



**Project:** MT EMERALD WIND FARM

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## 1.0 INTRODUCTION

This report presents the Noise Monitoring Plan (NMP) for the Mt Emerald Wind Farm.

The Mt Emerald Wind Farm is a consented project located between Mareeba and Atherton in Far North Queensland. The Development Permit for the Mt Emerald Wind Farm includes conditions which specify requirements for the control of environment noise associated with the project.

The NMP was commissioned by RATCH Australia Corporation (RAC) to establish the procedures that will be used to measure and assess whether the wind farm is operating in accordance with the requirements of the Development Permit. The NMP has also been prepared for the purpose of consultation with the chief executive administering the *Sustainable Planning Act 2009* (SPA) in advance of conducting the compliance testing.

This report specifies:

- Operational wind farm noise limits
- Operational wind farm noise monitoring and assessment procedures
- Operational wind farm noise compliance reporting requirements.

This report has been prepared on the basis of relevant information documented in the following Marshall Day Acoustics (MDA) reports:

- *Mt Emerald Wind Farm – Background Noise Monitoring* (report reference Rp 001 2015545ML) dated 12 September 2016 (referred to as the background noise report herein)
- *Mt Emerald Wind Farm – Revised Noise Assessment* (report reference Rp 002 2015545ML) dated 9 December 2016 (referred to as the revised noise assessment report herein).

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures* (ISO 1996-1:2016). 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 dB<sub>LA</sub>. 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.

The NMP has been prepared on the basis of the wind turbine selection and wind farm layout described in Appendix B and Appendix C respectively.

## 2.0 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.

The applicable conditions are attached to the Notice of Decision<sup>1</sup> dated 31 January 2017 and are summarised in Table 1 and reproduced in full in Appendix F.

**Table 1: Development Permit – Summary of A-weighted operational noise assessment requirements**

Condition	Summary Requirement
4	Defines 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
5(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. The assessment must account for potential Special Audible Characteristics (SACs) including tonality, impulsivity and amplitude modulation.
5(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 specifies 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.

<sup>1</sup> Notice of Decision issued by the Minister for Infrastructure, Local Government and Planning and Minister for Trade and Investment which approved changes to the conditions originally documented in a decision notice dated 24 April 2015

### 3.0 OPERATIONAL NOISE LIMITS

Operational noise limits apply at all existing and approved noise sensitive land uses (receivers) in the vicinity of the Mt Emerald Wind Farm at the date of this Development Permit (31 January 2017).

The coordinates of the receivers considered in this NMP are tabulated in Appendix D.

The noise limits defined by Condition 4 of the Development Permit are summarised in Table 2. The limits apply to the A-weighted noise level that is solely attributable to the operation of the wind farm

**Table 2: Development Permit – summary of noise limits**

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

Background noise monitoring has been carried out near the Mt Emerald Wind Farm to:

- Determine operational noise limits in accordance with the Development Permit; and
- Assist the identification of periods during the noise compliance monitoring which may be affected by background noise.

The background noise monitoring was carried out at the six (6) receivers described in Table 3.

**Table 3: Background noise monitoring locations**

Receiver	Description
R02	Nearest residential property to the west
R05	Nearest residential property to the southwest
R36	Nearest residential property to the northeast
R48	Selected in lieu of access to receiver R46 where monitoring was originally proposed. Chosen as an additional reference for properties located near to the area between monitoring locations R36 and R49
R49	Nearest residential property to the east
R78	Nearest residential property to the north

Details of the survey, analysis and noise limits derived in accordance with the Development Permit are provided in the background noise report. The noise limits are the same values which were presented in the revised noise assessment report prepared in accordance with condition 5(a) of the Development Permit.

The noise limits are presented in Table 4 and Table 5 for the day and night periods respectively. The limits are referenced to site wind speeds at a height of 90 m above ground level (the tallest hub height at the Mt Emerald Wind Farm) at the reference masts detailed in Table 6.

**Table 4: Daytime receiver limits, dB L<sub>Aeq</sub>**

Receiver	Site wind speed (m/s) at 90 m AGL at reference mast location										
	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	40.50

**Table 5: Night-time receiver noise limits, dB L<sub>Aeq</sub>**

Receiver	Site wind speed (m/s) at 90 m AGL at reference mast location										
	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 6: Site wind speed - reference mast location & applicable receivers**

Reference mast ID	Applicable receivers	Mast coordinates MGA 94 Zone 55	
		Easting	Northing
Mast_9530	R36, R48, R49	329088	8100271
Mast_9531	R02, R05, R78	325608	8101256

At all other receivers where a representation of background noise data is not available, compliance may be demonstrated by determining that operational wind farm noise levels are below the minimum noise limits of 37 dB L<sub>Aeq</sub> and 35 dB L<sub>Aeq</sub> for the day and night periods, respectively. However, where operational noise levels are potentially higher than the minimum limits, background noise data will be required in order to assess compliance.



#### 4.0 OPERATIONAL NOISE TESTING

The operational noise testing procedures presented in this section are based on:

- AS 4959:2010 as specified in the Development Permit
- The outline compliance monitoring plan detailed in Appendix H of the revised noise assessment
- The Queensland Department of Infrastructure, Local Government and Planning publication *State code 23: Wind farm development* dated July 2017 (Queensland State Code 23).

The preface of AS 4959:2010 notes that the objective of the Standard is to:

*[...] provide wind farm developers and relevant regulatory authorities with a suitable framework to develop a method for the measurement, prediction and assessment of noise from wind turbine generators (wind farms).*

The procedures within AS 4959:2010 are not prescriptive about all aspects of wind farm noise assessment, with example procedures and possible options provided to assist the development of methodologies for assessing compliance with criteria established by the Relevant Regulatory Authority.

Further, within the framework of the guidance set out in AS 4959:2010, the Standard notes the importance of consultation with the Relevant Regulatory Authority to develop an appropriate compliance testing procedure.

In light of the above, and the publication of detailed wind farm noise assessment guidance in Queensland State Code 23 since the Development Permit was issued, AS 4959:2010 has been referenced as a general framework for the testing procedures with this section. To define specific aspects of the testing procedures, Queensland State Code 23 has been referenced as relevant guidance on the approach that is expected to be preferred by the chief executive administering the SPA (the Relevant Regulatory Authority for the Mt Emerald Wind Farm). In particular, reference is made to Part 2 *Noise monitoring methodology* of Queensland Code 23 which states:

*This part defines the noise monitoring methodology to be used for operating wind farms in Queensland. It provides the method for measuring the noise from operating wind turbines; the results of which will be used for determining compliance with the noise criteria included within the code and any conditions of approval.*

Notwithstanding this, and in accordance with the guidance of AS 4959:2010, this NMP has been prepared for the purpose of consultation with the chief executive administering the SPA in advance of conducting the compliance testing.

#### 4.1 Noise measurement locations

Operational noise measurements shall be carried out at the six (6) preferred monitoring locations detailed in Table 1, subject to permission being granted by the landowners. These are the same receiver locations where updated background noise level measurements were carried out in 2016.

The monitoring locations are illustrated on the site layout plan provided in Appendix E.

**Table 7: Preferred monitoring for conducting compliance monitoring**

Receiver	Direction from wind farm	Nearest Turbine	Approximate distance, km
R02	west	47	2.1
R05	southwest	39	1.7
R36	northeast	1	1.8
R48	east	13	2.7
R49	east	11	1.8
R78	northeast	9	1.7

In the event that permission is not able to be obtained for conducting compliance measurements at the preferred noise sensitive receiver locations, alternative locations shall be considered.

