions. This research generally demonstrated that, with the exception of positions located at distances less than the typical separating distance of sensitive receiver locations, the more advanced prediction methods suggest higher levels of attenuation than the UK Institute of Acoustics guidance (i.e. providing further confidence in the UK Good Practice Guide values representing a cautious account of the effect of wind direction).

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[8] Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

[9] Bullmore, Sims, van Renterghem, Horoshenkov – *Wind Turbine Noise Propagation – Results of Numerical Modelling Techniques to Investigate Specific Scenarios*, International Meeting on Wind Turbine Noise in Glasgow, Scotland 2015

### J2.1 Definition of downwind propagation conditions

Wind speeds and directions which increase sound propagation from the turbines to the houses are termed downwind conditions. Under downwind conditions, the expected noise level from each turbine at each house is equal to the value predicted value according to ISO 9613-2 (with input parameters as described in the preceding section, including corrections for terrain features).

To provide a cautious account of changes in noise levels with wind direction, downwind conditions have been assumed to occur over a wide range of angles. Specifically, the range of these angles has been defined by assuming that downwind conditions occur for combinations of wind speeds and directions which equate to a vector wind speed of approximately 2 m/s in the direction from a turbine to receiver location.

While downwind propagation is frequently described in terms of wind speed and direction, the actual physical mechanism of downwind propagation relates to changes in wind speed with increasing height. A change in wind speed with height leads to a change in sound speed, in turn causing refraction of the sound wave (downwards refraction the case of sound travelling downwind). The relationship between wind direction and the sound speed profile in practice will be complex and vary considerably. It is for this reason that downwind conditions are described in simplified terms for noise propagation calculations and, similarly, why downwind conditions are assumed to occur even at relatively low downwind vector wind speeds.

Based on the above, a downwind propagation condition is considered to exist if the wind direction lies within a range of +/-80 degrees from a wind blowing directly from a turbine to a receiver location. That is, until the wind reaches a direction 10 degrees forward of a cross wind, the noise is assumed to equal that of the downwind level predicted according to ISO 9613-2.

### J2.2 Downwind vs crosswind propagation conditions

The calculation of noise levels under crosswind conditions is based on a maximum difference of 2 dB between noise levels occurring under downwind conditions and a cross-wind directly perpendicular to the line between a turbine and a receiver location. This value is consistent with expectations for an unscreened broad-band noise source propagating over relatively flat terrain.

In practice, this difference can be larger. In 1998, a comprehensive study, part funded by the European Commission *Development of a Wind Farm Noise Propagation Prediction Model* (the EC study) provided conclusions which stated:

> *At distances of 700m to 900m from the source, positive components of vector wind speed were found to increase the received noise level by up to 5dB(A) compared with the level measured under neutral propagation conditions.*

This maximum difference noted above relates to short term variations. The average difference is of the order of 2-3 dB.

Larger differences can also occur, particularly in complex environments or where the noise in question is dominated by distinct narrow frequencies bands. These types of factors are not applicable to the broad-band noise characteristics of a wind turbine, nor are they applicable to the proposed development site.

The adoption of a relatively small difference between noise levels under direct downwind and cross-wind conditions represents a cautious assumption.

### J2.3 Downwind vs upwind propagation conditions

The difference between noise levels occurring under downwind conditions and upwind conditions has been defined according to the values for complex landscapes defined in Table 40, as per the UK Institute of Acoustics guidance.

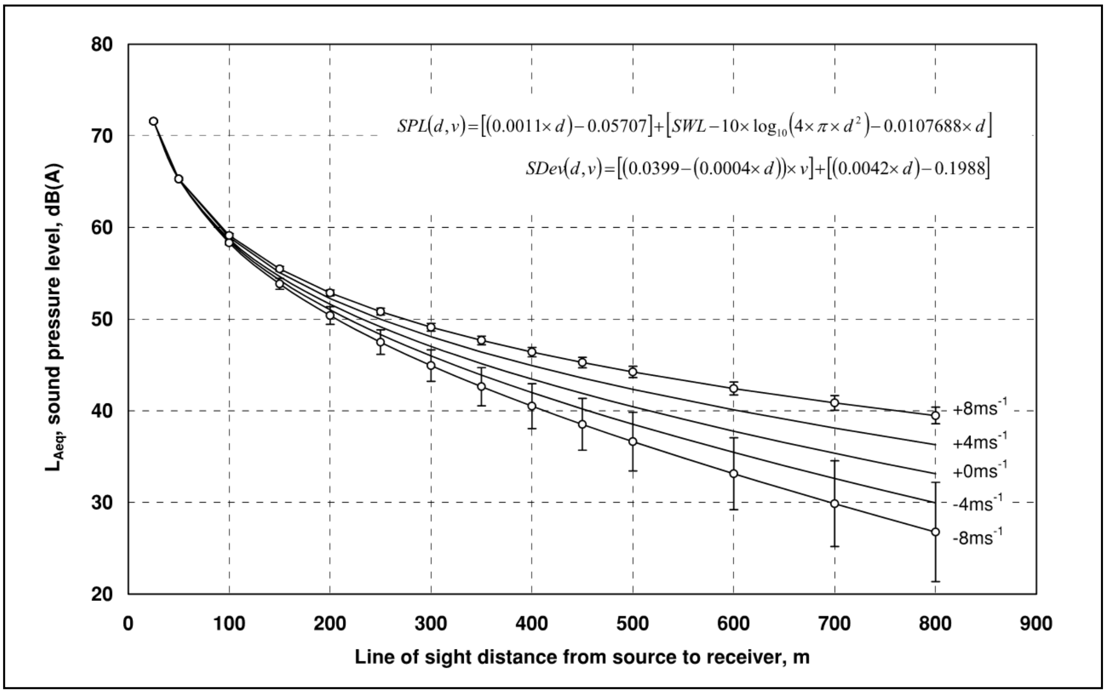
**Table 40: Maximum upwind attenuation values (dB) (difference between downwind and upwind attenuation)**

| Distance between turbine and receiver | Flat landscapes | Complex landscapes |
|---|---|---|
| ≤ 5.25 x maximum turbine tip height | 0 | 0 |
| 7.5 x maximum turbine tip height | 4.2 | 2.2 |
| 11 x maximum turbine tip height | 9 | 5 |
| 18 x maximum turbine tip height | 13 | 7.9 |

The level of turbine noise reaching a receiver under upwind conditions will be much more variable as a result of propagation being highly dependent on atmospheric turbulence and associated refraction and scattering effects. However, as an indication of the suitability of the values referred to in Table 40, reference is made to Figure 9-13 from the EC Study referenced in the UK Institute of Acoustics guidance. This data is reproduced in Figure 9 below and demonstrates the results of noise measurements made under varying wind speeds and directions ranging from vector wind speeds of +8 m/s (i.e. downwind conditions) to -8 m/s (i.e. from test location to sound source). Referring to the measurement data noted for the 700 m and 800 m distances, this chart demonstrates:

- Relatively little measurement variability under downwind directions compared to the high level of variability exhibited for upwind conditions;
- A difference of 5 dB or more between average noise levels measured under wind speeds of +4 m/s and -4 m/s;
- Differences ranging from 5 dB to more than 15 dB between noise levels measured under wind speeds of +8 m/s and -8m/s.

**Figure 9: Figure 9-13 from the EC Study**



Similar trends were demonstrated in the measurement data exhibited in the other studies referenced in this assessment. Specifically, measured differences between upwind and downwind noise levels from operational wind farms were typically greater than 10 dB, with reduced differences only occurring at locations where background noise was believed to have been the factor which limited the observed difference.

The values outlined in Table 40, in conjunction with minimum upwind attenuation values of 0-2 dB at the direction when upwind condition commence, have been used as the basis for interpolating the values of attenuation that apply to:

- The actual separating distance associated with each turbine-receiver pairing
- Upwind conditions other than a direct upwind direction (i.e. upwind directions other than a wind blowing directly from the receiver to the turbine location in question).

### J2.4 Propagation directivity

Based on the definitions provided in the preceding sections, and defining a relative wind direction[10] of 180 degrees as a wind blowing directly from a turbine to a receiver location (downwind), the proposed directivity relationship between noise levels and wind speed is summarised as follows:

- Wind directions between 100 degrees and 260 degrees: no reduction in noise levels assumed
- Wind directions 80 degrees and 100 degrees, and between 260 degrees and 280 degrees: 2 dB subtracted from the downwind predicted noise level
- Wind direction equal to 180 degrees: a value of between 0 dB and approximately 8 dB (based on the complex landscape attenuation rates) is subtracted from the downwind predicted noise, depending on the distance between the turbine and the receiver location in question.

Applying these attenuating factors at the defined wind directions, and interpolating over the intervening range for directions greater than 280 degrees and less than 80, a directional noise profile is produced, consistent the UK Institute of Acoustics guidance. For comparison purposes, the directional noise profiles for both flat and complex landscapes are presented in Figure 10 and Figure 11 respectively. The applicable profile used for modelling the noise of the Mt Emerald Wind Farm is the complex landscape directional profile illustrated in Figure 11.

[10] The relative wind direction being the angle between the actual wind direction and a line directed from a turbine to a receiver location.

Figure 10: Propagation directivity profile – flat landscape

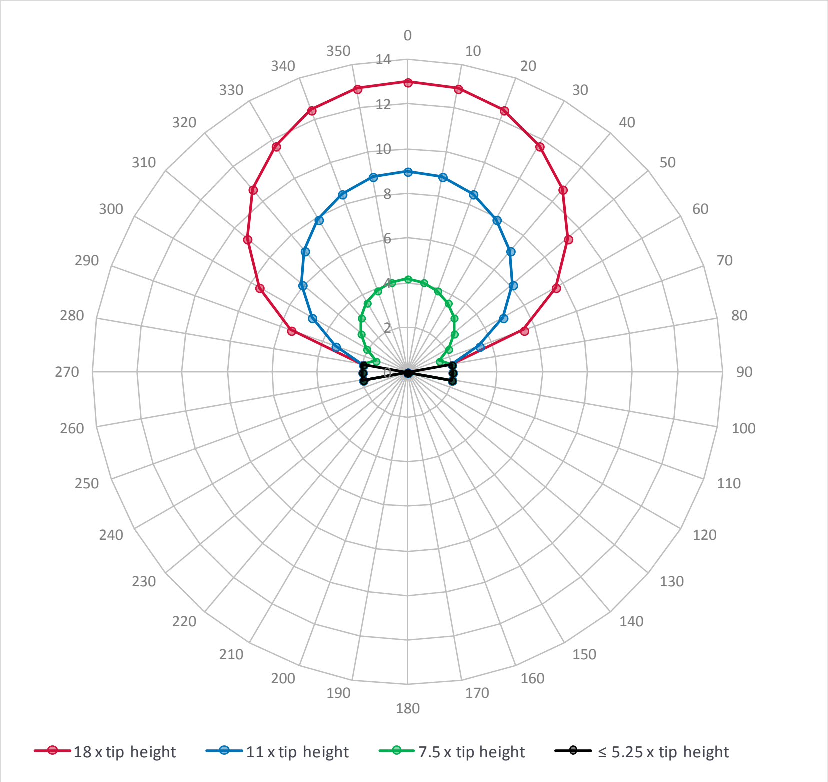
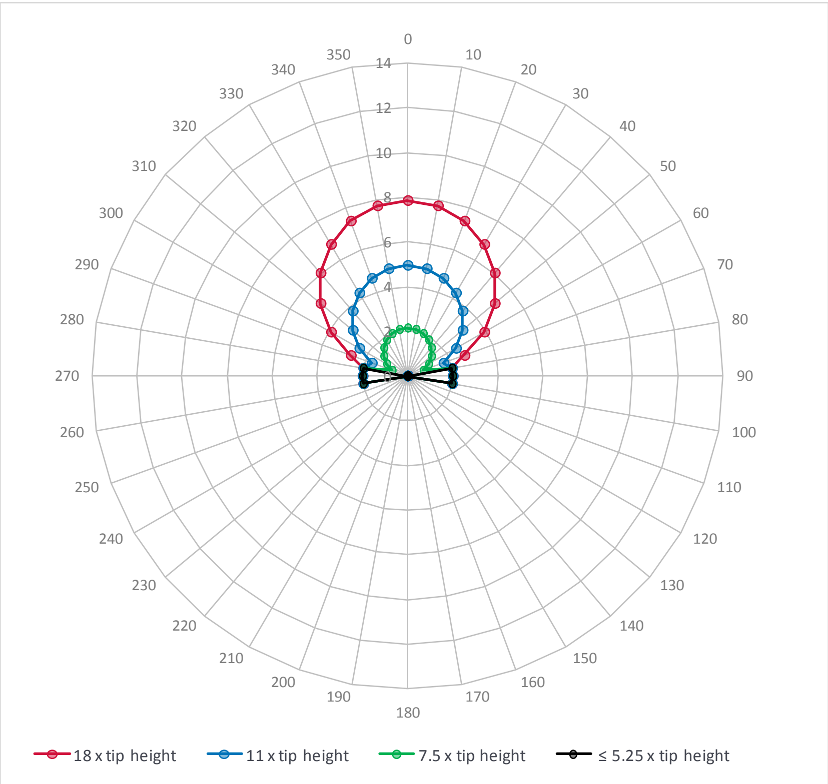



