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Acoustics 

WALLABY CREEK WIND FARM  
NOISE AND VIBRATION ASSESSMENT

Rp 002 r01 20220871 | 29 October 2025

**Project:** **WALLABY CREEK WIND FARM**

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**Report No.:** **Rp 002 r01 20220871**

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## EXECUTIVE SUMMARY

ACCIONA Energy Australia Global Pty Ltd (Applicant) is proposing to construct and operate the Wallaby Creek Wind Farm (Project), which is partly within the Central-West Orana Renewable Energy Zone (CWO-REZ) in New South Wales (NSW). The Project would be located in the Narromine Shire Council Local Government Area (LGA), close to Narromine and Tomingley.

The Project is proposed to consist of up to 38 wind turbines, a Battery Energy Storage System (BESS) with a capacity of up to 200 Megawatt (MW) / 400 MW hours (MWh) and supporting infrastructure. The Project would supply up to approximately 236 MW of electricity into the National Electricity Market (NEM) through connection to the electricity grid in Narromine.

This report presents the results of an assessment of noise, undertaken in accordance with the applicable Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-60247211), dated 11 February 2025, and is intended to supplement the Environmental Impact Statement (EIS) for the Project.

## METHOD

For the purposes of this assessment, one candidate wind turbine model has been nominated by the Applicant comprising the one noise modelling scenario that has been documented within this assessment.

Operational noise from the wind turbines has been assessed in accordance with the Technical Supplement for Noise, as required by SSD-60247211.<sup>1</sup>

The Technical Supplement for Noise refers to the SA Guidelines as the underlying noise assessment method for wind energy projects, subject to a set of supplementary procedures that are specific to NSW.<sup>2</sup>

A background noise monitoring survey was undertaken to obtain a representation of typical baseline conditions at receivers in the vicinity of the Project. The results are detailed in the Background Noise Assessment.<sup>3</sup>

Manufacturer specification data provided by the Applicant for the candidate wind turbine model has been used as the basis for the assessment. These specifications provide noise emission data in accordance with the international standard referenced in the Technical Supplement for Noise.<sup>4</sup> The noise emission data is consistent with the range of values expected for comparable types of multi megawatt wind turbine models that may be considered for the Project.

The noise emission data has been used with international standard ISO 9613-2:1996 to predict the level of noise expected to occur at neighbouring receivers.<sup>5</sup> The ISO 9613-2:1996 standard has been applied based on well-established input choices and adjustments, considering research and international guidance that is specific to wind farm noise assessment. ISO 9613-2:1996 is nominated as being an acceptable noise prediction method in the SA Guidelines.

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<sup>1</sup> NSW Department of Planning, Housing and Infrastructure, *Wind Energy Guideline: Technical Supplement for Noise Assessment*, November 2024 (Technical Supplement for Noise)

<sup>2</sup> SA Environmental Protection Authority, *Wind farms environmental noise guidelines*, first published in 2009; updated in 2021 (SA Guidelines)

<sup>3</sup> MDA, Rp 001 r01 20220871 – *Wallaby Creek Wind Farm– Background Noise Assessment* dated 29 October 2025 (Background Noise Report)

<sup>4</sup> International Electrotechnical Commission, IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques* (IEC 61400-11)

<sup>5</sup> International Organisation for Standardisation, ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2:1996)

## ASSESSMENT OVERVIEW

The results of the noise modelling for the Project demonstrate that the predicted noise levels for the proposed wind turbine layout are below the base noise limit determined in accordance with the Technical Supplement for Noise at all neighbouring non-associated receivers by a minimum margin of 2.8 dB.

To assess compliance with the applicable noise limit, the Technical Supplement for Noise also requires consideration of potential adjustments to the predicted wind turbine noise levels for special noise characteristics, comprising tonality and low frequency. Analysis of the noise emission frequency data for the proposed wind turbine model indicates that the noise from the Project is not expected to be characterised by tonality. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Indicative noise modelling also demonstrates the Project is predicted to result in noise levels below 60 dB  $L_{Ceq}$  at all assessed non-associated receivers (the threshold defined by the Technical Supplement for Noise for the presence of low frequency noise).

Accordingly, adjustments for special noise characteristics are not warranted and have therefore not been applied to the predicted noise levels.

The assessment has also considered operational noise from the proposed ancillary infrastructure, including substations and BESS. The predicted noise levels have been assessed in accordance with the NPfI.<sup>6</sup> The assessment demonstrates that ancillary infrastructure noise is predicted to be below the most stringent project noise trigger level of 35 dB  $L_{Aeq, 15 \text{ min}}$  at all non-associated receivers.

Predicted noise levels at associated receivers resulting from the operation of the Project wind turbines and BESS have also been included within this report. As per the requirements of the Technical Supplement for Noise, an assessment of impacts has not been conducted at these locations. The predicted noise levels are therefore provided within this report for information only.

A preliminary construction noise and vibration assessment has been conducted, accounting for typical equipment items and work practices, as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the ICNG and AVTG.<sup>7</sup>

The assessment indicates that some construction stages may result in elevated noise levels at non-associated receivers, due to the proximity of works on access tracks. This means that a detailed construction noise and vibration management plan (CNVMP) will be necessary once a main contractor is appointed and a more detailed schedule of equipment and plant items, construction method and work areas is known. This will include specific consideration of construction stages indicating elevated risks and will include the adoption of all feasible and reasonable mitigation measures and work practices where the highly noise affected management level continues to be exceeded.

The construction noise assessment also includes a blasting noise assessment, considering the wind turbine foundations as the locations at which blasting may be required. The outcomes of this assessment indicate that estimated airblast overpressure and ground vibration levels are expected to be below the recommended criteria specified in the ANZEC 1990 Report at all non-associated receivers.<sup>8</sup>

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<sup>6</sup> NSW Environment Protection Authority, *Noise Policy for Industry*, October 2017 (NPfI)

<sup>7</sup> NSW Department of Environment and Climate Change, *Interim Construction Noise Guideline*, July 2009 (ICNG); NSW Department of Environment and Conservation, *Assessing Vibration: A Technical Guideline*, February 2006 (AVTG)

<sup>8</sup> Australian and New Zealand Environment Council, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, dated September 1990 (ANZEC 1990 Report)

An assessment of traffic noise associated with construction activities has been conducted in accordance with the RNP.<sup>9</sup> The assessment established setback distances for local and freeway/arterial/sub-arterial roads within which applicable traffic noise criteria may be exceeded. Three receivers were identified to be within the defined setback distances. These receivers should be consulted prior to and during construction activities to manage impacts and considered in more detail as part of a future CNVMP.

## RECOMMENDATIONS

The findings of the operational noise assessment demonstrate that the Project is capable of being designed and operated to comply with the Project SEARs requirements. Prior to the commencement of construction it is recommended that the predicted noise levels for all components of the operational noise assessment be updated for the final Project configuration and equipment selections, in order to verify ongoing compliance with the SEARs and applicable noise policy.

Consistent with the Technical Supplement for Noise, compliance is also recommended to be verified by post-construction noise compliance monitoring. The compliance testing procedures should be documented in a compliance test plan. Given the size of the Project, it is recommended that the compliance testing procedures include provisions for early onsite noise emission testing of the wind turbines to verify consistency with the design validation modelling.

Measures for the management of construction noise and vibration would be implemented via a CNVMP to be prepared at a later stage of the Project when a construction contractor has been selected and specialised construction planning for the site has been developed. This would comprise a detailed, Project specific construction noise and vibration assessment, as well as Project specific noise mitigating work practices and physical noise controls (where required).

Overall, the noise and vibration assessment indicates that construction, operation and decommissioning of the Project can be designed and executed such that associated noise is capable of complying with the requirements of the Project SEARs (SSD-60247211).

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<sup>9</sup> NSW Department of Environment, Climate Change and Water, *Road Noise Policy*, March 2011 (RNP)

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## 1.0 INTRODUCTION

ACCIONA Energy Australia Global Pty Ltd (Applicant) is proposing to construct and operate the Wallaby Creek Wind Farm (the Project), which is partly within the Central-West Orana Renewable Energy Zone (CWO-REZ) in New South Wales (NSW). The Project would be located in the Narromine Shire Council Local Government Area (LGA), close to Narromine and Tomingley.

The Project would consist of up to 38 wind turbines, a Battery Energy Storage System (BESS) with a capacity of up to 200 Megawatts (MW) / 400 MW hours (MWh) and supporting infrastructure. The Project would supply up to approximately 236 MW of electricity into the National Electricity Market (NEM) through connection to the electricity grid in Narromine.

Marshall Day Acoustics (Australia) Pty Ltd (MDA) has been engaged by ERM Australia Pty Ltd (ERM) to prepare a noise and vibration assessment to support the Environmental Impact Statement (EIS) for the Project.

This report presents the results of an assessment of operational noise, construction noise and construction vibration for the proposed Project, undertaken in accordance with the applicable Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-60247211), dated 11 February 2025.

The SEARs require that the EIS assess:

- operational wind turbine noise in accordance with Wind Energy Guideline and the supporting Technical Supplement for Noise (refer to Section 6.0)<sup>10</sup>
- operational noise generated by ancillary infrastructure in accordance with the NPfI (refer to Section 7.0)<sup>11</sup>
- construction noise in accordance with the ICNG (refer to Section 10.0)<sup>12</sup>
- construction traffic noise under the RNP (refer to Section 11.0)<sup>13</sup>
- construction vibration under the AVTG (refer to Section 10.4)<sup>14</sup>
- cumulative operational noise impacts (considering other developments in the area) (refer to Section 8.0)

The noise assessment presented in this report is based on:

- operational noise limits determined in accordance with applicable regulatory documentation
- predicted wind turbine noise levels, based on the proposed Project layout and a candidate wind turbine model
- predicted noise levels from the ancillary infrastructure, based on noise emission data provided by the Applicant (and in some cases sourced from MDA's noise database)

<sup>10</sup> NSW Department of Planning, *Housing and Infrastructure, Wind Energy Guideline: Guidance for State significant wind energy development*, November 2024 (Wind Energy Guideline);  
NSW Department of Planning, *Housing and Infrastructure, Wind Energy Guideline: Technical Supplement for Noise Assessment*, November 2024 (Technical Supplement for Noise)

<sup>11</sup> NSW Environment Protection Authority, *Noise Policy for Industry*, October 2017 (NPfI)

<sup>12</sup> NSW Department of Environment and Climate Change, *Interim Construction Noise Guideline* dated July 2009 (ICNG)

<sup>13</sup> NSW Department of Environment, Climate Change and Water, *Road Noise Policy* dated March 2011 (RNP)

<sup>14</sup> NSW Department of Environment and Conservation, *Assessing Vibration: A Technical Guideline* dated February 2006 (AVTG)

The report also includes a risk assessment for noise impacts associated with blasting, in accordance with the ANZEC 1990 Report (refer to Section 10.5).

A glossary of terminology is provided in Appendix A with general information regarding the description of sound provided in Appendix B.

## 2.0 PROJECT OVERVIEW

### 2.1 Project description

The Project would be located partly within the CWO-REZ, approximately 30 kilometres (km) south-west of Dubbo, and 15 km to the north-east of Tomingley. It is located within the Narromine Shire Council LGA and comprises 43 lots across 13 landholdings.

The Project is a proposed wind farm with an estimated capacity of up to approximately 236 MW, supplying energy to the NEM as required via connection to the electricity grid in Narromine.

The Project proposes the installation, operation, maintenance and decommissioning of:

- up to 38 wind turbines
- a BESS with a capacity of up to 200 MW/400 MWh
- associated infrastructure such as a substation, operation and maintenance buildings, internal access track network, civil works and electrical infrastructure necessary to connect to the electricity transmission network.

The Project also includes temporary ancillary facilities required during the construction period, such as a temporary workers accommodation facility catering for the peak workforce, construction compounds, batching plants and laydown areas.

The coordinates of the wind turbines are tabulated in Appendix C.

A Project layout plan illustrating the wind turbine layout, approximate ancillary infrastructure locations, and noise sensitive receivers is provided in Figure 1.

The topography of the Project and surrounding area is depicted in the elevation map provided in Appendix D.

### 2.2 Receivers

Based on information provided in the Technical Supplement for Noise, receivers can comprise a range of noise sensitive land uses. However, the receivers identified by the Applicant in the vicinity of the Project are dwellings only.

On this basis, the term receiver is used throughout this report to refer to any residential receiver identified by the Applicant in the vicinity of the proposed Project.

A total of 83 receivers have been identified by the Applicant in the vicinity of the Project, of which 65 are located within 5 km of a Project wind turbine and have therefore been considered in this noise assessment, referred to as assessed receivers. This is a nominal distance commonly referenced on account of being significantly greater than the separation distance required to achieve compliance with the lowest possible noise limit prescribed in the Technical Supplement for Noise.

For the purposes of noise assessment, assessed receivers are separated into two distinct categories, based on the requirements of the Technical Supplement for Noise, the SA Guidelines, and guidance documented in the Wind Energy Guideline:

#### *Associated*

- A residence on privately-owned land for which the owner has reached a private agreement with the applicant in relation to the development and management of noise impacts.

#### *Non-associated*

- A residence on privately-owned land for which the owner has not reached a private agreement with the applicant in relation to the development.

- A residence on privately-owned land for which the owner has reached a private agreement with the applicant in relation to the development, but the private agreement does not include management of noise impacts.

Private agreements established between an applicant and landholders/owners can comprise two general types:

*Host agreements*

- Where applicants enter into private agreements with ‘host’ landholders who are willing to have Project infrastructure located on their land

*Impact agreements*

- Where private agreements are negotiated between the applicant and neighbours of the development when the development may significantly impact the neighbour or their land. The private agreement aims to manage and mitigate these impacts

Where a private agreement of either type specifically addresses noise, the affected residence is taken to be associated with the development for the purpose of the assessment.

All other receivers are categorised as non-associated.

Of the 65 assessed receivers, there are 16 that are subject to a host or impact agreement with the Applicant, with provisions included to address noise impacts. These receivers are therefore categorised as associated for the purposes of noise assessment. The remaining 49 assessed receivers, in not having either host or impact agreements, are categorised as non-associated.

The coordinates of the assessed receivers are tabulated in Appendix E.

## **2.3 Development lots**

The Wind Energy Guideline also requires that an assessment be conducted to determine the impact of the Project on the right for neighbouring landholders to develop their land for a permitted use.

To conduct this assessment, the Applicant has identified the development lots in the vicinity of the Project area that meet the assessment criteria defined in the Wind Energy Guideline, of which there are a total of 5.

The identified development lots are tabulated in Appendix F.

Figure 1: Project layout



### 3.0 NEW SOUTH WALES NOISE POLICY & GUIDELINES

The Project SEARs require that the following documents be referred to as part of the Noise and Vibration Assessment:

- Wind Energy Guideline
- Technical Supplement for Noise
- NPfI
- ICNG
- RNP
- AVTG.

Details of the guidance and noise criteria provided by these publications and any other relevant guidance documents are provided in the following sections.

#### 3.1 Wind Energy Guideline

The Wind Energy Guideline is the over-arching guidance document for the assessment of wind energy projects in NSW and includes key principles for the assessment of associated noise.

Generally, assessment of noise must be in accordance with the Technical Supplement for Noise, however, peripheral provisions related to development rights (which are not addressed in the Technical Supplement for Noise) are also included.

The development rights assessment requirements are also referred to in the Project SEARs under the key issues for 'Land' assessment. This means that the overall development rights assessment will be conducted by other parties, however it is appropriate for factors related to noise to be set out in this report.

The development rights assessment requires the spatial extents of relevant lots to be considered in the context of predicted noise levels for the Project. The proportion of the lot which is predicted to experience noise levels higher than the relevant noise criteria must be identified. This would inform an evaluation of whether the proposed development would impact the right for neighbouring landholders to develop their land for a permitted use.

#### 3.2 Technical Supplement for Noise

The Technical Supplement for Noise provides proponents of wind energy projects and the community with advice about how noise impacts are assessed for large-scale wind energy development projects that are a state significant development. The stated objective of the Technical Supplement for Noise is to ensure that the noise impacts of wind energy projects are appropriately identified, mitigated, and managed.

The Technical Supplement for Noise specifies that the assessment of wind turbine noise is to be conducted in accordance with the SA Guidelines, subject to a set of supplementary procedures that are specific to NSW. The variations relate to:

- *Noise limits for residences:* selection of a lower base noise limit in all areas of NSW, in recognition that the regional areas of NSW with high quality wind resources are more populated than the equivalent regions in South Australia.
- *Noise limits for other land uses:* definition of noise limits for national parks and reference to the NPfI for guidance on the acceptability of noise for other sensitive land uses
- *Special noise characteristics:* definition of additional procedures and establishing low frequency as an assessable characteristic.

- *Associated receivers:* these receivers do not require an assessment of noise impacts.
- *Noise monitoring:* definition of additional technical procedures, including the use of alternative/intermediate noise monitoring locations for compliance monitoring.

The elements of the Technical Supplement for Noise that are applicable to the current planning stage assessment are described in further detail below.

### 3.2.1 Noise limits for residences

In relation to noise limits, the variation defined in the Technical Supplement for Noise sets the base noise limit at a value of 35 dB  $L_{Aeq, 10 \text{ min}}$  for all projects, in lieu of the 35 to 40 dB  $L_{Aeq, 10 \text{ min}}$  base criterion range defined in the SA Guidelines. The criteria in the Technical Supplement for Noise are subsequently defined as follows:

*The predicted equivalent noise level, ( $L_{Aeq, 10}$ ),<sup>1</sup> adjusted for tonality and low-frequency noise, should not exceed 35 dB(A) or the background noise ( $L_{A90, 10}$ ) by more than 5 dB(A), whichever is greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.*

*1 Determined in accordance with section 4 of the SA Guidelines.*

The Technical Supplement for Noise also notes the following in relation to the types of receivers where the noise limits apply:

*Setting noise level objectives for wind turbines aims to retain noise levels that are compatible with surrounding land uses and ensure that noise levels do not significantly affect the lifestyle of people living in the area.*

*Applicants commonly negotiate agreements with private landholders to manage impacts where projects may not achieve noise limits. This means that landholders may enter into an agreement with applicants to accept noise levels above the prescribed noise limits. Where such an agreement is in place, these receivers do not require an assessment of noise impacts. Where known, these receivers should be identified in the scoping report and environmental impact statement, including on any relevant maps.*

Accordingly, the noise limits for residences defined in the Technical Supplement for Noise only apply to non-associated receivers. Associated receivers are discussed in Section 3.2.4.

### 3.2.2 Noise limits for other land uses

The Technical Supplement for Noise also defines noise limits for other land uses, with specific reference to national parks:

*The predicted noise level, adjusted for tonality and low-frequency noise, should not exceed  $L_{eq} 50$  dB(A) at designated passive recreation areas within national parks (when in use) for wind speed of 4 m/s or cut-in speed, whichever is greater. This criterion applies only to national parks and not to other types of protected areas, such as flora reserves or state conservation areas, as defined by a statutory source.*

In addition to this, the below text is provided regarding non-residential receivers:

*It is rare that wind energy projects impact other non-residential receivers. In cases where projects do impact other sensitive receivers, Table 2.2 of the NSW EPA Noise Policy for Industry provides guidance on the acceptability of such noise to those receivers.*

### 3.2.3 Special noise characteristics

Special noise characteristics addressed under the Technical Supplement for Noise are limited to tonality and low-frequency noise.

#### *Tonality*

Sounds which have unusually high levels of energy in a relatively narrow band of frequencies may be referred to as being tonal. Audible tonal sounds from wind turbines are generally related to rotational equipment in the wind turbine nacelle and can have a specific pitch dependent on the speed of rotation. This can cause the noise to be more annoying or noticeable. These tonal characteristics (as defined below) typically do not occur in well designed and well-maintained wind turbines.

The SA Guidelines require that development applications for wind energy projects report the following:

*To help determine whether there is tonality, the method and results of testing (such as in accordance with IEC 61400-11) carried out on the proposed WTG model to determine the presence of tonality should also be specified in the development application.*

Section 4 of the SA Guidelines further requires checks to be made during post completion compliance assessments.

In addition to the above requirements, the Technical Supplement for Noise also requires tonality to be assessed using the method described in Annex D of ISO 1996-2:2017.<sup>15</sup>

Based on the ISO 1996-2:2017 method, tonality is defined as when the level of a one-third octave band (with the descriptor in accordance with the SA Guidelines), exceeds the level of the adjacent bands on both sides by:

- 5 dB or more if the centre frequency of the band containing the tone is in the range 500 Hz to 10,000 Hz
- 8 dB or more if the centre frequency of the band containing the tone is in the range 160 Hz to 400 Hz, and/or
- 15 dB or more if the centre frequency of the band containing the tone is in the range 25 Hz to 125 Hz.

If tonality is found to be a repeated characteristic of the candidate wind turbine, 5 dB is to be added to the predicted or measured wind turbine noise levels.

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<sup>15</sup> International Organisation for Standardisation, *ISO 1996-2:2017 Acoustics - Description, measurement and assessment of environmental noise – Determination of environmental noise levels* dated July 2017 (ISO 1996-2:2017)

### *Low frequency noise*

Low frequency noise is present in all types of environmental noise and is particularly difficult to measure in the presence of wind due to the increased level of background noise. The Technical Supplement for Noise indicates that low frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted noise limits.

In NSW, contemporary approvals include the following requirement for low frequency noise:

*The presence of excessive low frequency noise that is a repeated characteristic\* [i.e. noise from the wind farm that is repeatedly greater than 60 dB(C) ] will incur a 5 dB(A) penalty, to be added to the measured noise level for the wind farm, unless a detailed low frequency noise assessment to the satisfaction of the Secretary demonstrates compliance with the proposed criteria for the assessment of low frequency noise disturbance (UK Department for Environment, Food and Rural Affairs (DEFRA, 2005)) for a steady state noise source.*

*\* The descriptor shall be in accordance with SA 2009, Section 4*

An assessment of C-weighted wind turbine noise levels must be undertaken against the 60 dB  $L_{Ceq}$  criterion at non-associated receivers in the vicinity of the Project. In the unlikely event that excessive low frequency noise is found to be a repeated characteristic of the wind turbine noise, 5 dB is to be added to the predicted or measured wind turbine noise levels.

Note that 5 dB is the maximum penalty that may be applied for special noise characteristics, irrespective of whether one or more characteristics are present.

#### 3.2.4 Associated receivers

The Technical Supplement for Noise indicates an assessment of noise impacts is not required for associated receivers i.e. host properties or receivers where a private agreement specifically addressing noise is in place between the landowner and the Applicant.

Noise levels at these locations would ultimately need to be managed in accordance with the private agreement. Predicted noise levels at these locations have been provided within this report for information only.

#### 3.2.5 Noise monitoring

Specific details regarding the noise monitoring requirements of the Technical Supplement for Noise can be found in the Background Noise Report.<sup>16</sup>

### 3.3 Noise Policy for Industry (NPfI)

The NPfI is the applicable guideline for assessing operational noise associated with the proposed ancillary infrastructure i.e. BESS and substations.

The NPfI provides a method for determining Project Noise Trigger Levels (PNTLs) that are used for assessing the potential impact of noise from industry at existing receivers. Specifically, the PNTLs provide a benchmark or objective for assessing a proposal or site. The NPfI states that the PNTLs are not intended for use as mandatory requirements, but represent the levels that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response; for example, further investigation of mitigation measures.

The PNTLs are derived from an analysis of the background noise environment and zoning information, accounting for acoustic amenity (described as project amenity noise levels) and, in the case of residential receivers, accounting for intrusiveness (described as project intrusiveness noise

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<sup>16</sup> MDA, Rp 001 r01 20220871 – Wallaby Creek Wind Farm– Background Noise Assessment dated 29 October 2025 (Background Noise Report)

levels). The PNTLs are defined as the minimum of the project amenity noise level and the project intrusiveness noise level (where applicable).

Assessments are conducted in terms of  $L_{Aeq, 15 \text{ min}}$ , as opposed to the  $L_{Aeq, 10 \text{ min}}$  used for wind turbine noise assessments.

Additional trigger levels are defined for the assessment of maximum noise level events. This is typically associated with sleep disturbance arising from noise sources that are characterised by transient events i.e. brief periods of increased noise levels and applies during the night-time period only.

The following subsections describe the amenity and intrusiveness noise levels used to determine the PNTLs. Further details on the derivation of appropriate PNTLs for the assessment of operational noise levels from ancillary infrastructure are provided in Section 7.1.

### 3.3.1 Project amenity noise levels

Project amenity noise levels are designed to prevent industrial noise continually increasing above an acceptable level over time with the expansion of infrastructure and development. The NPfI provides recommended amenity noise levels based on receiver categories and typical planning zones, from which the project amenity noise levels are derived.

The recommended amenity noise levels outlined in the NPfI have been determined on the basis of studies that relate industrial noise to annoyance in communities and have been subjectively scaled to reflect the perceived differential expectations and ambient noise environments of rural, suburban, and urban communities for residential receivers. They are based on protecting the majority of the community (90 %) from being highly annoyed by industrial noise.

The recommended amenity levels defined in the NPfI relate to total industry noise levels. The project amenity noise levels for an individual industry, i.e. the Project, are set at a level 5 dB below the recommended amenity levels to provide a margin for cumulative industry noise.

A further modification is made to standardise the amenity assessment time period to align with the intrusiveness assessment.

### 3.3.2 Project intrusiveness noise levels

The intrusiveness noise assessment is applicable to residential receivers and is based on knowledge of the background noise level at the receiver. The background noise levels are referred to as the Rating Background noise Level (RBL) in the NPfI.

The intrusiveness noise level is the RBL at the nearest noise sensitive location plus 5 dB. Therefore, the noise emissions from the subject industry, i.e. ancillary infrastructure associated with the Project, are considered to be intrusive if the source noise level ( $L_{Aeq, 15 \text{ min}}$ ) is greater than the RBL ( $L_{A90}$ ) plus 5 dB.

### 3.3.3 Sleep disturbance

The NPfI states that a detailed maximum noise level assessment should be undertaken where the subject development night-time noise levels at a residential location exceed:

- 40 dB  $L_{Aeq, 15 \text{ min}}$  or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- 52 dB  $L_{AFmax}$  or the prevailing RBL plus 15 dB, whichever is the greater.

The NPfI does not currently provide details on how to assess sleep disturbance but refers to the RNP.

### 3.4 Interim Construction Noise Guideline (ICNG)

The ICNG aims to provide a clear understanding of ways to identify and minimise noise from construction works through applying all ‘feasible’ and ‘reasonable’ work practices to control noise impacts. The guideline identifies sensitive land uses and recommends construction hours, provides quantitative and qualitative assessment methods, and subsequently advises on appropriate work practices.

The ICNG recommended standard construction hours are detailed in Table 1.

**Table 1: ICNG recommended standard hours of work**

| Work type           | Recommended standard hours of work    |                  |
|---------------------|---------------------------------------|------------------|
| Normal construction | Monday to Friday                      | 0700 to 1800 hrs |
|                     | Saturday                              | 0800 to 1300 hrs |
|                     | No work on Sundays or public holidays |                  |

In relation to assessed receivers considered in this assessment, and based on the recommended standard hours set out in Table 1, the ICNG provides two primary management levels for the assessment of noise at residential receivers:

- The noise affected management level ( $L_{Aeq, 15 \text{ min}}$ ) is the NPfI’s rating background noise level +10 dB
- The highly noise affected management level is prescriptively set at 75 dB  $L_{Aeq, 15 \text{ min}}$ .