The measurement systems shall be positioned in the vicinity of the dwelling at each of the preferred noise sensitive locations for compliance monitoring. The following specific measurement location requirements are noted:

- The measurements shall generally be on the wind farm side of the dwelling
- The measurements shall be within 20 m of the dwelling
- The measurements shall not occur within 5 m of a vertical reflecting surface
- The measurements shall occur as close as practically possible to the location of the background noise monitoring (refer to the background noise monitoring report for the coordinates and photographs of the preferred monitoring locations)
- The monitoring locations shall be located as far as practically possible from streams, watercourses and vegetation which may result in localised increases in background noise levels.

#### 4.2 Noise measurement procedures

The noise measurement procedures are to comprise unattended noise monitoring for a range of conditions, supplemented by attended measurements and observations.

The unattended noise monitoring shall adhere to the following requirements:

- The measurements shall occur for the measurement durations defined in Section 4.3
- The  $L_{A90}$  noise level shall be determined in consecutive ten (10) minute intervals synchronised with the interval commencing on the hour and each 10 minute increment following the start of each hour
- All noise measurements shall be conducted using low noise floor ( $\leq 20$  dB) instrumentation that is certified to Class 1 standards (highest standard of instrumentation for field measurements) in accordance with IEC 61672-1:2013 *Electroacoustics - Sound level meters - Part 1: Specifications*

- The independent (laboratory) calibration date of the sound level measurement instrumentation must be within 2 years of the measurement period, as specified in Section 5.5 of Australian Standard AS 1055: 2018 *Acoustics – Description and measurement of environmental noise*
- Microphones shall be fitted with enhanced wind shield systems (enlarged primary wind shields or secondary wind shields) designed 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* dated May 2013 (the IOA GPG)
- Subject to the consent of the residents, two (2) minute audio recordings shall be obtained for every ten (10) minute interval of the survey. The sampling rate for audio recordings shall be sufficient to allow assessment of tonality, if required, across the frequency range 10-5000 Hz
- Instantaneous one-third octave band sound pressure levels (fast response) shall be recorded in 100 ms intervals to enable an analysis of amplitude modulation if required.

Further information and guidance about data to be obtained during attended observations is provided in Section 4.4.

Non-acoustics data requirements such as site wind speeds and local weather data are detailed in subsequent sections.

### 4.3 Noise measurement timing and duration

The Queensland State Code 23 recommends that monitoring be undertaken twice within the first year of operation, once in the first three (3) months following operation and again following nine (9) months of operation.

For each survey, the unattended measurements shall comprise a minimum of six (6) weeks continuous monitoring, extended by up to four (4) weeks if required.

Extended surveys may be required to:

- Obtain data for wind speeds and directions that are representative of the range generally expected at the wind farm site (long term wind speed and direction trends are provided in Appendix G for reference). The target wind speed range for the measurements is from cut-in to the rated power of the turbines. Consideration must also be given to whether the amount of data obtained under downwind conditions obtained is representative for each noise monitoring location
- Address non-uniform distributions or a sparsity of noise measurement data in certain wind speeds or directions that may be consequential to the assessment outcome
- Address significant variations in measurement data which may be the result of seasonal factors or contaminating sounds, and which cannot be addressed with selective data filtering.

A preliminary analysis of the data may be required to assess the suitability of the data prior to completion of the measurements (refer to Section 5.0 of this NMP for details of analysis procedures).

If significant data limitations remain evident after the surveys have been extended by four (4) weeks, the merits of an additional survey extension shall be reviewed by the acoustic consultant responsible for conducting the testing. If further extensions are not considered to be warranted, the compliance assessment strategy for the location(s) in question shall be reviewed and the chief executive administering the SPA shall be consulted.

Adhering to the planned duration of monitoring will be dependent on the consent of the landowners of the preferred noise sensitive receiver locations for conducting the monitoring.

Details of the timing and scheduling of the attended observations that are to occur as part of the testing are provided in Section 4.4.

#### 4.4 Special Audible Characteristics

Condition 5(a) of the Development Permit specifies that the assessment of compliance shall account for Special Audible Characteristics including:

- Amplitude modulation
- Impulsiveness
- Tonality.

The following sub-sections provide information about the overall assessment method, the application of objective assessment procedures to the monitoring, and the objective procedures to be used.

Further details in relation to the analysis of these characteristics is provided subsequently in Section 5.9.

##### 4.4.1 General assessment procedures

The presence of Special Audible Characteristics (SACs) in the noise associated with the wind farm shall be reviewed on the basis of the following:

- Attended observations; and
- Site records during the monitoring period (comprising observations by site personnel and data from the site's complaint handling and management system – see description in Section 4.7).

In instances where SACs comprising amplitude modulation, impulsiveness or tonality are identified as potential feature(s) of the noise associated with the wind farm, an objective assessment of the sound's character shall be undertaken to assist in determining if penalties should be applied to the measured noise levels.

If SACs are confirmed to be present, the regularity of their occurrence shall be analysed using the procedure that is defined for tonality in Queensland Code 23.

If the SACs are found to occur sufficiently regularly, a penalty adjustment of 5 dB shall be applied to the derived wind farm noise level.

The Development Permit, AS 4959:2010 and Queensland Code 23 do not provide guidance with respect to penalties for amplitude modulation or impulsiveness, nor do these documents provide guidance for situations where more than one (1) SAC is identified as a characteristic of the wind farm sound. In lieu of specific guidance in these documents, the following shall apply:

- A total penalty adjustment of 5 dB shall be applied, irrespective of whether one or more SACs are identified. This approach is adopted from comparable guidance provided in the policies applied to wind farm noise assessment in NSW and Victoria (both of which do not apply cumulative penalty adjustments for the presence of multiple SACs)
- The assessment of whether SACs occur sufficiently regularly to warrant the application of penalty adjustments shall be made on the basis of the total number of samples in which a SAC is identified (i.e. the aggregated total number of samples in which different SACs were detected).

#### 4.4.2 Attended observations

To investigate whether SACs are a potential feature of the noise associated with the wind farm, attended observations shall be undertaken by a qualified acoustic engineer with experience in the assessment of wind farm sound.

Three (3) sets of attended observations shall be undertaken during each of the monitoring surveys as follows:

- During deployment of the monitoring instrumentation
- During an interim visit to the site
- During retrieval of the monitoring installation.

Scheduling of the deployment and retrieval of the monitoring equipment is dependent on practical considerations including timing of access to residential properties. However, the wind farm must be operating at the time of all attended observations, and attempts shall be made to arrange the periods of attendance to coincide with suitable weather conditions for conducting wind farm observations.

Suitable conditions are generally considered to be:

- Wind speeds between approximately 5 m/s and 10 m/s at the turbine hub-height
- Little or no rainfall
- Times when background noise levels are expected to be lower.

At least one (1) set of attended observations shall be conducted during the night-time period (2200 – 0600 hrs). Observations during the night shall avoid shoulder periods near sunrise or sunset when ambient noise levels may increase.

The attended observations should ideally include downwind conditions<sup>2</sup> between the wind farm and the preferred noise sensitive location. However, this will be dependent on the available wind conditions and will not always be practical. If wind conditions preclude observations under downwind conditions in the vicinity of noise sensitive locations, observations should be made at alternative orientations to the wind farm which are downwind of the wind farm at comparable separation distances (subject to practical access constraints) to obtain an indication of characteristics under downwind conditions.