Figure 11: Propagation directivity profile – complex landscape



# APPENDIX K DOWNWIND NOISE MODELLING - TABULATED PREDICTED NOISE LEVEL DATA

## K1 Daytime predicted A-weighted noise levels

**Table 41: Daytime Predicted Noise Levels**

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R01 | West group curtailed | 17.3 | 16.9 | 17.5 | 20.3 | 23.2 | 26.1 | 28.3 | 28.8 | 29.0 | 29.5 | 29.8 |
| R02 | West group curtailed | 24.8 | 24.7 | 25.2 | 27.8 | 30.8 | 33.7 | 35.7 | 36.0 | 35.9 | 36.6 | 36.8 |
| R03 | West group curtailed | 22.4 | 22.1 | 22.6 | 25.2 | 28.1 | 30.9 | 33.0 | 33.3 | 33.3 | 34.0 | 34.2 |
| R04 | West group curtailed | 22.2 | 21.9 | 22.4 | 25.0 | 27.9 | 30.7 | 32.8 | 33.1 | 33.1 | 33.8 | 34.1 |
| R05 | West group curtailed | 26.1 | 26.0 | 26.5 | 29.1 | 32.1 | 35.0 | 36.7 | 36.9 | 36.8 | 37.9 | 38.0 |
| R06 | West group curtailed | 24.6 | 24.5 | 24.9 | 27.5 | 30.5 | 33.3 | 35.2 | 35.5 | 35.4 | 36.3 | 36.5 |
| R07 | West group curtailed | 23.1 | 22.9 | 23.4 | 25.9 | 28.9 | 31.7 | 33.6 | 33.9 | 33.9 | 34.7 | 34.9 |
| R08 | West group curtailed | 22.5 | 22.3 | 22.7 | 25.3 | 28.2 | 31.1 | 33.0 | 33.3 | 33.3 | 34.1 | 34.3 |
| R09 | West group curtailed | 21.8 | 21.5 | 21.9 | 24.5 | 27.5 | 30.3 | 32.3 | 32.6 | 32.6 | 33.4 | 33.6 |
| R10 | West group curtailed | 21.0 | 20.7 | 21.1 | 23.7 | 26.6 | 29.4 | 31.4 | 31.7 | 31.7 | 32.5 | 32.8 |
| R100 | No turbines curtailed | 19.5 | 19.1 | 19.8 | 22.7 | 25.7 | 28.5 | 30.8 | 31.4 | 31.6 | 32.0 | 32.4 |
| R101 | No turbines curtailed | 18.9 | 18.5 | 19.2 | 22.0 | 25.0 | 27.9 | 30.1 | 30.7 | 30.9 | 31.3 | 31.7 |
| R102 | No turbines curtailed | 20.1 | 19.8 | 20.6 | 23.4 | 26.4 | 29.3 | 31.6 | 32.2 | 32.4 | 32.8 | 33.1 |
| R103 | No turbines curtailed | 20.1 | 19.7 | 20.6 | 23.4 | 26.4 | 29.3 | 31.6 | 32.2 | 32.3 | 32.7 | 33.0 |
| R104 | No turbines curtailed | 20.6 | 20.3 | 21.2 | 24.0 | 27.1 | 30.0 | 32.3 | 32.9 | 33.0 | 33.4 | 33.7 |
| R11 | West group curtailed | 19.4 | 19.2 | 19.9 | 22.7 | 25.7 | 28.5 | 30.7 | 31.2 | 31.3 | 31.7 | 32.0 |
| R117 | West group curtailed | 18.7 | 18.2 | 18.5 | 21.1 | 24.0 | 26.8 | 28.8 | 29.2 | 29.3 | 30.0 | 30.4 |
| R118 | West group curtailed | 19.9 | 19.5 | 19.9 | 22.4 | 25.3 | 28.1 | 30.2 | 30.6 | 30.6 | 31.3 | 31.7 |
| R119 | West group curtailed | 19.8 | 19.4 | 19.7 | 22.3 | 25.2 | 28.0 | 30.0 | 30.4 | 30.5 | 31.2 | 31.5 |
| R12 | West group curtailed | 18.3 | 17.9 | 18.6 | 21.3 | 24.3 | 27.1 | 29.3 | 29.9 | 30.0 | 30.4 | 30.7 |
| R120 | West group curtailed | 19.9 | 19.5 | 19.8 | 22.4 | 25.3 | 28.1 | 30.1 | 30.5 | 30.5 | 31.2 | 31.6 |
| R121 | West group curtailed | 18.0 | 17.5 | 17.8 | 20.3 | 23.2 | 26.1 | 28.2 | 28.5 | 28.7 | 29.4 | 29.8 |
| R122 | No turbines curtailed | 12.2 | 11.7 | 12.2 | 15.0 | 18.0 | 20.9 | 23.1 | 23.7 | 23.9 | 24.4 | 24.8 |
| R123 | No turbines curtailed | 15.3 | 14.7 | 15.3 | 18.0 | 21.0 | 23.9 | 26.1 | 26.7 | 26.9 | 27.4 | 27.9 |
| R13 | West group curtailed | 23.0 | 22.8 | 23.3 | 25.9 | 28.9 | 31.7 | 33.8 | 34.2 | 34.1 | 34.7 | 34.9 |
| R14 | West group curtailed | 23.2 | 22.9 | 23.4 | 26.0 | 29.0 | 31.8 | 33.8 | 34.1 | 34.1 | 34.8 | 35.1 |
| R15 | West group curtailed | 21.7 | 21.4 | 21.9 | 24.5 | 27.4 | 30.2 | 32.3 | 32.7 | 32.7 | 33.3 | 33.6 |
| R16 | West group curtailed | 23.3 | 23.1 | 23.6 | 26.1 | 29.1 | 31.9 | 33.9 | 34.2 | 34.2 | 34.9 | 35.2 |
| R17 | West group curtailed | 20.1 | 19.7 | 20.1 | 22.6 | 25.5 | 28.3 | 30.4 | 30.8 | 30.8 | 31.5 | 31.8 |
| R18 | No turbines curtailed | 18.2 | 17.8 | 18.4 | 21.1 | 24.1 | 26.9 | 29.2 | 29.8 | 29.9 | 30.2 | 30.6 |
| R19 | No turbines curtailed | 18.0 | 17.7 | 18.4 | 21.1 | 24.1 | 27.0 | 29.3 | 29.8 | 29.9 | 30.3 | 30.6 |
| R21 | No turbines curtailed | 20.8 | 20.7 | 21.7 | 24.6 | 27.6 | 30.5 | 32.9 | 33.6 | 33.6 | 33.8 | 34.0 |
| R22 | No turbines curtailed | 20.4 | 20.2 | 21.2 | 24.1 | 27.1 | 30.0 | 32.4 | 33.0 | 33.1 | 33.4 | 33.6 |
| R23 | No turbines curtailed | 18.9 | 18.7 | 19.6 | 22.4 | 25.5 | 28.4 | 30.7 | 31.3 | 31.4 | 31.7 | 31.9 |
| R24 | No turbines curtailed | 20.9 | 20.7 | 21.7 | 24.6 | 27.6 | 30.5 | 32.9 | 33.5 | 33.6 | 33.9 | 34.1 |

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R25 | No turbines curtailed | 21.4 | 21.4 | 22.5 | 25.4 | 28.5 | 31.4 | 33.8 | 34.4 | 34.5 | 34.7 | 34.9 |
| R26 | No turbines curtailed | 22.6 | 22.6 | 23.7 | 26.7 | 29.8 | 32.8 | 35.2 | 35.9 | 35.9 | 36.0 | 36.1 |
| R27 | No turbines curtailed | 22.4 | 22.4 | 23.5 | 26.5 | 29.6 | 32.6 | 35.0 | 35.7 | 35.7 | 35.9 | 36.1 |
| R28 | No turbines curtailed | 22.6 | 22.5 | 23.6 | 26.5 | 29.6 | 32.6 | 35.0 | 35.6 | 35.7 | 35.9 | 36.1 |
| R29 | No turbines curtailed | 23.2 | 23.1 | 24.1 | 27.0 | 30.1 | 33.1 | 35.4 | 36.1 | 36.2 | 36.4 | 36.5 |
| R30 | No turbines curtailed | 23.9 | 23.8 | 25.0 | 27.9 | 31.1 | 34.0 | 36.4 | 37.1 | 37.1 | 37.3 | 37.5 |
| R31 | No turbines curtailed | 22.1 | 21.9 | 22.9 | 25.8 | 28.8 | 31.8 | 34.1 | 34.7 | 34.8 | 35.1 | 35.3 |
| R32 | No turbines curtailed | 24.1 | 24.0 | 25.3 | 28.3 | 31.4 | 34.4 | 36.8 | 37.5 | 37.5 | 37.7 | 37.8 |
| R33 | No turbines curtailed | 23.5 | 23.4 | 24.5 | 27.4 | 30.5 | 33.5 | 35.9 | 36.5 | 36.6 | 36.8 | 37.0 |
| R34 | No turbines curtailed | 23.4 | 23.3 | 24.5 | 27.4 | 30.5 | 33.4 | 35.8 | 36.5 | 36.6 | 36.8 | 36.9 |
| R35 | No turbines curtailed | 24.1 | 24.1 | 25.3 | 28.3 | 31.5 | 34.4 | 36.9 | 37.6 | 37.6 | 37.8 | 37.9 |
| R36 | No turbines curtailed | 24.4 | 24.4 | 25.7 | 28.7 | 31.8 | 34.8 | 37.2 | 37.9 | 37.9 | 38.1 | 38.2 |
| R37 | No turbines curtailed | 22.8 | 22.7 | 23.8 | 26.8 | 29.8 | 32.8 | 35.2 | 35.8 | 35.9 | 36.1 | 36.3 |
| R38 | No turbines curtailed | 23.0 | 22.9 | 24.0 | 27.0 | 30.1 | 33.0 | 35.4 | 36.1 | 36.1 | 36.4 | 36.5 |
| R39 | No turbines curtailed | 23.6 | 23.5 | 24.7 | 27.7 | 30.8 | 33.8 | 36.2 | 36.9 | 36.9 | 37.1 | 37.2 |
| R40 | No turbines curtailed | 22.7 | 22.6 | 23.8 | 26.7 | 29.8 | 32.7 | 35.1 | 35.8 | 35.8 | 36.1 | 36.3 |
| R41 | No turbines curtailed | 22.5 | 22.4 | 23.5 | 26.4 | 29.5 | 32.4 | 34.8 | 35.5 | 35.6 | 35.8 | 36.0 |
| R42 | No turbines curtailed | 22.3 | 22.1 | 23.2 | 26.1 | 29.2 | 32.1 | 34.5 | 35.1 | 35.2 | 35.5 | 35.7 |
| R43 | No turbines curtailed | 22.4 | 22.2 | 23.3 | 26.2 | 29.3 | 32.2 | 34.6 | 35.3 | 35.3 | 35.6 | 35.8 |
| R44 | No turbines curtailed | 21.9 | 21.7 | 22.7 | 25.6 | 28.7 | 31.6 | 34.0 | 34.6 | 34.7 | 35.0 | 35.2 |
| R45 | No turbines curtailed | 22.2 | 22.0 | 23.1 | 26.0 | 29.0 | 32.0 | 34.3 | 35.0 | 35.1 | 35.3 | 35.5 |
| R46 | No turbines curtailed | 22.9 | 22.8 | 24.0 | 26.9 | 30.0 | 32.9 | 35.3 | 36.0 | 36.1 | 36.3 | 36.4 |
| R47 | No turbines curtailed | 22.7 | 22.6 | 23.7 | 26.6 | 29.7 | 32.6 | 35.0 | 35.7 | 35.7 | 36.0 | 36.1 |
| R48 | No turbines curtailed | 22.7 | 22.6 | 23.7 | 26.6 | 29.7 | 32.6 | 35.0 | 35.7 | 35.7 | 36.0 | 36.2 |
| R49 | No turbines curtailed | 25.6 | 25.6 | 26.9 | 29.9 | 33.0 | 36.0 | 38.5 | 39.2 | 39.2 | 39.3 | 39.4 |
| R50 | No turbines curtailed | 21.0 | 20.8 | 21.7 | 24.6 | 27.6 | 30.5 | 32.8 | 33.4 | 33.5 | 33.9 | 34.2 |
| R51 | No turbines curtailed | 20.7 | 20.4 | 21.3 | 24.2 | 27.2 | 30.1 | 32.4 | 33.0 | 33.2 | 33.5 | 33.8 |
| R52 | No turbines curtailed | 20.0 | 19.7 | 20.6 | 23.4 | 26.4 | 29.3 | 31.6 | 32.2 | 32.4 | 32.8 | 33.1 |
| R53 | No turbines curtailed | 19.9 | 19.5 | 20.4 | 23.2 | 26.3 | 29.2 | 31.5 | 32.1 | 32.2 | 32.6 | 32.9 |
| R54 | No turbines curtailed | 19.9 | 19.6 | 20.4 | 23.3 | 26.3 | 29.2 | 31.5 | 32.1 | 32.2 | 32.6 | 32.9 |
| R55 | No turbines curtailed | 19.8 | 19.4 | 20.3 | 23.1 | 26.2 | 29.1 | 31.4 | 32.0 | 32.1 | 32.5 | 32.8 |
| R56 | No turbines curtailed | 18.7 | 18.3 | 19.1 | 21.9 | 24.9 | 27.8 | 30.1 | 30.7 | 30.8 | 31.3 | 31.6 |
| R57 | No turbines curtailed | 22.7 | 22.6 | 23.6 | 26.6 | 29.6 | 32.6 | 34.9 | 35.6 | 35.6 | 35.9 | 36.1 |
| R58 | No turbines curtailed | 21.5 | 21.3 | 22.3 | 25.2 | 28.3 | 31.2 | 33.6 | 34.2 | 34.3 | 34.6 | 34.8 |
| R59 | No turbines curtailed | 21.5 | 21.4 | 22.5 | 25.5 | 28.5 | 31.5 | 33.9 | 34.5 | 34.6 | 34.8 | 35.0 |
| R60 | No turbines curtailed | 20.6 | 20.5 | 21.6 | 24.5 | 27.5 | 30.5 | 32.8 | 33.5 | 33.5 | 33.8 | 34.0 |
| R61 | No turbines curtailed | 19.9 | 19.7 | 20.6 | 23.4 | 26.4 | 29.3 | 31.7 | 32.3 | 32.4 | 32.7 | 33.0 |
| R62 | No turbines curtailed | 20.8 | 20.6 | 21.6 | 24.5 | 27.6 | 30.5 | 32.8 | 33.5 | 33.5 | 33.8 | 34.0 |