Where noise from construction works is above the noise affected management level, all feasible and reasonable work practices should be applied. Where the noise from construction works is above highly noise affected management level, restrictions to the hours of construction may be required.

The ICNG also defines the following 5 categories of works that might be undertaken outside the recommended standard hours:

- the delivery of oversized plant or structures that police or other authorities determine require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- public infrastructure works that shorten the length of the project and are supported by the affected community
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

The ICNG defines additional assessment and reporting requirements that apply if out of hours work is proposed, including justification of the need to work during these periods, including additional management levels for ground borne noise from construction vibration.

Construction works associated with the Project are only expected to occur during standard working hours and out of hours work is not specifically scheduled in the current conceptual construction works information provided by the Applicant. On this basis detailed assessment of out of hours works is not included in this report.

Notwithstanding the above, a conceptual assessment is included for potentially unavoidable works such as the delivery of oversized wind turbine components at times selected to minimise traffic disruption associated with intersection closures.

### 3.5 Assessing Vibration: A Technical Guideline (AVTG)

The Project SEARs stipulate that vibration related to construction and operation of the proposed Project should be assessed in accordance with the AVTG.

The AVTG presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. Preferred and maximum vibration values outlined in the AVTG are taken from BS 6472.<sup>17</sup>

The AVTG identifies three vibration categories. These are summarised below with examples:

- *Continuous vibration* – Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
- *Impulsive vibration* – Infrequent activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
- *Intermittent vibration* – Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Similar to other policy and guideline documentation, the AVTG allows for assessment at various receiver types.

#### 3.5.1 Intermittent vibration

The vibration characteristics of most construction activities, e.g. excavation and pilling, are considered to be intermittent. Intermittent vibration can be defined as interrupted periods of continuous vibration, e.g. heavy truck pass-bys or rock breaking, or continuous periods of impulsive vibration, e.g. impact pile driving.

Higher vibration levels are allowed for intermittent vibration compared with continuous vibration on the basis that the higher levels occur over a shorter time period. Hence, for intermittent vibration, human disturbance vibration levels are assessed on the basis of the vibration dose value (VDV), based on the level and the duration of the vibration events. Vibration criteria applicable to residential receivers for intermittent vibration sources are summarised in Table 2.

**Table 2: Preferred and maximum vibration levels for human disturbance limits, VDV ( $\text{m/s}^{1.75}$ )**

| Assessment period <sup>a</sup> | Preferred values <sup>a</sup> | Maximum values <sup>b</sup> |
|--------------------------------|-------------------------------|-----------------------------|
| Daytime                        | 0.20                          | 0.40                        |
| Night-time                     | 0.13                          | 0.26                        |

a Daytime is 0700 hrs to 2200 hrs and night-time is 2200 hrs to 0700 hrs

b These values are only indicative, and there may be a need to assess to other sensitive areas against the relevant criteria.

<sup>17</sup> BSI, BS 6472:1992 Evaluation of human exposure to vibration in buildings (1-80 Hz), 1992 (BS 6472).

### 3.5.2 Continuous and impulsive vibration

Vibration criteria applicable to the residential receivers in the vicinity of the Project for continuous and impulsive vibration sources, are summarised in Table 3.

**Table 3: Preferred and maximum vibration levels for human disturbance limits, m/s<sup>2</sup>**

| Vibration type       | Assessment period <sup>a</sup> | Preferred values <sup>b</sup> |              | Maximum values <sup>b</sup> |              |
|----------------------|--------------------------------|-------------------------------|--------------|-----------------------------|--------------|
|                      |                                | Z axis                        | X and Y axes | Z axis                      | X and Y axes |
| Continuous vibration | Daytime                        | 0.0100                        | 0.0071       | 0.020                       | 0.014        |
|                      | Night-time                     | 0.0070                        | 0.0050       | 0.014                       | 0.010        |
| Impulsive vibration  | Daytime                        | 0.3000                        | 0.2100       | 0.600                       | 0.420        |
|                      | Night-time                     | 0.1000                        | 0.0710       | 0.200                       | 0.140        |

a Daytime is 0700 hrs to 2200 hrs and night-time is 2200 hrs to 0700 hrs

b The preferred and maximum values are weighted Root Mean Square (RMS) acceleration values. These values are only indicative, and there may be a need to assess to other sensitive areas against the relevant criteria.

### 3.6 Road Noise Policy (RNP)

The Project SEARs indicate that additional traffic on public roads due to construction and operation of the Project must be assessed against the requirements of the RNP and relevant application notes.

The RNP provides noise level criteria for increased traffic flow as a result of a land-use development with the potential to create additional traffic, as detailed in Table 4.

**Table 4: Road traffic noise assessment criteria for residential land uses**

| Type of development                                                                                                                    | Day (0700-2200 hrs)                      | Night (2200-0700 hrs)                   |
|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------|
| Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments | 60 dB L <sub>Aeq, 15 hr</sub> (external) | 55 dB L <sub>Aeq, 9 hr</sub> (external) |
| Existing residences affected by additional traffic on existing local roads generated by land use developments                          | 55 dB L <sub>Aeq, 1 hr</sub> (external)  | 50 dB L <sub>Aeq, 1 hr</sub> (external) |

Additionally, the RNP requires that the relative increase in noise levels at residential receivers not exceed 12 dB for land use developments with the potential to generate additional traffic on existing freeways, arterial or sub-arterial roads. The relative increase criterion does not apply for local roads.

The RNP notes that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

Where night-time construction traffic is likely to occur, an assessment of sleep disturbance is appropriate. This is the same basis as the sleep disturbance assessment referenced for NPfI assessment in Section 3.3.1.

The RNP provides the following guidance on this matter:

- Maximum internal noise levels below 50–55 dB L<sub>Amax</sub> are unlikely to awaken people from sleep
- One or two noise events per night, with maximum internal noise levels of 65–70 dB L<sub>Amax</sub>, are not likely to affect health and wellbeing significantly.

Based on the assumption that an open window provides 10 dB attenuation (which would be typical of a facade with partially open windows), noise levels below 60 - 65 dB  $L_{Amax}$  outside an open bedroom window would be unlikely to cause awakening reactions.

Furthermore, one or two events with a noise level of 75 - 80 dB  $L_{Amax}$  outside an open bedroom window would be unlikely to affect health and well-being significantly.

### 3.7 ANZEC 1990 Report

Although not specified explicitly in the Project SEARS, the ANZEC 1990 Report is commonly referred to for guidance in the assessment of blasting noise and vibration.<sup>18</sup>

In its scope, the ANZEC 1990 Report provides the following context:

*The recommended criteria apply only to the minimisation of annoyance and discomfort [to persons at noise sensitive sites] arising from blasting. The control of damage from blasting is the responsibility of State/Territory mines authorities and reference should be made to these bodies to ascertain recommended damage criteria.*

*The recommended criteria are for guidance only and may be varied if necessary to suit local site conditions.*

The recommended criteria specified in the report are as follows:

- Airblast overpressure at sensitive sites should be:
  - below 115 dB  $L_{Zpeak}$  for 95 % of all blasts; and
  - below 120 dB  $L_{Zpeak}$  at all times.
- Ground vibration at sensitive sites should be:
  - below 5 mm/s (PPV) for 95 % of all blasts; and
  - below 10 mm/s (PPV) at all times.

From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 115 dB  $L_{Zpeak}$ . The probability of damage increases as the airblast levels increase above this level. Windows are the building element currently regarded as most sensitive to airblast, and damage to windows is considered as improbable below 140 dB  $L_{Zpeak}$ .

Based on the ANZEC 1990 Report, a limit of 115 dB  $L_{Zpeak}$  is referenced to practically minimise the risk of cosmetic or structural damage to typical residential constructions from airblast.

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<sup>18</sup> Australian and New Zealand Environment Council, *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, dated September 1990 (ANZEC 1990 Report)

## 4.0 NOISE PREDICTION METHOD

### 4.1 Operational noise

Operational noise levels are predicted using:

- Noise emission data for the wind turbines and ancillary infrastructure equipment
- A 3D digital model of the Project and the surrounding environment
- International standards used for the calculation of environmental sound propagation.

The method selected to predict noise levels is ISO 9613-2:1996.<sup>19</sup> The prediction method is consistent with the guidance provided by the SA Guidelines, as referenced in the Technical Supplement for Noise and has been shown to provide a reliable method of predicting the typical upper levels of the noise expected to occur in practice.

The method is generally applied in a comparable manner to both wind turbine and ancillary infrastructure noise levels. For example, for both types of sources, similar ground and atmospheric conditions are used for the calculations. However, when applied to wind turbine noise, additional and specific input choices apply, as detailed below.

Key elements of the noise prediction method are summarised in Table 5. Further discussion of the method and the calculation choices is provided in Appendix G.

**Table 5: Noise prediction elements**

| Detail                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Software                | Proprietary noise modelling software SoundPLANnoise version 9.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Method                  | <p>ISO 9613-2:1996, with adjustments to the method applied on the basis of the UK Institute of Acoustics guidance.<sup>20</sup></p> <p>The adjustments are applied within the SoundPLANnoise modelling software and relate to the influence of terrain screening and ground effects on sound propagation.</p> <p>Specific details of adjustments are noted below and are discussed in Appendix G.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Source characterisation | <p>Each source of operational noise is modelled as a point source of sound.</p> <p>The total sound of the component of the Project being modelled, i.e. the wind turbines or the ancillary infrastructure, is then calculated on the basis of simultaneous operation of all elements within that component, e.g. the sum of all wind turbine noise contributions at each receiver, or the sum of all ancillary infrastructure noise contributions at each receiver.</p> <p>To model the wind turbine components of the Project, the following specific procedures are noted:</p> <ul style="list-style-type: none"> <li>• Calculations of wind 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 wind turbine.</li> <li>• Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each wind turbine. Further discussion of terrain screening effects is provided below.</li> </ul> |

<sup>19</sup> International Organisation for Standardisation, ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2:1996)

<sup>20</sup> UK Institute of Acoustics, *A good practice guide to the application of ETSU-R-97 for the assessment and rating of WTG noise* (UK Institute of Acoustics guidance)

| Detail                                                | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Terrain data                                          | Digital elevation map with a cell size of 5 m throughout the Project and surrounds, sourced from ELVIS. <sup>21</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Terrain effects<br>(wind turbine-specific procedures) | <p>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 G.</p> <p><i>Valley effects:</i> +3 dB 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 wind turbine and calculation point is 50 % greater than would occur if the ground were flat.</p> <p><i>Terrain screening effects:</i> only calculated if the terrain blocks line of sight between the maximum tip height of the wind turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB.</p> <p>For reference purposes, the ground elevations at the wind turbine and receivers are tabled in Appendix C and Appendix E, respectively.</p> <p>The topography of the Project is depicted in the elevation map provided in Appendix D.</p>       |
| Ground conditions                                     | <p>Ground factor of <math>G = 0.5</math> on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix G.</p> <p>The ground around the Project corresponds to acoustically soft conditions (<math>G = 1</math>) according to ISO 9613-2. The adopted value of <math>G = 0.5</math> assumes that 50% of the ground cover is acoustically hard (<math>G = 0</math>) to account for variations in ground porosity and provide a cautious representation of ground effects.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Atmospheric conditions                                | <p>Temperature 10 °C and relative humidity 80%</p> <p>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 and SA Guidelines.</p> <p>The calculations are based on sound speed profiles which increase the propagation of sound from each wind turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point.<sup>22</sup></p> <p>The primary consideration for wind turbine noise assessment is wind speed and direction.</p> <p>The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every wind turbine at the Project. Other wind directions in which part or the entire wind farm is upwind of the receiver will result in lower noise levels. In some cases, it is not physically possible for a receiver to be simultaneously downwind of each wind turbine and the approach is therefore conservative in these instances.</p> |

<sup>21</sup> *Elvis - Elevation and Depth* - Foundation Spatial Data - <https://elevation.fsd.org.au/>

<sup>22</sup> The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

| Detail           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Receiver heights | <p>1.5 m above ground level.</p> <p>It is noted that the UK Institute of Acoustics guidance refers to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which results in lower noise levels. However, importantly, predictions in Australia do not generally subtract a margin recommended by the UK Institute of Acoustics guidance to account for differences between <math>L_{Aeq}</math> and <math>L_{A90}</math> noise levels. The magnitude of these differences is comparable and therefore balance each other out to provide similar predicted noise levels.</p> <p>This approach has been shown to be valid for predicting noise levels of wind farms expected to be measured using the <math>L_{A90}</math> parameter (per Technical Supplement for Noise).</p> |

## 4.2 Construction noise

Predicted noise levels have been calculated in general accordance with the method detailed in AS 2436.<sup>23</sup> This method enables the prediction of noise levels for sound propagation over hard or soft ground but does not provide the ability to calculate predicted noise levels for mixed ground cover with varied soil conditions.

The standard also notes that caution must be applied when considering predicted noise levels at distances beyond 100 m. For these reasons, predicted noise levels have been determined as the arithmetic average of the hard and soft ground prediction methods.

This approach is broadly consistent with the equivalent prediction procedure in BS 5228, as referenced in AS 2436. It provides a margin of caution with respect to ground conditions for the typical magnitude of separating distances between construction activities and neighbouring sensitive receivers.<sup>24</sup>

<sup>23</sup> Standards Australia, *AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites*, May 2010 (AS 2436)

<sup>24</sup> BSI, *BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites: Noise*, January 2009 (BS 5228)

## 5.0 EXISTING NOISE ENVIRONMENT

### 5.1 Policy

#### 5.1.1 Technical Supplement for Noise

Background noise level information is used to inform the setting of noise limits for the assessment of wind turbine noise under the Technical Supplement for Noise. This is due to the need to consider the changes in background noise levels and wind turbine noise levels for different wind conditions.

The procedures for determining background noise levels for the assessment of wind turbines are defined in the SA Guidelines, which is adopted by the Technical Supplement for Noise. Background noise levels are considered in terms of  $L_{A90, 10 \text{ min}}$ .

The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 3.1 of the SA Guidelines provides the following guidance:

*Background noise measurements should be carried out at locations that are relevant for assessing the impact of WTG noise on nearby premises (relevant receivers).*

*Relevant receiver locations are premises:*

- *in which someone resides or has development approval to build a residential dwelling*
- *at which the predicted noise level exceeds the base noise level for the area [35 or 40 dB(A)] for wind speeds up to the speed of the rated power*
- *that are representative of the worst-case situation when considering the range of premises, e.g. a house located among a group of nearby houses within a residential zone.*

The initial stage of a background noise monitoring program in accordance with the SA Guidelines therefore comprises:

- preliminary wind turbine noise predictions to identify all receivers where predicted noise levels are higher than 35 dB  $L_{Aeq}$
- identification of selected receivers where background noise monitoring should be undertaken prior to the development of the Project, if required.

If required, the survey involves simultaneous measurements of background noise levels at receivers and hub-height wind speeds at the Project. The survey typically extends over a period of several weeks to enable a range of wind speeds and directions to be measured. Data adversely affected by extraneous noise such as insect noise, rain and other considerations is filtered.

The results of the survey are then analysed to determine the trend between the background noise levels and the Project area wind speeds at the proposed hub height of the wind turbines. This trend defines the value of the background noise for the different wind speeds at which the wind turbines will operate. At the wind speeds when the value of the background noise is above 30 dB  $L_{A90}$ , the background noise levels are used to set the noise limits for the Project.

### 5.1.2 Noise Policy for Industry and Interim Construction Noise Guideline

Project noise trigger levels and noise management levels applicable to ancillary infrastructure operational noise and construction noise assessment also consider background noise levels.

Contrary to the time interval of the  $L_{A90, 10 \text{ min}}$  descriptor used for background noise assessment under the Technical Supplement for Noise, background noise levels in the NPfI and ICNG, referred to as RBLs are assessed in terms of  $L_{A90, 15 \text{ min}}$ .

Measurement procedures for determining rating background noise levels are set out in Fact Sheet B of the NPfI. Background noise data developed for an NPfI assessment is also suitable for use as part of an assessment under the ICNG.

## 5.2 Background noise levels

### 5.2.1 Technical Supplement for Noise

The Technical Supplement for Noise specifies that the Project will need to have undertaken monitoring to determine the background noise levels in the vicinity of the Project as part of the EIS submission.

To meet this requirement, background noise monitoring locations were considered based on proximity to wind turbines, the location of receivers, and the predicted noise contours detailed within this assessment.

Background noise monitoring was subsequently conducted at 4 receivers in the vicinity of the Project between March and May 2025. The background noise monitoring locations are summarised in Table 6.

**Table 6: Background noise monitoring locations**

| Receiver          | Nearest wind turbine | Distance from nearest wind turbine, m | Direction to nearest wind turbine, ° |
|-------------------|----------------------|---------------------------------------|--------------------------------------|
| 25                | 67                   | 1,856                                 | 252                                  |
| 85                | 75                   | 2,012                                 | 296                                  |
| 102 <sup>a</sup>  | 79                   | 1,820                                 | 119                                  |
| 1572 <sup>a</sup> | 43                   | 2,681                                 | 323                                  |

a Associated receiver

Analysis and results of the survey are detailed in the Background Noise Report.

A summary of the measured background noise levels is also provided in Appendix H.

The results of the background noise survey provide a representation of the typical noise levels in the vicinity of the Project during the noise monitoring period.

However, noise monitoring data collected at location 25 (and to a lesser extent, location 85) is subject to uncertainty associated with the contribution of road traffic noise under certain wind conditions. These results are therefore not considered to be suitable for characterising the background noise level and should not be referred to as the basis for background adjusted noise limits.

Noise monitoring data collected at the associated receivers 102 and 1572 is suitable for characterising the background noise levels at, and in the vicinity of, the monitoring locations. As noise limits at these locations are understood to be managed as part of the private agreements between the receivers and the Applicant, the data has not currently been used to derive noise limits.

On this basis, the measured noise levels presented within the Background Noise Report are provided for information only and have not been referred to as the basis for background adjusted noise limits. It is expected that the Technical Supplement for Noise base noise limit – 35 dB  $L_{Aeq\ 10\ min}$  - will be adopted for the full range of wind speeds at all non-associated receivers. This represents the most stringent noise limit that can be applied under the policy.

#### 5.2.2 Noise Policy for Industry and Interim Construction Noise Guideline

The NPfl recognises that very low background noise levels, particularly at night, can present challenges with the derivation of reasonable assessment criteria. Table 2.1 of the NPfl provides minimum assumed RBLs which are summarised in Table 7.

In the absence of measured RBLs, these minimums have been adopted for use within the assessment and are used for derivation of the NPfl PNTLs in Section 7.1 and ICNG management levels in Section 10.0.

**Table 7: Minimum assumed RBLs for NPfl and ICNG, dB  $L_{A90}$**

| Time of day <sup>a</sup> | Minimum assumed RBL |
|--------------------------|---------------------|
| Day                      | 35                  |
| Evening                  | 30                  |
| Night                    | 30                  |

a Time of day is defined as:

|         |                                                                                   |
|---------|-----------------------------------------------------------------------------------|
| Day     | 0700- 1800 hrs Monday to Saturday and 0800 - 1800 hrs Sundays and public holidays |
| Evening | 1800 - 2200 hrs Monday to Sunday and public holidays                              |
| Night   | the remaining periods                                                             |

## 6.0 WIND TURBINE OPERATIONAL NOISE ASSESSMENT

The model of wind turbine ultimately selected for the Project would be determined based on a range of design requirements.

Accordingly, to provide an assessment at this stage of the Project, it is necessary to consider a '*candidate wind turbine*' model that is representative of the size and type of wind turbine being considered. The purpose of a candidate wind turbine model is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of wind turbines being considered for the Project.

The candidate wind turbine model is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the wind turbine being regulated by control systems that vary the pitch of the wind turbine blades (the angular orientation of the blade relative to its axis).

**Table 8: Candidate wind turbine model specifications**

| Item                                                 | Detail   |
|------------------------------------------------------|----------|
| Make                                                 | Nordex   |
| Model                                                | N175/6.X |
| Rated power, MW                                      | 6.8      |
| Rotor diameter, m                                    | 175      |
| Modelled hub height, m                               | 180      |
| Equivalent tip height, m                             | 267.5    |
| Operating mode                                       | Mode 2   |
| Serrated trailing edge                               | Yes      |
| Highest sound power, dB L <sub>WA</sub> <sup>a</sup> | 107.0    |

a Includes +1.0 dB uncertainty adjustment to provide a margin for typical values of test uncertainty.

The candidate turbine can be operated in a variety of modes, permitting the maximum power output of the wind turbine to be restricted. This results in lower source sound power levels when compared to full power (unrestricted) modes.

This assessment has been based on all wind turbines using the 'Mode 2' power restricted mode. Operation in Mode 2 is an inherent requirement for the Project due to previous project-specific grid code requirements.

## 6.1 Wind turbine noise emissions

### 6.1.1 Sound power levels

The noise emissions of a wind turbine are described in terms of the sound power level for different wind speeds. The sound *power* level is a measure of the total sound energy produced by each wind turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the wind turbine.

Sound power level data for the candidate wind turbine model, including sound frequency characteristics, has been sourced from the following document:

- 9003492\_01\_pdf\_F008\_278\_A17\_EN\_R01\_Nordex\_N175\_6.X.pdf dated 8 May 2022.

Based on the data sourced from the manufacturer's specification, the noise modelling for this assessment involved:

- conversion of standardised wind speed (10 m above ground level) to hub height wind speed as per the method specified in IEC 61400-11
- conversion of third octave band level to octave band levels
- adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The overall A-weighted sound power levels (including the +1.0 dB addition) as a function of hub height wind speed are presented in Table 9.

**Table 9: Sound power levels per hub height wind speed, dB L<sub>WA</sub>**

| Operating mode      | Hub height wind speed, m/s |      |       |       |       |       |       |       |       |
|---------------------|----------------------------|------|-------|-------|-------|-------|-------|-------|-------|
|                     | 4                          | 5    | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| Mode 2 <sup>a</sup> | 97.1                       | 98.3 | 100.8 | 104.2 | 106.6 | 107.0 | 107.0 | 107.0 | 107.0 |

a Other power restricted modes are also available (but have not been considered for this assessment)

The reference octave band values used as the basis for this assessment are presented in Table 10.

**Table 10: Octave band sound power levels, dB L<sub>WA</sub>**

|                     | Octave band centre frequency, Hz |      |      |       |       |       |      |      |      |       |
|---------------------|----------------------------------|------|------|-------|-------|-------|------|------|------|-------|
| Operating mode      | 31.5                             | 63   | 125  | 250   | 500   | 1000  | 2000 | 4000 | 8000 | Total |
| Mode 2 <sup>a</sup> | 81.9                             | 89.8 | 96.6 | 100.0 | 100.5 | 101.4 | 99.3 | 90.0 | 73.5 | 107.0 |

a Based on one-third octave band levels at 9 m/s, being the highest overall A-weighted sound power level detailed in Table 9 manufacturer provided noise datasheet when considering low frequency content below 250 Hz.

The values presented above are considered typical of the range of noise emissions associated with comparable multi-megawatt wind turbines.

Industry research conducted with reference to sound power data for a range of wind turbine models has shown that there is not a clear relationship between wind turbine size, or power output, and the noise emission characteristics of a given wind turbine model.<sup>25</sup> In practice, the overall noise emissions of a wind turbine are dependent on a range of factors, including the wind turbine size, power output, blade design and rotational speed of the wind turbine.

While wind turbine sizes and power ratings of contemporary wind turbines have increased, the noise emissions of the wind turbines are comparable to, or lower than, previous generations of wind turbines. This is a result of design improvements, notably, measures to reduce the speed of rotation of the wind turbines, and enhanced blade design features such as serrations for noise control.

#### 6.1.2 Tonality

Information concerning potential tonality is often limited at the planning stage of a project, and narrow band test data for tonality (in the form of IEC 61400-11 tonality data, as referenced in the SA Guidelines) is presently unavailable for the candidate wind turbine model. However, the occurrence of tonality in the noise of contemporary multi-megawatt wind turbine designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Further, the third octave band data detailed in the manufacturer's specification has been assessed against the additional tonality test prescribed in the Technical Supplement for Noise (detailed in Section 3.2.3). This test did not indicate the presence of tonality at any of the available hub height wind speeds.

On this basis, adjustments for tonality have not been applied to the predicted noise levels presented in this assessment. Notwithstanding this, the potential for tonality would be subject to further review and controls, i.e. contractual performance specifications, during the wind turbine procurement stage of the Project, following approval of the Project, and again following the construction of the Project.

#### 6.1.3 Low frequency noise

The Technical Supplement for Noise prescribes a criterion for the application of low frequency noise penalty adjustments, based on C-weighted noise levels. However, there is no established or verified engineering method for the prediction of C-weighted noise levels associated with the operation of wind turbines.

For the purposes of this report, a risk assessment approach has been adopted using a simplified prediction method to estimate C-weighted noise levels. Details of the assessment are provided in Appendix I.

The risk assessment indicates calculated low frequency noise levels are below the applicable thresholds for the application of penalties at all non-associated receivers. On the above basis, adjustments for low frequency noise have not been applied to the predicted noise levels presented in this assessment.

The effects of wind turbine noise on health and amenity are discussed in Appendix J.

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<sup>25</sup> Van den Berg, Frits & Koppen, Erik & Boon, Jaap & Ekelschot-Smink, Madelon. - *Sound power of onshore wind turbines and its spectral distribution*. Sound & Vibration. 59 - 2025

## 6.2 Predicted noise levels

This section of the report presents the predicted A-weighted wind turbine noise levels at surrounding receivers, and an assessment of compliance with the applicable noise limits.

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 wind 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. For this reason, noise levels presented in this section are reported to one decimal place.

The predicted noise levels are for conditions when the wind turbine's noise emissions have reached their highest level (corresponding with hub height wind speeds of 9 m/s for the candidate wind turbine model) and the wind is directed from the Project to each receiver. The predicted noise levels include + 1.0 dB allowance to account for wind turbine sound power level measurement uncertainty, as described in Section 6.1.1.

### 6.2.1 Non-associated receivers

The base noise limit applicable to the Project at all other receivers i.e. classified as non-associated for noise assessment purposes, is 35 dB  $L_{Aeq, 10 \text{ min}}$  as detailed in Section 3.2.1.

Non-associated receivers with predicted noise levels greater than 30 dB  $L_{Aeq, 10 \text{ min}}$  are shown in Table 11.