If the available weather conditions and operating conditions at the time of attendance do not permit representative observations to be made, additional attended observations may need to be carried out. In addition, the acoustic engineer shall review the site records (see description in Section 4.7) to determine if additional attended observations may be warranted.

Each set of attended observations in the vicinity of the compliance monitoring locations shall comprise observations for at least ten (10) minutes. The minimum duration of the observations shall be increased to thirty (30) minutes per observation location when the sound of the wind farm is clearly audible.

During each attended observation, and at all locations, audio samples shall be obtained to provide a record of the sound environment at the time of the inspection and provide a basis for further objective assessment if required.

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<sup>2</sup> Downwind conditions are generally defined as wind speeds and directions which equate to a positive vector wind speed of at least 2 to 3 m/s in the direction from the nearest turbines and the observation location

#### 4.4.3 Application of objective assessments

The findings of the attended observations shall be used to determine whether an objective assessment of SACs is warranted. Specifically, if one or more potential SACs are identified during the attended observations, an objective assessment of the audio recording obtained during the attended observations shall be carried out.

Objective assessments shall also be instigated if site records (see Section 4.7) are indicative of potential SACs. An objective assessment shall be undertaken for the audio recording obtained during the corresponding period.

The objective assessment shall be undertaken for each type of potential SAC which is observed while in attendance at the site, or which has been indicated by the site records. The results shall be used to assist the decision to apply penalties and, if so, when to apply penalties.

If the objective assessment(s) indicate the presence of SAC(s) which may warrant the application of penalties, the objective assessment(s) shall be carried out for all audio records obtained from the unattended compliance monitoring.

If the objective assessment(s) do not indicate the presence of SAC(s) at levels which warrant the application of penalties, the objective assessment(s) may still need to be carried out for the unattended audio records, to determine the potential for a penalty to be warranted as a result of their occurrence at other times. In such instances, the acoustic engineer responsible for conducting the objective assessment(s) shall determine the need for further investigation of the unattended audio records and shall document the determination in the reporting for the compliance assessment (see reporting requirements subsequently in Section 6.0).

The objective assessment methods to be used are detailed in Section 4.4.4 and information in relation to the application of SAC related penalties is detailed Section 5.9 as part of the operational noise analysis requirements of the compliance assessment.

Caution must be exercised when conducting objective assessment of unattended audio recordings. Applying the objective assessment methods to the total combined sound of the wind farm and ambient environment will inevitably produce false-positives caused by sound sources that are unrelated to the operation of the wind farm (e.g. bird or insect noise in an audio sample may result in a tone being determined in the sound recording). Penalties shall only be applied when the wind farm is confirmed as the source of the identified character. Penalties are also strictly only applicable to the component of the sound that is solely attributable to the operation of the wind farm. The results of automated analysis of unattended audio recordings will therefore likely require the application of data filtering measures to remove false positives for periods with attributes that are most likely related to ambient sounds (e.g. tonality as a result of birds or insects). Further guidance is provided in Section 5.9.

In instances where there is uncertainty about whether penalties are warranted at the compliance monitoring locations, data or observations from intermediate locations near to the turbines may be referenced where available.

The absence of impulsiveness or tonality in the sound of the wind farm at intermediate locations is sufficient to conclude an absence of these SACs at the corresponding receivers. However, due to the complex mechanisms associated with potential amplitude modulation, the assessment of amplitude modulation must always be undertaken at locations that are representative of the receiver locations being assessed.

#### 4.4.4 Objective assessment methods

The applicable objective assessment methods are defined in Table 8.

Objective assessment methods can produce false positives and false negatives, particularly when applied to large volumes of unattended measurement results which are affected by a combination of ambient and wind farm related sounds. The results of objective assessments must therefore always be considered in conjunction with the findings of the attended observations.

**Table 8: SAC objective assessment procedures**

SAC	Objective assessment procedure
Amplitude modulation	UK Institute of Acoustics' Amplitude Modulation Working Group publication <i>Final Report - A Method for Rating Amplitude Modulation in Wind Turbine Noise Version 1</i> dated 9 August 2016 (UK IOA AM procedure)
Impulsiveness	Australian Standard AS 1055:2018 <i>Description and measurement of environmental noise</i> (AS 1055:2018)  The method defined in Appendix E (informative) <i>Objective method for application of an impulse adjustment to receiver noise</i> .
Tonality	Queensland Code 23

The procedures for amplitude modulation and impulsiveness have been nominated in the absence of defined procedures in the Development Permit, AS 4959:2010, Queensland Code 23 or other policies commonly applied to wind farm noise assessment in Australia.

These procedures are considered representative of current industry best practice. If any alternative method is proposed to be used, the justification for the alternative will need to be documented for review by the chief executive responsible for administering the SPA.

Further information concerning the nominated procedures is provided in the following sub-sections.

##### *Amplitude modulation*

The UK IOA AM procedure provides a detailed procedure to quantify amplitude modulation. However, it does not define a method for determining the penalty which should be applied when amplitude modulation is assessed to be present.

Relevant guidance on the application of penalty adjustments in conjunction with the UK IOA AM procedure is documented in the UK government commissioned research report titled *Review of the evidence on the response to amplitude modulation from wind turbines and the findings* documented in the report *Wind Turbine AM Review Phase 2 Report* dated August 2016 (the UK government AM review).

The UK government AM review shall be referenced in determining whether amplitude modulation is present at a sufficient level to warrant the application of penalties.

It is noted that the UK government AM review penalty scheme represents a sliding scale system of penalties according to the magnitude of the level of amplitude modulation i.e. the value of the penalty varies according to the level of amplitude modulation. This type of penalty system is used when penalties are applied to individual measurement samples as part of analysing the compliance data. This contrasts with the approach to penalties defined in Queensland Code 23 (specifically in relation to tonality) which is based on applying a fixed value penalty of 5 dB according to how frequently a SAC is present.

Accordingly, while the UK IOA procedure and UK government AM review are informative, their application to an assessment of amplitude modulation based on a fixed penalty value, depending on whether the characteristics occurs sufficiently regularly, requires a judgement to be made. The following factors shall be accounted for in determining whether a penalty is warranted:

- The number of measurement periods in which amplitude modulation is identified at a level which would attract a penalty according to the UK government AM review
- The portion of identified measurement periods which attract a penalty for amplitude modulation according to the UK government AM review, but at a level which equates to penalty less than 5 dB according to the UK government AM review.

The reasoning for the choice of whether to apply a penalty adjustment shall be fully documented in the compliance reporting.

#### *Impulsiveness*

As per the nominated method for amplitude modulation, the AS 1055:2018 penalty scheme represents a sliding scale system of penalties according the magnitude of the level of impulsiveness. Applying AS 1055:2018 to an assessment of impulsiveness based on a fixed penalty value, depending on whether the characteristics occurs sufficiently regularly, requires a judgement to be made. The following factors shall be accounted for in determining whether a penalty is warranted:

- The number of measurement periods in which impulsiveness is identified at a level which would attract a penalty according to AS 1055:2018
- The number of identified measurement periods which attract a penalty for impulsiveness according to AS 1055:2018, but at a level which equates to penalty less than 5 dB according AS 1055:2018.

The reasoning for the choice of whether to apply a penalty adjustment shall be fully documented in the compliance reporting.