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R63 | No turbines curtailed | 17.4 | 17.1 | 17.9 | 20.7 | 23.8 | 26.7 | 29.0 | 29.6 | 29.7 | 30.0 | 30.3 |
| R64 | No turbines curtailed | 18.3 | 18.0 | 18.8 | 21.6 | 24.7 | 27.5 | 29.9 | 30.5 | 30.6 | 31.0 | 31.3 |
| R65 | No turbines curtailed | 17.6 | 17.2 | 18.1 | 20.9 | 23.9 | 26.8 | 29.1 | 29.7 | 29.8 | 30.3 | 30.6 |
| R66 | No turbines curtailed | 16.8 | 16.5 | 17.4 | 20.2 | 23.2 | 26.1 | 28.4 | 29.0 | 29.2 | 29.5 | 29.8 |
| R67 | No turbines curtailed | 17.1 | 16.8 | 17.6 | 20.5 | 23.5 | 26.4 | 28.7 | 29.3 | 29.4 | 29.8 | 30.1 |
| R68 | No turbines curtailed | 17.0 | 16.6 | 17.5 | 20.3 | 23.3 | 26.2 | 28.5 | 29.1 | 29.2 | 29.6 | 30.0 |
| R69 | No turbines curtailed | 16.3 | 15.9 | 16.7 | 19.5 | 22.5 | 25.4 | 27.7 | 28.3 | 28.4 | 28.9 | 29.2 |
| R70 | No turbines curtailed | 16.1 | 15.7 | 16.5 | 19.3 | 22.4 | 25.2 | 27.5 | 28.1 | 28.3 | 28.7 | 29.1 |
| R71 | No turbines curtailed | 15.6 | 15.2 | 16.0 | 18.8 | 21.8 | 24.7 | 27.0 | 27.6 | 27.8 | 28.2 | 28.6 |
| R72 | No turbines curtailed | 15.2 | 14.8 | 15.6 | 18.4 | 21.4 | 24.3 | 26.6 | 27.2 | 27.4 | 27.9 | 28.2 |
| R73 | No turbines curtailed | 17.0 | 16.6 | 17.3 | 20.1 | 23.1 | 26.0 | 28.3 | 28.9 | 29.0 | 29.5 | 29.8 |
| R74 | No turbines curtailed | 16.3 | 15.9 | 16.6 | 19.5 | 22.5 | 25.3 | 27.6 | 28.2 | 28.4 | 28.8 | 29.2 |
| R75 | No turbines curtailed | 16.0 | 15.5 | 16.3 | 19.1 | 22.1 | 25.0 | 27.3 | 27.8 | 28.0 | 28.5 | 28.8 |
| R76 | No turbines curtailed | 15.8 | 15.3 | 16.0 | 18.8 | 21.8 | 24.7 | 27.0 | 27.5 | 27.7 | 28.2 | 28.6 |
| R77 | No turbines curtailed | 13.3 | 12.8 | 13.4 | 16.1 | 19.1 | 22.0 | 24.2 | 24.8 | 25.0 | 25.5 | 25.9 |
| R78 | No turbines curtailed | 23.8 | 23.9 | 24.9 | 27.8 | 30.9 | 33.9 | 36.3 | 36.9 | 36.9 | 37.1 | 37.2 |
| R79 | West group curtailed | 19.1 | 18.8 | 19.3 | 22.0 | 25.0 | 27.8 | 30.0 | 30.5 | 30.6 | 31.0 | 31.3 |
| R80 | West group curtailed | 19.4 | 19.2 | 19.9 | 22.7 | 25.7 | 28.6 | 30.8 | 31.4 | 31.5 | 31.8 | 32.1 |
| R81 | West group curtailed | 21.2 | 20.9 | 21.3 | 23.9 | 26.8 | 29.6 | 31.7 | 32.0 | 32.0 | 32.7 | 33.0 |
| R82 | No turbines curtailed | 22.7 | 22.6 | 23.7 | 26.7 | 29.7 | 32.7 | 35.1 | 35.7 | 35.8 | 36.0 | 36.2 |
| R83 | No turbines curtailed | 23.2 | 23.1 | 24.3 | 27.2 | 30.3 | 33.2 | 35.6 | 36.3 | 36.4 | 36.6 | 36.7 |
| R84 | No turbines curtailed | 21.4 | 21.3 | 22.4 | 25.3 | 28.4 | 31.3 | 33.7 | 34.3 | 34.4 | 34.6 | 34.8 |
| R89 | No turbines curtailed | 21.4 | 21.4 | 22.3 | 25.1 | 28.2 | 31.1 | 33.4 | 34.1 | 34.1 | 34.3 | 34.4 |
| R90 | No turbines curtailed | 19.5 | 19.3 | 20.2 | 23.0 | 26.0 | 28.9 | 31.2 | 31.9 | 31.9 | 32.2 | 32.4 |
| R91 | No turbines curtailed | 19.7 | 19.3 | 20.2 | 23.0 | 26.0 | 28.9 | 31.2 | 31.8 | 31.9 | 32.3 | 32.7 |
| R92 | No turbines curtailed | 19.2 | 18.8 | 19.5 | 22.3 | 25.4 | 28.2 | 30.5 | 31.1 | 31.3 | 31.7 | 32.1 |
| R93 | No turbines curtailed | 19.8 | 19.4 | 20.2 | 23.0 | 26.1 | 28.9 | 31.2 | 31.8 | 32.0 | 32.4 | 32.7 |
| R94 | No turbines curtailed | 19.4 | 19.0 | 19.8 | 22.6 | 25.6 | 28.5 | 30.8 | 31.4 | 31.5 | 32.0 | 32.3 |
| R95 | No turbines curtailed | 19.2 | 18.8 | 19.6 | 22.4 | 25.4 | 28.3 | 30.6 | 31.1 | 31.3 | 31.8 | 32.1 |
| R96 | No turbines curtailed | 19.3 | 18.8 | 19.6 | 22.4 | 25.4 | 28.3 | 30.6 | 31.2 | 31.3 | 31.8 | 32.1 |
| R97 | No turbines curtailed | 19.2 | 18.8 | 19.6 | 22.4 | 25.4 | 28.3 | 30.6 | 31.1 | 31.3 | 31.7 | 32.1 |
| R98 | No turbines curtailed | 18.8 | 18.4 | 19.1 | 21.9 | 24.9 | 27.8 | 30.1 | 30.7 | 30.8 | 31.3 | 31.7 |
| R99 | No turbines curtailed | 19.7 | 19.3 | 20.1 | 22.9 | 25.9 | 28.8 | 31.1 | 31.7 | 31.9 | 32.3 | 32.6 |
| RANGEVIEW | No turbines curtailed | 16.5 | 15.9 | 16.6 | 19.4 | 22.4 | 25.3 | 27.6 | 28.1 | 28.3 | 28.8 | 29.2 |
| WALKAMIN | No turbines curtailed | 19.1 | 18.7 | 19.4 | 22.2 | 25.2 | 28.1 | 30.4 | 31.0 | 31.1 | 31.6 | 32.0 |

## K2 Night-time predicted A-weighted noise levels

**Table 42: Night-time Predicted Noise Levels**

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R01 | West group curtailed | 17.3 | 16.9 | 17.5 | 20.3 | 23.2 | 26.1 | 27.9 | 28.5 | 28.6 | 29.4 | 29.7 |
| R02 | West group curtailed | 24.8 | 24.7 | 25.2 | 27.8 | 30.8 | 33.6 | 33.9 | 34.5 | 34.6 | 36.2 | 36.4 |
| R03 | West group curtailed | 22.4 | 22.1 | 22.6 | 25.2 | 28.1 | 30.9 | 31.6 | 32.2 | 32.3 | 33.6 | 33.8 |
| R04 | West group curtailed | 22.2 | 21.9 | 22.4 | 25.0 | 27.9 | 30.7 | 31.5 | 32.0 | 32.2 | 33.4 | 33.7 |
| R05 | West group curtailed | 26.1 | 26.0 | 26.5 | 29.1 | 32.1 | 34.9 | 34.6 | 35.0 | 35.2 | 36.6 | 36.7 |
| R06 | West group curtailed | 24.6 | 24.5 | 24.9 | 27.5 | 30.5 | 33.2 | 33.4 | 33.9 | 34.0 | 35.3 | 35.5 |
| R07 | West group curtailed | 23.1 | 22.9 | 23.4 | 25.9 | 28.9 | 31.5 | 31.8 | 32.3 | 32.5 | 33.9 | 34.1 |
| R08 | West group curtailed | 22.5 | 22.3 | 22.7 | 25.3 | 28.2 | 30.9 | 31.4 | 32.0 | 32.2 | 33.4 | 33.6 |
| R09 | West group curtailed | 21.8 | 21.5 | 21.9 | 24.5 | 27.5 | 30.3 | 30.9 | 31.5 | 31.6 | 32.8 | 33.1 |
| R10 | West group curtailed | 21.0 | 20.7 | 21.1 | 23.7 | 26.6 | 29.3 | 30.1 | 30.7 | 30.9 | 31.9 | 32.2 |
| R100 | Northeast group curtailed | 19.5 | 19.1 | 19.8 | 22.7 | 25.7 | 28.1 | 28.5 | 28.8 | 29.0 | 29.5 | 30.7 |
| R101 | Northeast group curtailed | 18.9 | 18.5 | 19.2 | 22.0 | 25.0 | 27.5 | 27.9 | 28.2 | 28.4 | 28.9 | 30.1 |
| R102 | Northeast group curtailed | 20.1 | 19.8 | 20.6 | 23.4 | 26.4 | 28.8 | 29.1 | 29.4 | 29.6 | 30.1 | 31.3 |
| R103 | Northeast group curtailed | 20.1 | 19.7 | 20.6 | 23.4 | 26.4 | 28.8 | 29.0 | 29.4 | 29.6 | 30.1 | 31.3 |
| R104 | Northeast group curtailed | 20.6 | 20.3 | 21.2 | 24.0 | 27.1 | 29.5 | 29.5 | 29.9 | 30.1 | 30.5 | 31.8 |
| R11 | West group curtailed | 19.4 | 19.2 | 19.9 | 22.7 | 25.7 | 28.5 | 30.0 | 30.7 | 30.8 | 31.5 | 31.7 |
| R117 | West group curtailed | 18.7 | 18.2 | 18.5 | 21.1 | 24.0 | 26.7 | 27.8 | 28.4 | 28.6 | 29.8 | 30.1 |
| R118 | West group curtailed | 19.9 | 19.5 | 19.9 | 22.4 | 25.3 | 28.1 | 29.0 | 29.6 | 29.9 | 31.0 | 31.4 |
| R119 | West group curtailed | 19.8 | 19.4 | 19.7 | 22.3 | 25.2 | 27.9 | 28.9 | 29.5 | 29.7 | 30.9 | 31.2 |
| R12 | West group curtailed | 18.3 | 17.9 | 18.6 | 21.3 | 24.3 | 27.1 | 29.0 | 29.6 | 29.8 | 30.3 | 30.6 |
| R120 | West group curtailed | 19.9 | 19.5 | 19.8 | 22.4 | 25.3 | 28.0 | 29.0 | 29.6 | 29.8 | 31.0 | 31.3 |
| R121 | West group curtailed | 18.0 | 17.5 | 17.8 | 20.3 | 23.2 | 26.0 | 27.3 | 27.9 | 28.1 | 29.2 | 29.6 |
| R122 | Northeast group curtailed | 12.2 | 11.7 | 12.2 | 15.0 | 18.0 | 20.4 | 21.2 | 21.7 | 21.9 | 22.5 | 23.6 |
| R123 | Northeast group curtailed | 15.3 | 14.7 | 15.3 | 18.0 | 21.0 | 23.3 | 23.7 | 24.1 | 24.3 | 24.9 | 26.2 |
| R13 | West group curtailed | 23.0 | 22.8 | 23.3 | 25.9 | 28.9 | 31.7 | 32.3 | 32.9 | 33.0 | 34.4 | 34.6 |
| R14 | West group curtailed | 23.2 | 22.9 | 23.4 | 26.0 | 29.0 | 31.7 | 32.3 | 32.8 | 33.0 | 34.3 | 34.5 |
| R15 | West group curtailed | 21.7 | 21.4 | 21.9 | 24.5 | 27.4 | 30.2 | 30.9 | 31.5 | 31.7 | 33.0 | 33.3 |
| R16 | West group curtailed | 23.3 | 23.1 | 23.6 | 26.1 | 29.1 | 31.8 | 32.4 | 32.9 | 33.1 | 34.4 | 34.6 |
| R17 | West group curtailed | 20.1 | 19.7 | 20.1 | 22.6 | 25.5 | 28.3 | 29.2 | 29.8 | 30.0 | 31.2 | 31.6 |
| R18 | Northeast group curtailed | 18.2 | 17.8 | 18.4 | 21.1 | 24.1 | 26.9 | 28.5 | 28.7 | 28.8 | 29.2 | 29.7 |
| R19 | Northeast group curtailed | 18.0 | 17.7 | 18.4 | 21.1 | 24.1 | 26.9 | 28.5 | 28.8 | 28.9 | 29.3 | 29.7 |
| R21 | Northeast group curtailed | 20.8 | 20.7 | 21.7 | 24.6 | 27.6 | 30.4 | 30.9 | 31.1 | 31.2 | 31.8 | 32.4 |
| R22 | Northeast group curtailed | 20.4 | 20.2 | 21.2 | 24.1 | 27.1 | 29.9 | 30.1 | 30.4 | 30.5 | 31.0 | 31.7 |
| R23 | Northeast group curtailed | 18.9 | 18.7 | 19.6 | 22.4 | 25.5 | 28.2 | 28.7 | 29.0 | 29.1 | 29.6 | 30.3 |
| R24 | Northeast group curtailed | 20.9 | 20.7 | 21.7 | 24.6 | 27.6 | 30.3 | 30.6 | 30.5 | 30.6 | 31.2 | 32.1 |
| R25 | Northeast group curtailed | 21.4 | 21.4 | 22.5 | 25.4 | 28.5 | 31.2 | 31.3 | 31.2 | 31.3 | 31.8 | 32.7 |

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R26 | Northeast group curtailed | 22.6 | 22.6 | 23.7 | 26.7 | 29.8 | 32.7 | 33.4 | 33.5 | 33.6 | 34.0 | 34.6 |
| R27 | Northeast group curtailed | 22.4 | 22.4 | 23.5 | 26.5 | 29.6 | 32.4 | 32.1 | 32.2 | 32.3 | 32.7 | 33.6 |
| R28 | Northeast group curtailed | 22.6 | 22.5 | 23.6 | 26.5 | 29.6 | 32.3 | 32.2 | 32.4 | 32.5 | 32.9 | 33.9 |
| R29 | Northeast group curtailed | 23.2 | 23.1 | 24.1 | 27.0 | 30.1 | 32.7 | 32.4 | 32.6 | 32.7 | 33.1 | 34.0 |
| R30 | Northeast group curtailed | 23.9 | 23.8 | 25.0 | 27.9 | 31.1 | 33.6 | 32.8 | 33.0 | 33.1 | 33.5 | 34.7 |
| R31 | Northeast group curtailed | 22.1 | 21.9 | 22.9 | 25.8 | 28.8 | 31.4 | 31.3 | 31.5 | 31.6 | 32.1 | 33.3 |
| R32 | Northeast group curtailed | 24.1 | 24.0 | 25.3 | 28.3 | 31.4 | 34.0 | 32.8 | 33.0 | 33.1 | 33.5 | 35.0 |
| R33 | Northeast group curtailed | 23.5 | 23.4 | 24.5 | 27.4 | 30.5 | 33.1 | 32.6 | 32.8 | 32.9 | 33.3 | 34.7 |
| R34 | Northeast group curtailed | 23.4 | 23.3 | 24.5 | 27.4 | 30.5 | 33.0 | 32.5 | 32.7 | 32.8 | 33.2 | 34.6 |
| R35 | Northeast group curtailed | 24.1 | 24.1 | 25.3 | 28.3 | 31.5 | 34.0 | 32.9 | 33.1 | 33.2 | 33.5 | 35.1 |
| R36 | Northeast group curtailed | 24.4 | 24.4 | 25.7 | 28.7 | 31.8 | 34.3 | 33.0 | 33.3 | 33.3 | 33.7 | 35.1 |
| R37 | Northeast group curtailed | 22.8 | 22.7 | 23.8 | 26.8 | 29.8 | 32.3 | 31.6 | 31.9 | 32.0 | 32.4 | 33.8 |
| R38 | Northeast group curtailed | 23.0 | 22.9 | 24.0 | 27.0 | 30.1 | 32.5 | 31.9 | 32.2 | 32.3 | 32.6 | 34.1 |
| R39 | Northeast group curtailed | 23.6 | 23.5 | 24.7 | 27.7 | 30.8 | 33.1 | 32.3 | 32.6 | 32.7 | 33.0 | 34.6 |
| R40 | Northeast group curtailed | 22.7 | 22.6 | 23.8 | 26.7 | 29.8 | 32.2 | 31.7 | 32.0 | 32.1 | 32.5 | 33.9 |
| R41 | Northeast group curtailed | 22.5 | 22.4 | 23.5 | 26.4 | 29.5 | 31.8 | 31.3 | 31.7 | 31.8 | 32.2 | 33.6 |
| R42 | Northeast group curtailed | 22.3 | 22.1 | 23.2 | 26.1 | 29.2 | 31.5 | 31.1 | 31.4 | 31.6 | 31.9 | 33.3 |
| R43 | Northeast group curtailed | 22.4 | 22.2 | 23.3 | 26.2 | 29.3 | 31.6 | 31.2 | 31.6 | 31.7 | 32.1 | 33.5 |
| R44 | Northeast group curtailed | 21.9 | 21.7 | 22.7 | 25.6 | 28.7 | 31.0 | 30.8 | 31.1 | 31.3 | 31.7 | 33.1 |
| R45 | Northeast group curtailed | 22.2 | 22.0 | 23.1 | 26.0 | 29.0 | 31.3 | 30.9 | 31.2 | 31.4 | 31.7 | 33.2 |
| R46 | Northeast group curtailed | 22.9 | 22.8 | 24.0 | 26.9 | 30.0 | 32.2 | 31.5 | 31.8 | 31.9 | 32.3 | 33.9 |
| R47 | Northeast group curtailed | 22.7 | 22.6 | 23.7 | 26.6 | 29.7 | 31.9 | 31.3 | 31.6 | 31.7 | 32.1 | 33.6 |
| R48 | Northeast group curtailed | 22.7 | 22.6 | 23.7 | 26.6 | 29.7 | 31.9 | 31.3 | 31.6 | 31.8 | 32.1 | 33.6 |
| R49 | Northeast group curtailed | 25.6 | 25.6 | 26.9 | 29.9 | 33.0 | 34.8 | 34.3 | 34.6 | 34.7 | 34.9 | 36.5 |
| R50 | Northeast group curtailed | 21.0 | 20.8 | 21.7 | 24.6 | 27.6 | 29.9 | 30.0 | 30.4 | 30.6 | 31.0 | 32.3 |
| R51 | Northeast group curtailed | 20.7 | 20.4 | 21.3 | 24.2 | 27.2 | 29.5 | 29.7 | 30.1 | 30.2 | 30.7 | 31.9 |
| R52 | Northeast group curtailed | 20.0 | 19.7 | 20.6 | 23.4 | 26.4 | 28.7 | 28.9 | 29.3 | 29.5 | 29.9 | 31.2 |
| R53 | Northeast group curtailed | 19.9 | 19.5 | 20.4 | 23.2 | 26.3 | 28.5 | 28.7 | 29.1 | 29.3 | 29.8 | 31.1 |
| R54 | Northeast group curtailed | 19.9 | 19.6 | 20.4 | 23.3 | 26.3 | 28.6 | 28.8 | 29.2 | 29.4 | 29.8 | 31.1 |
| R55 | Northeast group curtailed | 19.8 | 19.4 | 20.3 | 23.1 | 26.2 | 28.4 | 28.6 | 29.0 | 29.2 | 29.6 | 30.9 |
| R56 | Northeast group curtailed | 18.7 | 18.3 | 19.1 | 21.9 | 24.9 | 27.2 | 27.5 | 27.9 | 28.1 | 28.6 | 29.9 |
| R57 | Northeast group curtailed | 22.7 | 22.6 | 23.6 | 26.6 | 29.6 | 31.7 | 31.3 | 31.7 | 31.8 | 32.2 | 33.7 |
| R58 | Northeast group curtailed | 21.5 | 21.3 | 22.3 | 25.2 | 28.3 | 30.4 | 30.2 | 30.6 | 30.8 | 31.1 | 32.5 |
| R59 | Northeast group curtailed | 21.5 | 21.4 | 22.5 | 25.5 | 28.5 | 30.4 | 30.1 | 30.5 | 30.6 | 30.9 | 32.3 |
| R60 | Northeast group curtailed | 20.6 | 20.5 | 21.6 | 24.5 | 27.5 | 29.6 | 29.1 | 29.5 | 29.6 | 29.9 | 31.3 |
| R61 | Northeast group curtailed | 19.9 | 19.7 | 20.6 | 23.4 | 26.4 | 28.6 | 28.4 | 28.7 | 28.9 | 29.3 | 30.6 |
| R62 | Northeast group curtailed | 20.8 | 20.6 | 21.6 | 24.5 | 27.6 | 29.6 | 29.2 | 29.6 | 29.7 | 30.1 | 31.5 |
| R63 | Northeast group curtailed | 17.4 | 17.1 | 17.9 | 20.7 | 23.8 | 25.8 | 26.1 | 26.5 | 26.7 | 27.0 | 28.2 |