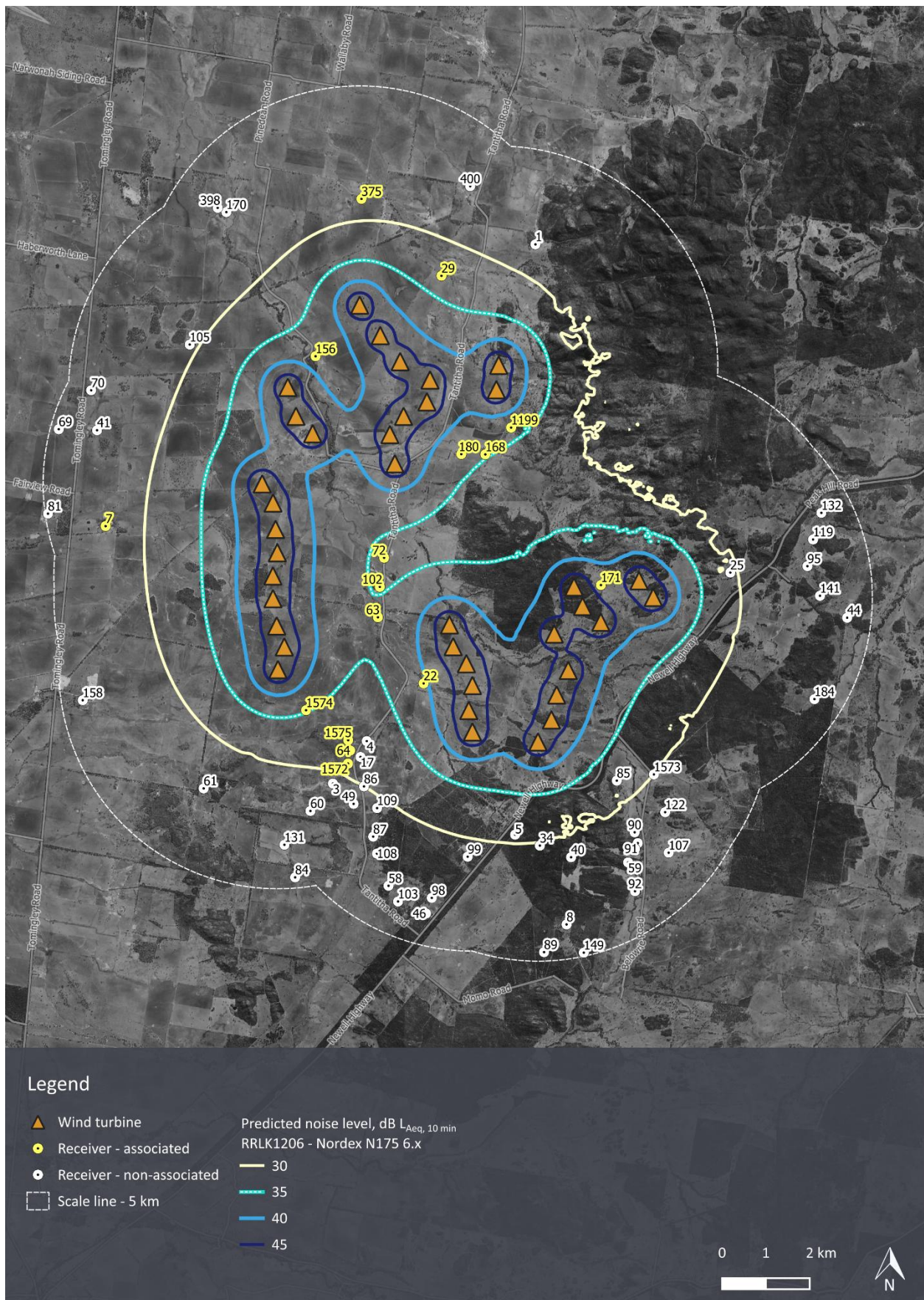
**Table 11: Predicted noise levels at non-associated receivers greater than 30 dB  $L_{Aeq, 10 \text{ min}}$**

| Receiver | Distance to nearest turbine, m | Predicted noise level, dB $L_{Aeq, 10 \text{ min}}$ |
|----------|--------------------------------|-----------------------------------------------------|
| 4        | 2,427                          | 32.2                                                |
| 5        | 2,186                          | 30.7                                                |
| 17       | 2,624                          | 31.3                                                |
| 25       | 1,856                          | 30.7                                                |
| 85       | 2,012                          | 31.6                                                |

Table 11 indicates that the predicted wind turbine noise levels at all non-associated receivers are below the Technical Supplement for Noise base noise limit of 35 dB  $L_{Aeq, 10 \text{ min}}$  by a minimum margin of 2.8 dB.

Predicted noise contours for the candidate wind turbine model are shown in Figure 2

Predicted noise levels for all receivers and at each integer wind speed are tabulated in Appendix K, including receivers where the highest predicted noise level is below 30 dB  $L_{A90}$ .



### 6.2.2 Associated receivers

The predicted noise level at all associated receivers is presented in Table 12 for informative purposes only.

**Table 12: Predicted noise levels at associated receivers, dB  $L_{Aeq}$  10 min**

| Receiver | Distance to nearest turbine, m | Predicted noise level |
|----------|--------------------------------|-----------------------|
| 7        | 3,706                          | 27.6                  |
| 22       | 1,088                          | 39.3                  |
| 29       | 1,960                          | 32.9                  |
| 63       | 1,651                          | 35.3                  |
| 64       | 2,482                          | 31.4                  |
| 72       | 2,145                          | 34.6                  |
| 102      | 1,820                          | 34.9                  |
| 156      | 968                            | 38.0                  |
| 168      | 1,509                          | 35.3                  |
| 171      | 641                            | 43.1                  |
| 180      | 1,439                          | 36.8                  |
| 375      | 2,430                          | 28.2                  |
| 1199     | 946                            | 36.8                  |
| 1572     | 2,681                          | 30.7                  |
| 1574     | 1,142                          | 35.3                  |
| 1575     | 2,279                          | 31.8                  |

### 6.3 Development rights

As discussed in Section 3.1, the Wind Energy Guideline requires an assessment of impact on development rights to be conducted, of which noise is a component. The evaluation of noise impact is conducted by comparing the predicted noise contours with the spatial extents of the subject development lots. The extent of the development lot that may experience an exceedance of the relevant noise criteria is a consideration in the overall of evaluation of impact for the lot.

The development rights assessment sits under the 'Land' assessment requirements in the Project SEARs. On this basis it is expected that the overall assessment of impacts will be conducted by other parties, however, factors related to wind turbine noise are evaluated and reported in this section, to inform the overall assessment. Assessment related to ancillary infrastructure noise is considered independently in later sections, due to differing noise criteria.

The Applicant has provided information on nearby development lots (refer Section 2.3 and Appendix F). Figure 3 provides a graphical representation of the subject development lots and wind turbine predicted noise contours. It can be seen from that there are several development lot boundaries that intersect with the 35 dB  $L_{Aeq}$  10 min wind turbine predicted noise contour.

The area of these intersections with the total area of the development lot is tabulated in Table 13.

**Table 13: Development lot area greater than 35 dB  $L_{Aeq, 10 \text{ min}}$**

| ID   | Lot number     | Total lot area, ha | Lot area above 35 dB, ha |
|------|----------------|--------------------|--------------------------|
| DE2  | 2//DP1084141   | 1,259              | 228                      |
| DE7  | 11//DP755125   | 606                | 4                        |
| DE22 | 142//DP1083899 | 449                | 143                      |
| DE25 | 38//DP42130    | 421                | 118                      |
| DE27 | 8//DP772054    | 273                | 20                       |

As shown in Table 13, significant portions of each development lot are below 35 dB  $L_{Aeq, 10 \text{ min}}$ . Even for the most constrained lot, more than 65% of the lot does not experience exceedances of the relevant noise criteria.

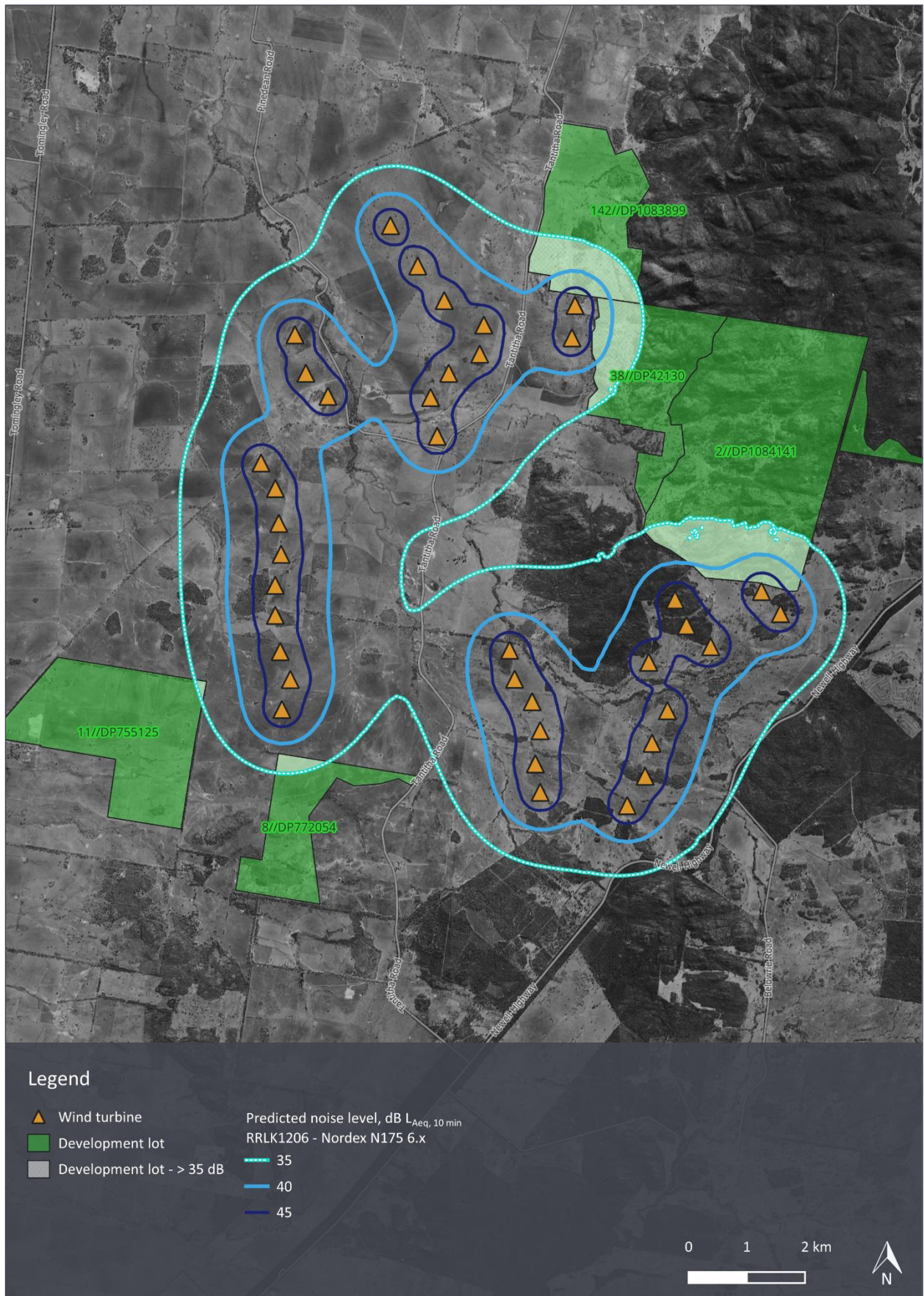
Based on the guidance provided in the Wind Energy Guideline it is not expected that operational noise from the wind turbines will impact the right for neighbouring landholders to develop their land for a permitted use, however this will need to be considered in totality with other disciplines as part of the overall evaluation of development rights impacts.

#### 6.4 Discussion

The results shown in Table 12 demonstrate that the predicted noise levels at non-associated receivers are below Technical Supplement for Noise base noise limit of 35 dB  $L_{Aeq, 10 \text{ min}}$  by a minimum margin of 2.8 dB. Evaluation of noise factors related to development rights indicates that adverse noise impact is not expected.

The above findings indicate that the Project is capable of being designed and operated to comply with the operational wind turbine noise requirements of the Technical Supplement for Noise and Wind Energy Guideline, and therefore the relevant requirements of the Project SEARs.

Figure 3: Wind turbine noise contours in relation to development lots



## 7.0 ANCILLARY INFRASTRUCTURE OPERATIONAL NOISE ASSESSMENT

### 7.1 Project noise trigger levels

For the purposes of this planning assessment, all receivers have been considered to be Rural Residential, based on the definitions set out in Table 2.3 of the NPfI. On this basis, and considering the minimum assumed RBLs detailed in Section 5.2.2, the PNTLs derived for assessment of ancillary infrastructure are summarised in Table 14. The derived PNTLs are the lowest i.e. most stringent noise limits that can practically be derived under the NPfI.

**Table 14: NPfI PNTLs, dB L<sub>Aeq</sub>, 15 min**

| Time of day          | Project noise trigger level |
|----------------------|-----------------------------|
| Day <sup>a</sup>     | 40                          |
| Evening <sup>b</sup> | 35                          |
| Night <sup>c</sup>   | 35                          |

a 0700 - 1800 hrs Monday to Saturday and 0800 - 1800 hrs Sundays and public holidays

b 1800 - 2200 hrs Monday to Sunday and public holidays

c the remaining periods

The ancillary infrastructure has the potential to operate under worst-case operational conditions at any time in a 24-hour period. This means that operation during the evening or night period, for which the most stringent project noise trigger level of 35 dB L<sub>Aeq</sub>, 15 min applies, will be the controlling factor for compliance. Generally, the assessment provided herein considers this worst-case operation only.

The noise sources associated with the Project typically give rise to steady noise levels and are not typically characterised by brief momentary increases in noise levels. Accordingly, the additional procedures defined in the NPfI for assessing maximum noise levels events associated with potential sleep disturbance (refer Section 3.3.3) are not relevant. The assessment is therefore based on noise levels of the equipment assessed in terms of the L<sub>Aeq</sub> 15 min descriptor, which is adopted by the NPfI for the assessment of average noise energy over a 15-minute period.

### 7.2 Ancillary infrastructure noise sources

Based on information provided by the Applicant, permanent noise generating ancillary infrastructure that is proposed to be developed as part of the Project is limited to:

- a single grid-scale BESS with a capacity of up to 200 MW/400 MWh
- one substation.

Other permanent ancillary infrastructure is also proposed such as an Operations & Maintenance (O&M) facility.

Based on information provided by the Applicant, the O&M facility is not expected to comprise significant noise generating plant or equipment, with maintenance activities typically occurring within a shed/building. Staff attendance and activities will occur during typical working hours, with minimal activities occurring during the night period. Based on this, and considering the distance to receivers, noise associated with the O&M facility is also not considered further.

The approximate coordinates of the ancillary infrastructure noise sources considered for assessment are shown in Table 15 and shown graphically within the context of the broader project in Figure 4.

**Table 15: Approximate ancillary infrastructure coordinates – GDA 2020 MGA zone 55**

| Item <sup>a</sup> | Easting, m | Northing, m |
|-------------------|------------|-------------|
| Substation        | 622,354    | 6,413,922   |
| BESS              | 622,517    | 6,413,857   |

a Represents the centroid of the proposed substation/BESS boundary

### 7.2.1 BESS

At this stage of the Project, a developed BESS design has not been established, however for the purposes of the noise assessment a design concept has been prepared by the Applicant. This concept comprises a layout of inverters, containerised battery units and High-Voltage (HV) transformers. The discrete position of each equipment item at the proposed BESS location is shown in Figure 4.

A summary of the relevant information provided to MDA by the Applicant is shown in Table 16.

**Table 16: BESS equipment details**

| Equipment item             | Quantity |
|----------------------------|----------|
| Inverter                   | 64       |
| Containerised battery unit | 96       |
| HV transformer – 250 MVA   | 1        |

### 7.2.2 Substation

Substation noise sources relevant for consideration within an environmental noise assessment are limited to HV transformers.

Information provided to MDA by the Applicant regarding the HV transformers at the substation includes:

- Spatial data indicating the boundary of the substation (used to derive the positions shown in Figure 4).
- Specification details including power rating (MVA) and quantity.

The relevant specifications of the HV transformers at the substation, as provided to MDA by the Applicant, are shown in Table 17.

**Table 17: Substation HV transformer specification**

| Equipment item           | Quantity |
|--------------------------|----------|
| HV transformer – 150 MVA | 2        |

Figure 4: Ancillary infrastructure noise source overview



### 7.3 Sound power level data

Sound power levels for individual ancillary infrastructure equipment items, as used in the noise model, are detailed in Table 18. Data is provided as un-weighted (linear) octave band sound power level spectra and A-weighted overall sound power level.

**Table 18: Sound power levels for ancillary infrastructure equipment items, dB L<sub>w</sub>**

| Item                     | Octave band centre frequency, Hz |     |     |     |      |      |      |                 |
|--------------------------|----------------------------------|-----|-----|-----|------|------|------|-----------------|
|                          | 63                               | 125 | 250 | 500 | 1000 | 2000 | 4000 | L <sub>WA</sub> |
| BESS                     |                                  |     |     |     |      |      |      |                 |
| Inverter                 | 93                               | 97  | 94  | 94  | 92   | 91   | 91   | 98              |
| Battery unit             | 83                               | 86  | 86  | 82  | 85   | 82   | 76   | 89              |
| HV transformer (250 MVA) | 102                              | 104 | 99  | 99  | 93   | 88   | 83   | 99              |
| Substation               |                                  |     |     |     |      |      |      |                 |
| HV transformer (150 MVA) | 99                               | 101 | 96  | 96  | 90   | 85   | 80   | 96              |

Additional information with respect to the source of the data is shown in Table 19.

**Table 19: Ancillary infrastructure sound power level data description**

| Item                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Inverter                   | <p>Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 have been provided by the Applicant.<sup>26</sup> The sound power levels adopted for the purposes of noise modelling represent the inverter cooling system operating at 100% and <u>do not</u> include a noise attenuation kit.</p> <p>The test report does not specify an ISO 3744:2010 expanded measurement uncertainty value, however 3 dB has been added to the sound power level of each source to account for measurement uncertainty. This is expected to be conservative given the low probability all inverter equipment items concurrently trending to the upper limit of the uncertainty range.</p> <p>Due to commercial sensitivities the specific inverter manufacturer and model is not detailed in this report but has been confirmed by the Applicant to be representative of the specification required for the Project.</p> |
| Containerised battery unit | <p>Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 have been provided by the Applicant. The sound power levels adopted for the purposes of noise modelling represent the battery cooling system operating at 100% and <u>do not</u> include a noise attenuation kit.</p> <p>The test report also indicates an expanded measurement uncertainty value determined in accordance with ISO 3744:2010 of 5 dB, which has been added to the sound power level of each source. This is expected to be conservative given the low probability of all inverter equipment items concurrently trending to the upper limit of the uncertainty range.</p> <p>Due to commercial sensitivities the specific battery unit manufacturer and model is not detailed in this report but has been confirmed by the Applicant to be representative of the specification required for the Project.</p>                  |
| HV transformers            | <p>At this stage of the Project, specific details of the transformer makes and models are yet to be finalised.</p> <p>In the absence of measured sound power level data for a specific transformer model, reference has been made to the standard maximum method for estimating overall transformer sound power levels for a given power rating described in AS 60076-10:2023, and the power ratings specified for each transformer model by the Applicant (as detailed in Section 7.2).<sup>27</sup></p> <p>Octave band spectrum data for each transformer was then estimated by applying Bies &amp; Hansen corrections from <i>Table 11.27, (Location 1a for outdoor transformer noise)</i> to the determined overall sound power level.<sup>28</sup></p>                                                                                                                                                                                  |

<sup>26</sup> International Organisation for Standardisation, *ISO 3744:2010 Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane* (ISO 3744:2010)

<sup>27</sup> Standards Australia, *Australian Standard AS 60076-10:2023 Part 10: Determination of sound levels* (IEC 60076-10:2016 (ED. 2.0) MOD) (AS 60076-10:2023)

<sup>28</sup> Bies, D. H. & Hansen, C. H, *Engineering noise control: theory and practice* (Fourth edition.). p. 601, 2009

## 7.4 Noise modelling method

All equipment items are modelled as omnidirectional point sources of noise with associated octave band sound power level noise emissions.

The noise modelling method adopted for ancillary infrastructure noise predictions is equivalent to that documented in Section 4.1, with the exception of the UK Institute of Acoustics guidance modifications which have only been applied to wind turbine noise predictions.

## 7.5 Predicted noise levels

Predicted noise levels for the operation of the ancillary infrastructure have been predicted at all receivers referenced in Appendix E.

Results are provided for receivers within 3 km of the ancillary infrastructure locations only. 3 km is significantly greater than the separation distance required to achieve compliance with the most stringent NPfI PNTL.

All receivers within 3 km of the proposed ancillary infrastructure are associated receivers. Similarly to wind turbine noise, ancillary infrastructure noise at associated receivers will be managed based on the private agreements established between the receiver and the Applicant. Results for these receivers are provided in Table 20 for information only.

**Table 20: Predicted ancillary infrastructure noise levels at receivers within 3 km of BESS/substation, dB L<sub>Aeq</sub>, 15 min**

| Receiver                    | BESS | Substation | Total <sup>a</sup> |
|-----------------------------|------|------------|--------------------|
| <i>Associated receivers</i> |      |            |                    |
| 63                          | 29   | 15         | 29                 |
| 72                          | 47   | 31         | 47                 |
| 102                         | 39   | 20         | 39                 |
| 180                         | 30   | 16         | 30                 |

a BESS and Substation noise levels combined

With regards to receiver 72 – the Applicant has confirmed that there is an agreement in place for the dwelling to remain unoccupied throughout construction and operation of the Project, should it be approved. The risk of noise impact at this location is therefore negligible.

Recognising that no non-associated receivers are located within 3 km of proposed ancillary infrastructure locations, the predicted noise level at the nearest non-associated receiver is included in Table 21 for additional context. All other non-associated receivers are located further away and would have lower predicted noise levels.

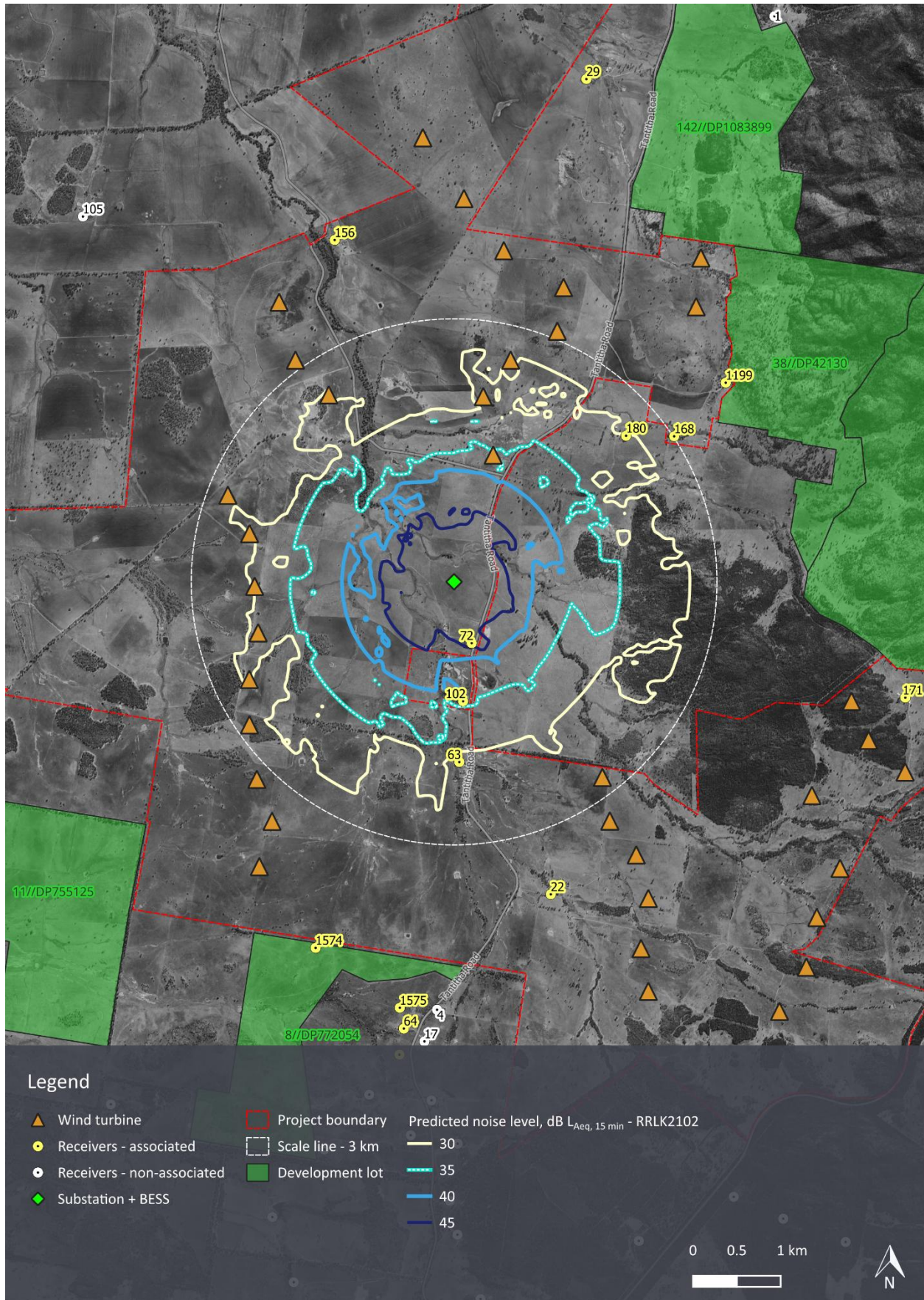
**Table 21: Predicted ancillary infrastructure noise levels at the nearest non-associated receiver, dB L<sub>Aeq</sub>, 15 min**

| Receiver                        | BESS | Substation | Total <sup>a</sup> |
|---------------------------------|------|------------|--------------------|
| <i>Non-associated receivers</i> |      |            |                    |
| 4                               | 20   | < 10       | 20                 |

The results shown above demonstrate that the predicted noise level at the nearest non-associated receiver is below the minimum NPfI PNTL of 35 dB L<sub>Aeq</sub> 15min by a minimum margin of 15 dB.

Predicted noise contours are shown in Figure 5.

Figure 5: Ancillary infrastructure noise contours



## 7.6 Tonality

Noise associated with the operation of inverters and transformers has the potential to be tonal in nature.

Fact Sheet C of the NPfI sets out corrections for annoying noise characteristics, including tonality, that must be applied where the characteristics are evident at receiver locations.

Tonality has been evaluated by reviewing predicted third octave band sound pressure levels at the nearest receivers, within the context of the objective method specified in Fact Sheet C.

On this basis, a modifying factor correction for tonality is not indicated to be applicable to the ancillary infrastructure assessment and has not been applied to the predicted noise levels.

Notwithstanding the above, the predicted ancillary infrastructure noise level at the nearest non-associated receiver is low (20 dB  $L_{Aeq, 15 \text{ min}}$ ) with noise levels at further non-associated receivers indicated to be lower. If a tonality penalty were to be applied, there would still be a significant compliance margin. Additionally, the audibility of any present tone in the context of typical background noise levels, even at night, is likely to be limited. On this basis tonality is not expected to be a risk for non-associated receivers.

## 7.7 Development rights

An evaluation of noise factors related to development rights has been conducted for ancillary infrastructure noise, following the same approach as that outlined for wind turbine noise (refer Section 6.3).

Figure 5 indicates that none of the development lots identified by the Applicant intersect with the 35 dB  $L_{Aeq, 15 \text{ min}}$  noise contours for ancillary infrastructure noise.

Based on the guidance provided in the Wind Energy Guideline ancillary infrastructure noise is not expected to be a contributing factor to adverse impacts to development rights, however this will need to be considered in totality with other disciplines as part of the overall evaluation of development rights impacts.

## 7.8 Discussion

The results shown in Table 21 demonstrate that predicted noise levels are below the 35 dB  $L_{Aeq, 15 \text{ min}}$  night-time PNTL at all non-associated receivers, by a margin of 15 dB or more. Evaluation of noise factors related to development rights indicates that adverse noise impact is not expected.