## **4.5 Site wind speeds**

During the construction of the wind farm, the two (2) reference mast detailed in Table 6 have been removed and replaced by four (4) permanent masts. The location of the new permanent masts has been selected to account for the need for wake free data. At the time of preparing this report, a report is being prepared by a qualified wind engineer detailing the relationship and correlation between the new masts and the reference masts.

Site wind speeds shall be collected in ten (10) minute periods throughout each of the noise monitoring surveys. The timing of each ten (10) minute sample shall be synchronised with the interval commencing on the hour and each 10 minute sample following the start of each hour.

This data shall be used to determine the wind speed at 90 m AGL (the reference wind speed height) corresponding to free-field conditions (i.e. free from turbine wake effects) representative of the reference mast locations listed in Table 6 of Section 3.0. Consistent with the wind speed data referenced for the background noise monitoring, the wind data to be used for the noise compliance monitoring is the arithmetic mean wind speed for each ten (10) minute period.

Wind speeds at 90 m AGL which are determined from wind speed measurements at heights below 90 m shall be determined using the procedures outlined in the IOA GPG *Supplementary Guidance Note 4: Wind Shear*, or an alternative method deemed appropriate by the wind engineer responsible for the supply of the data



Wind speeds may need to be measured at different locations for different wind directions in order to obtain data that is not influenced by the wake effects of upwind turbines (e.g. collection of wind data at upwind locations around the perimeter of the wind farm). Wind speeds measured at different locations will need to be translated to the wind speed at the reference mast locations (i.e. to determine the wind speed which would have been measured at the reference masts in the absence of the effect of the wind farm).

All procedures used to determine 90 m AGL wind speeds at the reference mast locations shall be validated and documented by the wind engineer for the project (see reporting requirements in Section 6.0).

#### **4.6 Local weather data**

The following local weather data shall be recorded during each noise survey:

- Local wind speeds: wind speeds at 1.5 m AGL shall be measured in ten (10) minute samples at a minimum of one (1) noise compliance monitoring location each for the compliance monitoring locations to the northeast/east of the wind farm (receivers R32, R48 and R78) and to west of the wind farm (receivers R02 and R05). In accordance with Queensland Code 23, the local wind speed must be measured to an accuracy of  $\pm 1$  m/s or better
- Rainfall: rainfall shall be measured in ten (10) minute intervals at a minimum of one (1) noise compliance monitoring location during the survey. In accordance with Queensland Code 23, the system must be able to measure the occurrence of precipitation greater than 0.2 mm in a measurement interval.

The timing of each ten (10) minute sample for the local weather data shall be synchronised with the interval commencing on the hour and each 10 minute increment following the start of each hour.

#### **4.7 Wind farm site data and records**

The following data shall be obtained from the wind farm operators:

- Site operational data: the operational status of each turbine shall be recorded in ten (10) minute samples and shall contain sufficient detail to differentiate whether a turbine was operating (including its mode of operation), available to operate, configured in an atypical mode of operation or shutdown. Each ten (10) minute sample of data shall be synchronised with the interval commencing on the hour and each ten (10) minute increment following the start of each hour
- Site records: site personnel shall be advised of the noise monitoring and shall be requested to record any observations with respect to atypical operations or noise levels (related to both the wind farm and ambient environment) which may influence the measurements. These observations, as well as any noise complaints independently recorded via the site's complaint handling and management system, shall be provided to the acoustic consultant. As a minimum, each record shall include details of the time, duration and location of the observation.

## 5.0 OPERATIONAL NOISE ANALYSIS

### 5.1 Rainfall

Any ten (10) minute sample in which rainfall greater than 0.1 mm occurred shall be filtered and therefore removed from the analysis.

The measurement data shall also be reviewed to identify and filter periods following rainfall in which the trend of the measurements indicates the noise levels are likely to have been elevated as a result of wet roads or flow noise associated with drainage systems and local watercourses.

### 5.2 Local wind speed

Any ten (10) minute period in which the average local wind speed is greater than 5 m/s occurred shall be filtered and therefore removed from the analysis.

Queensland Code 23 indicates that this type of filtering should be applied when the local wind speed in a measurement period exceeds 5 m/s for 90 % of the time rather than an average value of 5 m/s. The average value is nominated in this NMP on the basis of the following:

- The average wind speed value is a more readily derived measurement parameter
- The average wind speed value will generally be higher than value exceeded for 90 % of the measurement interval, and therefore represents a more stringent criterion for determining whether or not a measurement sample has been affected by wind induced extraneous noise (i.e. the average will result in a greater number of measurement sample being identified as affected by extraneous noise). Experience of long term wind farm noise monitoring surveys around Australia has demonstrated that the more stringent average-based approach can be adopted without excessive loss of data.

### 5.3 Extraneous noise screening

The measured noise data shall be reviewed to identify and filter periods in which extraneous noise sources are likely to have affected the measurements. Extraneous noise sources include, but are not limited to, domestic machinery, agricultural operations, construction noise or elevated bird/frog/insect noise.

Individual ten (10) minute measurement samples that are likely to have been affected by high frequency extraneous noise shall be identified and filtered from the analysis when the following conditions<sup>3</sup> are satisfied:

- The highest A-weighted one-third octave band noise level is greater than 1 kHz; and
- The identified one-third octave band A-weighted noise level is greater than a level of 20 dB  $L_{A90}$  and is within 5 dB of the broadband A-weighted noise level for the ten (10) minute sample in question.

The above procedure is identical to the screening process applied to the analysis of the background sound monitoring data for the Mt Emerald Wind Farm.

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<sup>3</sup> Griffin, D., Delaire, C., & Pischedda, P. (2013). Methods of identifying extraneous noise during unattended noise measurements. *20th International Congress of Sound & Vibration*.

The sound of a wind farm is unlikely to result in tones above 1 kHz at noise sensitive locations (due to high levels of atmospheric sound absorption at frequencies above 1 kHz) and, in the unlikely event of such a tone occurring, it is unlikely to dominate the sound pressure level of a one-third octave band. However, the procedure outlined above shall not be used to remove any measurement sample where the identified one-third octave band corresponds to a frequency in which the attended observations have indicated the potential for tones related to the operation of the wind farm. Further discussion of extraneous noise screening related to seasonal variations is provided in Section 5.5.

#### 5.4 Atypical wind farm operation screening

The compliance assessment shall be based on data obtained during periods that are representative of the normal operating conditions of the wind farm.

The operational records for each turbine shall be reviewed for each ten (10) minute sample to identify any periods of atypical operation or shutdown. These periods shall be excluded from the analysis if the overall noise level of the wind farm is likely to have been reduced.

As a minimum, any ten (10) minute period in which relevant turbines are not available to generate power, or operate in an atypical mode of operation, shall be identified and removed from the analysis for the relevant monitoring location being considered.

The turbines that are considered not relevant for each receiver location are identifiable as the turbines with the lowest predicted noise levels which collectively result in a predicted noise level 15 dB<sup>4</sup> lower than the total predicted noise level of the wind farm at the receiver. This means that if any or all of the non-relevant turbines were to not operate during a given measurement period, the reduction in total noise level would be 0.1 dB or less and would therefore generally be inconsequential to the assessment outcome.

#### 5.5 Review of seasonal considerations

Seasonal variations can affect both the level of background noise and operational wind farm noise.

##### 5.5.1 Background noise

The main potential sources of seasonal variations in background noise are:

- Rainfall (see data filtering procedures in Section 5.1)
- Insect, bird and other fauna noise (see data filtering procedures in Section 5.3)
- Local domestic plant such as air-conditioning or heating
- Changes in domestic or agricultural activity in the vicinity of the monitoring location.