| House | Operating scenario | Hub Height wind speeds (m/s) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| R64 | Northeast group curtailed | 18.3 | 18.0 | 18.8 | 21.6 | 24.7 | 26.8 | 26.5 | 26.9 | 27.1 | 27.5 | 28.9 |
| R65 | Northeast group curtailed | 17.6 | 17.2 | 18.1 | 20.9 | 23.9 | 26.1 | 26.2 | 26.6 | 26.9 | 27.3 | 28.6 |
| R66 | Northeast group curtailed | 16.8 | 16.5 | 17.4 | 20.2 | 23.2 | 25.4 | 25.5 | 25.9 | 26.1 | 26.5 | 27.6 |
| R67 | Northeast group curtailed | 17.1 | 16.8 | 17.6 | 20.5 | 23.5 | 25.6 | 25.4 | 25.8 | 26.0 | 26.4 | 27.8 |
| R68 | Northeast group curtailed | 17.0 | 16.6 | 17.5 | 20.3 | 23.3 | 25.4 | 25.2 | 25.6 | 25.8 | 26.2 | 27.7 |
| R69 | Northeast group curtailed | 16.3 | 15.9 | 16.7 | 19.5 | 22.5 | 24.7 | 24.7 | 25.1 | 25.3 | 25.7 | 27.0 |
| R70 | Northeast group curtailed | 16.1 | 15.7 | 16.5 | 19.3 | 22.4 | 24.5 | 24.5 | 24.9 | 25.1 | 25.5 | 26.8 |
| R71 | Northeast group curtailed | 15.6 | 15.2 | 16.0 | 18.8 | 21.8 | 23.9 | 24.1 | 24.5 | 24.7 | 25.2 | 26.3 |
| R72 | Northeast group curtailed | 15.2 | 14.8 | 15.6 | 18.4 | 21.4 | 23.6 | 23.7 | 24.1 | 24.3 | 24.8 | 26.0 |
| R73 | Northeast group curtailed | 17.0 | 16.6 | 17.3 | 20.1 | 23.1 | 25.3 | 25.1 | 25.5 | 25.7 | 26.1 | 27.6 |
| R74 | Northeast group curtailed | 16.3 | 15.9 | 16.6 | 19.5 | 22.5 | 24.5 | 24.4 | 24.8 | 25.1 | 25.5 | 27.0 |
| R75 | Northeast group curtailed | 16.0 | 15.5 | 16.3 | 19.1 | 22.1 | 24.2 | 24.0 | 24.5 | 24.7 | 25.2 | 26.6 |
| R76 | Northeast group curtailed | 15.8 | 15.3 | 16.0 | 18.8 | 21.8 | 24.0 | 24.0 | 24.4 | 24.7 | 25.1 | 26.5 |
| R77 | Northeast group curtailed | 13.3 | 12.8 | 13.4 | 16.1 | 19.1 | 21.5 | 22.2 | 22.7 | 22.9 | 23.4 | 24.5 |
| R78 | Northeast group curtailed | 23.8 | 23.9 | 24.9 | 27.8 | 30.9 | 33.8 | 33.9 | 34.0 | 34.1 | 35.0 | 35.7 |
| R79 | West group curtailed | 19.1 | 18.8 | 19.3 | 22.0 | 25.0 | 27.8 | 29.5 | 30.1 | 30.3 | 30.9 | 31.2 |
| R80 | West group curtailed | 19.4 | 19.2 | 19.9 | 22.7 | 25.7 | 28.5 | 30.5 | 31.1 | 31.2 | 31.7 | 31.9 |
| R81 | West group curtailed | 21.2 | 20.9 | 21.3 | 23.9 | 26.8 | 29.6 | 30.2 | 30.8 | 31.0 | 32.4 | 32.6 |
| R82 | Northeast group curtailed | 22.7 | 22.6 | 23.7 | 26.7 | 29.7 | 32.4 | 32.2 | 32.4 | 32.5 | 32.9 | 33.9 |
| R83 | Northeast group curtailed | 23.2 | 23.1 | 24.3 | 27.2 | 30.3 | 32.7 | 32.0 | 32.3 | 32.4 | 32.8 | 34.2 |
| R84 | Northeast group curtailed | 21.4 | 21.3 | 22.4 | 25.3 | 28.4 | 31.1 | 31.1 | 31.0 | 31.1 | 31.7 | 32.5 |
| R89 | Northeast group curtailed | 21.4 | 21.4 | 22.3 | 25.1 | 28.2 | 31.0 | 32.5 | 32.7 | 32.7 | 32.9 | 33.3 |
| R90 | Northeast group curtailed | 19.5 | 19.3 | 20.2 | 23.0 | 26.0 | 28.9 | 30.6 | 31.0 | 31.1 | 31.3 | 31.7 |
| R91 | Northeast group curtailed | 19.7 | 19.3 | 20.2 | 23.0 | 26.0 | 28.3 | 28.6 | 29.0 | 29.2 | 29.6 | 30.9 |
| R92 | Northeast group curtailed | 19.2 | 18.8 | 19.5 | 22.3 | 25.4 | 27.7 | 28.0 | 28.4 | 28.6 | 29.1 | 30.4 |
| R93 | Northeast group curtailed | 19.8 | 19.4 | 20.2 | 23.0 | 26.1 | 28.4 | 28.7 | 29.1 | 29.3 | 29.8 | 31.0 |
| R94 | Northeast group curtailed | 19.4 | 19.0 | 19.8 | 22.6 | 25.6 | 28.0 | 28.3 | 28.7 | 28.9 | 29.4 | 30.6 |
| R95 | Northeast group curtailed | 19.2 | 18.8 | 19.6 | 22.4 | 25.4 | 27.8 | 28.1 | 28.5 | 28.7 | 29.2 | 30.4 |
| R96 | Northeast group curtailed | 19.3 | 18.8 | 19.6 | 22.4 | 25.4 | 27.8 | 28.1 | 28.5 | 28.7 | 29.2 | 30.4 |
| R97 | Northeast group curtailed | 19.2 | 18.8 | 19.6 | 22.4 | 25.4 | 27.8 | 28.1 | 28.5 | 28.7 | 29.2 | 30.4 |
| R98 | Northeast group curtailed | 18.8 | 18.4 | 19.1 | 21.9 | 24.9 | 27.3 | 27.7 | 28.1 | 28.3 | 28.8 | 30.0 |
| R99 | Northeast group curtailed | 19.7 | 19.3 | 20.1 | 22.9 | 25.9 | 28.4 | 28.7 | 29.1 | 29.3 | 29.7 | 30.9 |
| RANGEVIEW | Northeast group curtailed | 16.5 | 15.9 | 16.6 | 19.4 | 22.4 | 24.7 | 25.1 | 25.5 | 25.8 | 26.3 | 27.5 |
| WALKAMIN | Northeast group curtailed | 19.1 | 18.7 | 19.4 | 22.2 | 25.2 | 27.7 | 28.1 | 28.4 | 28.6 | 29.1 | 30.3 |

# APPENDIX L DIRECTIONAL NOISE MODELLING RESULTS

## L1 Receiver location R02

**Figure 12: Hub-height wind speed 8 m/s**

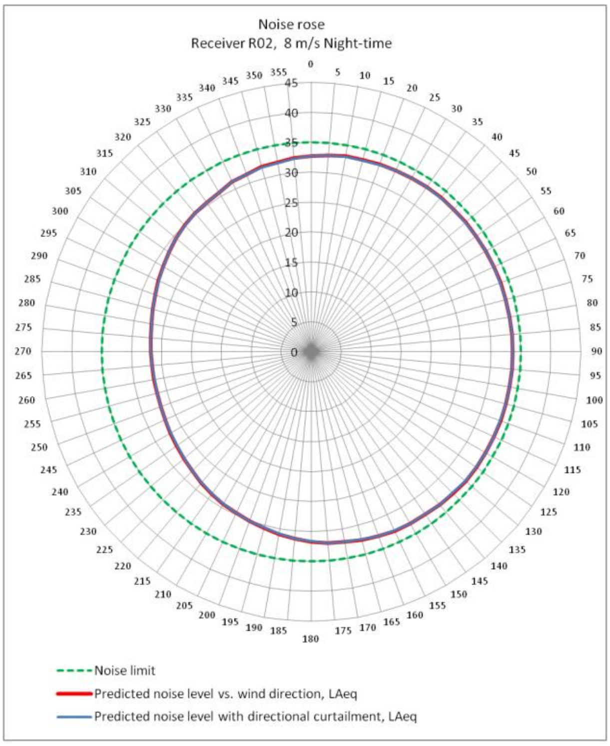
| Day | Night |
|---|---|
| not applicable<br>(no curtailment applied) |  |

**Figure 13: Hub-height wind speed 9 m/s**

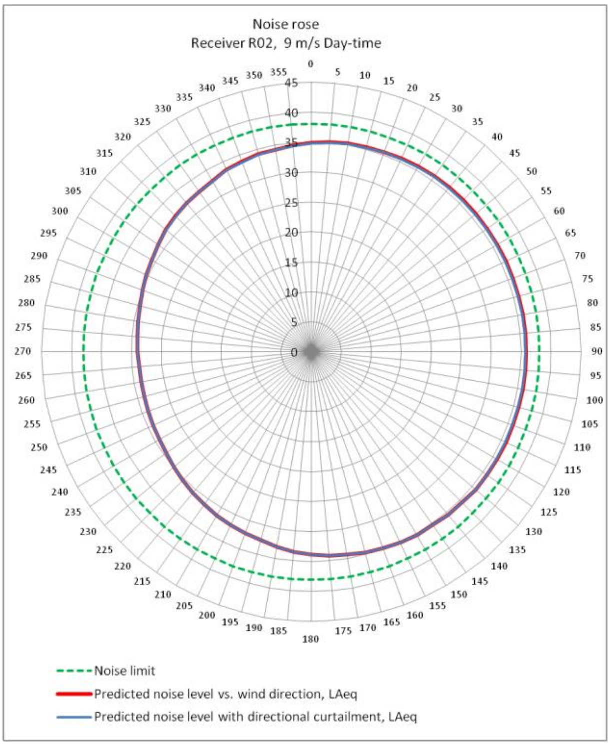
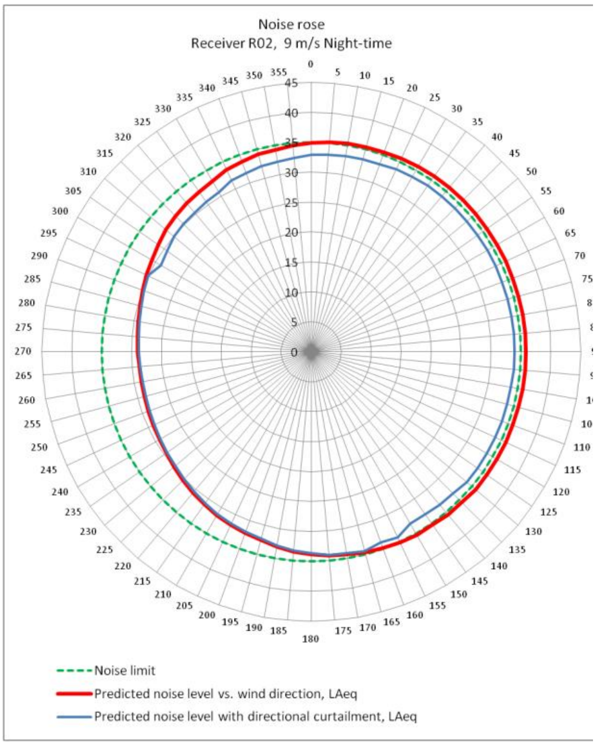
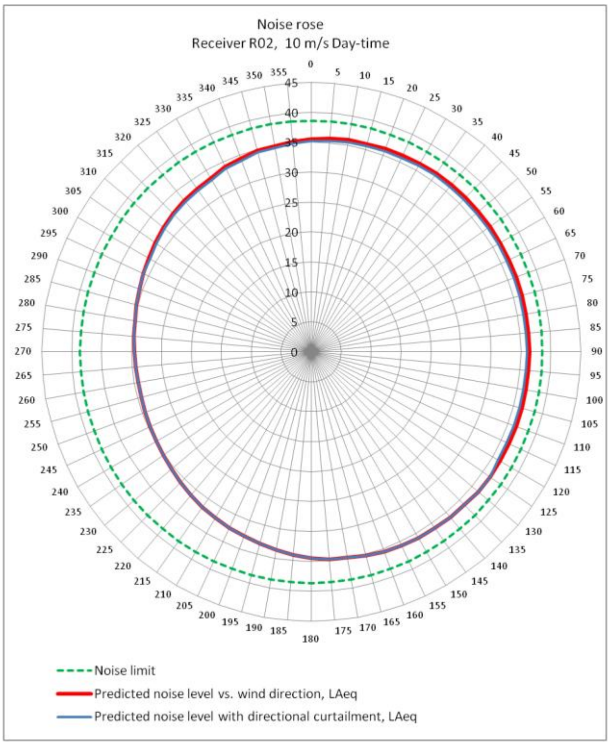
| Day | Night |
|---|---|
|  |  |