The above findings indicate that the Project is capable of being designed and operated to comply with the operational ancillary infrastructure noise requirements of the NPfI and Wind Energy Guideline, and therefore the relevant requirements of the Project SEARs.

## 8.0 CUMULATIVE OPERATIONAL NOISE ASSESSMENT

The Project SEARs requires:

*assessment of the cumulative noise impacts (considering other developments in the area).*

Based on information provided by ERM/the Applicant, the other developments in the area of the Project that are being considered within the broader EIS are shown in Table 22.

**Table 22: Other developments in the vicinity of the Project**

| SSD/SSI application number | Project name                            | Approximate distance, km <sup>a</sup> |
|----------------------------|-----------------------------------------|---------------------------------------|
| SSD-50701505               | Narromine Battery Energy Storage System | 11                                    |
| SSD-451258                 | Forest Glen Solar Farm                  | 18                                    |
| SSD-9176045                | Tomingley Gold Extension Project        | 25                                    |
| SSD-8777                   | Maryvale Solar Farm                     | 35                                    |
| SSI-7475                   | Inland Rail Parkes to Narromine         | 38                                    |
| SSI-9487                   | Inland Rail Narromine to Narrabri       | 38                                    |
| SSD-8696                   | Suntop Solar Farm                       | 47                                    |
| SSD-6785                   | Gilgandra Solar Farm                    | 48                                    |
| SSD-55968733               | Burroway Solar Farm                     | 60                                    |
| [pending]                  | Burroway Wind Farm                      | 60                                    |

a Calculated from the centre of the Project O&M facility

On the basis that none of the projects listed above are located within 10 km of the Project, it is not expected that cumulative noise will be a relevant consideration for this Project. It has therefore not been addressed further within this assessment.

## 9.0 RECOMMENDED OPERATIONAL NOISE MANAGEMENT MEASURES

Recommendations to provide appropriate management of operational noise factors during subsequent stages of Project development and provided below:

- The predicted operational wind turbine noise levels should be updated prior to construction with sound power levels of the wind turbine selected for the Project. This is to verify ongoing compliance with the requirements of the Wind Energy Guideline, Technical Supplement for Noise and Project SEARs.
- The predicted operational ancillary infrastructure noise levels should be updated prior to construction with the developed design and sound power levels of the final Project design and equipment selections. This is to verify ongoing compliance with the requirements of the Wind Energy Guideline, NPfl and Project SEARs.
- An operational noise management plan (ONMP) should be prepared prior to commencement of operations which identifies how compliance with the Project's operational noise limits will be demonstrated, including details of testing procedures and reporting time frames following commencing operation of the Project.
- Following construction, compliance monitoring should be conducted to satisfy the Technical Supplement for Noise including evaluation of special noise characteristics.

In addressing the SEARs and assessing operational wind turbine noise in accordance with the Wind Energy Guideline and Technical Supplement for Noise, it is expected that the Project will satisfy the applicable noise limits and guidance for development rights.

Further given the magnitude of the indicated compliance margin it is not expected that noise control measures are likely to be required for the Project, even under extraordinary conditions.

Notwithstanding this, consideration should be given to available contingency strategies to reduce noise levels, in the unlikely event they are required. These should be documented in the ONMP.

The following summarises the two key measures available to reduce the noise:

- *Procurement contract*

The procurement contract for the supply of wind turbine to the Project will typically include specifications concerning the allowable total noise emissions from the wind turbine, and the permissible noise characteristics of the wind turbine.

In the event that wind turbine emissions are found to exceed the contracted values, the supplier will be required to implement measures to reduce the noise to the contracted value. This can include measures to rectify manufacturing defects or appropriate control settings.

- *Noise reduction management strategy*

Modern wind farms include control systems which enable the operation of the wind turbine to be varied according to environmental constraints. Specifically, variable pitch wind turbines as proposed for this Project include control functions which enable the noise emissions of the wind turbines to be selectively controlled; by adjusting the pitch of blade, the noise emissions of the wind turbine can be reduced.

In addition, where required, the wind turbines can be selectively shut down under relevant wind speeds and directions. These types of control measures can be used separately, or in combination, to achieve noise reductions for predetermined wind speed ranges and directions.

## 10.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

### 10.1 Overview

The construction of the Project will generate noise and vibration as a result of activities occurring both on and off the site.

As per the Project SEARs, construction noise is to be assessed in accordance with the ICNG (see Section 3.4) and construction vibration in accordance with the AVTG (see Section 3.5).

Off-site noise generating activities considered within this assessment are limited to heavy vehicle movements to and from the site. These have been addressed separately in the traffic noise assessment, documented in Section 11.0.

On-site works include a range of activities such as construction of access tracks, transmission infrastructure, wind turbine foundations and erection of the wind turbines.

Construction of a wind farm mostly occurs at relatively large separating distances from receivers, with most of the work typically limited to standard working hours.

The only exceptions are for potentially unavoidable works or low-noise managed-works. Unavoidable works outside of standard hours may comprise the delivery of oversized wind turbine components at times selected to minimise traffic disruption associated with intersection closures, and potentially wind turbine installation activities that are sensitive to weather conditions, e.g. installation of rotors or concrete pouring during summer.

Should these works be required, an out of hours construction noise and vibration assessment should be conducted during the detailed design stage. Additionally, authorisation from the relevant authority - expected to be the Planning Secretary or the Department of Planning, Housing and Infrastructure (DPHI) - should be sought, based on justification provided by the Applicant or its contractors. Supporting information for the justification may include evidence of consultation with potentially affected receivers, details of reasonable and feasible noise mitigation measures which are to be implemented, or an assessment of out of hours construction noise and vibration impacts.

As per the ICNG, noise associated with the construction of a wind farm may require the adoption of reasonable and feasible general management measures and considerate working practices. These measures are normally documented and agreed in a construction noise and vibration management plan (CNVMP) for inclusion in a broader environmental management plan (EMP). These documents are typically prepared for review and approval by the responsible authority prior to commencing any construction works.

At this stage a detailed construction strategy is not known but would be developed at a later date once a main contractor is appointed. Therefore, the following sections provide general information regarding the types of activities that are expected to be associated with the construction of the Project, and reference data that should be considered as part of the preparation of a future CNVMP for the Project.

It is also noted that although this report typically considers receivers located within 5 km of a wind turbine, an expanded receiver dataset has been included within the construction noise assessment. This has been done to account for the 4 receivers located outside of the 5 km wind turbine scale line, and nearby to the proposed transmission line extension to the north of the Project site. The location of these receivers can be seen in the construction layouts shown in Appendix L.

Although these receivers are subject to lease agreements with the Applicant to host the transmission line infrastructure on their land, these agreements do not include any provisions related to operational noise. On this basis they are considered as non-associated receivers within this assessment.

## 10.2 Construction activities

Construction of a wind farm project typically involves tasks such as:

- Access road construction
- Cable trench digging
- Construction of overhead transmission lines
- O&M/construction compound/workers accommodation construction
- Substation/BESS construction
- Wind turbine foundations/hardstands
- Wind turbine/temporary met mast assembly.

Specific details of the construction program and the number, type, and duty of the construction plant to be used would be determined during the advanced stages of the Project when a construction contractor has been selected.

For the purposes of this noise assessment, the Applicant has provided spatial data and noise inputs that align with the construction staging assumed as part of the broader EIS.

Appendix L provides a site layout denoting the key work areas associated with each construction stage.

Appendix M details typical major equipment items associated with the above construction stages, alongside noise levels developed on the basis of reference data from AS 2436 and previous project experience. These are conceptual assumptions provided by the Applicant and provide an approximation of potential construction equipment and processes. Project specific equipment and processes will be determined once a main contractor is appointed.

As shown in Appendix M, typical construction plant sound power levels range from approximately 99 -121 dB  $L_{WA}$  per equipment item.

Based on the groupings of major plant items during key construction tasks, the total aggregated noise emissions for the proposed works stages typically ranges from 120 - 125 dB  $L_{WA}$ . These predictions are based on the assumption that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period thus providing a conservative approach that is unlikely to occur in practice.

## 10.3 Construction noise assessment

Noise levels associated with each of the main construction tasks have been predicted at the nearest associated and non-associated receivers to provide an indication of the upper range of noise levels.

Given that the precise equipment selections and methods of working would be determined once a main contractor is appointed, and that the noise associated with construction plant and activity varies significantly, the predicted noise levels are provided in the following sections as an indicative range of levels which may occur in practice.

The predicted noise level ranges for each of the main construction tasks are provided in Table 23 and Table 24 for non-associated and associated receivers, respectively.

**Table 23: Indicative range of construction noise predictions at the most affected associated receiver, dB L<sub>Aeq</sub>, 15 min**

| Construction stage                      | Nearest receiver (distance, m) | Predicted level range | Noise affected management level | Exceedance | Highly noise affected management level | Exceedance |
|-----------------------------------------|--------------------------------|-----------------------|---------------------------------|------------|----------------------------------------|------------|
| 1 - Early works                         | 72 (20)                        | 85-95                 | 45                              | Up to 50   | 75                                     | 10-20      |
| 2 - Main laydown construction           | 72 (1,190)                     | 45-55                 | 45                              | Up to 10   | 75                                     | -          |
| 3 - Substation construction             | 29 (220)                       | 60-70                 | 45                              | Up to 25   | 75                                     | -          |
| 4 - Roads, hardstands, foundations, etc | 63 (270)                       | 60-70                 | 45                              | Up to 25   | 75                                     | -          |
| 5 - Wind turbine installation           | 63 (270)                       | 60-70                 | 45                              | Up to 25   | 75                                     | -          |
| 6 - Energisation and commissioning      | 29 (220)                       | 55-65                 | 45                              | Up to 20   | 75                                     | -          |
| 7 - BESS Construction and installation  | 72 (550)                       | 50-60                 | 45                              | Up to 15   | 75                                     | -          |
| 8 - Demobilisation                      | 72 (1,190)                     | 40-50                 | 45                              | Up to 5    | 75                                     | -          |

**Table 24: Indicative range of construction noise predictions at the most affected non-associated receiver, dB L<sub>Aeq</sub>, 15 min**

| Construction stage                      | Nearest receiver (distance, m) | Predicted level range | Noise affected management level | Exceedance | Highly noise affected management level | Exceedance |
|-----------------------------------------|--------------------------------|-----------------------|---------------------------------|------------|----------------------------------------|------------|
| 1 - Early works                         | 4 (30)                         | 80-90                 | 45                              | Up to 45   | 75                                     | 5-15       |
| 2 - Main laydown construction           | 105 (5,300)                    | 30-40                 | 45                              | -          | 75                                     | -          |
| 3 - Substation construction             | 392 (380)                      | 55-65                 | 45                              | Up to 20   | 75                                     | -          |
| 4 - Roads, hardstands, foundations, etc | 5 (440)                        | 55-65                 | 45                              | Up to 20   | 75                                     | -          |
| 5 - Wind turbine installation           | 5 (440)                        | 55-65                 | 45                              | Up to 20   | 75                                     | -          |
| 6 - Energisation and commissioning      | 392 (380)                      | 50-60                 | 45                              | Up to 15   | 75                                     | -          |
| 7 - BESS Construction and installation  | 4 (4,730)                      | 30-40                 | 45                              | -          | 75                                     | -          |
| 8 - Demobilisation                      | 105 (5,300)                    | 25-35                 | 45                              | -          | 75                                     | -          |

The following can be seen from the construction noise predictions shown in Table 23 and Table 24:

- Construction noise levels are predicted to be below the highly noise affected management level for all associated and non-associated receivers during all assessed construction stages, except for '1 - Early Works'. During this stage, an exceedance of up to 15 dB is predicted for non-associated receivers, and up to 20 dB for associated receivers.
- Construction noise levels are predicted to be up to 45-50 dB above the noise affected management levels at the nearest non-associated and associated receiver during '1 – Early works'.
- Construction noise levels are predicted to be up to 50 dB above the noise affected management level at the nearest affected associated receiver during '1 – Early works'.

#### 10.3.1 Discussion – Early works

The data shown in Table 23 and Table 24, indicates that '1 – Early works' is the construction stage most likely to result in high predicted noise levels at the receiver locations.

Based on information provided by the Applicant, it is understood that the '1 – Early works' construction stage includes the construction of access roads, as well as upgrade works on public roads.

These activities involve a brief period of elevated noise while work is carried out to improve existing roads or tracks (where required), create new intersections at Project access points, and initiate Project access tracks.

During these initial works, construction noise levels of up to 75-95 dB  $L_{Aeq}$  could be expected for brief periods when road and access work is carried out at distances within less than 100 m from a receiver. Based on the spatial data associated with the '1 – Early works' work area (shown in Appendix L), there are 3 associated, and 3 non-associated receivers located within 100 m of the work area.

For context, the predicted noise levels are comparable to, and typical of, noise levels produced by general road maintenance works and activity.

Regardless, it is expected that the Applicant will be required to apply all feasible and reasonable work practices to reduce the noise levels and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as relevant contact details.

Feasible and reasonable work practices and noise control processes should be detailed in a Project specific CNVMP once a main contractor is appointed, and representative construction works are evaluated. This is likely to result in lower predicted noise levels than documented in this report due to reduction of conservative assumptions and better representation of Project specific works.

#### 10.3.2 Discussion – General

The majority of construction activities considered within this assessment typically occur nearby to the wind turbine and ancillary infrastructure locations. These works are therefore subject to larger setback distances to receivers than would be expected for the construction of access tracks, which typically run closer to receivers. As a result, construction noise levels associated with these activities are predicted to be lower.

Depending on environmental factors such as the background noise level and wind direction, construction noise associated with more distant works could still be audible at surrounding receivers. In particular, given the low background noise levels that typically occur in rural environments at low wind speeds, it is possible that construction noise could be higher than the background noise level in some instances.

The ICNG indicates:

*The noise affected level represents the point above which there may be some community reaction to noise.*

- *Where the predicted or measured  $L_{Aeq}(15\text{ min})$  is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.*
- *The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.*

The predicted noise levels summarised in Table 23 and Table 24 demonstrate that the highly noise affected management levels are expected to be exceeded by up to 20 dB at some receivers - generally located adjacent to the '1 – Early works' work area – during the construction of access roads.

The ICNG provides additional comments with respect to highly noise affected management levels:

*The highly noise affected level represents the point above which there may be strong community reaction to noise.*

- *Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:*
  - 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences)*
  - 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.*

Therefore, community consultation and negotiation of respite periods should be considered during a future detailed CNVMP.

Evaluation of Project specific construction work processes and equipment will also be required once a main contractor is appointed, to provide a more representative assessment of construction noise than the conceptual assumptions detailed in this report.

The current conceptual assessment does however indicate that for the '1 – Early works' stage adverse impact may be unavoidable, and it will be essential to minimise noise, establish best practices and constructively mitigate impacts. Additionally, should future assessment of Project specific construction indicate that predicted noise levels continue to be above the noise affected management levels, then a detailed CNVMP will be required, outlining all feasible and reasonable work practices to reduce the noise levels.

If noise levels for the Project specific assessment are above the highly noise affected levels, it may be necessary to inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as relevant contact details.

## 10.4 Construction vibration assessment

The prediction of vibration propagation through the ground is convoluted and complex, and depends on several factors including damping, reflection, and impedance in-ground conditions. A detailed vibration propagation assessment is considered to be a site-specific assessment and often requires a combination of baseline vibration assessment, empirical measurement of equipment and analytical methods. Assessment of this nature is outside of the scope of a planning stage vibration risk assessment.

The AVTG provides guidance with respect to the assessment of human comfort due to vibration from construction works. This guideline distinguishes between intermittent, impulsive, and continuous vibration sources, which can be generated by construction activities. For the purposes of this planning risk assessment only residential receivers are considered.

### 10.4.1 Intermittent vibration

The AVTG indicates that intermittent vibration should be assessed in terms of the vibration dose value (VDV). Representative VDV values for construction works are calculated considering the magnitude and duration of vibration events and are highly specific to site conditions, equipment selections and operational durations. As such, calculation of VDV levels is not typical or practical at the planning stage but will need to be considered as part of a later detailed vibration assessment.

The AVTG recommends that best management practices in all cases should be to reduce values as far as practicable, and a comprehensive community consultation program should be developed.

### 10.4.2 Continuous vibration

Vibration due to some construction operations can be considered continuous depending on the duration and nature of the works. Since the guide values for continuous vibration are independent of exposure duration, indicative safe working distances can be developed. Appendix D of the CNVG sets out minimum working distances from sensitive receivers for typical items of vibration intensive plant.<sup>29</sup> The minimum distances, reproduced in Table 25 are quoted for effects relating to human comfort.

**Table 25: Recommended minimum working distances for human response limits for vibration intensive plant**

| Plant item              | Rating/description                | Minimum working distance, m |
|-------------------------|-----------------------------------|-----------------------------|
| Vibratory roller        | < 50 kN (typically 1-2 tonnes)    | 15 to 20                    |
|                         | < 100 kN (typically 2-4 tonnes)   | 20                          |
|                         | < 200 kN (typically 4-6 tonnes)   | 40                          |
|                         | < 300 kN (typically 7-13 tonnes)  | 100                         |
|                         | > 300 kN (typically 13-18 tonnes) | 100                         |
|                         | > 300 kN (> 18 tonnes)            | 100                         |
| Small hydraulic hammer  | 300 kg – 5 to 12 t excavator      | 7                           |
| Medium hydraulic hammer | 900 kg – 12 to 18 t excavator     | 23                          |
| Large hydraulic hammer  | 1600 kg – 18 to 34 t excavator    | 73                          |
| Vibratory pile driver   | Sheet piles                       | 20                          |

<sup>29</sup> Transport for NSW, *Construction Noise & Vibration Guideline – Public Transport Infrastructure*, September 2023 (CNVG)

| Plant item    | Rating/description | Minimum working distance, m  |
|---------------|--------------------|------------------------------|
| Pile boring   | ≤ 800 mm           | N/A                          |
| Hammer piling | 12 t down force    | 50                           |
| Jackhammer    | Handheld           | Avoid contact with structure |

a Reproduced from Table 20 of Appendix D of the CNVG

The CNVG notes that the minimum working distances for human comfort relate to continuous vibration and are indicative. In practice, appropriate minimum working distances will vary depending on the particular item of plant and local geotechnical conditions. The CNVG further notes that for most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, likely equating to greater minimum working distances.

It can be seen from Table 23 and Table 24 that the minimum working distances, even for the most significant noise generating equipment, are significantly less than the minimum distances between all proposed construction stage work areas and receivers, with the exception of '1 – Early works'.

Based on the minimum working distances shown in Table 25, there are instances in which the use of vibration intensive plant during the '1 – Early works' stage could result in exceedances of the human response limits for continuous vibration. On this basis it is expected that vibration impacts will need to be considered in detail during the planning of construction works/the development of a Project CNVMP.

As with construction noise, any vibration impacts associated with the '1 – Early works' stage are expected to be temporary and limited in duration. The activities most likely to result in vibration impacts during this stage relate to access road construction, which is expected to progress quickly through the relevant work areas. As a result, any impacts at nearby receivers are likely to be short-term and localised. To address these potential impacts, construction vibration will need to be managed through the implementation of feasible and reasonable mitigation measures, to be outlined in a Project-specific CNVMP.

## 10.5 Blasting

The specific requirement for blasting will be determined once a main contractor is appointed and project-specific construction plans and methods are established. However, at this stage, the Applicant has advised that for the purposes of the EIS assessment, it is assumed that blasting will be required as part of the construction of the wind farm.

Theoretical modelling of airblast and ground vibration is complex and subject to considerable uncertainty. The blasting process is highly non-linear, and the variability of ground and rock conditions limits the accuracy of predictions.

In the absence of the specific information required in accordance with the ANZEC 1990 Report, it is not possible to provide site specific airblast and ground vibration levels.

Notwithstanding the above, to provide an indication of the effects of blasting, airblast overpressure levels and ground vibration levels have been estimated using the method detailed in AS2187-2, based on generic assumptions.<sup>30</sup> It is not feasible to establish whether these assumptions are suitable for the Project site until such time as a blasting plan is established and necessary site characteristics have been evaluated.

<sup>30</sup> Australian Standards, AS 2187-2:2006 Explosives—Storage, transport and use, Part 2: Use of explosives (AS 2187-2)

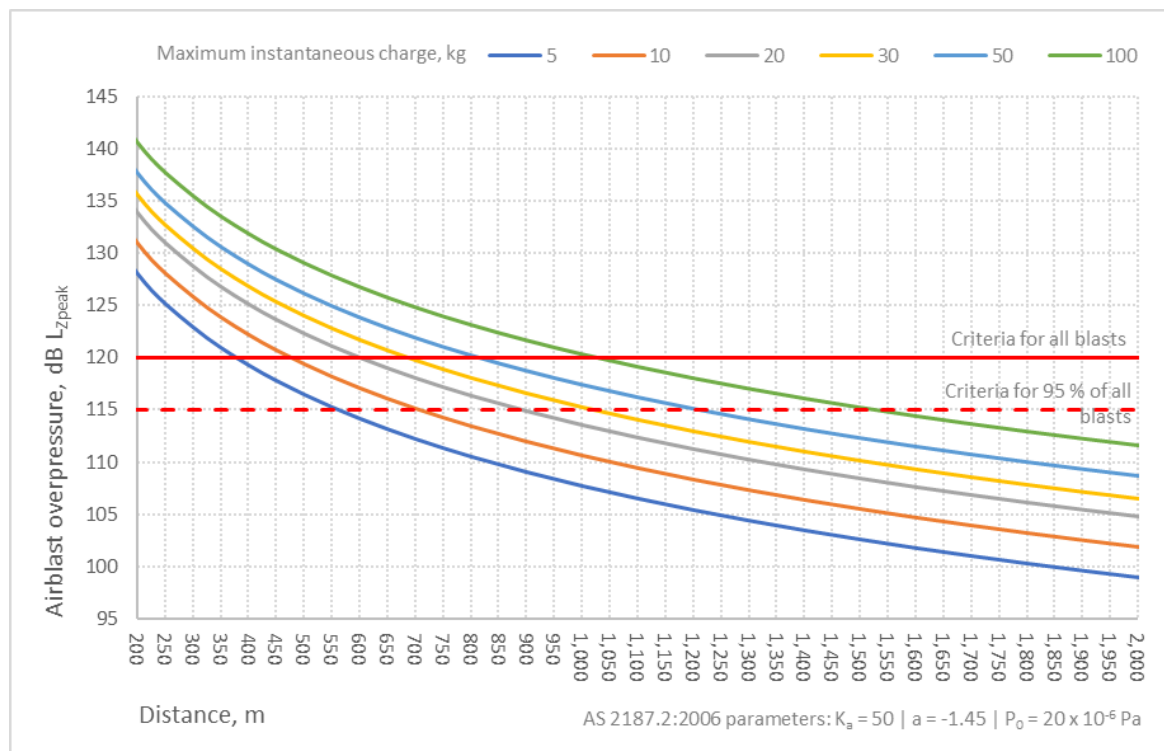
The method accounts for the separation distance, the mass of the charge detonated in any given instant (referred to as the maximum instantaneous charge), the configuration of the charge (unconfined versus confined blastholes), and site characteristics that can be evaluated from measurements of test shots.

### 10.5.1 Airblast overpressure

Estimated airblast overpressure levels are presented in Figure 6 for a range of separating distances and maximum instantaneous charge weights. The estimated levels are based on confined blasthole charges and assumed site characteristics.<sup>31</sup>

The criteria specified in the ANZEC 1990 Report are also shown in Figure 6

**Figure 6: Estimated airblast overpressure levels for  $K_a = 50$  and  $a = -1.45$**



### 10.5.2 Ground vibration

Estimated ground vibration levels are presented in Figure 7 for a range of separating distances and maximum instantaneous charge weights. The estimated levels are based on assumed site characteristics.<sup>32</sup>

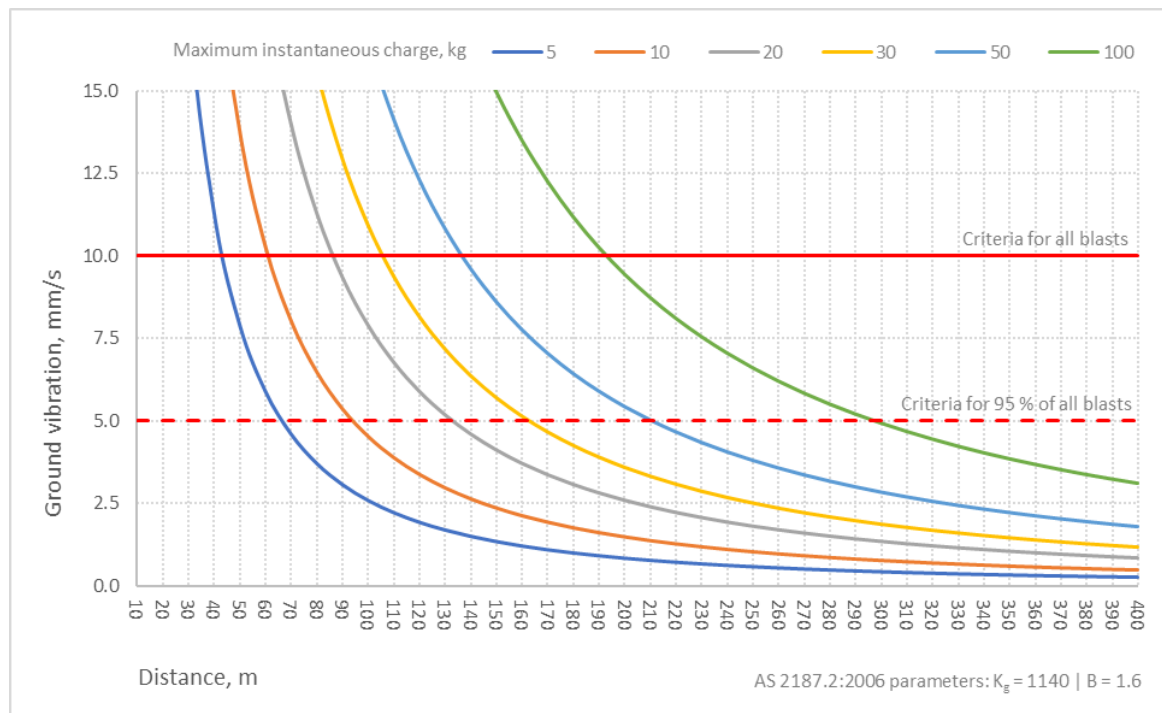
The criteria specified in the ANZEC 1990 Report are also shown in Figure 7

<sup>31</sup> Site-specific characteristics are defined in terms of a site exponent and site constant.

AS 2187-2 refers to a site exponent of -1.45 for estimating overpressure, with corresponding site constants commonly ranging from 10 to 100. In lieu of site-specific data, a site exponent of -1.45 and a mid-value site constant of 50 has been assumed for estimating overpressure.

<sup>32</sup> In lieu of site-specific data, a site exponent of 1.6 and a site constant of 1140 as provided in the example calculation in AS 2187-2 has been assumed for estimating ground vibration.

Figure 7: Estimated ground vibration levels for  $K_g = 1140$  and  $B = 1.6$



### 10.5.3 Blasting locations

Based on information provided by the Applicant, it is understood that blasting is currently assumed to be required as part of the construction of the wind turbine foundations.