Other sources of background noise variation may relate to changes in vegetation, wind direction and wind shear.

The data shall be reviewed to identify any anomalous trends that are indicative of significant seasonal variations. These types of effects may be evident as elevated noise levels (in relation to the data contained in the background noise report) at low wind speeds (less than 3 m/s at hub height), or striations in the data characterised by relatively constant levels across a range of wind speeds (e.g. as would occur if domestic or agricultural machinery significantly influences the measurements).

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<sup>4</sup> A level that is 10 dB below the noise source under investigation is generally used for environmental noise assessment work considered. However, a source of noise that is 10 dB lower in level will contribute 0.4 dB to the total noise level. A 0.4 dB level variation may alter a wind farm compliance assessment outcome. Hence the selection of a lower threshold based on being 15 dB lower than the level of the highest turbine contribution.

Any identified variations in the measured levels that are likely to be attributable to seasonal changes in background noise levels shall be filtered from the analysis where possible. If the effect cannot be reliably filtered, and the effect is sufficient to preclude an assessment of the wind farm's compliance, supplementary procedures (see Section 5.8) or repeat measurements will be required.

### 5.5.2 Wind farm noise

The main potential source of seasonal variation in wind farm noise levels is wind direction and wind speed.

The wind directions and wind speeds that occurred during the survey shall be reviewed to determine whether the conditions were representative of the range generally expected at the wind farm site, having regard to the long term trend data provided in Appendix G. In particular, if upwind or crosswind conditions are found to have occurred more regularly than is generally expected at the site, repeat measurements will generally be required.

In some cases, a sensitivity analysis or supplementary assessment (see Section 5.8 for procedures) may be sufficient to enable an assessment of compliance without further measurement extensions.

For example, while Queensland Code 23 is based on evaluating compliance for the aggregated measurement data for the range of conditions normally expected at the site (subject to considerations relating to subsets of data as noted in Section 5.6), an analysis limited to data obtained under downwind conditions may be sufficient to demonstrate compliance. Additionally, the availability of limited data for high wind speeds may be addressed by using other information relating to the change in the wind farm's sound emission with increasing wind speed (e.g. sound power level test data obtained in accordance with IEC 61400-11:2012 or measurement data obtained at intermediate locations or other compliance monitoring locations around the wind farm – see supplementary procedures in Section 5.8).

The assessment is referenced to hub height wind speeds and therefore seasonal wind shear variations are primarily relevant to potential variations in background sound levels rather than wind farm noise levels. However, wind shear may be relevant to the assessment of SACs. This is because increased wind shear may result in lower background noise levels for a given wind speed (i.e. increasing the likelihood of the wind farm being audible) and may also affect the sound characteristics of the wind farm. Attended observations must therefore include time periods when increased wind shear could be expected (note the requirement in Section 4.3 for at least one set of attended observations to occur during the night period for each stage of the surveys).

## 5.6 Correlation of noise levels and site wind speeds

The measured noise levels shall be separately correlated with the derived site wind speeds (see Section 4.5) for the day and night periods as follows:

- Day: 0600-2200 hrs
- Night: 2200-0600 hrs.

In accordance with Queensland Code 23, the measured  $L_{A90}$  noise levels for each ten (10) minute period shall be used as a proxy for the assessment of  $L_{Aeq}$  noise levels associated with the operation of the wind farm.

A chart of the measured  $L_{A90}$  noise levels site wind speeds shall be produced for the day and night periods for each measurement location. A line of best fit determined from a third order regression analysis is to be applied to the correlated data. Supporting information will be required if alternative methods of correlation are adopted to provide a better representation of the variation in noise levels with wind speeds (e.g. analysis of individual wind speed bins).

Queensland Code 23 is based on evaluating compliance for the aggregated measurement data for the range of wind directions normally expected at the site. However, the measurement data shall be reviewed to identify any distinctive trends or large variations in level which warrant definition and analysis of a subset of the data. These subsets may be defined by wind direction, time of day or a combination of the two. In particular, data corresponding to downwind conditions to the receiver location shall be reviewed.

Any identified subsets that are found to warrant analysis shall be assessed separately when comparing the derived wind farm noise levels with the compliance limits. When assessing these subsets, consideration may need to be given to how background noise levels vary for the specific subset being assessed.

### 5.7 Adjustment for background noise levels

The background noise levels documented in the background noise monitoring report shall be used to adjust compliance monitoring results for the influence of background noise levels.

The adjustment is applied by logarithmically subtracting the pre-construction (background noise monitoring) regression line from the post-construction (operational noise monitoring) regression line to determine the derived wind farm noise.

The tabulated background data to be used for this analysis is reproduced in Appendix H.

### 5.8 Supplementary procedures

The data filtering and background noise adjustment procedures detailed in Section 5.1 to Section 5.7 shall be used to reduce the influence of background noise levels.

If the residual influence of background noise precludes a definitive assessment of compliance, supplementary procedures shall be used to reduce the uncertainty.

A supplementary analysis shall be undertaken by comparing data measured at the compliance monitoring locations during upwind and downwind conditions (subject to the availability of data for the downwind directions). Higher noise levels during downwind conditions are indicative of the results being influenced by the operation of the wind farm. Conversely, comparable noise levels during upwind and downwind conditions are indicative of an environment dominated by the influence of sources that are not related to the operation of the wind farm (primarily for sites where background noise levels are not expected to vary significantly with wind direction).

Supplementary measurements may also be undertaken at intermediate locations that are positioned nearer to the wind farm to:

- Assist the evaluation of noise levels solely attributable to the operation of the wind farm
- Provide data for reference locations where testing can be repeated, if required, for the purposes of re-assessing compliance in future.

If noise measurements are undertaken at an intermediate location between the wind farm and the noise sensitive receiver location(s), this data may be used to assist an assessment of the wind farm at the compliance monitoring locations.

Intermediate locations, where used, and subject to practical access constraints, shall generally be located:

- In the vicinity of the predicted 45 dB  $L_{A90}$  contour associated with the wind farm
- At positions that are suitable for measuring conditions that are representative of downwind propagation from the wind farm to the noise sensitive receiver location, accounting for all turbines that significantly contribute to the total wind farm noise levels at the noise sensitive location.

Noise measurement data obtained at intermediate locations shall be used as follows:

- Noise level versus wind speed profile: data obtained at an intermediate location shall be used to define the profile of the change in measured wind turbine noise levels with increasing wind speeds. This profile shall then be compared to the profile measured at the compliance monitoring location to determine if increasing noise levels at the noise sensitive location are attributable to the wind farm (i.e. the profiles at the intermediate and the compliance monitoring locations are equivalent) or the influence of wind related background noise levels (i.e. the profiles at the intermediate and the compliance monitoring location are not equivalent)
- Data filtering: any ten (10) minute period in which the measured noise level at the noise sensitive location is higher than the simultaneously measured level at the intermediate location shall be considered background noise affected and may be removed from the analysis

Data obtained at intermediate location can also sometimes be extrapolated to the compliance monitoring locations to inform an assessment of compliance. However, due to the complexity of the terrain profile around the Mt Emerald Wind Farm, this approach is generally not suitable in this instance because of the increased uncertainty introduced by differences between the sound propagation paths to intermediate locations and receiver locations. In lieu of extrapolation of intermediate measurement location data, the results of in-situ sound power level verification testing may be used to assist an assessment of compliance (i.e. by verifying the turbines noise emissions and recalculating receiver noise levels using the same prediction methodology reference in the revised noise assessment report).