**Figure 14: Hub-height wind speed 10 m/s**

**Day**




**Night**

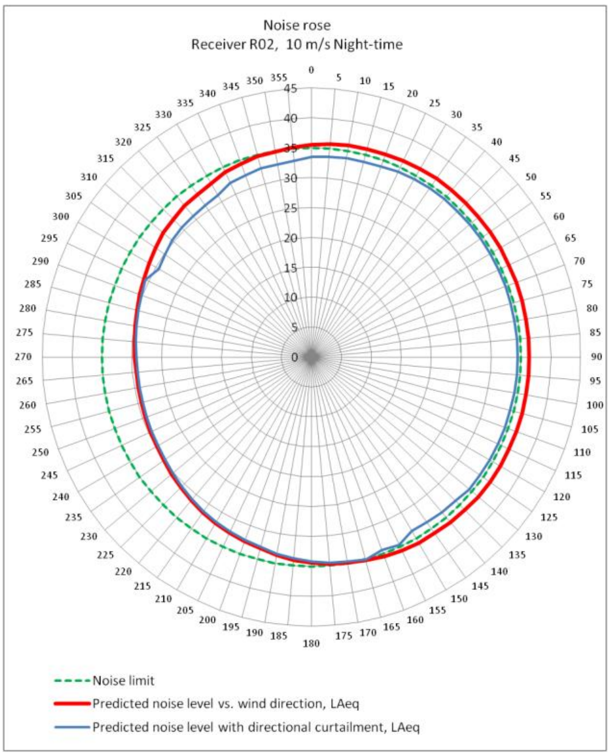
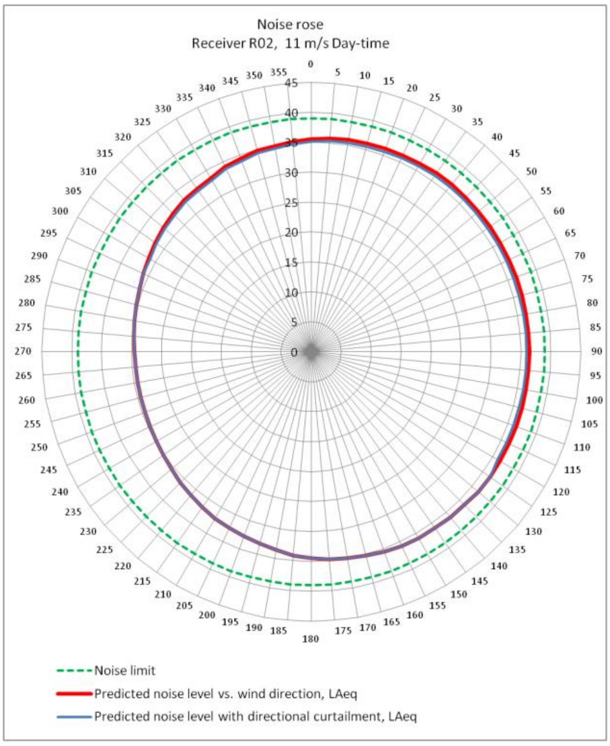



**Figure 15: Hub-height wind speed 11 m/s**

**Day**




**Night**

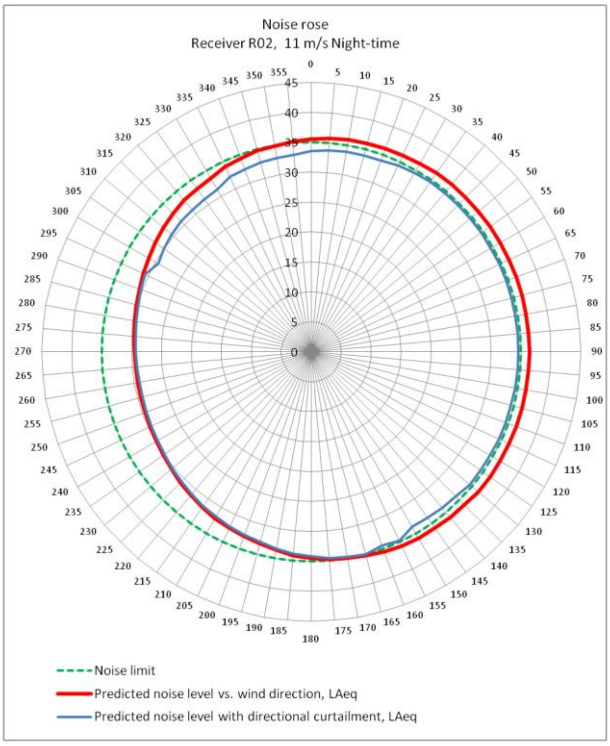


**Figure 16: Hub-height wind speed 12 m/s**

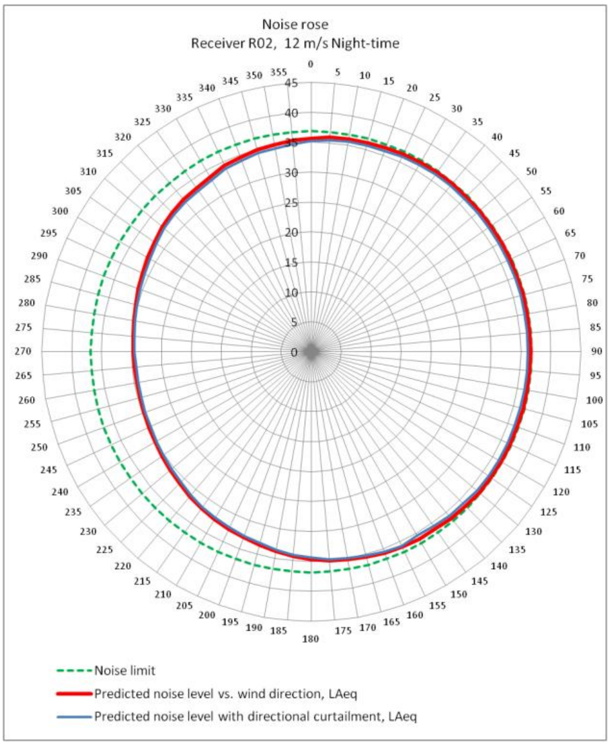
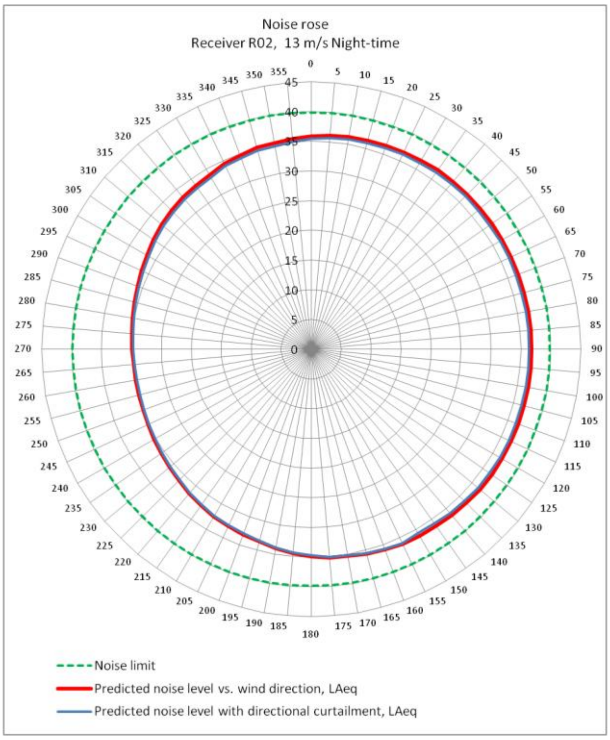
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 17: Hub-height wind speed 13 m/s**

| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |

## L2 Receiver location R05

**Figure 18: Hub-height wind speed 8 m/s**

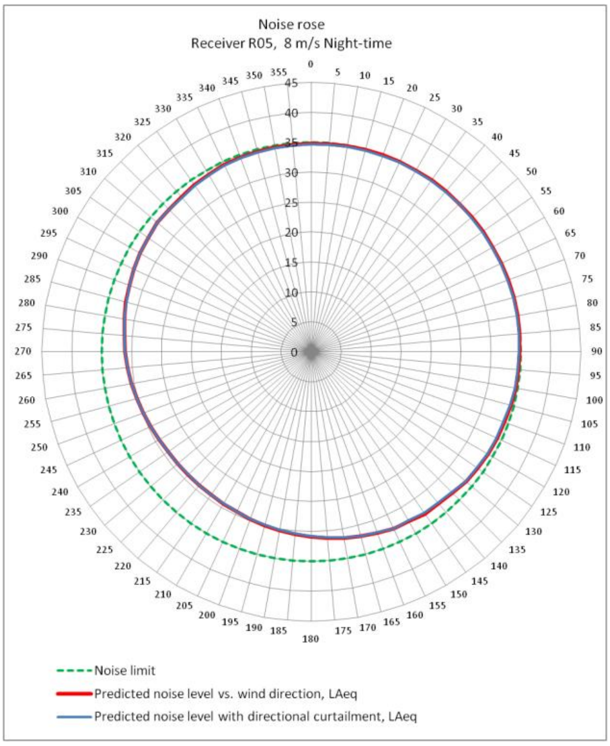
| Day | Night |
|---|---|
| Not applicable<br><br>(no curtailment applied) |  |

**Figure 19: Hub-height wind speed 9 m/s**

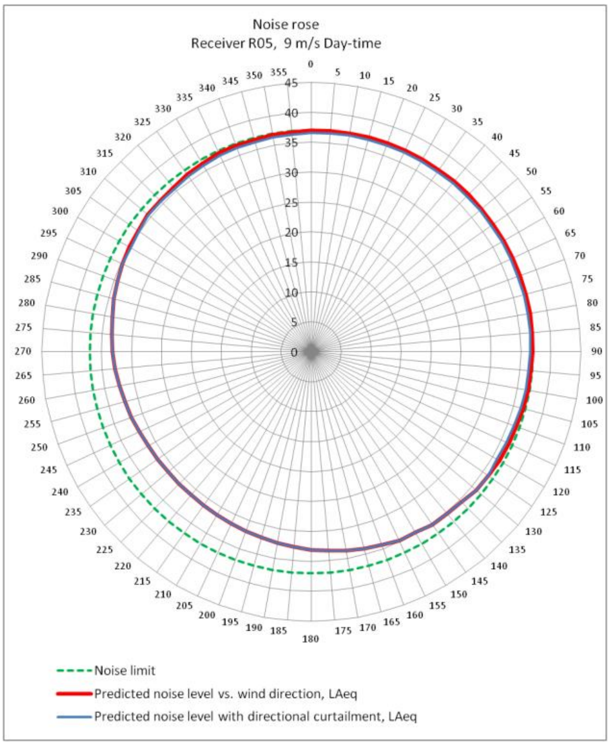
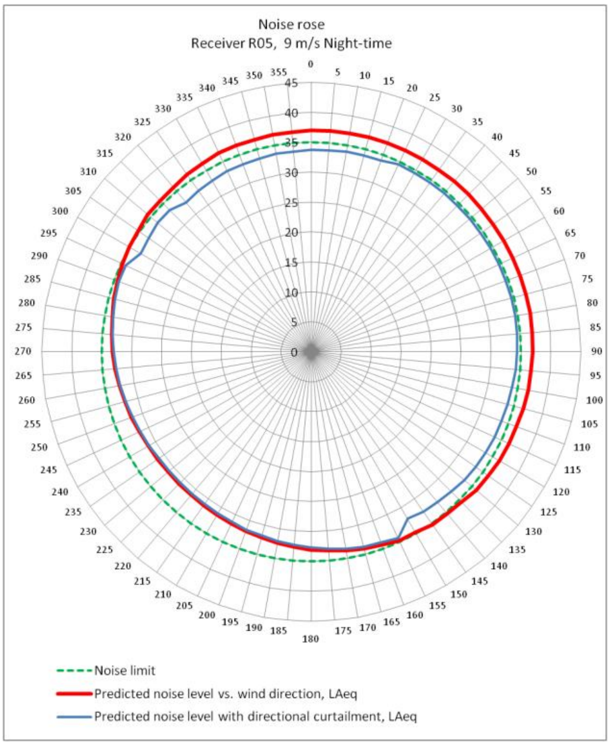
| Day | Night |
|---|---|
|  |  |

**Figure 20: Hub-height wind speed 10 m/s**

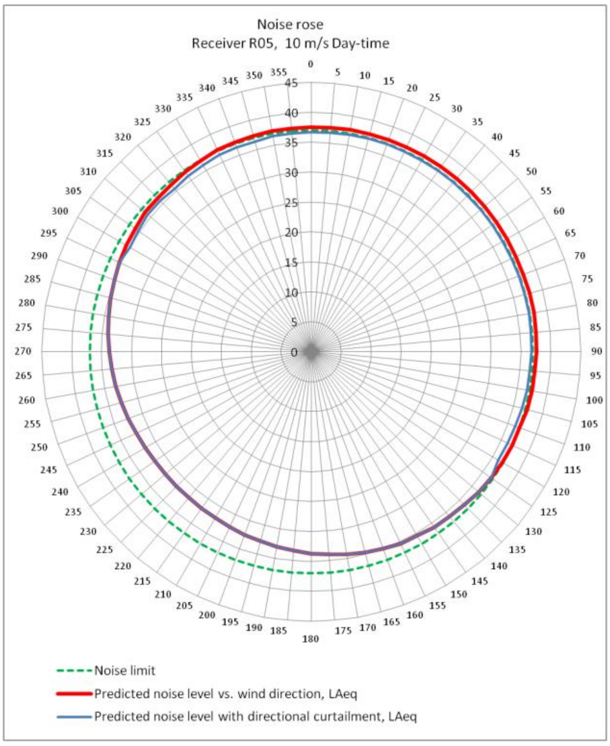
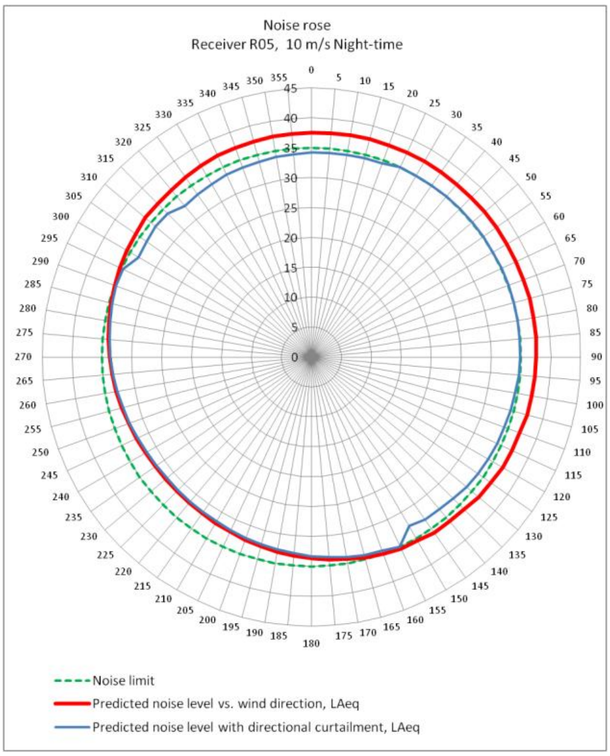
| Day | Night |
|---|---|
|  |  |