The minimum distance between non-associated receivers and potential blasting locations (such as wind turbine foundations) are summarised in Table 26.

Table 26: Nearest non-associated receiver to blasting locations

| Receiver ID | Distance to nearest blasting location, m | Wind turbine ID |
|-------------|------------------------------------------|-----------------|
| 25          | 1,847                                    | 67              |

### 10.5.4 Discussion

Based on the distances shown in Table 26, the following can be established:

- Estimated airblast overpressure levels are below the criteria set for all blasts at all non-associated receivers.
- Estimated ground vibration levels are below the criteria set for all blasts at all non-associated receivers.

If blasting is required, it is recommended that the activities be controlled using blast management procedures documented in an approved construction management plan. The procedures would need to identify the locations where blasting would be conducted. They would also need to describe the testing, management and monitoring measures which would be implemented to achieve the ANZEC 1990 Report criteria. This is expected to involve conducting test shots to evaluate site specific characteristics, in turn enabling the selection of suitable maximum instantaneous charge weights that are appropriate for the site.

It is noted that 2 associated receivers (171, 1199) are located less than 1,000 m from a blasting location. Airblast overpressure levels at these locations will need to be managed in accordance with the relevant private agreements.

## 10.6 Decommissioning

Similar construction activities to those detailed in Section 10.2 are expected to be required during the decommissioning of the Project. Decommissioning activities are likely to be less intensive than during construction and occur over a shorter duration. Additionally, the '1 – Early works' construction stage, involving public road upgrades and access road construction, is unlikely to form part of decommissioning works and associated potential adverse impacts are unlikely to be present.

On this basis no further assessment has been conducted.

## 10.7 Construction noise and vibration recommendations

At this stage of the Project, only a preliminary, conceptual assessment of construction noise and vibration impact risk is feasible. Once a more detailed schedule of equipment and plant items, construction method and work areas are known, a detailed construction noise assessment and CNVMP should be prepared.

Any future CNVMP should include site and process specific noise management work practices designed to mitigate the impact of construction noise activities, including traffic noise.

The ICNG provides extensive details and guidance with respect to noise mitigation including:

- universal work practices
- consultation and notification
- plant and equipment
- on-site controls
- work scheduling
- transmission path and at-receiver considerations.

All of the above items should be considered as part of the future CNVMP.

Generally, it is likely to be feasible for a majority of works to be restricted to normal working hours, i.e. the ICNG recommended standard construction hours detailed in Section 3.4. This will assist in limiting noisy activities to times of the day when intrusive impacts or adverse reactions may be less likely.

In some cases, construction works may be required to occur outside of these hours. Such activities are typically related to public infrastructure, i.e. timing oversized deliveries to avoid hazardous traffic conditions or weather windows, or aspects of wind turbine assembly which must occur in still wind conditions for safety reasons. Where out of hours works are proposed, the ICNG advises:

- *A strong justification would typically be required for works outside the recommended standard hours.*
- *The proponent should apply all feasible and reasonable work practices to meet the noise affected level.*
- *Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.*

General experience of wind farm developments has indicated that construction noise tends to represent a limited risk factor. This is particularly the case for the Project where significant separation distances (multiple kilometres) are present between work areas and receivers. With reasonable and feasible work practices, including respite periods, community communication and targeted noise management where elevated noise levels are indicated, it is expected that noise associated with the construction and decommissioning of the Project can be acceptably managed.

## 11.0 TRAFFIC NOISE ASSESSMENT

Noise criteria for the assessment of traffic associated with the construction and operation of the Project are detailed in Section 3.6.

Traffic generation during the operation of the Project is expected to be limited, with construction stage traffic likely to comprise the significant majority of traffic movements associated with the Project. On this basis, operational traffic on public roads is not considered further in this report as it is likely to be very low and have negligible noise impacts.

Based on information provided by the Applicant, noise impacts associated with construction traffic along both the Newell Highway and the adjoining Bensons Road, Pinedean Road and Tantitha Road have been assessed.

It is understood that the Project will target the use of existing major roads and designated heavy vehicle routes, with existing traffic flows expected to be greater than any increase arising from construction of the Project. On this basis traffic noise along the broader transport route has not been considered further in this report - increases in traffic noise levels experienced by receivers near these major roads are likely to be negligible.

The base traffic flows and estimated construction traffic flows along the roads considered within this assessment have been provided by Amber Organisation in correspondence dated 8 April 2024. The traffic data is reproduced in Table 27.

Based on the definitions in the RNP, the Newell Highway is considered to be a freeway or motorway/arterial road, while Bensons Road, Pinedean Road and Tantitha Road are local roads. The assessment has been based on the relevant RNP criteria for each road category.

**Table 27: Construction traffic and base traffic flows on public roads – vehicles (% heavy vehicles)**

| Road category                                              | Existing traffic |                    | Future:<br>existing + construction traffic |                    |
|------------------------------------------------------------|------------------|--------------------|--------------------------------------------|--------------------|
|                                                            | Day <sup>a</sup> | Night <sup>a</sup> | Day <sup>a</sup>                           | Night <sup>a</sup> |
| <b>Local roads <sup>b</sup></b>                            |                  |                    |                                            |                    |
| Bensons Road                                               | 3 (33%)          | 2 (50%)            | 50 (2%)                                    | 49 (2%)            |
| Pinedean Road                                              | 3 (33%)          | 2 (50%)            | 63 (23%)                                   | 62 (23%)           |
| Tantitha Road                                              | 3 (33%)          | 2 (50%)            | 63 (23%)                                   | 62 (23%)           |
| <b>Freeways or motorways/arterial roads <sup>c,d</sup></b> |                  |                    |                                            |                    |
| Newell Highway                                             | 2,109 (31%)      | 385 (37%)          | 2,452 (34%)                                | 456 (6%)           |

a Day is 0700 - 2200 hrs; Night is 2200 - 0700 hrs

b Day & Night: Peak 1 hr AADT (annual average daily traffic)/% heavy vehicles

c Day: Total 15 hr AADT/% heavy vehicles

d Night: Total 9 hr AADT/% heavy vehicles

### 11.1 Screening assessment

In considering feasible and reasonable mitigation measures, the RNP states that an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. On this basis, to assess noise impacts from construction traffic, an initial screening test is undertaken in the following section to evaluate whether existing road traffic noise levels would increase beyond this threshold.

Where the predicted traffic noise increase is 2 dB or less, no further assessment is conducted, as impacts will be barely perceptible. However, where the road traffic noise levels are predicted to increase by more than 2 dB as a result of additional traffic, consideration is given to the actual noise levels associated with the construction traffic and whether or not these levels comply with the road traffic noise criteria detailed in Table 4 of Section 3.6.

A 2 dB increase in relative traffic noise level is approximately equal to a 60 % increase in traffic flow.

The relative traffic flow increases that are estimated to occur on the roads included within this assessment during the construction of the Project are shown in Table 28.

**Table 28: Relative increase to traffic flow on public roads**

| Road category                               | Relative increase |        |
|---------------------------------------------|-------------------|--------|
|                                             | Day               | Night  |
| <b>Local roads</b>                          |                   |        |
| Bensons Road                                | 1,567%            | 2,350% |
| Pinedean Road                               | 2,000%            | 3,000% |
| Tantitha Road                               | 2,000%            | 3,000% |
| <b>Freeways or motorways/arterial roads</b> |                   |        |
| Newell Highway                              | 16%               | 21%    |

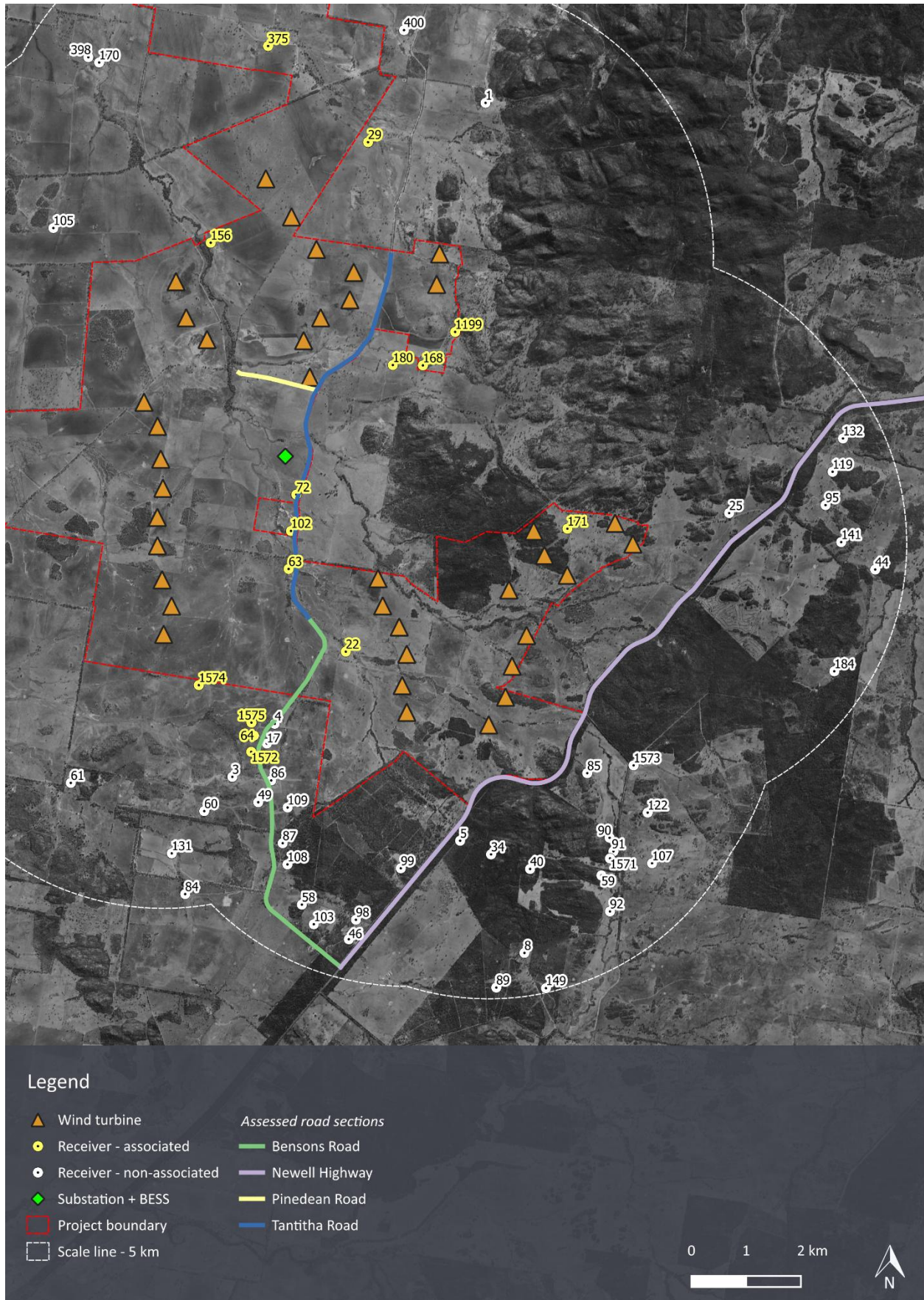
Based on the data in Table 28, the relative traffic noise level increase due to the proposed construction activities is predicted to be:

- Below the 2 dB threshold on all freeways or motorways/arterial roads considered within the assessment.
- Above the 2 dB threshold on all local roads considered within the assessment.

On this basis, the detailed assessment documented herein has only considered construction traffic noise along Bensons Road, Pinedean Road and Tantitha Road.

The location of each of the assessed road sections in relation to the Project is shown in Figure 8.

Figure 8: Assessed road sections in relation to the Project



## 11.2 Construction traffic predictions

Based on the information provided in Table 27, it is noted that both the existing traffic volumes and those associated with the construction of the Project are generally low in absolute levels, particularly when considering traffic flows on local roads. The CoRTN prediction method, preferred by Transport for NSW (TfNSW) and the EPA, is not typically applied where traffic flows are less than 50 vehicles per hour.<sup>33</sup> A correction factor for low traffic volumes, applicable when considering traffic flows lower than 200 vehicles per hour, has been applied where relevant, in accordance with CoRTN.

From the traffic data in Table 27, traffic noise levels have been predicted in the vicinity of the assessed roads using the following method and assumptions:

- Traffic speed set to 100 km/h.
- Roads assessed as a local road as defined in the RNP.
- Predicted noise levels include an additional +2.5 dB correction for facade reflection as required by the RNP.
- $L_{Aeq, 1h}$  levels are calculated as CoRTN  $L_{A10(1hr)}$  - 3 dB, per RMS practice (noting that this research was conducted by the RMS which has now been absorbed into TfNSW).
- Grass or cultivated fields assumed between the road and receivers.

Modifying corrections for Australian conditions or for road surface conditions have not been applied as applicable data for the road surfaces in question is not available.

Table 29 shows a summary of the minimum setback distances from the assessed roads, beyond which compliance with the RNP criteria is predicted to be achieved during the day and night periods.

**Table 29: Minimum setback distance for RNP compliance**

| Road               | Minimum setback distance, m |       | ID of receivers within setback zone |         |
|--------------------|-----------------------------|-------|-------------------------------------|---------|
|                    | Day                         | Night | Day                                 | Night   |
| <i>Local roads</i> |                             |       |                                     |         |
| Bensons Road       | 25                          | 50    | -                                   | 4       |
| Pinedean Road      | 45                          | 90    | -                                   | -       |
| Tantitha Road      | 45                          | 90    | -                                   | 102, 72 |

As shown in Table 29, there are 3 receivers located within the predicted night setback zones for RNP compliance. There are no receivers located within the day period setback zones for any of the assessed roads.

Notwithstanding the prediction results, the increase in traffic noise from the already low existing volumes may result in a noticeable increase in noise during some periods of construction. Noise mitigation options are generally limited for local roads, with community consultation and regular communication being the most effective and practical means of minimising adverse impacts.

It is recommended that residents residing nearby to Bensons Road and Tantitha Road be included in consultation prior to, and during, construction.

Alternative practical methods for minimising noise impact may include limiting construction traffic speed for the affected road sections. Reducing construction traffic speeds would reduce the minimum setback distances and potential for adverse noise impacts to these receivers.

<sup>33</sup> UK Department of Transport, The Calculation of Road Traffic Noise (CoRTN)

### 11.3 Sleep disturbance due to construction traffic

The majority of construction traffic movements will occur during the day period, as construction works associated with the Project are only expected to occur during standard working hours.

Out of hours work is not specifically scheduled in the current conceptual construction works information provided by the Applicant.

Notwithstanding the above, a conceptual assessment is included for potentially unavoidable works requiring Oversize/Overmass vehicles (OSOM), e.g. for the delivery of oversized wind turbine components at times selected to minimise traffic disruption associated with intersection closures.

Based on the RNP sleep disturbance criteria established in Section 3.6, an external noise level screening threshold of 65 dB  $L_{Amax}$  is established to assess the potential for sleep disturbance due to construction traffic during the periods of OSOM delivery. Based on typical OSOM vehicle noise data, a maximum external noise level of 65 dB  $L_{Amax}$  or higher, is feasible at receivers within 40 m of the OSOM vehicle movements.

Receiver 72 is the sole associated receiver that is located within 40 m of the assessed road sections. Should the Project be approved, there is an agreement in place for the dwelling to remain unoccupied throughout construction and operation of the wind farm. As a result, sleep disturbance impacts to nearby receivers are considered to be low risk.

## 12.0 CONCLUSION

MDA has been engaged to prepare this noise and vibration assessment to support the EIS for the Project.

Operational noise from the wind turbines has been assessed in accordance with the Wind Energy Guideline and Technical Supplement for Noise, as required by the applicable SEARs (SSD-60247211), dated 11 February 2025. The Technical Supplement for Noise specifies that the assessment of wind turbine noise is to be conducted in accordance with the SA Guidelines, subject to a set of supplementary procedures that are specific to NSW. The Wind energy guideline additionally requires noise factors related to development rights to be evaluated.

A background noise monitoring survey was undertaken to obtain a representation of typical baseline conditions at receivers in the vicinity of the Project. The results are detailed in the Background Noise Report.

Assessment of wind turbine operational noise at non-associated receivers has been conducted considering the base noise limit, 35 dB  $L_{Aeq, 10 \text{ min}}$ , in the Technical Supplement for Noise. This represents the most stringent noise limits that can be applied under the policy.

For the purposes of this assessment, one candidate wind turbine model has been nominated by the Applicant comprising the one noise modelling scenario that has been documented within this assessment.

Noise emission data representing the candidate wind turbine model has been used with international standard ISO 9613-2:1996 to predict the level of noise expected to occur at neighbouring receivers.

The results of the noise modelling for the Project demonstrate that the predicted noise levels for the proposed wind turbine layout are below the base noise limit determined in accordance with the Technical Supplement for Noise at all neighbouring non-associated receivers by a minimum margin of 2.8 dB, including consideration of tonality and special noise characteristics.

The assessment has also considered operational noise from the proposed permanent noise generating ancillary infrastructure, specifically substations and BESS. Predicted noise levels at all non-associated receivers are below the most stringent project noise trigger level of 35 dB  $L_{Aeq 15 \text{ min}}$  by a minimum margin of 15 dB.

Predicted noise levels at associated receivers resulting from the operation of the Project wind turbines and BESS have also been included within this report. As per the requirements of the Technical Supplement for Noise, an assessment of impacts has not been conducted at these locations. The predicted noise levels are therefore provided within this report for information only.

With respect to development rights, evaluation of noise factors related to operation of the proposed wind turbines and ancillary infrastructure indicates that noise is not expected to be a contributing factor to adverse impacts to development rights.

A preliminary construction noise and vibration assessment has been conducted, accounting for typical equipment items and work practices, as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the ICNG and AVTG.

The assessment indicates that some construction stages may result in elevated noise levels at non-associated receivers, due to the proximity of works on access tracks. This means that a detailed CNVMP will be necessary once a main contractor is appointed and a more detailed schedule of equipment and plant items, construction method and work areas is known. This will include specific consideration of construction stages indicating elevated risks and will include the adoption of all feasible and reasonable mitigation measures and work practices where the highly noise affected

management level continues to be exceeded. The ICNG provides extensive guidance for the management of construction noise levels such that construction noise and vibration mitigation and the amenity of receivers can be coordinated in a holistic manner.

The construction noise assessment also includes a blasting noise assessment, considering the wind turbine foundations as the locations at which blasting may be required. The outcomes of this assessment indicate that estimated airblast overpressure and ground vibration levels are expected to be below the recommended criteria specified in the ANZEC 1990 Report at all non-associated receivers

An assessment of traffic noise associated with construction traffic movements on local and freeway/arterial/sub-arterial roads has been conducted in accordance with the RNP. The assessment established setback distances for local and freeway/arterial/sub-arterial roads within which applicable traffic noise criteria may be exceeded, within which 3 receivers were identified. These receivers should be consulted prior to and during construction activities to manage impacts and considered in more detail as part of a future CNVMP.

Cumulative wind turbine and ancillary infrastructure noise impacts have been assessed considering a number of nearby developments. It is concluded that adverse cumulative noise does not warrant detailed consideration as all of the nearby projects are located greater than 10 km away from the Project. This should be reviewed during subsequent stages of the Project to accommodate any new or evolved development in the vicinity of the Project.

The findings of the operational noise assessment demonstrate that the Project is capable of being designed and operated to comply with the Project SEARs requirements. Prior to the commencement of construction, it is recommended that the predicted noise levels for all components of the operational noise assessment be updated for the final Project configuration and equipment selections, in order to verify ongoing compliance with the SEARs and applicable noise policy.

Consistent with the Technical Supplement for Noise, compliance is also recommended to be verified by post-construction noise compliance monitoring. The compliance testing procedures should be documented in a compliance test plan. Given the size of the Project, it is recommended that the compliance testing procedures include provisions for early onsite noise emission testing of the wind turbines to verify consistency with the design validation modelling.

Measures for the management of construction noise and vibration would be implemented via a CNVMP to be prepared at a later stage of the Project when a construction contractor has been selected and specialised construction planning for the site has been developed. This would comprise a detailed, Project specific construction noise and vibration assessment, as well as Project specific noise mitigating work practices and physical noise controls (where required).

Overall, the noise and vibration assessment indicates that construction, operation and decommissioning of the Project can be designed and executed such that associated noise is capable of complying with the requirements of the Project SEARs (SSD-60247211).

## APPENDIX A GLOSSARY OF TERMINOLOGY

| Term                                | Definition                                                                                                                                                                                                                                                                                                                                                                              | Abbreviation                     |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| A-weighting                         | A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.                                                                                                                                                                                                                                                                     | See discussion below this table. |
| A-weighted 90 <sup>th</sup> centile | The A-weighted pressure level that is exceeded for 90% of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.                                                                                               | L <sub>A90</sub>                 |
| A-weighted average noise level      | The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.<br><br>The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 2200-0700 hrs. | L <sub>Aeq (t)</sub>             |
| A-weighted maximum noise level      | The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.                                                                                                                                                                                                                                                                                 | L <sub>Amax</sub>                |
| C-weighting                         | The process by which noise levels are corrected to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 dB).                                                                                                                                                                                                                     | See discussion below this table  |
| Decibel                             | The unit of sound level.                                                                                                                                                                                                                                                                                                                                                                | dB                               |
| Hertz                               | The unit for describing the frequency of a sound in terms of the number of cycles per second.                                                                                                                                                                                                                                                                                           | Hz                               |
| Octave Band                         | A range of frequencies. 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.                                                                                                                                                                | -                                |
| Third octave band                   | One-third of an octave band. Used for more detailed analysis of sound frequency data.                                                                                                                                                                                                                                                                                                   |                                  |
| Peak Particle Velocity              | The measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment                                                                                                                                                                                                                                                                                  | PPV                              |
| Sound power level                   | A measure of the total sound energy emitted by a source, expressed in dB.                                                                                                                                                                                                                                                                                                               | L <sub>w</sub>                   |
| Tonality                            | A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).                                                                                                                                                                                                                                   | -                                |

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 – 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 dB L<sub>A</sub>.

Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report, unless included in a direct quote of external documentation.

## **APPENDIX B DESCRIPTION OF SOUND**

Sound is an important feature of the environment in which we live; it provides information about our surroundings and influences our overall perception of amenity and environmental quality.

While sound is a familiar concept, its description can be complex. A glossary of terms and abbreviations is provided in Appendix A.

This appendix provides general information about the definition of sound and the ways that different sound characteristics are described.

### **B1 Definition of sound**

Sound is a term used to describe very small and rapid changes in the pressure of the atmosphere. Importantly, for pressure fluctuations to be considered sound, the rise and fall in pressure needs to be repeated at rates ranging from tens to thousands of times per second.

These small and repetitive fluctuations in pressure can be caused by many things such as a vibrating surface in contact with the air (e.g. the cone of a speaker) or turbulent air movement patterns. The common feature is a surface or region of disturbance that displaces the adjacent air, causing a very small and localised compression of the air, followed by a small expansion of the air.

These repeated compressions and expansions then spread into the surrounding air as waves of pressure changes. Upon reaching the ear of an observer, these waves of changing pressure cause structures within the ear to vibrate; these vibrations then generate signals which can be perceived as sounds.

The waves of pressure changes usually occur as complex patterns, comprising varied rates and magnitudes of pressure changes. The pattern of these changes will determine how a sound spreads through the air and how the sound is ultimately perceived when it reaches the ear of an observer.

### **B2 Physical description of sound**

There are many situations where it can be useful to objectively describe sound, such as the writing or recording of music, hearing testing, measuring the sound environment in an area or evaluating new man-made sources of sound.

Sound is usually composed of complex and varied patterns of pressure changes. As a result, several attributes are used to describe sound. Two of the most fundamental sound attributes are:

- sound pressure; and
- sound frequency.

Each of these attributes is explained in the following sections, followed by a discussion about how each of these attributes varies.

#### **B2.1 Sound pressure**

The compression and expansion of the air that is associated with the passage of a sound wave results in changes in atmospheric pressure. The pressure changes associated with sound represent very small and repetitive variations that occur amidst much greater pressures associated with the atmosphere.

The magnitude of these pressure changes influences how quiet or loud a sound will be; the smaller the pressure change, the quieter the sound, and vice versa. The perception of loudness is complex though, and different sounds can seem quieter or louder for reasons other than differences in pressure changes.

To provide some context, Table 30 lists example values of pressure associated with the atmosphere and different sounds. The key point from these example values is that even an extremely loud sound equates to a change in pressure that is thousands of times smaller than the typical pressure of the atmosphere.

**Table 30: Atmospheric pressure versus sound pressure – example values of pressure**

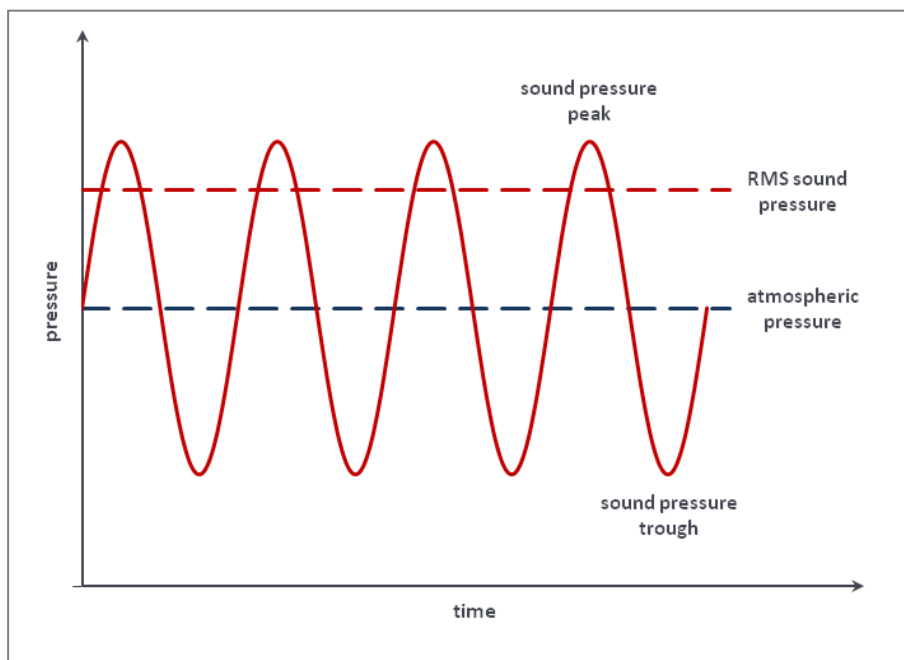
| Example                                                           | Pascals | Bars         | Pounds per square inch (PSI) |
|-------------------------------------------------------------------|---------|--------------|------------------------------|
| Atmospheric pressure                                              | 100,000 | 1            | 14.5                         |
| Pressure change due to weather front                              | 10,000  | 0.1          | 1.5                          |
| Pressure change associated with sound at the threshold of pain    | 20      | 0.0002       | 0.003                        |
| Pressure change associated with sound at the threshold of hearing | 0.00002 | 0.0000000002 | 0.000000003                  |

The pressure values in Table 30 also show that the range of pressure changes associated with quiet and loud sounds span over a very large range, albeit still very small changes compared to atmospheric pressure. To make the description of pressure changes more practical, sound pressure is expressed in dB.