In some instances, a conclusive assessment of compliance may require other noise compliance monitoring methods to be considered. This may involve:

Targeted assessment of specific conditions (i.e. wind speeds, wind directions and times of day);

- Additional measurements at a representative location where background noise levels are lower;  
or
- Attended measurements for targeted wind conditions with the wind farm on and off.

## 5.9 Application of penalties for SACs

If one or more SACs are confirmed to be present in 10 % or more of the measurement samples at a particular integer wind speed, a penalty adjustment of 5 dB shall be applied to the derived wind farm noise level at that integer wind speed.

Specifically, the following shall be carried out:

- The number of ten (10) minute intervals in which one or more SACs are potentially present shall be determined for each integer value of the site wind speed
- If the number of ten (10) minute intervals potentially containing one or more SACs is less than 10 % of the total number of all ten (10) minute obtained in each integer wind speed bin (defined as winds between  $\pm 0.5$  m/s of the integer wind speed) between cut-in and rated power, the occurrence of SACs is not sufficiently frequent to warrant the application of a penalty adjustment
- If the number of ten (10) minute intervals containing one or more SACs is 10 % or more of the total number of all ten (10) minute obtained in each integer wind speed bin between cut-in and rated power, the occurrence of SACs is sufficiently frequent to warrant the application of a penalty adjustment.

## 6.0 OPERATIONAL NOISE REPORTING

Compliance reports shall be submitted to the chief executive responsible for administering the SPA within six (6) weeks of completing each of the two (2) compliance monitoring surveys.

The reporting shall adhere to the documentation requirements detailed in Section 8.3 of AS 4959:2010, and shall include the following additional information:

- Details of the operational configuration of the turbines during the compliance monitoring; in particular, identification of the turbines using sound curtailment modes, and the wind speeds and wind directions for which these modes were used
- Supporting documentation for the site wind speed data referenced in the compliance assessment
- Charts illustrating the noise measurement results shall clearly identify all samples that have been filtered from the analysis due to rainfall or the identification of extraneous noise influences. The analysis shall be supplemented by a summary table for each noise monitoring location detailing the total number of measurements points, the number of points that have been removed, and the final number of data points that the analysis has been based on
- Full details of all attended observations conducted for the purpose of identifying where SACs are potentially present in the sound of the wind farm
- Full details of any supplementary procedures that have been adopted as part of conducting the compliance assessment.

**APPENDIX A GLOSSARY OF TERMINOLOGY**

<b>Amplitude Modulation</b>	Sound that is characterised by a rhythmic and higher than normal rise and fall in sound level at regular intervals.
<b>A-weighting</b>	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
<b>Day</b>	0600 to 2200 hrs as detailed in the Development Permit
<b>dB</b>	Decibel. The unit of sound level.
<b>Downwind conditions</b>	Generally defined as wind speeds and directions which equate to a positive vector wind speed of at least 2 to 3 m/s in the direction from the nearest turbines and the observation location
<b>Frequency</b>	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
<b>Hertz (Hz)</b>	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
<b>Impulsiveness</b>	Sound that is characterised by a distinct and very rapid rise in sound level (e.g. a car door closing or the impact sound of a hammer)
<b>L<sub>A90</sub></b>	The A-weighted noise level equalled or exceeded for 90 % of the measurement period. This is commonly referred to as the background sound level.
<b>L<sub>Aeq</sub></b>	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.
<b>Night</b>	2200 to 0600 hrs as detailed in the Development Permit
<b>Receivers</b>	Existing or approved noise sensitive land uses as of the date of the Development Permit for the Mt Emerald Wind Farm, comprising existing or approved residential dwellings.
<b>Special Audible Characteristics</b>	Features of a sound which, when present, increase the likelihood of adverse reaction the sound. These characteristics include tonality, impulsiveness and amplitude modulation.
<b>Tonality</b>	Sound characterized by a single frequency component or narrow-band components that emerge audibly from the total sound (e.g. whines or hissing sounds)



## APPENDIX B MT EMERALD WIND FARM TURBINE SELECTION

The wind farm comprises fifty-three (53) 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 9.

**Table 9: Selected wind turbines**

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

## APPENDIX C TURBINE COORDINATES

The following table sets out the coordinates of the fifty-three (53) turbine layout of the Mt Emerald Wind Farm.

**Table 10: Mt Emerald Wind Farm turbine coordinates – MGA 94 zone 55**

Turbine	Easting	Northing	Turbine model
1	328792	8102560	V117
2	328903	8102219	V117
3	328983	8101892	V117
4	328466	8101926	V117
5	328402	8102310	V117
6	328458	8101575	V117
7	328031	8101732	V117
8	327768	8101472	V117
9	327574	8102211	V112
10	329242	8100793	V117
11	329738	8100745	V117
12	329581	8101021	V117
13	329644	8101320	V117
14	328498	8101272	V117
15	328537	8100981	V112
16	328753	8100703	V112
17	329043	8100457	V112
18	329113	8100157	V112
19	329228	8099859	V117
20	329648	8099620	V117
21	329790	8099328	V117
22	329970	8099041	V117
23	328157	8100695	V117
24	328045	8100267	V117
25	328206	8099881	V117
26	328648	8099655	V117
27	328824	8099088	V117
28	327652	8099773	V117
29	328376	8099384	V117
30	328058	8099149	V112

Turbine	Easting	Northing	Turbine model
31	328292	8098872	V117
32	328726	8098695	V112
33	329067	8098362	V117
34	327392	8099290	V117
35	327187	8099577	V117
36	326793	8099845	V112
37	326708	8100606	V117
38	326556	8101046	V117
39	326484	8100150	V112
40	326222	8100448	V112
41	325941	8100734	V112
42	325931	8101065	V112
43	325539	8101383	V112
44	325930	8101603	V117
45	326364	8101775	V117
46	325803	8102201	V117
47	325402	8101713	V112
48	325266	8102037	V112
49	325197	8102351	V117
50	325535	8102589	V112
51	326071	8102642	V117
52	326263	8102926	V117
53	326071	8103211	V117

## APPENDIX D RECEIVER COORDINATES

The following table sets out the one hundred and twenty-three (123) locations considered in the preparation of the NMP. These coordinates correspond to the same receivers referenced in the revised noise assessment for the Mt Emerald Wind Farm, subject to the following notes:

- R13: it is understood there is no dwelling at this location. It is unknown if an approval for a dwelling existed at the date of approval for the wind farm
- R89: this location to the north of the wind farm was indicated as a receiver in the revised noise assessment – subsequent investigations have determined that this is located on industrial premises (waste management facility) and is not a residential dwelling.