**Figure 21: Hub-height wind speed 11 m/s**

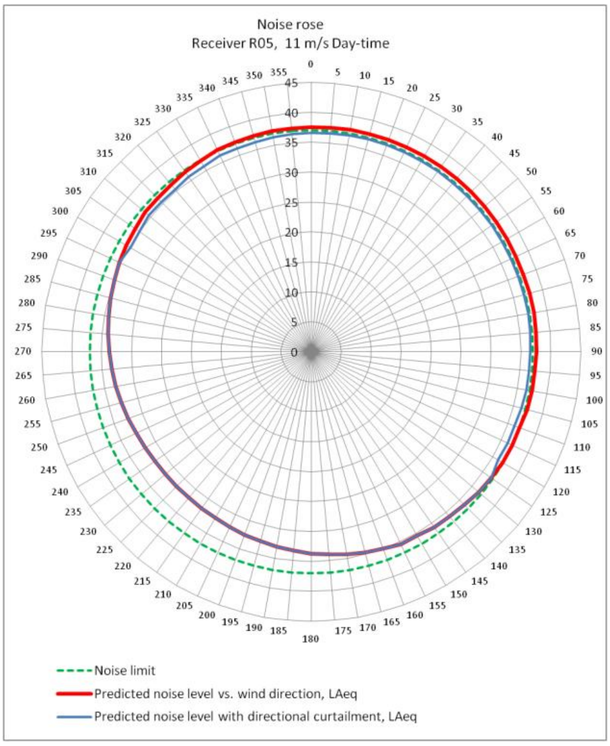
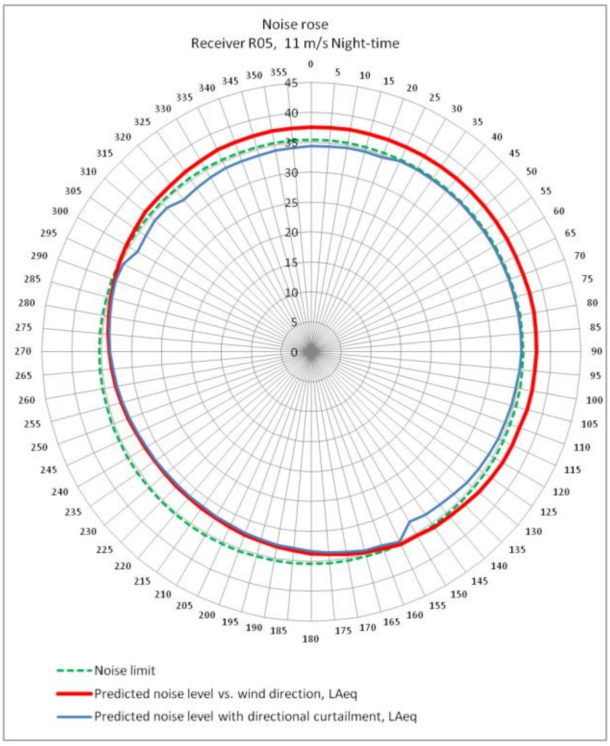
| Day | Night |
|---|---|
|  |  |

**Figure 22: Hub-height wind speed 12 m/s**

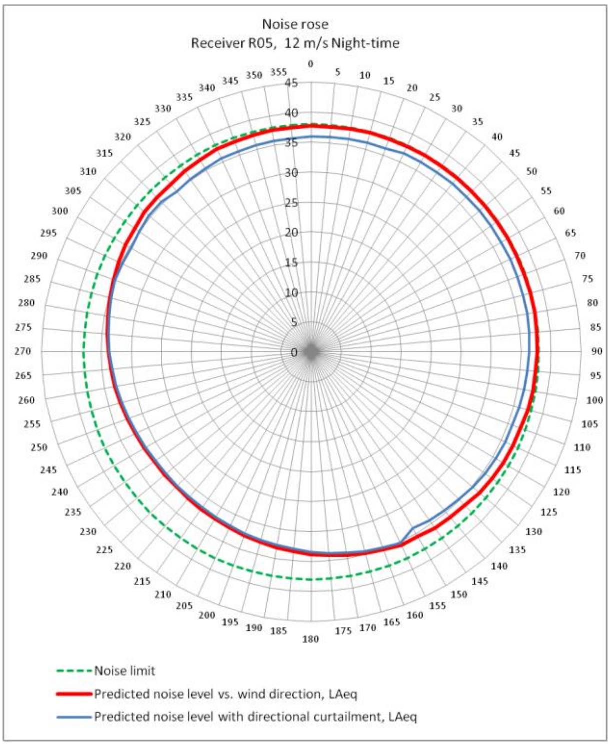
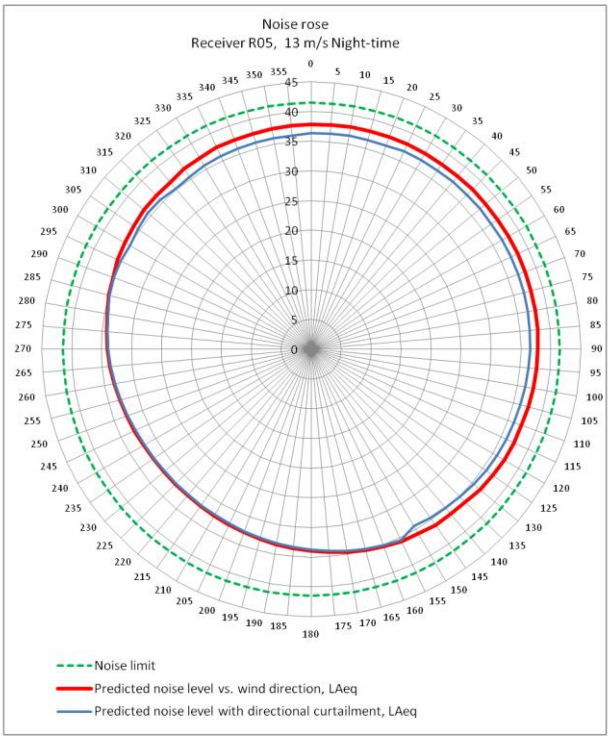
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 23: Hub-height wind speed 13 m/s**

| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |

## L3 Receiver location R36

**Figure 24: Hub-height wind speed 8 m/s**

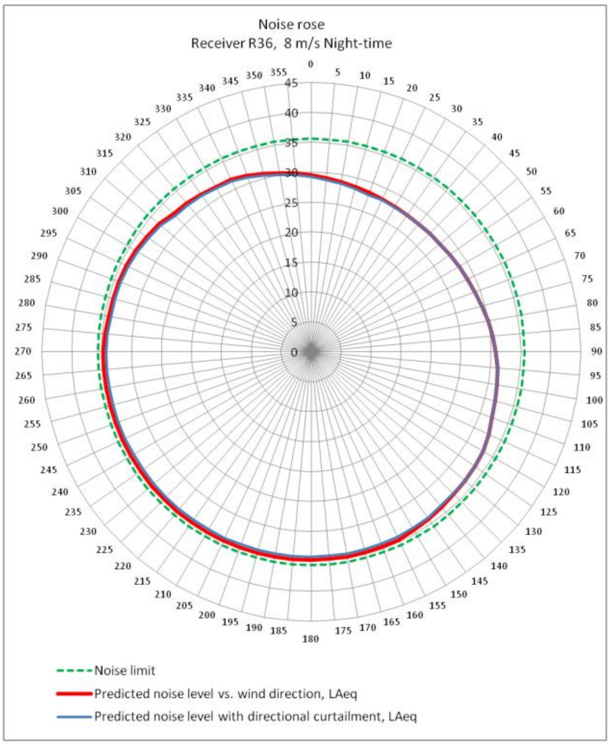
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 25: Hub-height wind speed 9 m/s**

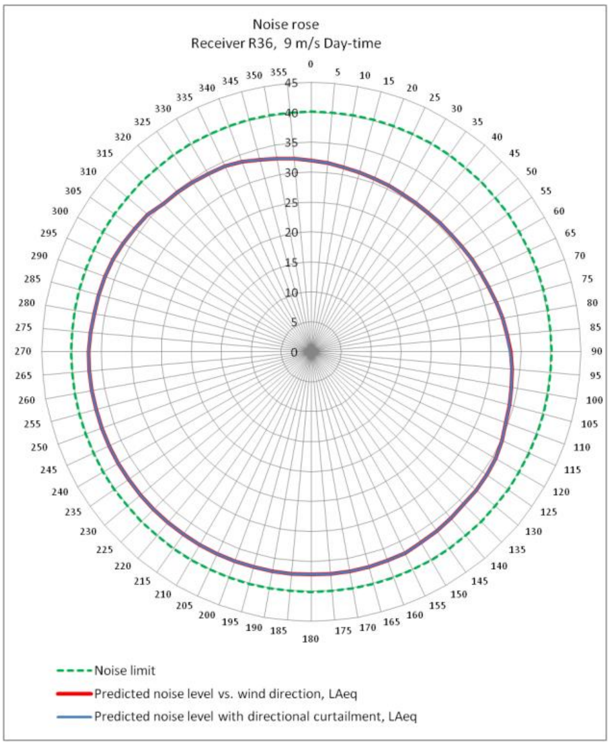
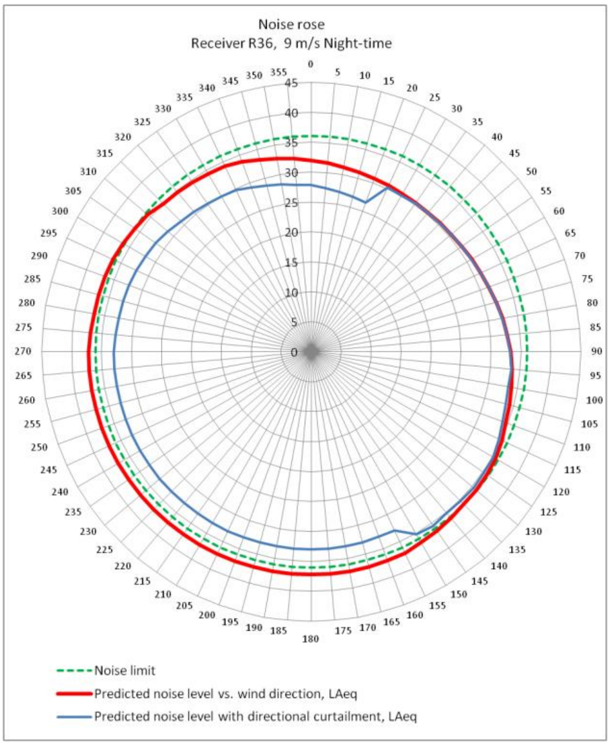
| Day | Night |
|---|---|
|  |  |

**Figure 26: Hub-height wind speed 10 m/s**

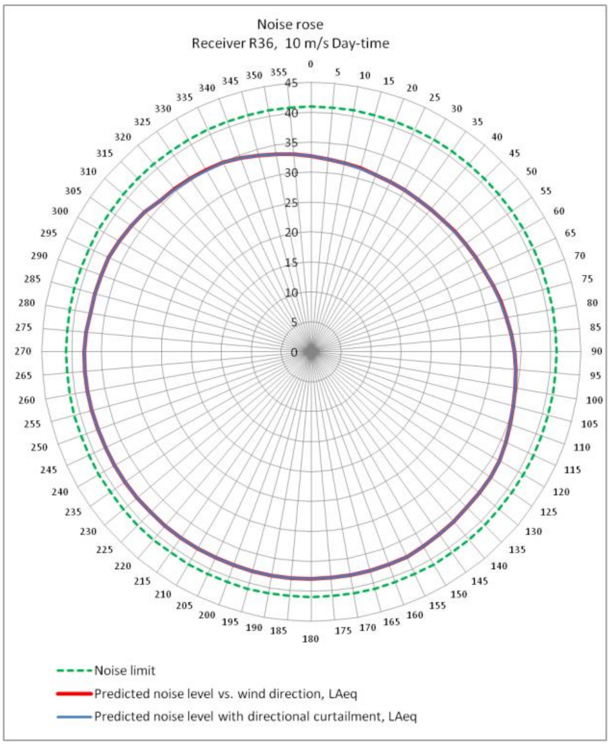
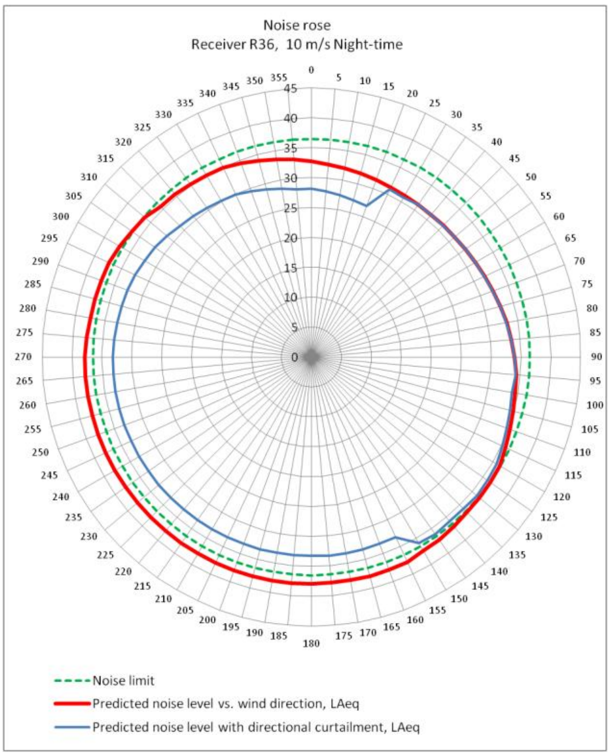
| Day | Night |
|---|---|
|  |  |

**Figure 27: Hub-height wind speed 11 m/s**

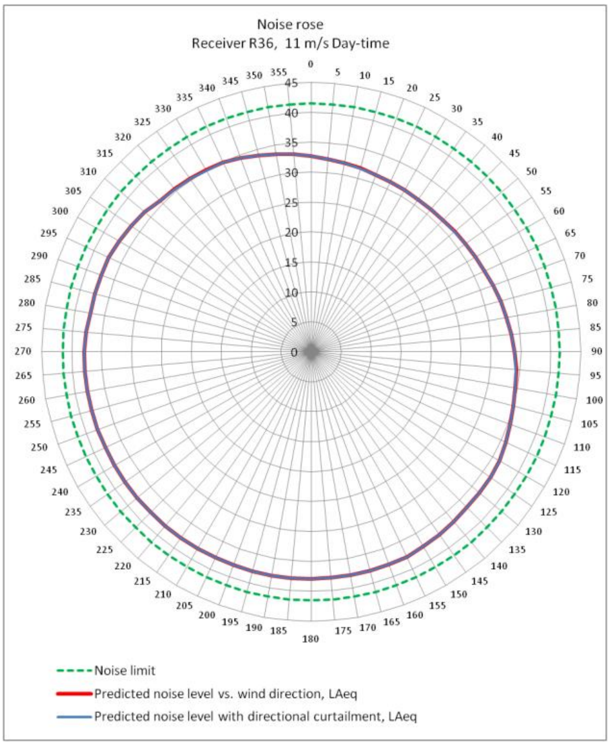
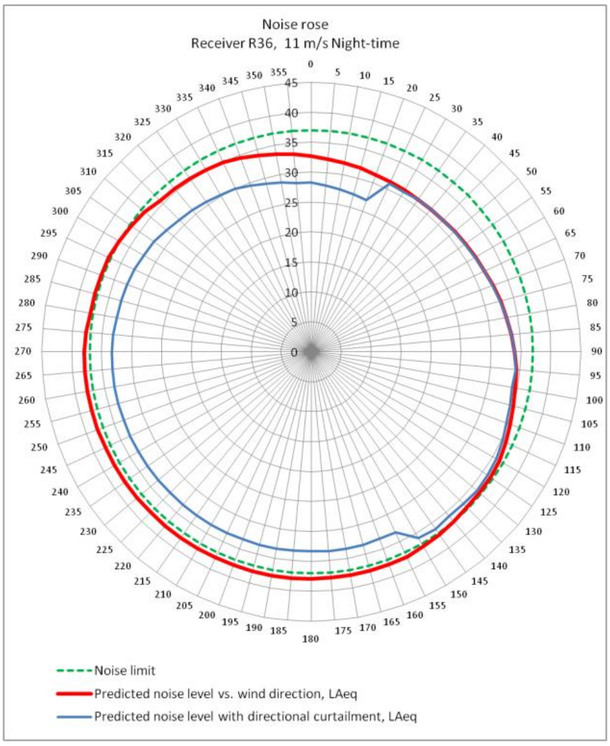
| Day | Night |
|---|---|
|  |  |