To illustrate the pressure variation associated with sound, Figure 9 shows the repetitive rise and fall in pressure of a very simple and steady sound. This figure illustrates the peaks and troughs of pressure changes relative to the underlying pressure of the atmosphere in the absence of sound. The magnitude of the change in pressure caused by the sound is then described as the sound pressure level. Since the magnitude of the change is constantly varying, the sound pressure may be defined in terms of:

- Peak sound pressure levels: the maximum change in pressure relative to atmospheric pressure i.e. the amplitude as defined by the maximum depth or height of the peaks and troughs respectively; or
- Root mean square (RMS) sound pressure levels: the average of the amplitude of pressure changes, accounting for positive changes above atmospheric pressure, and negative pressure changes below atmospheric pressure.

**Figure 9: Pressure changes relative to atmospheric pressure associated with sound**



## B2.2 Frequency

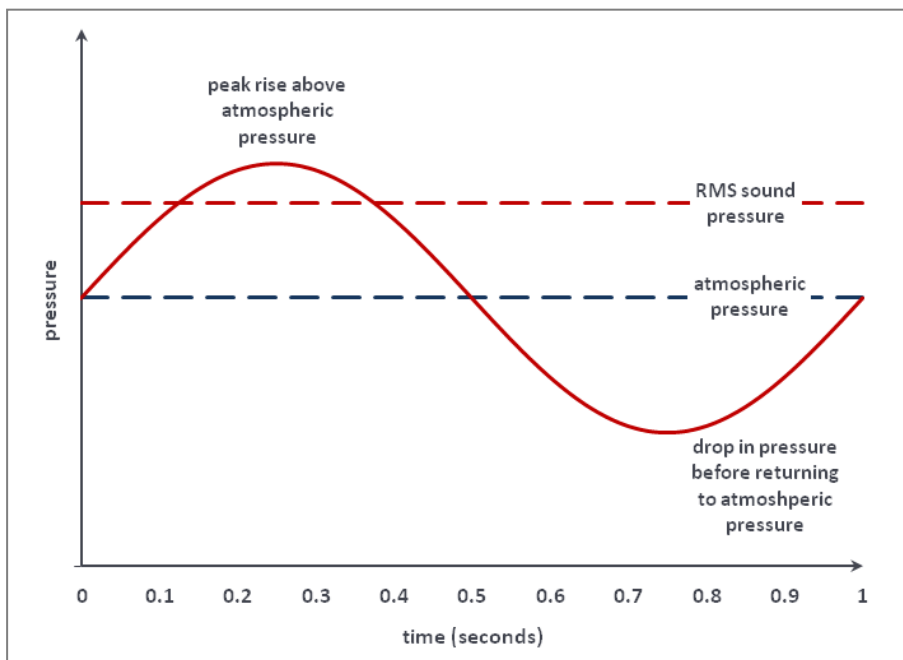
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period. The rate of change in pressure is an important feature that determines whether it can be perceived as a sound by the human ear.

Repetitive changes in pressure can occur as a result of a range of factors with widely varying rates of fluctuation. However, only a portion of these fluctuations can be perceived as sound. In many cases, the rate of fluctuation will either be too slow or too fast for the human ear to detect the pressure change as a sound. For example, local fluctuations in atmospheric pressure can be created by someone waving their hands back and forth through the air; the reason this cannot be perceived as a sound is the rate of fluctuation is too slow.

At the rates of fluctuation that can be detected as sound, the rate will influence the character of the sound that is perceived. For example, slow rates of pressure change correspond to rumbling sounds, while fast rates correspond to whistling sounds.

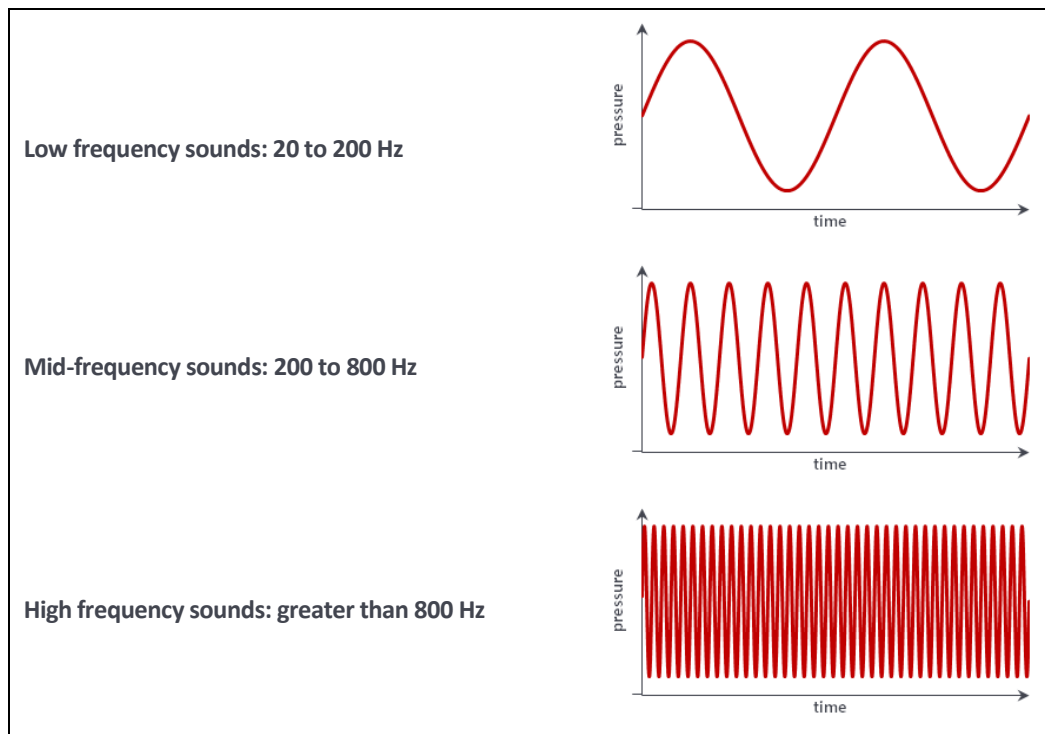
The rate of fluctuation is numerically described in terms of the number of pressure fluctuations that occur in a single second. Specifically, it is the number of cycles per second of the pressure rising above, falling below, and then returning to atmospheric pressure. The number of these cycles per second is expressed in Hz. This concept of cycles per second is illustrated in Figure 10 which illustrates a 1 Hz pressure fluctuation. The figure provides a simple illustration of a single cycle of pressure rise and fall occurring in a period of a single second.

**Figure 10: Illustration of a pressure fluctuation with a frequency of 1 Hz**



The rate that sound pressure rises and falls will vary depending on the source of the sound. For example, the surface of a tuning fork vibrates at a specific rate, in turn causing the pressure of the adjacent air to fluctuate at the same rate. Recalling the idea of pressure fluctuations from someone waving their hands, the pressure would fluctuate at the same rate as the hands move back and forth; a few times a second translating to a very low frequency below our hearing range (termed an infrasonic frequency). Examples of low and high frequency sound are easily recognisable, such as the low frequency sound of thunder, and the high frequency sound of crashing cymbals. To demonstrate the differences in the patterns of different frequencies of sound, Figure 11 illustrates the relative rates of pressure change for low, mid and high frequency sounds. Note that in each case the amplitude of the pressure changes remains the same; the only change is the number of fluctuations in pressure that occur over time.

Figure 11: Examples of the rate of change in pressure fluctuations for low, mid and high frequencies



### B2.3 Sound pressure and frequency variations

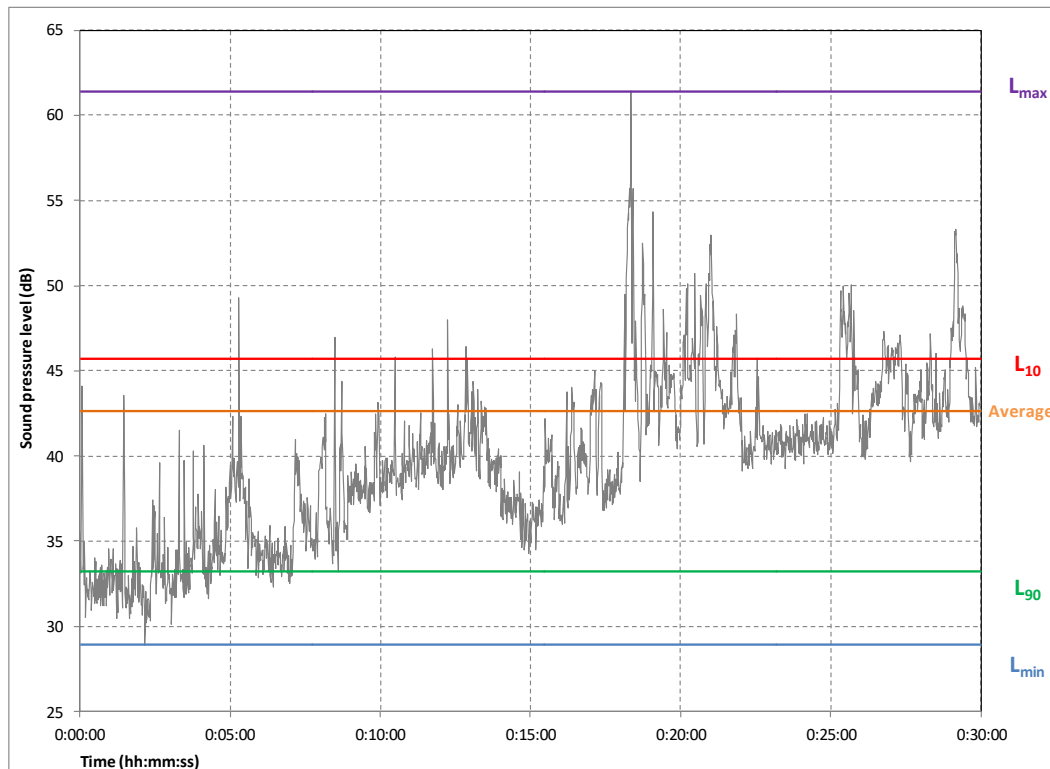
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

The simplest type of sound comprises a single constant sound pressure level and a single constant frequency. However, most sounds are made up of many frequencies, and may include low, mid and high frequencies. Sounds that are made up of a relatively even mix of frequencies across a broad range of frequencies are referred to as being '*broadband*'. Common examples of broadband sounds include flowing water, the rustling of leaves, ventilation fans and traffic noise.

Further, sound quite often changes from moment to moment, in terms of both pressure levels and frequencies. The time varying characteristics of sound are important to how we perceive sound. For example, rapid changes in sound level produced by voices provide the component of sound that we interpret as intelligible speech. Variations in sound pressure levels and frequencies are also features which can draw our attention to a new source of sound in the environment.

To demonstrate this, Figure 12 illustrates an example time-trace of total sound pressure levels which varies with time. This variation presents challenges when attempting to describe sound pressure levels. As a result, multiple metrics are generally needed to describe sound pressure, such as the average, minimum or maximum noise levels. Other ways of describing sound include statistics for describing how often a defined sound pressure level is exceeded; for example, typical upper sound levels are often described as an  $L_{10}$  which refers to the sound pressure exceeded for 10% of the time, or typical lower levels or lulls which are often described as an  $L_{90}$  which refers to the sound exceeded for 90% of the time.

Figure 12: Example of noise metrics that may be used to measure a time-varying sound level



This example illustrates variations in terms of just total sound pressure levels, but the variations can also relate to the frequency of the sound, and frequently the number of sources affecting the sound.

These types of variations are an inherent feature of most sound fields and are an important point of context in any attempt to describe sound.

### B3 Hearing and perception of sound

This section provides a discussion of:

- The use of the decibel to practically describe sound levels in a way that corresponds to the pressure levels the human ear can detect as sounds; and
- The relationship between sound frequency and human hearing.

The section concludes with a discussion of some of the complicating non-acoustic factors that influence our perception of sound.

#### B3.1 Sound pressure and the decibel

Previous sections discussed the wide range of small pressure fluctuations that the ear can detect as sound. Owing to the wide range of these fluctuations, the way we hear sound is more practically described using dB. The dB system serves two key purposes:

- Compressing the numerical range of the quietest and loudest sounds commonly experienced.  
As an indication of this benefit, the pressure of the loudest sound that might be encountered is around a million times greater than the quietest sound that can be detected. In contrast, the dB system reduces this to a range of approximately 0-120 dB.
- Consistently representing sound pressure level changes in a way that correlate more closely with how we perceive sound pressure level changes.

For example, a 10 dB change from 20-30 dB will generally be subjectively like a 10 dB change from 40-50 dB. However, expressed in units of pressure as Pascals, the 40-50 dB change is ten times greater

than the 20-30 dB change. For this reason, sound pressure changes cannot be meaningfully communicated in terms of units of pressure such as Pascals.

Sound pressure levels in most environments are highly variable, so it can be misleading to describe what different ranges of sound pressure levels correspond to. However, as a broad indication, Table 31 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

**Table 31: Example sound pressure levels that might be experienced in different environments**

| Environment                                                                  | Example sound pressure level |               |
|------------------------------------------------------------------------------|------------------------------|---------------|
|                                                                              | Decibel, dB                  | Pascal, Pa    |
| Outside in an urban area with traffic noise                                  | 50-70                        | 0.006-0.06    |
| Outside in a rural area with distant sounds or moderate wind rustling leaves | 30-50                        | 0.0006-0.006  |
| Outside in a quiet rural environment in calm conditions                      | 20-30                        | 0.0002-0.0006 |
| Inside a quiet bedroom at night                                              | <20                          | 0.0002        |

The impression of how much louder or quieter a sound is, will be influenced by the magnitude of the change in sound pressure. Other important factors will also influence this, such as the frequency of the sound which is discussed in the following section. However, to provide a broad indication, Table 32 provides some examples of how changes in sound pressure levels, for a sound with the same character, can be perceived.

**Table 32: Perceived changes in sound pressure levels**

| Sound pressure level change, dB | Indicative change in perceived sound                                               |
|---------------------------------|------------------------------------------------------------------------------------|
| 1                               | Unlikely to be noticeable                                                          |
| 2-3                             | Likely to be just noticeable                                                       |
| 4-5                             | Clearly noticeable change                                                          |
| 10                              | Distinct change - often subjectively described as halving or doubling the loudness |

The example sound pressure level changes in Table 32 are based on side by side comparison of a steady sample of sound heard at different levels. In practice, changes in sound pressure levels may be more difficult to perceive for a range of reasons, including the presence of other sources of sound, or gradual changes which occur over a longer period.

### B3.2 Sound frequency and loudness

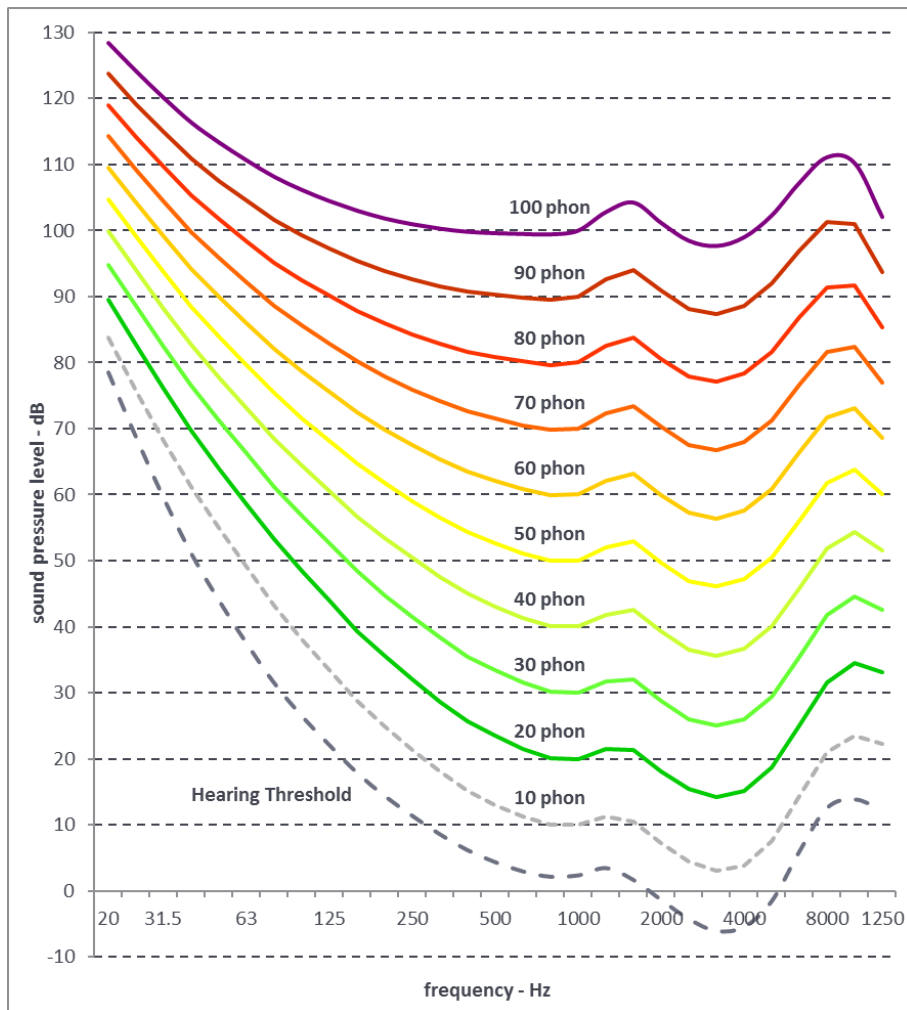
Although sound pressure level and the sensation of loudness are related, the sound pressure level is not a direct measure of how loud a sound appears to humans. Human perception of sound varies and depends on a number of physical attributes, including frequency, level and duration.

An example of the relationship between the sensation of loudness and frequency is demonstrated in Figure 13. The chart presents equal loudness curves for sounds of different frequencies expressed in 'phons'. Each point on the phon curves represents a sound of equal loudness. For example, the 40 phon curve shows that a sound level of 100 dB at 20 Hz (a very low frequency sound) would be of equal loudness to a level of 40 dB at 1,000 Hz (a whistling sound) or approximately 50 dB at just under 8,000 Hz (a very high pitch sound). The information presented is based on an international standard that defines equal loudness levels for sounds comprising individual frequencies.<sup>34</sup>

<sup>34</sup> ISO 226:2003 *Acoustics - Normal equal-loudness-level contours*, 2003

In practice, sound is usually composed of many different frequencies, so this type of data can only be used as an indication of how different frequencies of sound may be perceived. An individual's perceptions of sound can also vary significantly. For example, the lower dashed line in Figure 13 shows the threshold of hearing, which represents the sounds an average listener could correctly identify at least 50% of the time. However, these thresholds represent the average of the population. In practice, an individual's hearing threshold can vary significantly from these values, particularly at the low frequencies.

**Figure 13: Equal loudness contours for pure tone sounds**



The noise curves in Figure 13 demonstrate that human hearing is most sensitive at frequencies from 500 Hz to 4,000 Hz, which usefully corresponds to the main frequencies of human speech. The contours also demonstrate that sounds at low frequencies must be at much higher sound pressure levels to be judged equally loud as sounds at mid to high frequencies.

To account for the sensitivity of the ear to different frequencies, a set of adjustments were developed to enable sound levels to be measured in a way that more closely aligns with human hearing. Sound levels adjusted in this way are referred to as A-weighted sound levels.

### B3.3 Interpretation of sound and noise

Human interpretation of sound is influenced by many factors other than its physical characteristics, such as how often the sound occurs, the time of day it occurs and a person's attitude towards the source of the sound.

For example, the sound of music can cause very different reactions, from relaxation and pleasure through to annoyance and stress, depending on individual preferences, the type of music and the circumstances in which the music is heard. This example illustrates how sound can sometimes be considered noise; a term broadly used to describe unwanted sounds or sounds that have the potential to cause negative reactions.

The effects of excess environmental sound are varied and complicated and may be perceived in various ways including sensations of loudness, interference with speech communication, interference with working concentration or studying, disruption of resting/leisure periods, and disturbance of sleep. These effects can give rise to behavioural changes such as avoiding the use of exposed external spaces, keeping windows closed, or timing restful activities to avoid the most intense periods of disruption. Prolonged annoyance or interference with normal patterns can lead to possible effects on mental and physical health. In this respect, the World Health Organization (preamble to the *Constitution of the World Health Organization*, 1946) defines health in the following broad terms:

*A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*

The World Health Organization Guidelines for Community Noise (Berglund, Lindvall, & Schwela, 1999) documents a relationship between the definition of health and the effects of community noise exposure by noting that:

*This broad definition of health embraces the concept of well-being, and thereby, renders noise impacts such as population annoyance, interference with communication, and impaired task performance as 'health' issues.*

The reaction that a community has to sound is highly subjective and depends on a range of factors including:

- The hearing threshold of individuals across the audible frequency range. These thresholds vary widely across the population, particularly at the lower and upper ends of the audible frequency range. For example, at low frequencies the distribution of hearing thresholds varies above and below the mean threshold by more than 10 dB.
- The attitudes and sensitivities of individuals to sound, and their expectations of what is considered an acceptable level of sound or intrusion. This in turn depends on a range of factors such as general health and the perceived importance of sound amongst other factors relevant to overall amenity perception.
- The absolute sound pressure level of the sound in question. The threshold for the onset of community annoyance varies according to the type of sound; above such thresholds, the percentage of the population annoyed generally increases with increasing sound pressure level.
- The sound pressure level of the noise relative to background noise conditions in the area, and the extent to which general background noise may offer beneficial masking effects.
- The characteristics of the sound in question such as whether the sound is constant, continually varies, or contains distinctive audible features such as tones, low frequency components or impulsive sound which may draw attention to the noise.
- The site location and the compatibility of the source in question with other surrounding land uses. For example, whether the source is in an industrial or residential area.

- The attitudes of the community to the source of the sound. This may be influenced by factors such as the extent to which those responsible for the sound are perceived to be adopting reasonable and practicable measures to reduce their emissions, whether the activity is of local or national significance and whether the noise producer actively consults and/or liaises with the community.
- The times when the sound is present, the duration of exposure to increased sound levels, and the extent of respite periods when the sound is reduced or absent (for example, whether the sound ceases at weekends).

The combined influence of the above considerations means that physical sound levels are only one factor influencing community reaction to sound. Importantly, this means that individual reactions and attitudes to the same type and level of sound will vary within a community.

## APPENDIX C WIND TURBINE COORDINATES

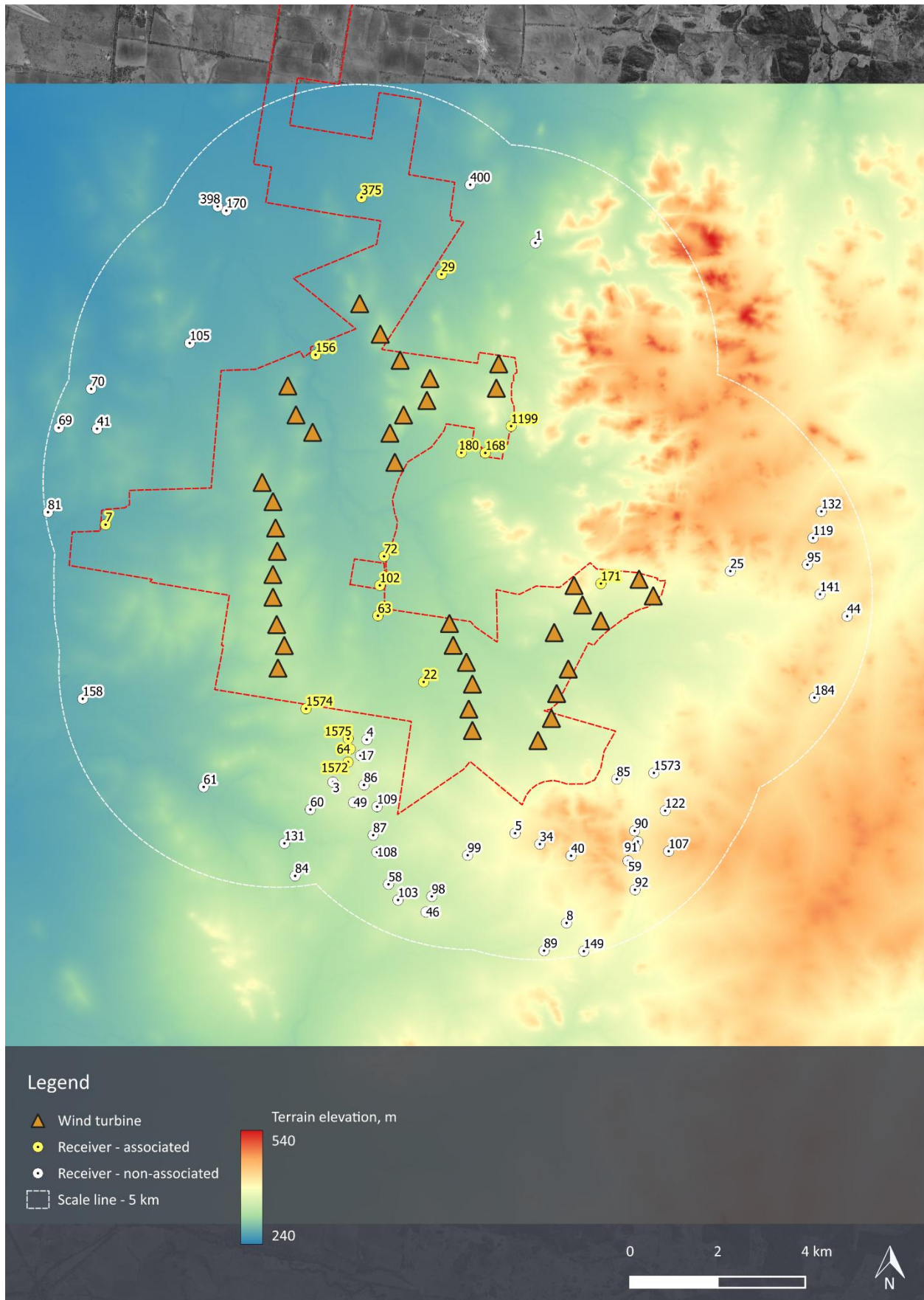
Table 33 sets out the coordinates of the proposed wind turbines based on the Project layout provided by the Applicant via email dated 12 December 2024.