**Table 11: Receiver locations – MGA 94 Zone 55**

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 <sup>[A]</sup>	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 <sup>[B]</sup>	324925	8104393
R26	327385	8104239	R90	323839	8105103
R27	328640	8104706	R91	333946	8102712
R28	328814	8104996	R92	334049	8103397

Receiver	Easting	Northing	Receiver	Easting	Northing
R29	329227	8104783	R93	333585	8103544
R30	329632	8104345	R94	333738	8103749
R31	329738	8105254	R95	333737	8103972
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			

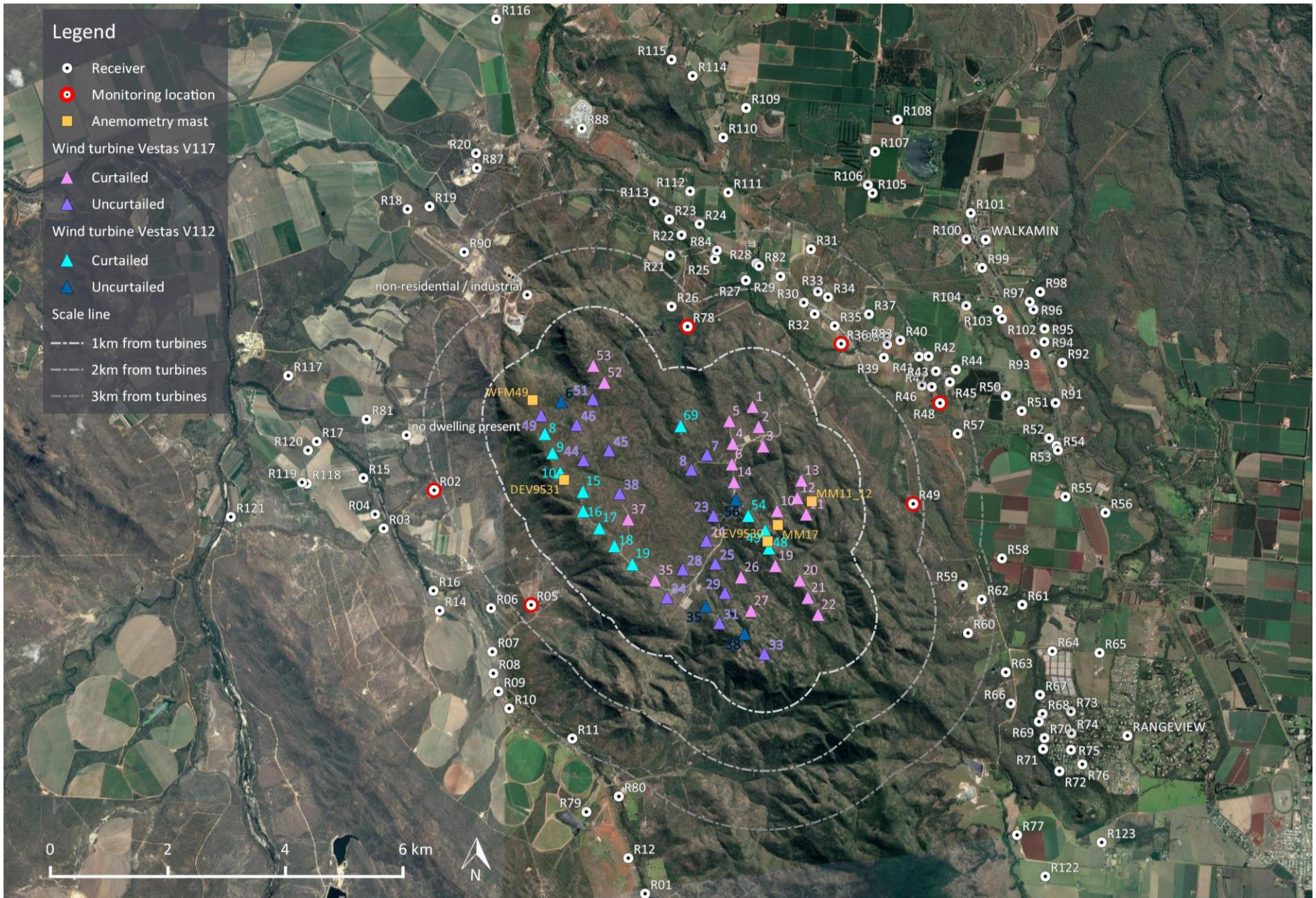
Note A: no dwelling structure at this location at the time of preparing this report

Note B: industrial premises – not a residential dwelling

## **APPENDIX E SITE LAYOUT PLAN**

A site layout plan for the turbines, site meteorological masts and receiver locations is provided on the following page.

This layout map also indicates the operational configuration of the turbines considered in the revised noise assessment report i.e. the types of turbines used at the site and the turbines which utilise curtailed modes of operation for certain wind speeds and directions. The information with respect to curtailment must be regarded as is indicative only and may be subject to change. Any requirement to refer to operating modes for the purpose of noise testing or analysis of noise testing data will necessitate conformation of the applicable operating modes at the site.



## APPENDIX F DEVELOPMENT PERMIT – NOISE REQUIREMENTS

The following operational noise requirements are reproduced from *Schedule 1: Conditions of Approval* of the Development Permit, as amended by the Notice of Decision issued by the Minister for Infrastructure, Local Government and Planning and Minister for Trade and Investment dated 31 January 2017.

4. *The wind farm development must be designed and operated to ensure that:*
- Prior to commencement of use and then to be maintained.*
- (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:*
- (i) *35dB(A); or*
- (ii) *The background noise level ( $L_{A90}$ ) plus 5dB(A);*
- and*
- (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:*
- (i) *37dB(A); or*
- (ii) *The background noise level ( $L_{A90}$ ) plus 5dB(A)*
- (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.*
- (d) *Measurements of background noise or 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.*