**Figure 28: Hub-height wind speed 12 m/s**

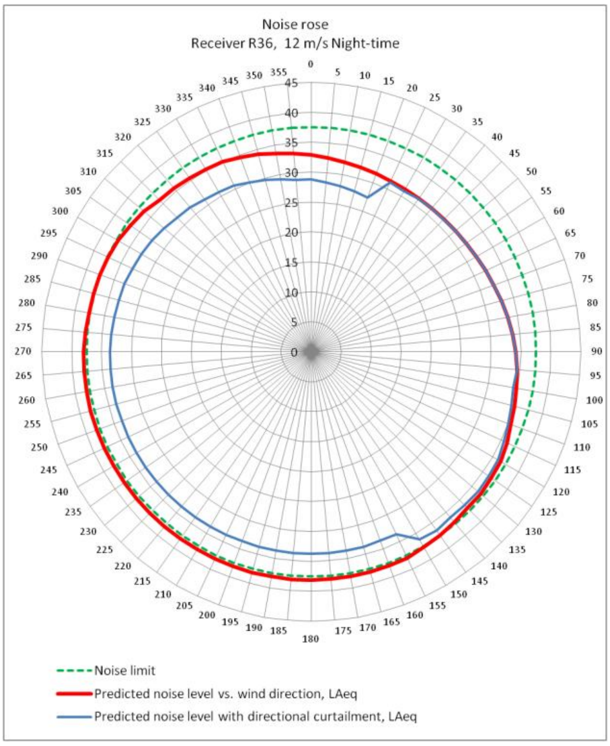
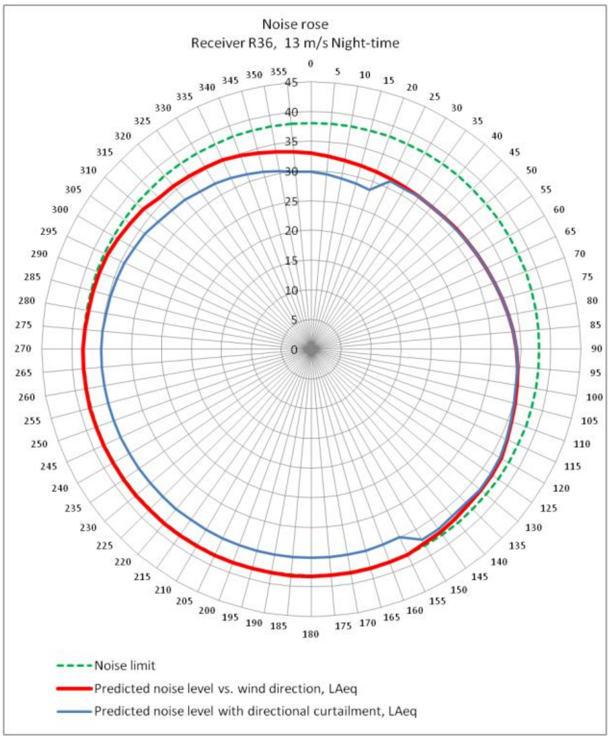
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 29: Hub-height wind speed 13 m/s**

| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |

## L4 Receiver location R49

**Figure 30: Hub-height wind speed 8 m/s**

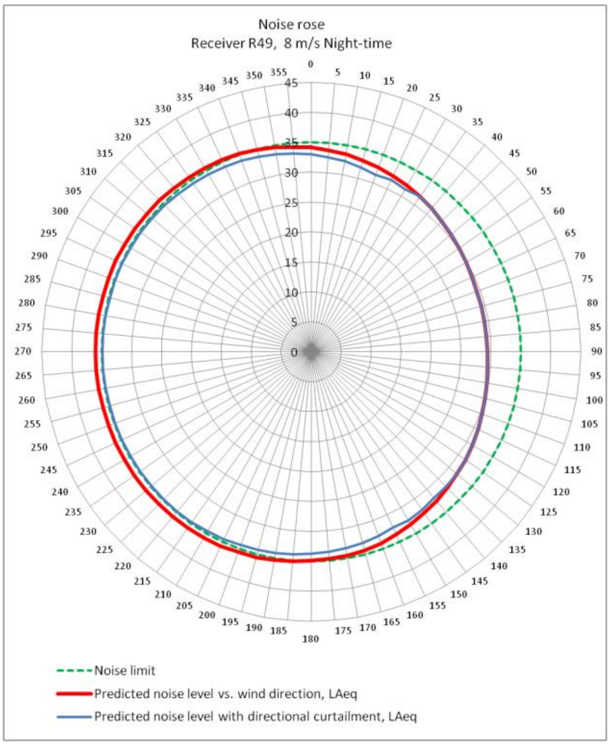
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 31: Hub-height wind speed 9 m/s**

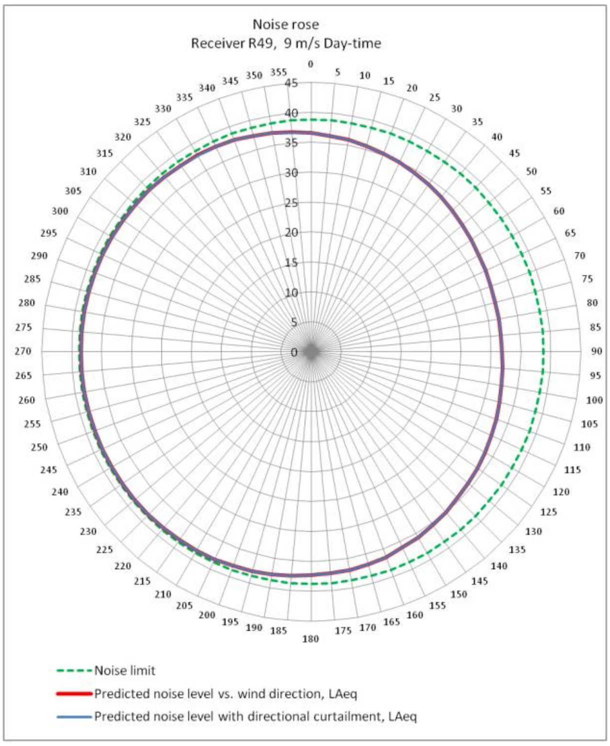
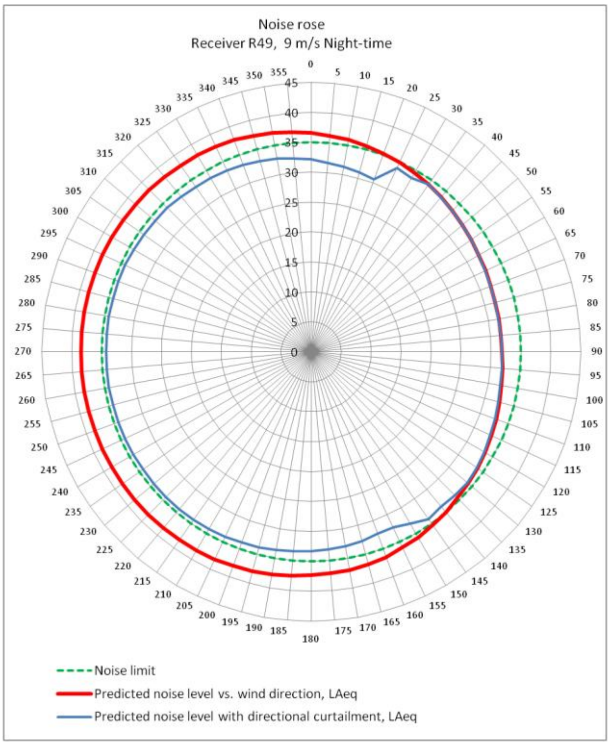
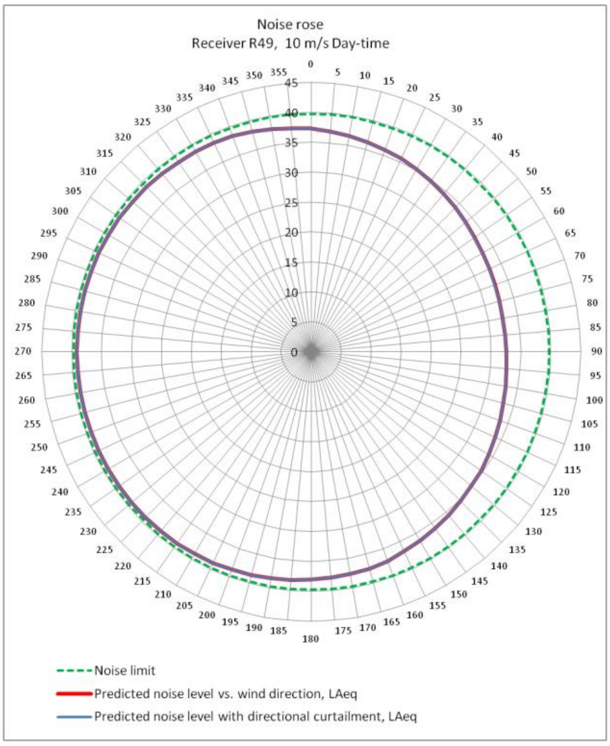
| Day | Night |
|---|---|
|  |  |

**Figure 32: Hub-height wind speed 10 m/s**

**Day** | **Night**



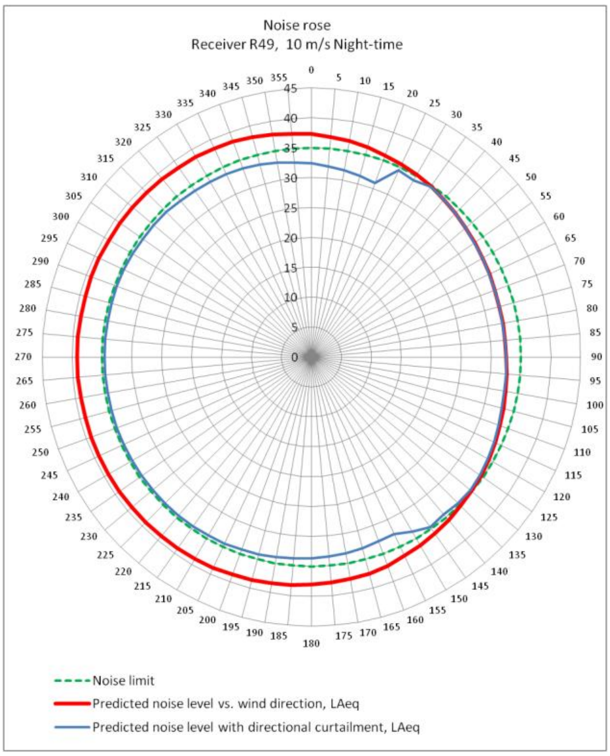
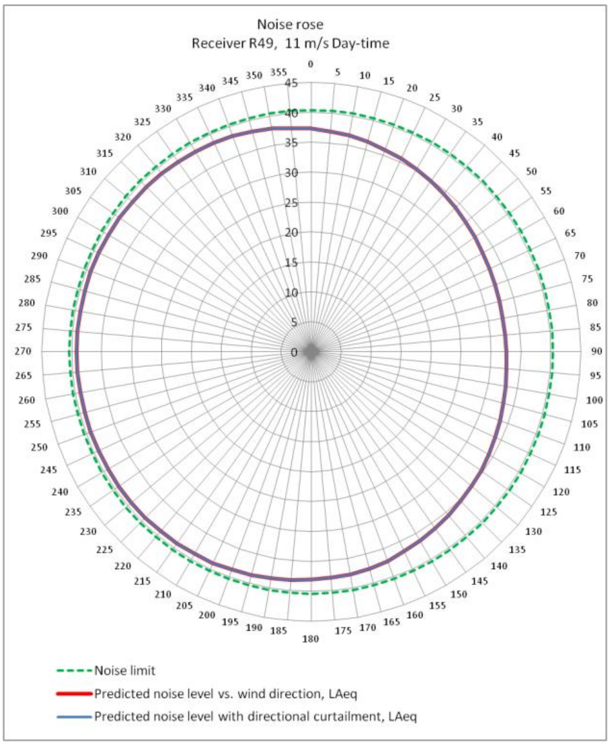




**Figure 33: Hub-height wind speed 11 m/s**

**Day** | **Night**



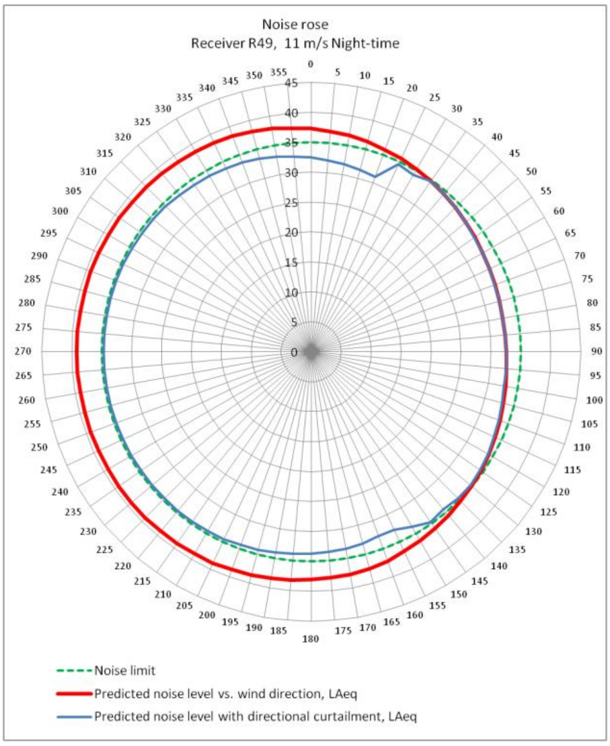



**Figure 34: Hub-height wind speed 12 m/s**

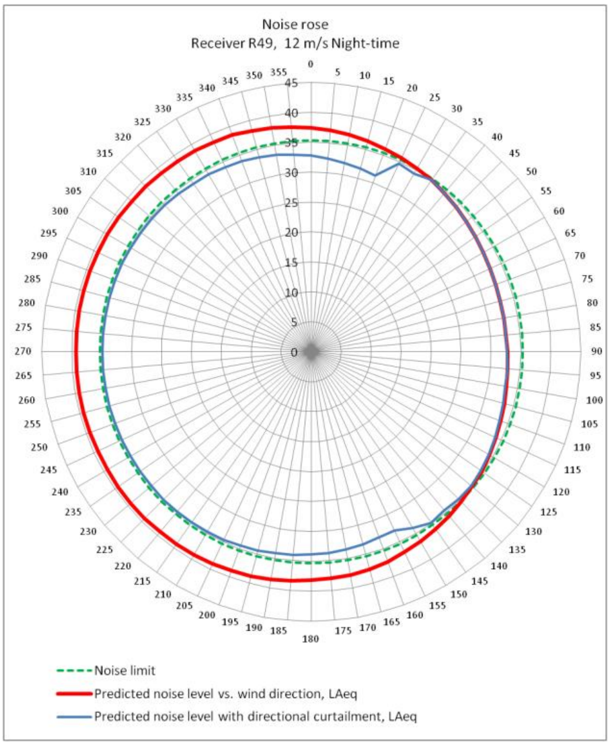
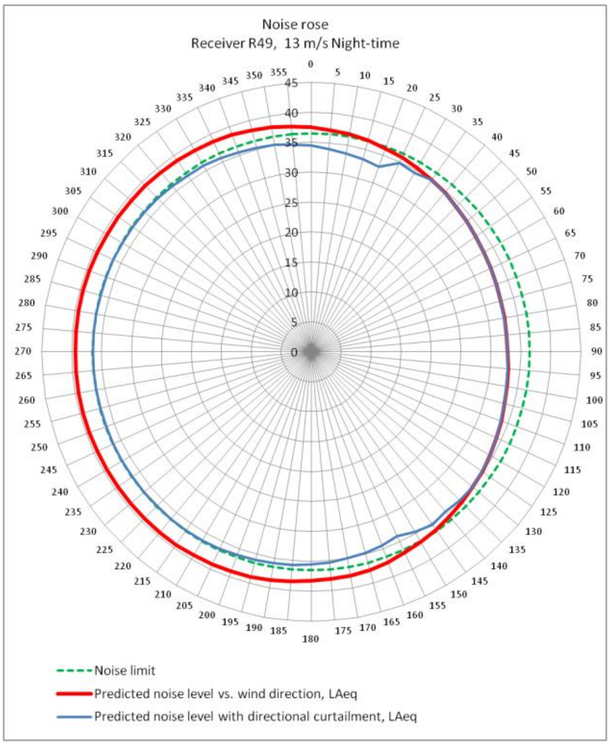
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 35: Hub-height wind speed 13 m/s**

| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |

## L5 Receiver location R78

**Figure 36: Hub-height wind speed 8 m/s**

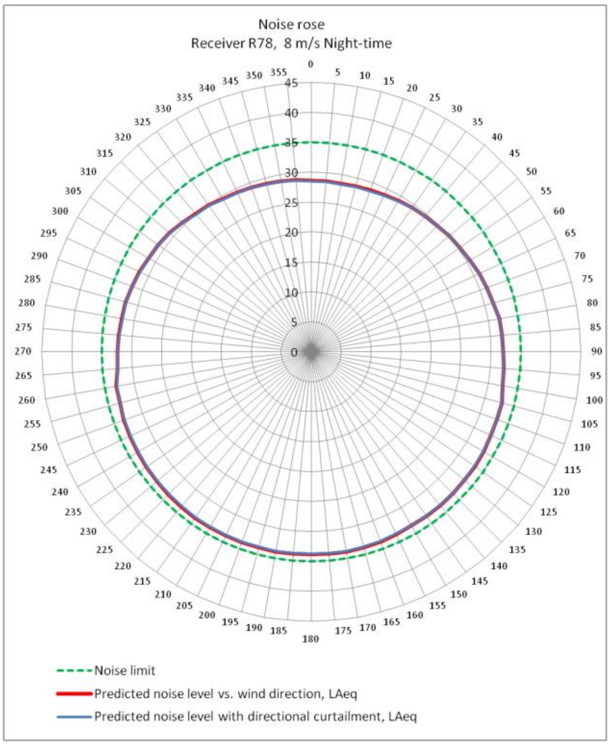
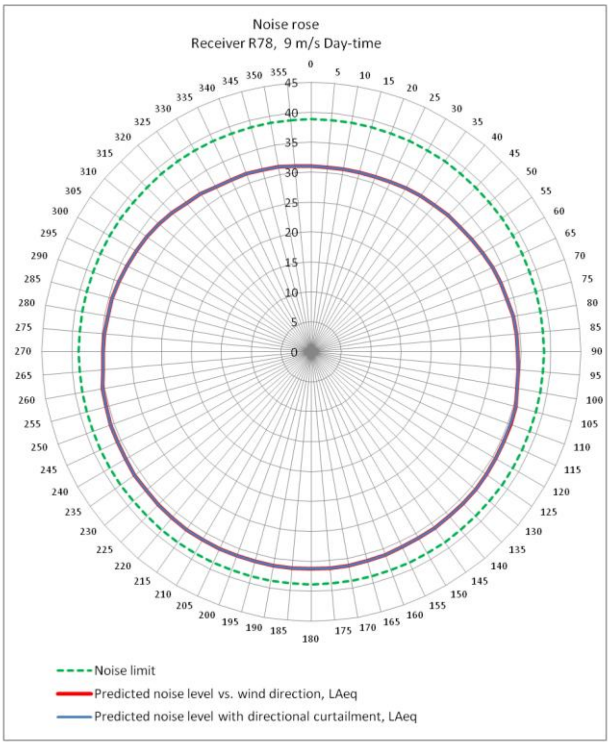
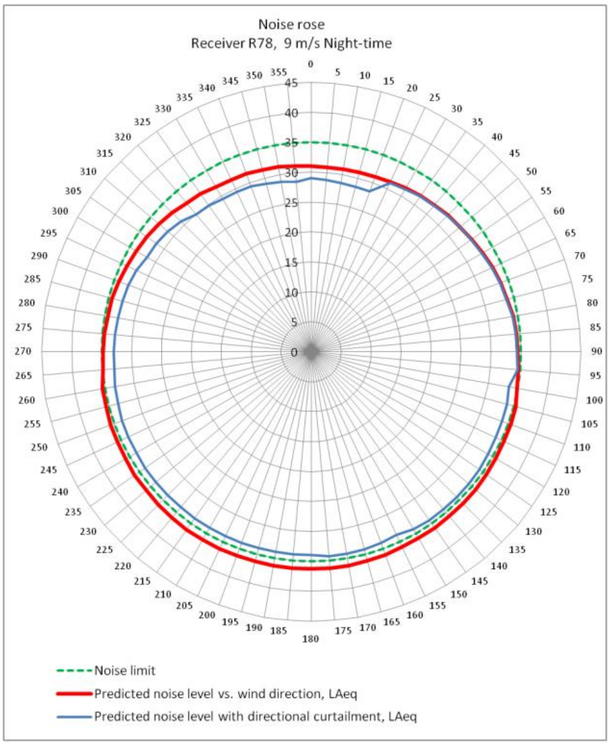
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |

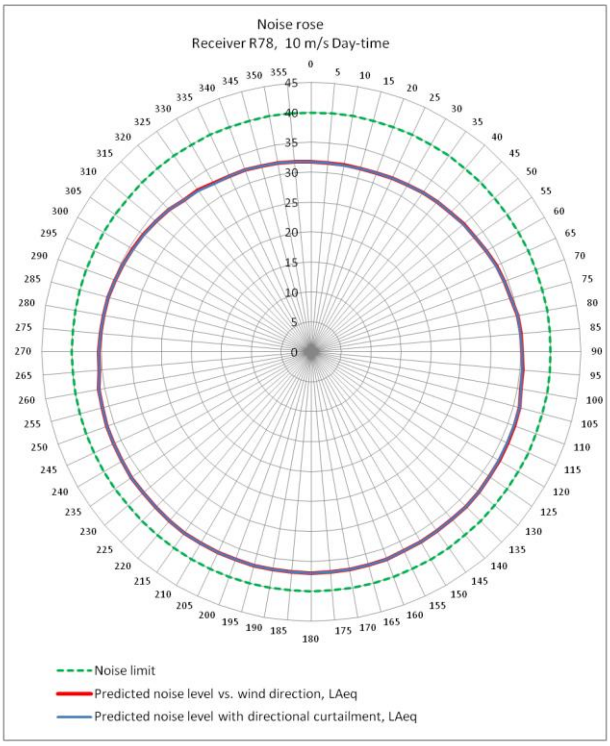
**Figure 37: Hub-height wind speed 9 m/s**

| Day | Night |
|---|---|
|  |  |

MARSHALL DAY Acoustics

**Figure 38: Hub-height wind speed 10 m/s**

**Day**




**Night**

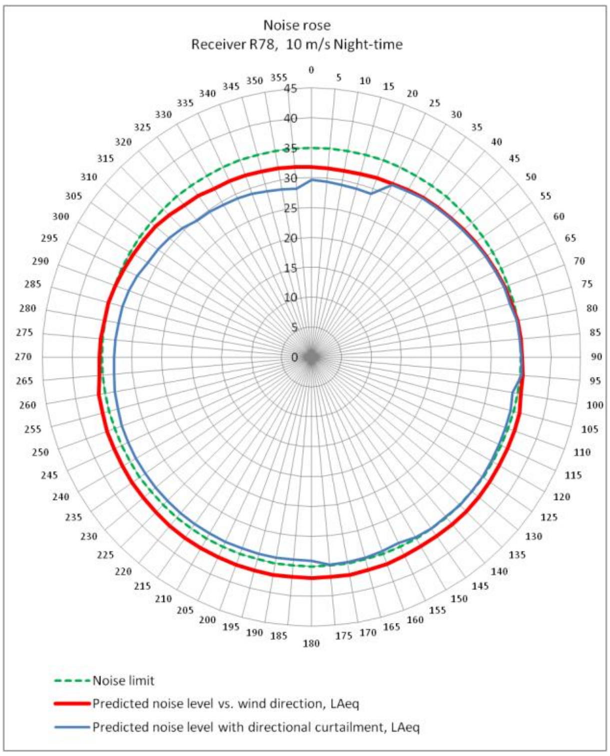
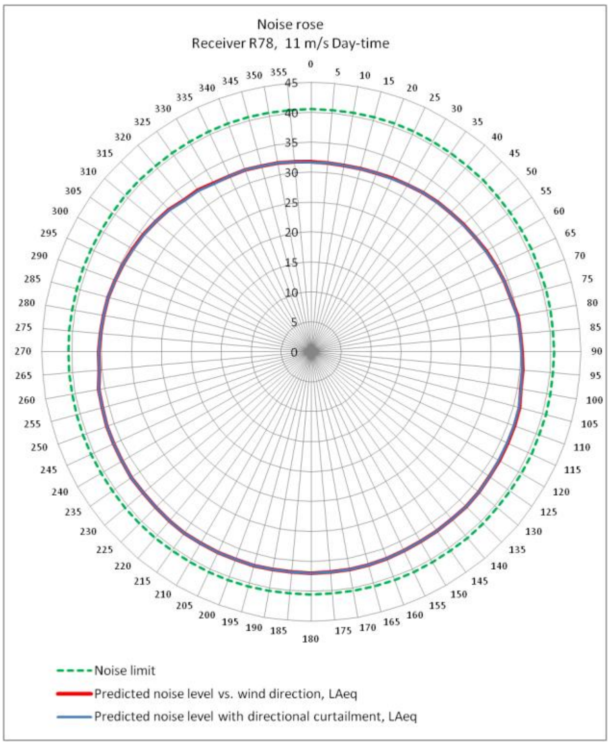



**Figure 39: Hub-height wind speed 11 m/s**

**Day**




**Night**

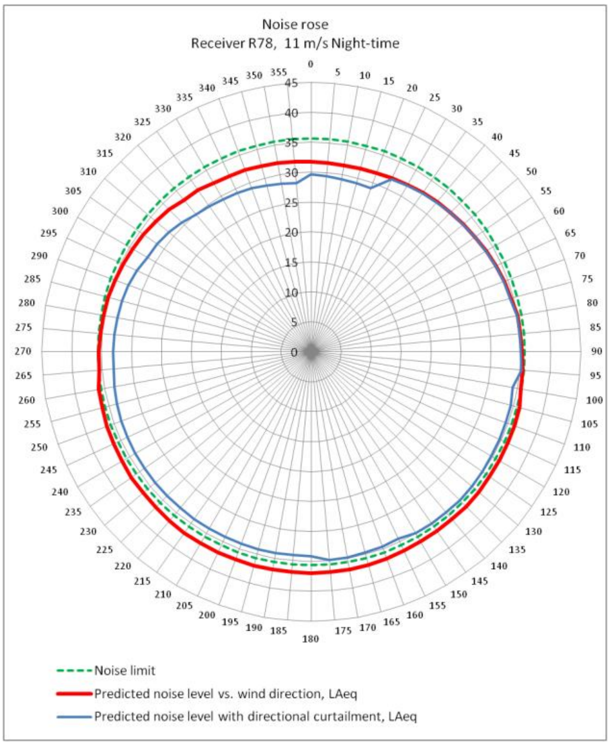


**Figure 40: Hub-height wind speed 12 m/s**

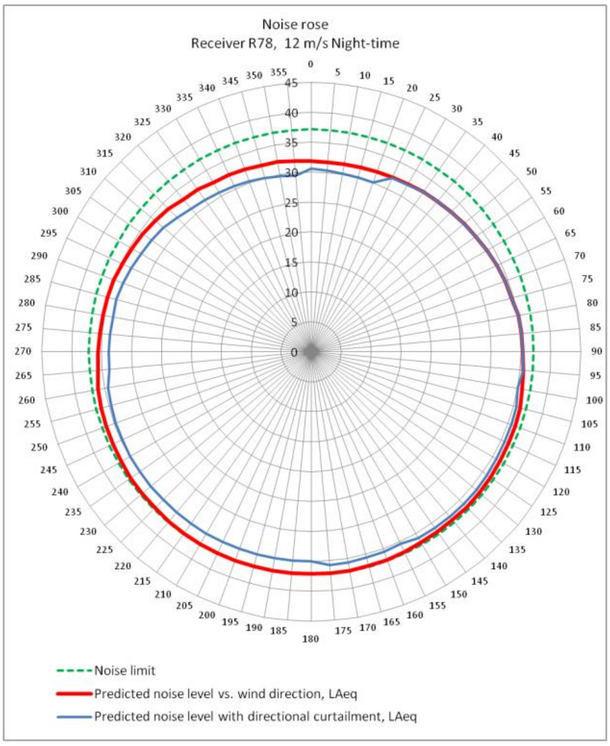
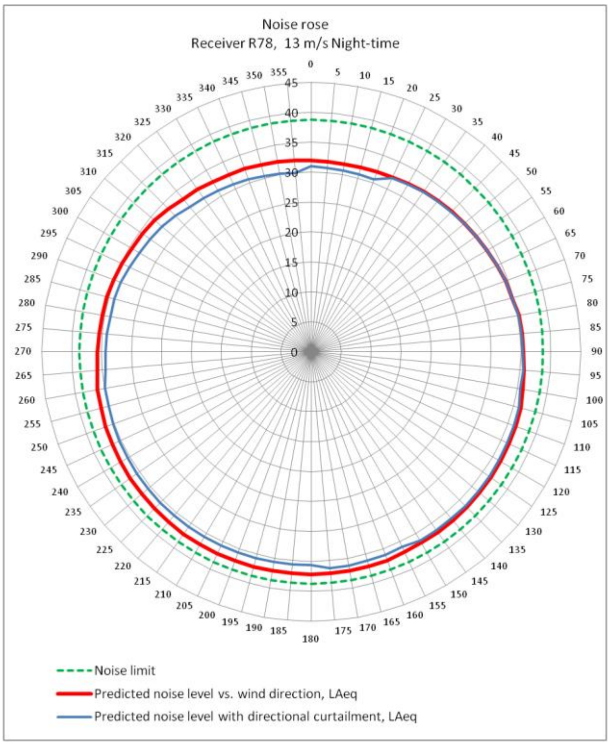
| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |



**Figure 41: Hub-height wind speed 13 m/s**

| Day | Night |
|---|---|
| Not applicable<br>(no curtailment applied) |  |