**Table 33: Proposed wind turbine coordinates – GDA2020 MGA zone 55**

| Wind turbine ID | Easting, m | Northing, m | Terrain elevation, m |
|-----------------|------------|-------------|----------------------|
| 8               | 625,170    | 6,417,616   | 329                  |
| 9               | 625,117    | 6,417,059   | 355                  |
| 20              | 621,997    | 6,418,987   | 302                  |
| 21              | 622,467    | 6,418,293   | 321                  |
| 22              | 622,921    | 6,417,699   | 307                  |
| 23              | 623,603    | 6,417,279   | 346                  |
| 24              | 623,532    | 6,416,780   | 341                  |
| 25              | 622,999    | 6,416,450   | 326                  |
| 26              | 622,687    | 6,416,034   | 301                  |
| 27              | 622,800    | 6,415,368   | 299                  |
| 35              | 619,773    | 6,414,910   | 303                  |
| 36              | 620,020    | 6,414,472   | 303                  |
| 37              | 620,078    | 6,413,871   | 308                  |
| 38              | 620,118    | 6,413,340   | 309                  |
| 39              | 620,017    | 6,412,809   | 313                  |
| 40              | 620,019    | 6,412,292   | 323                  |
| 41              | 620,103    | 6,411,669   | 330                  |
| 42              | 620,277    | 6,411,190   | 334                  |
| 43              | 620,132    | 6,410,674   | 328                  |
| 66              | 628,374    | 6,412,702   | 381                  |
| 67              | 628,699    | 6,412,322   | 372                  |
| 68              | 626,889    | 6,412,559   | 419                  |
| 69              | 627,084    | 6,412,115   | 361                  |
| 70              | 627,501    | 6,411,754   | 351                  |
| 71              | 626,438    | 6,411,485   | 338                  |
| 72              | 626,758    | 6,410,654   | 343                  |
| 73              | 626,494    | 6,410,094   | 344                  |
| 74              | 626,374    | 6,409,528   | 355                  |
| 75              | 626,067    | 6,409,023   | 351                  |
| 79              | 624,046    | 6,411,692   | 316                  |

| Wind turbine ID | Easting, m | Northing, m | Terrain elevation, m |
|-----------------|------------|-------------|----------------------|
| 80              | 624,131    | 6,411,194   | 319                  |
| 81              | 624,433    | 6,410,808   | 323                  |
| 82              | 624,571    | 6,410,310   | 328                  |
| 83              | 624,488    | 6,409,740   | 329                  |
| 84              | 624,571    | 6,409,252   | 340                  |
| 92              | 620,357    | 6,417,111   | 292                  |
| 93              | 620,544    | 6,416,451   | 288                  |
| 94              | 620,924    | 6,416,055   | 292                  |

APPENDIX D SITE TOPOGRAPHY



## APPENDIX E ASSESSED RECEIVER COORDINATES

Table 34 sets out the 65 assessed receivers considered within this assessment. This includes 16 associated receivers where a host or impact agreement has been formalised between the landowners and the Applicant. Further details are provided in Section 2.2.

Data has been supplied by the Applicant on 2 June 2025.

**Table 34: Assessed receivers – GDA2020 MGA zone 55**

| Receiver ID                    | Easting, m | Northing, m | Terrain elevation, m | Nearest wind turbine | Distance to nearest wind turbine, m |
|--------------------------------|------------|-------------|----------------------|----------------------|-------------------------------------|
| <i>Non-associated receiver</i> |            |             |                      |                      |                                     |
| 1                              | 626,010    | 6,420,372   | 317                  | 8                    | 2,887                               |
| 3                              | 621,386    | 6,408,074   | 353                  | 43                   | 2,893                               |
| 4                              | 622,160    | 6,409,042   | 338                  | 84                   | 2,427                               |
| 5                              | 625,545    | 6,406,908   | 394                  | 75                   | 2,186                               |
| 8                              | 626,720    | 6,404,860   | 380                  | 75                   | 4,218                               |
| 17                             | 622,016    | 6,408,681   | 349                  | 84                   | 2,624                               |
| 25                             | 630,458    | 6,412,887   | 395                  | 67                   | 1,856                               |
| 34                             | 626,110    | 6,406,658   | 414                  | 75                   | 2,372                               |
| 40                             | 626,823    | 6,406,393   | 426                  | 75                   | 2,743                               |
| 41                             | 616,003    | 6,416,133   | 275                  | 35                   | 3,967                               |
| 44                             | 633,124    | 6,411,856   | 413                  | 67                   | 4,453                               |
| 46                             | 623,512    | 6,405,110   | 360                  | 84                   | 4,279                               |
| 49                             | 621,859    | 6,407,610   | 357                  | 84                   | 3,175                               |
| 58                             | 622,656    | 6,405,742   | 339                  | 84                   | 4,002                               |
| 59                             | 628,125    | 6,406,275   | 414                  | 75                   | 3,438                               |
| 60                             | 620,873    | 6,407,448   | 331                  | 43                   | 3,315                               |
| 61                             | 618,437    | 6,407,963   | 293                  | 43                   | 3,203                               |
| 69                             | 615,130    | 6,416,156   | 274                  | 35                   | 4,810                               |
| 70                             | 615,870    | 6,417,045   | 269                  | 35                   | 4,453                               |
| 81                             | 614,883    | 6,414,230   | 270                  | 35                   | 4,939                               |
| 84                             | 620,525    | 6,405,934   | 320                  | 43                   | 4,760                               |
| 85                             | 627,867    | 6,408,141   | 385                  | 75                   | 2,012                               |
| 86                             | 622,096    | 6,408,008   | 350                  | 84                   | 2,775                               |
| 87                             | 622,305    | 6,406,863   | 337                  | 84                   | 3,297                               |
| 89                             | 626,206    | 6,404,228   | 374                  | 75                   | 4,800                               |
| 90                             | 628,274    | 6,406,962   | 406                  | 75                   | 3,024                               |

| Receiver ID                | Easting, m | Northing, m | Terrain elevation, m | Nearest wind turbine | Distance to nearest wind turbine, m |
|----------------------------|------------|-------------|----------------------|----------------------|-------------------------------------|
| 91                         | 628,345    | 6,406,715   | 412                  | 75                   | 3,248                               |
| 92                         | 628,281    | 6,405,618   | 394                  | 75                   | 4,066                               |
| 95                         | 632,217    | 6,413,033   | 411                  | 67                   | 3,593                               |
| 98                         | 623,643    | 6,405,466   | 346                  | 84                   | 3,902                               |
| 99                         | 624,462    | 6,406,405   | 372                  | 84                   | 2,854                               |
| 103                        | 622,873    | 6,405,384   | 349                  | 84                   | 4,228                               |
| 105                        | 618,118    | 6,418,088   | 274                  | 92                   | 2,449                               |
| 107                        | 629,050    | 6,406,496   | 430                  | 75                   | 3,913                               |
| 108                        | 622,392    | 6,406,476   | 337                  | 84                   | 3,533                               |
| 109                        | 622,395    | 6,407,514   | 343                  | 84                   | 2,790                               |
| 119                        | 632,346    | 6,413,641   | 430                  | 67                   | 3,882                               |
| 122                        | 628,970    | 6,407,421   | 407                  | 75                   | 3,320                               |
| 131                        | 620,280    | 6,406,677   | 312                  | 43                   | 4,004                               |
| 132                        | 632,536    | 6,414,249   | 421                  | 67                   | 4,297                               |
| 141                        | 632,504    | 6,412,357   | 398                  | 67                   | 3,809                               |
| 149                        | 627,113    | 6,404,217   | 384                  | 75                   | 4,922                               |
| 158                        | 615,677    | 6,409,975   | 275                  | 43                   | 4,513                               |
| 170                        | 618,954    | 6,421,109   | 265                  | 20                   | 3,714                               |
| 184                        | 632,377    | 6,410,000   | 411                  | 67                   | 4,354                               |
| 398                        | 618,756    | 6,421,206   | 264                  | 20                   | 3,932                               |
| 400                        | 624,521    | 6,421,699   | 285                  | 20                   | 3,709                               |
| 1571                       | 628,281    | 6,406,584   | 416                  | 75                   | 3,299                               |
| 1573                       | 628,713    | 6,408,283   | 389                  | 74                   | 2,656                               |
| <i>Associated receiver</i> |            |             |                      |                      |                                     |
| 7                          | 616,199    | 6,413,946   | 275                  | 35                   | 3,706                               |
| 22                         | 623,458    | 6,410,359   | 318                  | 80                   | 1,088                               |
| 29                         | 623,864    | 6,419,656   | 291                  | 21                   | 1,960                               |
| 63                         | 622,414    | 6,411,867   | 305                  | 79                   | 1,651                               |
| 64                         | 621,781    | 6,408,827   | 344                  | 43                   | 2,482                               |
| 72                         | 622,555    | 6,413,224   | 302                  | 79                   | 2,145                               |
| 102                        | 622,457    | 6,412,561   | 303                  | 79                   | 1,820                               |
| 156                        | 620,991    | 6,417,821   | 278                  | 92                   | 968                                 |
| 168                        | 624,866    | 6,415,582   | 318                  | 9                    | 1,509                               |

| Receiver ID | Easting, m | Northing, m | Terrain elevation, m | Nearest wind turbine | Distance to nearest wind turbine, m |
|-------------|------------|-------------|----------------------|----------------------|-------------------------------------|
| 171         | 627,504    | 6,412,602   | 374                  | 68                   | 641                                 |
| 180         | 624,317    | 6,415,588   | 313                  | 24                   | 1,439                               |
| 375         | 622,039    | 6,421,410   | 272                  | 20                   | 2,430                               |
| 1199        | 625,454    | 6,416,193   | 336                  | 9                    | 946                                 |
| 1572        | 621,730    | 6,408,530   | 347                  | 43                   | 2,681                               |
| 1574        | 620,774    | 6,409,747   | 337                  | 43                   | 1,142                               |
| 1575        | 621,735    | 6,409,064   | 338                  | 43                   | 2,279                               |

## APPENDIX F DEVELOPMENT LOTS

Table 35 sets out the 5 development lots considered within this assessment.

Data has been supplied by the Applicant on 4 June 2025.

**Table 35: Development lots**

| ID   | Lot number     |
|------|----------------|
| DE2  | 2//DP1084141   |
| DE7  | 11//DP755125   |
| DE22 | 142//DP1083899 |
| DE25 | 38//DP42130    |
| DE27 | 8//DP772054    |

## APPENDIX G WIND TURBINE NOISE PREDICTION MODEL

In Australia, wind turbine noise predictions are typically calculated using ISO 9613-2:1996, with a set of conservative assumptions tailored to wind farm assessment, as detailed in the UK Institute of Acoustics guidance.

A revised version of the standard, ISO 9613-2:2024, was published earlier in 2024 based on broadly equivalent procedures to ISO 9613-2:1996, subject to refinements, clarifications, and supplementary advice for different types of sources.<sup>35</sup> Notably, ISO 9613-2:2024 introduces an informative annex on wind turbine noise modelling to reflect the recommendations of the UK Institute of Acoustics guidance.

At the date of preparing this report, MDA is reviewing the implementation of ISO-9613-2:2024 in SoundPLANnoise. This is a standard quality assurance process undertaken by MDA before using any revised noise modelling standard.

The core elements of the two versions (particularly with respect to wind farm noise modelling), are similar, and proprietary software options already implement the UK Institute of Acoustics guidance with respect to ISO 9613-2:1996.

On this basis ISO 9613-2:1996 continues to be used and referenced in Australia and has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by MDA and direct reference to the standard in the South Australia Guidelines, NZS 6808:2010 and AS 4959:2010.<sup>36</sup>

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  $\pm 45$  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 emissions from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from source to receiver.

To calculate far-field noise levels according to ISO 9613-2:1996, the noise emissions of each wind 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.

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<sup>35</sup> ISO 9613-2:2024 *Acoustics — Attenuation of sound during propagation outdoors Part 2: Engineering method for the prediction of sound pressure levels outdoors* (ISO 9613-2:2024)

<sup>36</sup> Standards New Zealand, *NZS 6808:2010 Acoustics – Wind farm noise*, February 2010 (NZS 6808:2010); Standards Australia, *AS 4959:2010 Acoustics – Measurement, prediction and assessment of noise from wind turbine generator*, March 2010 (AS 4959:2010)

The octave band attenuation factors are then applied to the noise emission data to determine the corresponding octave band and total calculated noise level at receivers.

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 9613-2:1996 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of  $G = 0.5$  for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all wind 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°C and relative humidity of 70% to 80%, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613-2:1996 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 9613-2:1996 as an appropriate prediction method 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 (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613-2:1996 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 9613-2:1996 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 (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2:1996 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 guidance. It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB 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 methods.

A range of measurement and prediction studies for wind farms in which MDA staff have been associated in have provided further support for the use of ISO 9613-2:1996 and  $G = 0.5$  as an appropriate representation of typical upper noise levels expected to occur in practice.<sup>37</sup>

The findings of these studies demonstrate the suitability of ISO 9613-2:1996 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 considered in the original ISO 9613;
- 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 5 m/s.

In addition to the choice of ground factor referred to above, adjustments to ISO 9613-2:1996 for screening and valleys effects are applied based on recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK Institute of Acoustics guidance. The following adjustments are applied to the calculations:

- Screening effects as a result of terrain are limited to 2 dB;
- Screening effects are assessed based on each wind turbine being represented by a single noise source located at the maximum tip height of the wind turbine rotor; and
- An adjustment of 3 dB is added to the predicted noise contribution of a wind turbine if the terrain between the wind turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50% greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLANnoise 9.1 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the Project and surrounds to evaluate the path between each wind turbine and receiver pairing, and then subsequently applies the adjustments to each wind turbine's predicted noise contribution where appropriate.

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<sup>37</sup> 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;  
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 ;  
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.

## APPENDIX H TABULATED BACKGROUND NOISE LEVELS

Table 36: Background noise bin levels, dB LA90

| Receiver          | Hub height wind speed, m/s <sup>a</sup> |      |                          |                          |                          |                          |                          |      |      |      |
|-------------------|-----------------------------------------|------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------|------|------|
|                   | 3                                       | 4    | 5                        | 6                        | 7                        | 8                        | 9                        | 10   | 11   | 12   |
| 25                | 31.3                                    | 32.1 | <b>33.2</b> <sup>a</sup> | <b>34.7</b> <sup>b</sup> | <b>34.8</b> <sup>b</sup> | <b>34.4</b> <sup>b</sup> | <b>33.5</b> <sup>b</sup> | 32.9 | 33.8 | 34.6 |
| 85                | 27.4                                    | 28.0 | 28.8                     | <b>30.2</b> <sup>b</sup> | <b>30.5</b> <sup>b</sup> | <b>30.0</b> <sup>b</sup> | 29.9                     | 30.2 | 31.0 | 31.9 |
| 102 <sup>c</sup>  | 24.1                                    | 24.8 | 25.8                     | 27.9                     | 30.3                     | 32.5                     | 34.2                     | 35.4 | 36.5 | 36.9 |
| 1572 <sup>c</sup> | 20.6                                    | 21.2 | 22.2                     | 23.5                     | 24.5                     | 25.1                     | 25.3                     | 25.7 | 26.5 | 27.4 |

a Met mast WCM2 at 623,038 / 6,416,569 - 180 m above ground level

b Anomalous background noise bin level – see Background Noise Report for discussion

c Associated receiver

## APPENDIX I C-WEIGHTING ASSESSMENT RESULTS

### I1 Introduction

Presented below are details of the risk assessment carried out for the purpose of gauging whether penalties for low frequency, as detailed in the Technical Supplement for Noise, are applicable.

### I2 Assessment requirement

The following excerpt concerning C-weighted wind turbine noise have been reproduced from the Technical Supplement for Noise:

#### ***Low-frequency noise***

*Analysis of wind turbine spectra shows that low-frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted criteria in section 3.1.*

*In the unlikely event that excessive low-frequency noise is a repeated characteristic – that is, noise from the wind project would repeatedly be greater than 60 dB(C) – of the wind turbine noise, dB(A) must be added to the predicted or measured noise level from the wind energy project.*

#### ***Penalties for special noise characteristics***

*In NSW, assessments must adjust the wind energy project noise level where they identify excessive levels of tonality, low-frequency noise, or a combination of both, in accordance with this technical supplement to a maximum adjustment of 5 dB(A). The noise monitoring report should report the results of these calculations.*

### I3 Prediction method

As stated in Section 6.1.3, there is not a commonly used, practical method to accurately predict wind turbine low frequency noise levels at receiver locations.

In this case, the C-weighted noise levels at receiver locations have been estimated using a simplified approach based on the same noise modelling methods as described above for A-weighted levels, but with the ground absorption parameter set to  $G = 0$  (hard ground) to account for the increased influence of ground reflections at low frequencies, and the low frequency octave band extended to 16 Hz.

C-weighted noise levels have been predicted for the wind speed at which the worst-case sound power levels occur, as specified in Section 6.1.1.

### I4 Results

Table 37 presents the results of the preliminary C-weighted noise predictions for all assessed non-associated receivers.

The results show that the predicted low frequency noise levels are below the applicable threshold of 60 dB  $L_{Ceq, 10 \text{ min}}$  for the application of penalties at all non-associated receivers.

Table 37: Predicted C-weighted noise levels

| Receiver | Predicted noise level, dB $L_{Ceq, 10 \text{ min}}$ |
|----------|-----------------------------------------------------|
| 1        | 56.5                                                |
| 3        | 57.8                                                |
| 4        | 59.6                                                |
| 5        | 58.3                                                |
| 8        | 54.2                                                |
| 17       | 59.0                                                |
| 25       | 57.7                                                |
| 34       | 57.6                                                |
| 40       | 56.5                                                |
| 41       | 55.8                                                |
| 44       | 54.1                                                |
| 46       | 55.2                                                |
| 49       | 57.4                                                |
| 58       | 55.6                                                |
| 59       | 54.2                                                |
| 60       | 56.7                                                |
| 61       | 55.7                                                |
| 69       | 54.8                                                |
| 70       | 55.3                                                |
| 81       | 54.9                                                |
| 84       | 55.0                                                |
| 85       | 58.6                                                |
| 86       | 58.1                                                |
| 87       | 56.7                                                |
| 89       | 54.3                                                |
| 90       | 56.3                                                |
| 91       | 55.6                                                |
| 92       | 53.5                                                |
| 95       | 54.6                                                |
| 98       | 55.6                                                |
| 99       | 57.1                                                |
| 103      | 55.3                                                |

| Receiver | Predicted noise level, dB $L_{\text{Ceq}}$ , 10 min |
|----------|-----------------------------------------------------|
| 105      | 57.5                                                |
| 107      | 55.4                                                |
| 108      | 56.3                                                |
| 109      | 57.7                                                |
| 119      | 54.6                                                |
| 122      | 56.4                                                |
| 131      | 55.6                                                |
| 132      | 53.8                                                |
| 141      | 54.3                                                |
| 149      | 53.9                                                |
| 158      | 54.9                                                |
| 170      | 55.3                                                |
| 184      | 53.6                                                |
| 398      | 55.0                                                |
| 400      | 55.7                                                |
| 1571     | 54.4                                                |
| 1573     | 57.8                                                |

The risk assessment indicates that the calculated low frequency noise levels are below the applicable thresholds for the application of penalties at all non-associated receivers. On the above basis, adjustments for low frequency noise have not been applied to the predicted noise levels presented in this assessment.

## APPENDIX J EFFECTS OF WIND TURBINE NOISE

In terms of the effect of wind turbine noise, one of the most important consideration is how the sound is perceived. However, judging whether or not a sound is noisy is highly subjective, and depends on many factors including the setting where the sound is heard, the character of the sound, and factors that influence how an individual perceives the sound.

In recognition of the rural settings where wind farms are usually built, wind farms are required to adhere to strict noise controls. Wind farm policies in Australia are among the most stringent international standards and set limits using a combination of a base (or fixed value) limit and an allowable margin above the background.

### J1 Health and amenity

Sound is an important feature of the environment in which we live; it provides information about our surroundings and is a key influence on our overall perception of amenity and environmental quality. Sound is therefore an environmental quality that must be considered as part of any proposal to develop new infrastructure that could influence the sound environment of neighbouring communities.

Excessive or unwanted sound is commonly referred to as noise and can have a range of effects on people, depending on a range of physical and contextual factors. The *Guidelines for Community Noise* 1999 prepared by the World Health Organisation (WHO) provides a health-based framework of guideline limits and values to address the broad definition of health given as:

*A state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity*

This broad definition means that effects ranging from community annoyance, sleep disturbance and speech interference, through to direct physiological impacts such as hearing damage, are all identified as potential health considerations. An important aspect of this range of considerations is that some effects will be highly dependent on the listener's perception and attitude to the noise in question, such as annoyance, while other effects are primarily related to the level of sound and the direct physiological risks these may represent, such as hearing damage.

Environmental noise policies, including those applied to wind farms, establish objective noise criteria to address these health considerations. In particular, environmental noise policies define criteria which are chosen to prevent direct physiological risks of sound and minimise as far as practically possible adverse health considerations such as annoyance and sleep disturbance.

Practically minimising the risks of noise effects related to annoyance and sleep disturbance requires the potential range of responses to sound to be considered. In this respect, it is important to note that individual attitudes and reactions to sound are highly variable and will depend on a complex set of acoustic and non-acoustic factors. These include the level and character of the sound in question, the time of day the sound occurs, the regularity of the sound, the environment in which the sound is heard, the individuals hearing acuity, and an individual's personal opinion and perception of the sound source or development in question. The latter will in turn depend on other complicating factors such as visual impressions of the source in question and the perceived community benefit, or otherwise, of the source in question.

Due to the complexity and range of potential responses to sound, it is not possible to define limits that will guarantee an audible sound will be acceptable to all individuals; this will always be a matter of personal judgement for each individual. Further, it is usually not feasible or practical to design new development or infrastructure to inaudible noise levels. As a result, minimising the risks of noise effects involves setting criteria which prevents the majority of people from being disturbed. This requires regulatory authorities to strike a balance between amenity and development, setting noise limits which are as stringent as can be practically achieved without preventing new development.

This type of approach to noise policy was outlined by the Victorian Department of Health in their 2013 publication on wind farm sound and health which states:

*Noise standards are used not only for environmental noise (such as wind farms and traffic noise) but also for industry and even household appliances.*

*Noise standards are set to protect the majority of people from annoyance. The wide individual variation in response to noise makes it unrealistic to set standards that will protect everyone from annoyance. A minority of people may still experience annoyance even at sound levels that meet the standard. This is the case not only for wind farms, but for all sources of noise.*

The subject of health effects related to operational wind farms in Australia has been extensively considered by the Commonwealth Government's National Health and Medical Research Council (NHMRC) and the Australian Medical Association; in particular, the NHMRC has undertaken and coordinated a systematic review of evidence related to wind farms and health. The research reviews and public statements produced by these peak health bodies support that, as with any audible sound, wind farm noise can represent a potential source of annoyance or sleep disturbance for some individuals.<sup>38</sup> Their findings did however indicate that there was no reliable evidence to support a relationship between wind farm noise and direct adverse effects on human health.

In July 2012, Health Canada undertook a large-scale epidemiology study in response to community health concerns expressed in relation to wind turbines. The following conclusions were made from this research.<sup>39</sup>

*The following were not found to be associated with [Wind Turbine Noise] exposure:*

- *self-reported sleep (e.g., general disturbance, use of sleep medication, diagnosed sleep disorders);*
- *self-reported illnesses (e.g., dizziness, tinnitus, prevalence of frequent migraines and headaches) and chronic health conditions (e.g., heart disease, high blood pressure and diabetes); and*
- *self-reported perceived stress and quality of life.*

*While some individuals reported some of the health conditions above, the prevalence was not found to change in relation to [Wind Turbine Noise] levels.*

[...]

*The following was found to be statistically associated with increasing levels of [Wind Turbine Noise]:*

- *annoyance towards several wind turbine features (i.e. noise, shadow flicker, blinking lights, vibrations, and visual impacts).*

<sup>38</sup> *Systematic review of the human health effects of wind farms*, 2013, Adelaide University, commissioned by the NMRC; NHMRC Information Paper: *Evidence on Wind Farms and Human Health*, February 2015, National Health and Medical Research Council;

AMA Position Statement: *Wind Farms and Health*, 2014, Australian Medical Association

<sup>39</sup> <https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/everyday-things-emit-radiation/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html>

In 2018, the World Health Organization released the *Environmental Noise Guidelines for the European Region* which concluded: <sup>40</sup>

*In accordance with the prioritization process, the GDG set a guideline exposure level of 45.0 dB L<sub>den</sub> for average exposure, based on the relevant increase of the absolute %HA. The GDG stressed that there might be an increased risk for annoyance below this noise exposure level, but it could not state whether there was an increased risk for the other health outcomes below this level owing to a lack of evidence. As the evidence on the adverse effects of wind turbine noise was rated low quality, the GDG made the recommendation conditional.*

[...]

*Based on the low quantity and heterogeneous nature of the evidence, the GDG was not able to formulate a recommendation addressing sleep disturbance due to wind turbine noise at night time.*

As detailed in the MDA paper *WHO Environmental Noise Guidelines for the European Region: conditional recommendation for wind turbine noise in the context of Australian regulations*, achieving compliance with NZS 6808 corresponds to noise levels that are consistent with the recommendations of the 2018 WHO European Noise Guidelines. <sup>41</sup>

These findings lend support to the suitability of the wind farm noise controls applied in New South Wales, which are intended to provide reasonable protection of health and amenity at noise sensitive locations.

Further discussions of specific noise considerations related low-frequency sound and infrasound are provided in the following section.

## **J2 Low frequency noise, infrasound, and ground vibration**

The limits adopted for the assessment of operational noise from wind farms represent relatively low levels which have been specified in recognition of the quieter rural environments in which wind farms are normally located.

However, consistent with noise policies applied to other forms of development, the criteria are not intended to restrict wind farm noise to inaudible levels. Accordingly, a wind farm which achieves compliance with the criteria may still be audible at surrounding receivers on some occasions; this will depend on a range of factors such as the time of day, the speed and direction of the wind, the proximity to wind turbines, the extent of vegetation around the dwelling, and the degree to which the dwelling is sheltered from prevailing wind conditions. Irrespective of the relatively low levels which operational wind farm noise is restricted to, an individual's judgement of the audible noise from a wind farm is highly subjective and will be influenced by a range of contextual factors.

The subject of wind farm noise and its characteristics has attracted considerable attention. Specific attention has been directed to alleged matters relating to low frequency sound as well as infrasound and vibration. Low frequency sounds are generally regarded as sounds above 20 Hz and extending upwards into the range of 100-200 Hz. The definition of infrasound often varies in different jurisdictions but is generally accepted to refer to frequencies of sound which lie below 20 Hz. While 20 Hz is commonly cited as the lower bound of audibility, frequencies below 20 Hz can still be audible, provided that the level of the sound is sufficiently high to exceed the threshold of audibility at those frequencies.

<sup>40</sup> <https://www.euro.who.int/en/health-topics/environment-and-health/noise/environmental-noise-guidelines-for-the-european-region>

<sup>41</sup> <http://tinyurl.com/WTN2019-Delaire>

In common with many other sources of noise, wind turbines emit infrasound, low frequency sound and ground vibrations. However, what is often overlooked is that these types of sound and vibration are a feature of the everyday environment in which we live and arise from a wide range of natural sources such as the wind and the ocean to man-made sources such as domestic appliances, transportation and agricultural equipment. The important point in relation to wind turbines is that the levels of these types of emissions are low and therefore, in many cases, cannot generally be reliably measured amidst normal background levels.

The Technical Supplement for Noise states the following concerning infrasound:

*The government does not require applicants to conduct a health impact assessment in relation to wind energy development and very low frequency sound known as infrasound. This is based on the findings of the National Health and Medical Research Council in 2015 that concluded that there is no direct evidence that exposure to wind farm noise affects physical or mental health, and there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans.*

These types of emissions have been the subject of considerable misrepresentation in media commentary. Notably, the work of Dr Geoff Leventhall, a prominent UK consultant in the field of acoustics and vibration, and researcher in the field of low frequency noise is often cited in some documents which continue to claim concerns about infrasound and low frequency noise from wind turbines. However, Dr Leventhall has regularly made clear statements to assert that there is no significant infrasound from current designs of wind turbines and very little low frequency sound, neither of which are anywhere near the sorts of levels which would represent a direct health risk for neighbouring residents of modern wind farms. An example of such publication, co-authored by Dr Leventhall, was published in the UK Institute of Acoustics Bulletin in March 2009.<sup>42</sup> This publication was prepared as an agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed by local councils and community groups campaigning against wind farm developments. The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern.