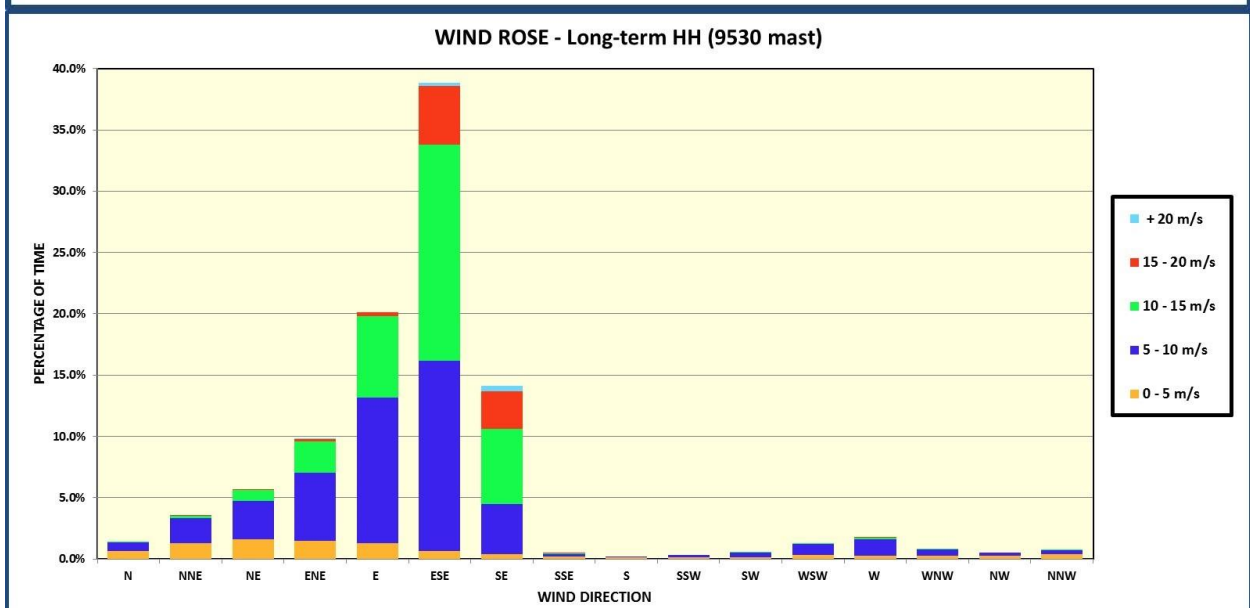
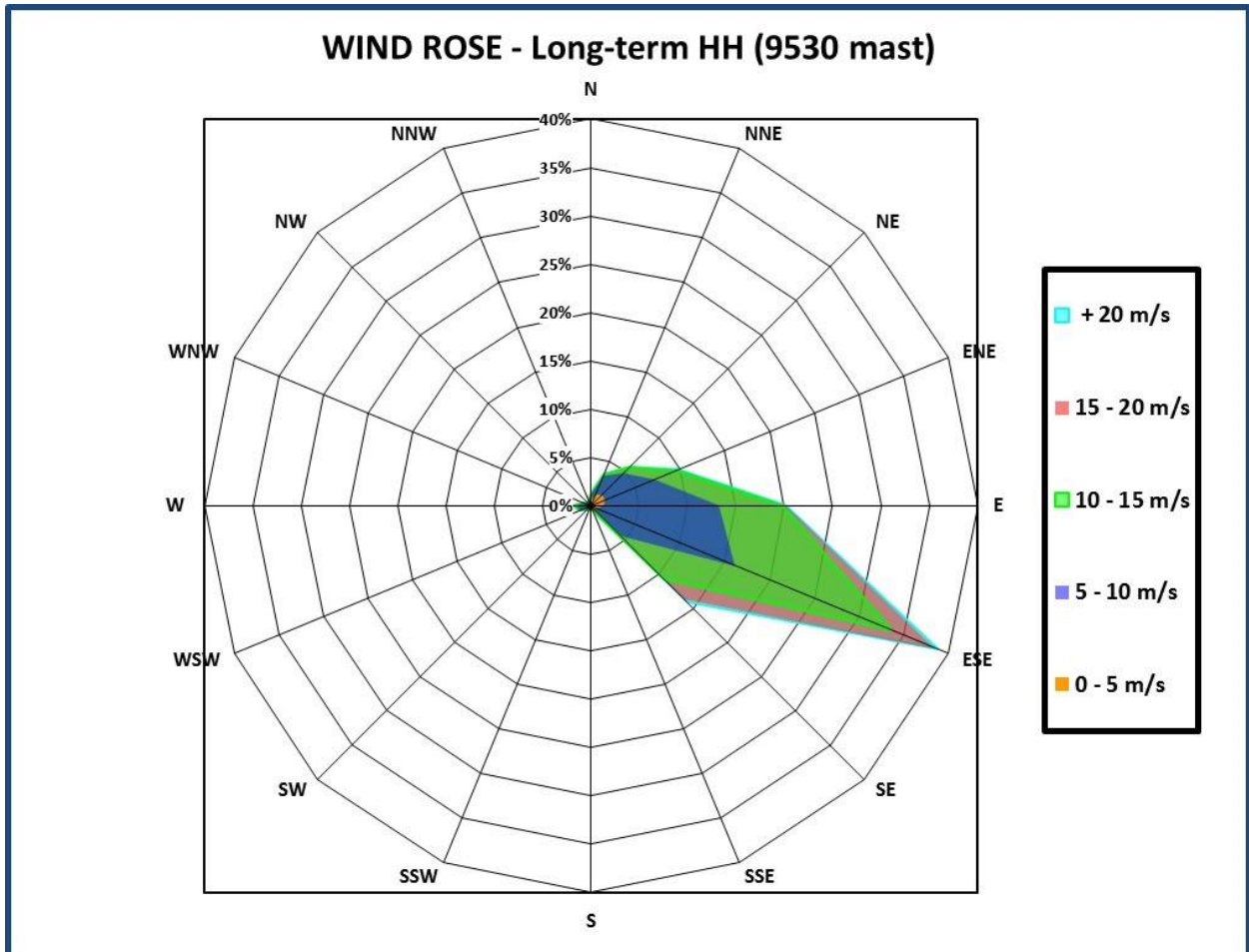


5. (a) *Submit to the chief executive administering the SPA a revised noise assessment report, certified by a suitably qualified acoustic consultant, demonstrating that the proposed wind farm can meet the noise levels specified in condition 4 of this approval. The report is to:*
- (a) *Prior to the commencement of site / operational / building work*
- i. *Model the acoustic impacts of the wind farm based on the revised Turbine Location and Development Footprint Plan submitted in accordance with condition 2 of this approval.*
- 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.*
- ii. *Identify any design specifications or operational restrictions that may be necessary to ensure compliance with the noise levels specified in condition 4, such as turbine types or limitations on hours of operation of specific turbines.*
- (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 condition 4 of this approval. The report is to:*
- (c) *Within twelve (12) months of the completion of construction and then to be maintained*
- 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.*
- 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.*

**APPENDIX G SITE WIND SPEED AND DIRECTION TRENDS**

Representative long-term wind speed and direction at 90 m AGL for a period of 8 years are summarised in the following wind roses, provided by RATCH Australia Corporation.

Wind data shown below has been extrapolated to 90 m AGL based on wind speed and direction measured at 80 m AGL at met mast 9530, located within the wind farm site.



## APPENDIX H BACKGROUND NOISE DATA

The following data shall be referenced for the compliance assessment of the wind farm.

This data is reproduced from Appendix G of the background noise monitoring report and relates to the data obtained under all wind directions. These are the same background noise values used to determine the applicable operational noise limits presented in Section 3.0 of this NMP.

If required, additional data relating solely to downwind directions is also provided in Appendix G of the background noise monitoring report for some of the receiver locations.

**Table 12: Measured A-weighted daytime background noise levels, dB LA90**

Receiver	Hub height wind speed (m/s)										
	3	4	5	6	7	8	9	10	11	12	13
R02	28.9	29.4	30.1	30.9	31.7	32.4	33.1	33.6	34.0	34.1	34.0
R05	26.0	27.1	27.9	28.5	29.0	29.4	30.0	30.8	32.0	33.5	35.7
R36	28.5	29.4	30.4	31.6	32.9	34.0	35.1	35.9	36.5	36.6	36.3
R48	30.5	31.8	33.2	34.6	35.9	37.1	38.1	38.8	39.3	39.3	38.9
R49	27.8	28.2	29.0	30.1	31.3	32.6	33.8	34.7	35.4	35.6	35.2
R78	26.0	26.4	27.5	28.9	30.6	32.3	33.8	35.0	35.5	35.3	34.2

**Table 13: Measured A-weighted night-time background noise levels, dB LA90**

Receiver	Hub height wind speed (m/s)										
	3	4	5	6	7	8	9	10	11	12	13
R02	24.6	24.7	24.8	25.0	25.2	25.7	26.5	27.8	29.5	31.8	34.9
R05	24.1	24.8	25.2	25.6	25.9	26.4	27.2	28.5	30.4	33.0	36.4
R36	28.4	28.9	29.3	29.7	30.2	30.6	31.0	31.5	32.0	32.5	33.1
R48	28.9	29.6	30.1	30.3	30.5	30.7	30.9	31.3	31.8	32.6	33.8
R49	25.3	25.5	25.8	26.1	26.5	27.0	27.7	28.4	29.3	30.3	31.5
R78	22.3	22.8	23.5	24.4	25.4	26.5	27.8	29.2	30.6	32.1	33.7

The locations of the reference masts for the site wind speeds in Table 12 and Table 13 are detailed in Section 3.0 of this NMP (see Table 6).