On the subject of infrasound and low frequency noise, the article notes:

*Infrasound is the term generally used to describe sound at frequencies below 20 Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles. Sounds at frequencies from about 20 Hz to 200 Hz are conventionally referred to as low frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view.*

*A Portuguese group has been researching 'Vibro-acoustic Disease' (VAD) for about 25 years. Their research initially focussed on aircraft technicians who were exposed to very high overall noise levels, typically over 120 dB. A range of health problems has been described for the technicians, which the researchers linked to high levels of low frequency noise exposure. However other research has not confirmed this. Wind farms expose people to sound pressure levels orders of magnitude less than the noise levels to which the aircraft technicians were exposed. The Portuguese VAD group has not produced evidence to support their new hypothesis that infrasound and low frequency noise from wind turbines causes similar health effects to those experienced by the aircraft technicians.*

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<sup>42</sup> Institute of Acoustics Bulletin – Bowdler, Bullmore, Davis, Hayes, Jiggins, Leventhall, McKenzie - *Prediction and Assessment of Wind Turbine Noise* – March 2009

Another example of the misrepresentations made in relation to the environmental effects of wind turbines centred around work carried out by Keele University in the UK on ground vibration. Professor Peter Styles and his team at Keele University undertook a study of the effects of wind turbines on the seismic detection array at Eskdalemuir, Scotland. The results of this work were widely misinterpreted and resulted in a statement from Professor Styles:<sup>43</sup>

*We are writing to clarify some misconceptions [...] about wind farm noise. Whilst it is technically correct that ‘vibrations can be picked up as far away as 10km’, to give the impression that they can be felt at this distance is highly misleading. The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect. The Dunlaw study was designed to measure effects of extremely low level vibration on one of the quietest sites (Eskdalemuir) in the world, and one which houses one of the most sensitive seismic installations in the world. Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health. It is, however, an issue for the Eskdalemuir seismic array, as it can detect this level of vibration. It is designed to detect explosions and earthquakes of a low magnitude from all over the world. The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect the low frequency sound. There is no scientific evidence to suggest that infrasound has an impact on human health.*

More recent measurements have demonstrated that infrasound and low frequency sound produced by regularly encountered natural and man-made sources, such as the infrasound produced by the wind or distant traffic, is comparable to that of modern wind turbines, noting that:<sup>44</sup>

*Infrasound levels in the rural environment appear to be controlled by localised wind conditions. During low wind periods, levels as low as 40dB(G) were measured at locations both near to and away from wind turbines. At higher wind speeds, infrasound levels of 50 to 70dB(G) were common at both wind farm and non-wind farm sites.*

*Organised shutdowns of the wind farms adjacent to [sic: measurement locations] indicate that there did not appear to be any noticeable contribution from the wind farm to the G-weighted infrasound level measured at either house. This suggests that wind turbines are not a significant source of infrasound at houses located approximately 1.5 kilometres away from wind farm sites*

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<sup>43</sup> Keele University Rejects Renewable Energy Foundation’s Low Frequency Noise Research Claims

<sup>44</sup> Sonus report for Pacific Hydro - Infrasound measurements from wind farms and other sources – November 2010  
See [http://www.pacifichydro.com.au/media/192017/infrasound\\_report.pdf](http://www.pacifichydro.com.au/media/192017/infrasound_report.pdf);

Evans, T., Cooper, J. & Lenchine, V., *Infrasound levels near wind farms and in other environments*, South Australian Environment Protection Authority, Adelaide, 2013 - See [https://www.epa.sa.gov.au/files/477912\\_infrasound.pdf](https://www.epa.sa.gov.au/files/477912_infrasound.pdf)

In 2010, the UK Health Protection Agency published a report on the health effects of exposure to ultrasound and infrasound. The exposures considered in the report related to medical applications and general environmental exposure. The report notes: <sup>45</sup>

*Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*

[...]

*For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects.*

Also, a State Government of Victorian Department of Health document concludes the following in relation to infrasound from wind farms: <sup>46</sup>

*Infrasound is audible when the sound levels are high enough. The hearing threshold for infrasound is much higher than other frequencies. Infrasound from wind farms is at levels well below the hearing threshold and is therefore inaudible to neighbouring residents.*

These studies all indicate that infrasound levels from the proposed Project are anticipated to be comparable with existing ambient levels.

In February 2015, the National Health and Medical Research Council (NHMRC) released an information paper addressing human health effects of wind farms which includes consideration of noise. <sup>47</sup>

From well over 4,000 articles which were identified during the NHMRC review, only thirteen (13) studies across Europe, North America and Australia satisfied a set of pre-specified eligibility criteria for detailed review and therefore form the basis of the report, which concludes:

*Examining whether wind farm emissions may affect human health is complex, as both the character of the emissions and individual perceptions of them are highly variable. After careful consideration and deliberation of the body of evidence, NHMRC concludes that there is currently no consistent evidence that wind farms cause adverse health effects in humans. Given the poor quality of current direct evidence and the concern expressed by some members of the community, high quality research into possible health effects of wind farms, particularly within 1,500 metres (m), is warranted.*

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<sup>45</sup> Health Protection Agency UK – *Health Effects of Exposure to Ultrasound and Infrasound – Report of the independent Advisory Group on Non-ionising Radiation* - 2010

<sup>46</sup> [Public Statement: Wind Turbines and Health - July 2010](#)

<sup>47</sup> *Information Paper - Evidence on Wind Farms and Human Health*, February 2015

The NSW *Noise Assessment Bulletin* issued in December 2016 (being the assessment guideline for wind turbine noise assessment in NSW, prior to the publication of the Wind energy guideline and Technical Supplement for Noise) refers to this advice and states the following in its section on Noise and Health:

*High levels of noise are associated with adverse health outcomes. To examine this potential relationship the National Health and Medical Research Council (NHMRC) undertook a comprehensive assessment of the scientific evidence on wind farms and human health. In 2015, the NHMRC concluded that “there is no direct evidence that exposure to wind turbine noise affects physical or mental health”, and there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans relating to infrasound. More specifically, they stated that, “while exposure to environmental noise is associated with health effects, these effects occur at much higher levels of noise than are likely to be perceived by people living in close proximity to wind farms in Australia”.*

These studies all indicate that infrasound levels are anticipated to be comparable with existing ambient levels and, as such, are not expected to represent an impact from the proposed wind farm. Similarly, vibration levels from wind turbines are well below perception thresholds, and low frequency levels are typically low.

## APPENDIX K TABULATED PREDICTED NOISE LEVELS

Table 38: Predicted noise levels for all assessed receivers, dB  $L_{Aeq, 10 \text{ min}}$

| Receiver                       | Hub-height wind speed, m/s |      |      |      |      |      |      |      |      |
|--------------------------------|----------------------------|------|------|------|------|------|------|------|------|
|                                | 4                          | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
| <i>Non-associated receiver</i> |                            |      |      |      |      |      |      |      |      |
| 1                              | 17.9                       | 19.1 | 21.6 | 25.0 | 27.4 | 27.8 | 27.8 | 27.8 | 27.8 |
| 3                              | 19.5                       | 20.7 | 23.2 | 26.6 | 29.0 | 29.4 | 29.4 | 29.4 | 29.4 |
| 4                              | 22.3                       | 23.5 | 26.0 | 29.4 | 31.8 | 32.2 | 32.2 | 32.2 | 32.2 |
| 5                              | 20.8                       | 22.0 | 24.5 | 27.9 | 30.3 | 30.7 | 30.7 | 30.7 | 30.7 |
| 8                              | 14.5                       | 15.7 | 18.2 | 21.6 | 24.0 | 24.4 | 24.4 | 24.4 | 24.4 |
| 17                             | 21.4                       | 22.6 | 25.1 | 28.5 | 30.9 | 31.3 | 31.3 | 31.3 | 31.3 |
| 25                             | 20.8                       | 22.0 | 24.5 | 27.9 | 30.3 | 30.7 | 30.7 | 30.7 | 30.7 |
| 34                             | 19.8                       | 21.0 | 23.5 | 26.9 | 29.3 | 29.7 | 29.7 | 29.7 | 29.7 |
| 40                             | 18.4                       | 19.6 | 22.1 | 25.5 | 27.9 | 28.3 | 28.3 | 28.3 | 28.3 |
| 41                             | 16.5                       | 17.7 | 20.2 | 23.6 | 26.0 | 26.4 | 26.4 | 26.4 | 26.4 |
| 44                             | 13.9                       | 15.1 | 17.6 | 21.0 | 23.4 | 23.8 | 23.8 | 23.8 | 23.8 |
| 46                             | 15.4                       | 16.6 | 19.1 | 22.5 | 24.9 | 25.3 | 25.3 | 25.3 | 25.3 |
| 49                             | 19.0                       | 20.2 | 22.7 | 26.1 | 28.5 | 28.9 | 28.9 | 28.9 | 28.9 |
| 58                             | 16.1                       | 17.3 | 19.8 | 23.2 | 25.6 | 26.0 | 26.0 | 26.0 | 26.0 |
| 59                             | 15.4                       | 16.6 | 19.1 | 22.5 | 24.9 | 25.3 | 25.3 | 25.3 | 25.3 |
| 60                             | 17.8                       | 19.0 | 21.5 | 24.9 | 27.3 | 27.7 | 27.7 | 27.7 | 27.7 |
| 61                             | 16.7                       | 17.9 | 20.4 | 23.8 | 26.2 | 26.6 | 26.6 | 26.6 | 26.6 |
| 69                             | 14.9                       | 16.1 | 18.6 | 22.0 | 24.4 | 24.8 | 24.8 | 24.8 | 24.8 |
| 70                             | 15.7                       | 16.9 | 19.4 | 22.8 | 25.2 | 25.6 | 25.6 | 25.6 | 25.6 |
| 81                             | 15.0                       | 16.2 | 18.7 | 22.1 | 24.5 | 24.9 | 24.9 | 24.9 | 24.9 |
| 84                             | 15.0                       | 16.2 | 18.7 | 22.1 | 24.5 | 24.9 | 24.9 | 24.9 | 24.9 |
| 85                             | 21.7                       | 22.9 | 25.4 | 28.8 | 31.2 | 31.6 | 31.6 | 31.6 | 31.6 |
| 86                             | 20.1                       | 21.3 | 23.8 | 27.2 | 29.6 | 30.0 | 30.0 | 30.0 | 30.0 |
| 87                             | 17.9                       | 19.1 | 21.6 | 25.0 | 27.4 | 27.8 | 27.8 | 27.8 | 27.8 |
| 89                             | 14.1                       | 15.3 | 17.8 | 21.2 | 23.6 | 24.0 | 24.0 | 24.0 | 24.0 |
| 90                             | 17.9                       | 19.1 | 21.6 | 25.0 | 27.4 | 27.8 | 27.8 | 27.8 | 27.8 |
| 91                             | 17.0                       | 18.2 | 20.7 | 24.1 | 26.5 | 26.9 | 26.9 | 26.9 | 26.9 |
| 92                             | 14.0                       | 15.2 | 17.7 | 21.1 | 23.5 | 23.9 | 23.9 | 23.9 | 23.9 |

| Receiver                   | Hub-height wind speed, m/s |      |      |      |      |      |      |      |      |
|----------------------------|----------------------------|------|------|------|------|------|------|------|------|
|                            | 4                          | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
| 95                         | 15.3                       | 16.5 | 19.0 | 22.4 | 24.8 | 25.2 | 25.2 | 25.2 | 25.2 |
| 98                         | 16.1                       | 17.3 | 19.8 | 23.2 | 25.6 | 26.0 | 26.0 | 26.0 | 26.0 |
| 99                         | 18.8                       | 20.0 | 22.5 | 25.9 | 28.3 | 28.7 | 28.7 | 28.7 | 28.7 |
| 103                        | 15.6                       | 16.8 | 19.3 | 22.7 | 25.1 | 25.5 | 25.5 | 25.5 | 25.5 |
| 105                        | 19.4                       | 20.6 | 23.1 | 26.5 | 28.9 | 29.3 | 29.3 | 29.3 | 29.3 |
| 107                        | 16.1                       | 17.3 | 19.8 | 23.2 | 25.6 | 26.0 | 26.0 | 26.0 | 26.0 |
| 108                        | 17.3                       | 18.5 | 21.0 | 24.4 | 26.8 | 27.2 | 27.2 | 27.2 | 27.2 |
| 109                        | 19.4                       | 20.6 | 23.1 | 26.5 | 28.9 | 29.3 | 29.3 | 29.3 | 29.3 |
| 119                        | 14.9                       | 16.1 | 18.6 | 22.0 | 24.4 | 24.8 | 24.8 | 24.8 | 24.8 |
| 122                        | 17.8                       | 19.0 | 21.5 | 24.9 | 27.3 | 27.7 | 27.7 | 27.7 | 27.7 |
| 131                        | 16.0                       | 17.2 | 19.7 | 23.1 | 25.5 | 25.9 | 25.9 | 25.9 | 25.9 |
| 132                        | 13.9                       | 15.1 | 17.6 | 21.0 | 23.4 | 23.8 | 23.8 | 23.8 | 23.8 |
| 141                        | 14.8                       | 16.0 | 18.5 | 21.9 | 24.3 | 24.7 | 24.7 | 24.7 | 24.7 |
| 149                        | 13.7                       | 14.9 | 17.4 | 20.8 | 23.2 | 23.6 | 23.6 | 23.6 | 23.6 |
| 158                        | 15.0                       | 16.2 | 18.7 | 22.1 | 24.5 | 24.9 | 24.9 | 24.9 | 24.9 |
| 170                        | 15.8                       | 17.0 | 19.5 | 22.9 | 25.3 | 25.7 | 25.7 | 25.7 | 25.7 |
| 184                        | 13.8                       | 15.0 | 17.5 | 20.9 | 23.3 | 23.7 | 23.7 | 23.7 | 23.7 |
| 398                        | 15.4                       | 16.6 | 19.1 | 22.5 | 24.9 | 25.3 | 25.3 | 25.3 | 25.3 |
| 400                        | 16.5                       | 17.7 | 20.2 | 23.6 | 26.0 | 26.4 | 26.4 | 26.4 | 26.4 |
| 1571                       | 15.6                       | 16.8 | 19.3 | 22.7 | 25.1 | 25.5 | 25.5 | 25.5 | 25.5 |
| 1573                       | 20.1                       | 21.3 | 23.8 | 27.2 | 29.6 | 30.0 | 30.0 | 30.0 | 30.0 |
| <i>Associated receiver</i> |                            |      |      |      |      |      |      |      |      |
| 7                          | 17.7                       | 18.9 | 21.4 | 24.8 | 27.2 | 27.6 | 27.6 | 27.6 | 27.6 |
| 22                         | 29.4                       | 30.6 | 33.1 | 36.5 | 38.9 | 39.3 | 39.3 | 39.3 | 39.3 |
| 29                         | 23.0                       | 24.2 | 26.7 | 30.1 | 32.5 | 32.9 | 32.9 | 32.9 | 32.9 |
| 63                         | 25.4                       | 26.6 | 29.1 | 32.5 | 34.9 | 35.3 | 35.3 | 35.3 | 35.3 |
| 64                         | 21.5                       | 22.7 | 25.2 | 28.6 | 31.0 | 31.4 | 31.4 | 31.4 | 31.4 |
| 72                         | 24.7                       | 25.9 | 28.4 | 31.8 | 34.2 | 34.6 | 34.6 | 34.6 | 34.6 |
| 102                        | 25.0                       | 26.2 | 28.7 | 32.1 | 34.5 | 34.9 | 34.9 | 34.9 | 34.9 |
| 156                        | 28.1                       | 29.3 | 31.8 | 35.2 | 37.6 | 38.0 | 38.0 | 38.0 | 38.0 |
| 168                        | 25.4                       | 26.6 | 29.1 | 32.5 | 34.9 | 35.3 | 35.3 | 35.3 | 35.3 |

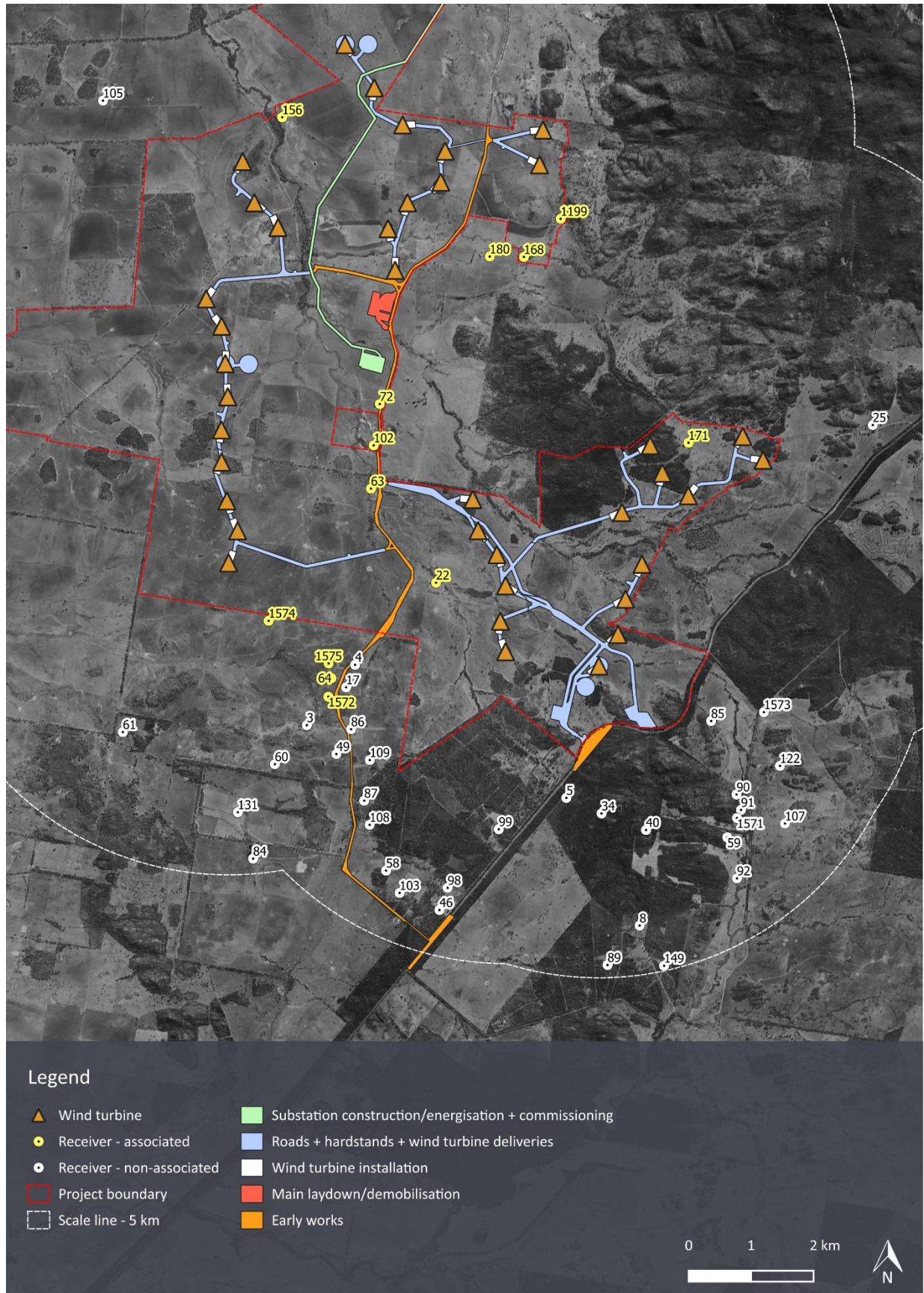
| Receiver | Hub-height wind speed, m/s |      |      |      |      |      |      |      |      |
|----------|----------------------------|------|------|------|------|------|------|------|------|
|          | 4                          | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
| 171      | 33.2                       | 34.4 | 36.9 | 40.3 | 42.7 | 43.1 | 43.1 | 43.1 | 43.1 |
| 180      | 26.9                       | 28.1 | 30.6 | 34.0 | 36.4 | 36.8 | 36.8 | 36.8 | 36.8 |
| 375      | 18.3                       | 19.5 | 22.0 | 25.4 | 27.8 | 28.2 | 28.2 | 28.2 | 28.2 |
| 1199     | 26.9                       | 28.1 | 30.6 | 34.0 | 36.4 | 36.8 | 36.8 | 36.8 | 36.8 |
| 1572     | 20.8                       | 22.0 | 24.5 | 27.9 | 30.3 | 30.7 | 30.7 | 30.7 | 30.7 |
| 1574     | 25.4                       | 26.6 | 29.1 | 32.5 | 34.9 | 35.3 | 35.3 | 35.3 | 35.3 |
| 1575     | 21.9                       | 23.1 | 25.6 | 29.0 | 31.4 | 31.8 | 31.8 | 31.8 | 31.8 |

## APPENDIX L CONSTRUCTION LAYOUT

Figure 14: Construction layout plan - North



Figure 15: Construction layout plan - South



## APPENDIX M CONSTRUCTION EQUIPMENT, WORK STAGES AND ACOUSTIC DATA

Sound power levels for the types of equipment used to construct a wind farm have been determined from guidance and data sources including AS 2436, and noise level data from previous projects of a similar nature.

Table 39 summarises the noise emissions used to represent key items of plant associated with construction.

**Table 39: Construction noise sources sound power level data, dB L<sub>WA</sub>**

| Noise source                        | Sound power level |
|-------------------------------------|-------------------|
| Bulldozer                           | 108               |
| Concrete agitator truck             | 109               |
| Concrete pump truck                 | 108               |
| Crane (200 t)                       | 105               |
| Crane (mobile)                      | 104               |
| Excavator                           | 107               |
| Forklift                            | 106               |
| Generator                           | 99                |
| Grader                              | 110               |
| Jack hammers                        | 121               |
| Piling (bored)                      | 111               |
| Roller (vibratory)                  | 108               |
| Scraper                             | 116               |
| Telehandler                         | 99                |
| Truck (> 20 t)                      | 107               |
| Truck (water cart)                  | 107               |
| Vehicle (light commercial e.g. 4WD) | 106               |

Overall aggregated total sound power levels for key construction tasks have been determined on the basis of a typical schedule of equipment associated with each task. The actual equipment choices and equipment numbers for each task are not presently defined in detail, and therefore the schedule of equipment listed here does not represent a final or definitive list of plant. The equipment schedule is therefore presented solely as an indication of typical construction noise levels.

The overall total aggregated sound power levels for each of the key construction tasks are detailed in Table 40. These have been developed based on the assumption that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

**Table 40: Approximate aggregate sound power levels of key construction tasks, dB L<sub>WA</sub>**

| Construction task                  | Plant/Equipment                                                                                                                                                                                                                                                                                                                                                                    | Approx. aggregate level, L <sub>WA</sub> |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| BESS Construction and installation | 1 x Bulldozer,<br>2 x Concrete agitator truck,<br>1 x Concrete pump truck,<br>1 x Crane (200 t),<br>1 x Crane (mobile),<br>1 x Forklift,<br>2 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Piling (bored),<br>1 x Roller (vibratory),<br>2 x Scraper,<br>2 x Truck (> 20 t),<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler | 125                                      |
| Demobilisation                     | 1 x Crane (200 t),<br>1 x Crane (mobile),<br>1 x Jack hammers,<br>1 x Truck (> 20 t),<br>4 x Vehicle (light commercial e.g. 4WD)                                                                                                                                                                                                                                                   | 120                                      |
| Early works                        | 1 x Bulldozer,<br>1 x Concrete agitator truck,<br>1 x Concrete pump truck,<br>1 x Excavator,<br>1 x Forklift,<br>1 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Roller (vibratory),<br>1 x Truck (> 20 t),<br>1 x Truck (water cart),<br>2 x Vehicle (light commercial e.g. 4WD)                                                                                        | 125                                      |
| Energisation and commissioning     | 1 x Forklift,<br>2 x Generator,<br>1 x Jack hammers,<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler                                                                                                                                                                                                                                    | 120                                      |

| Construction task                                  | Plant/Equipment                                                                                                                                                                                                                                                                                                                                                                                      | Approx. aggregate level, L <sub>WA</sub> |
|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| Main laydown construction                          | 1 x Bulldozer,<br>3 x Excavator,<br>1 x Forklift,<br>2 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Piling (bored),<br>1 x Roller (vibratory),<br>2 x Scraper,<br>2 x Truck (> 20 t),<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler                                                                                                          | 125                                      |
| Roads, hardstands, foundations, and auxiliary pads | 1 x Bulldozer,<br>2 x Concrete agitator truck,<br>1 x Concrete pump truck,<br>1 x Crane (200 t),<br>1 x Crane (mobile),<br>3 x Excavator,<br>1 x Forklift,<br>2 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Piling (bored),<br>1 x Roller (vibratory),<br>2 x Scraper,<br>2 x Truck (> 20 t),<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler | 125                                      |
| Substation construction                            | 1 x Bulldozer,<br>2 x Concrete agitator truck,<br>1 x Concrete pump truck,<br>1 x Crane (200 t),<br>1 x Crane (mobile),<br>3 x Excavator,<br>1 x Forklift,<br>2 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Piling (bored),<br>1 x Roller (vibratory),<br>2 x Scraper,<br>2 x Truck (> 20 t),<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler | 125                                      |

| Construction task         | Plant/Equipment                                                                                                                                                                                                                        | Approx. aggregate level, L <sub>WA</sub> |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| Wind turbine installation | 1 x Crane (200 t),<br>1 x Crane (mobile),<br>1 x Forklift,<br>2 x Generator,<br>1 x Grader,<br>1 x Jack hammers,<br>1 x Roller (vibratory),<br>1 x Truck (water cart),<br>10 x Vehicle (light commercial e.g. 4WD),<br>1 x Telehandler | 125                                      |

## APPENDIX N TECHNICAL SUPPLEMENT FOR NOISE – INFORMATION REQUIREMENTS

The Technical Supplement for Noise specifies the minimum information to be provided in a noise report accompanying an EIS. The requirements and the location within this report where the requirement is addressed, are summarised in Table 41.

**Table 41: Technical Supplement for Noise – information requirements**

| Information requirement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Location of relevant content            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| <ul style="list-style-type: none"> <li><i>the model used to predict the wind energy project noise levels and input assumptions and the factors used in the model, noting that noise-management mode or sector management (i.e. stopping individual turbines or combinations, or operating in low noise mode, during identified meteorological conditions) should not be used in the primary modelling or predicting of noise levels. Any modelling and predictions that incorporate noise-management mode or sector management must be reported separately</i></li> </ul> | Section 4.1/Appendix G                  |
| <ul style="list-style-type: none"> <li><i>background noise measurement locations including the time and duration of the background noise monitoring program</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                | See Background Noise Report/Section 5.0 |
| <ul style="list-style-type: none"> <li><i>wind speed monitoring locations within the project area, heights above ground and graphical plot of hub height wind speed versus background noise level</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                          | See Background Noise Report/Section 5.0 |
| <ul style="list-style-type: none"> <li><i>a summary of the project's noise criteria at each integer wind speed based</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                       | See Section 5.0                         |
| <ul style="list-style-type: none"> <li><i>likely performance specifications of the wind turbines and their locations</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                       | Figure 1/Section 6.1/Appendix C         |
| <ul style="list-style-type: none"> <li><i>predicted noise levels at the closest non-associated residences to the wind energy project at each integer wind speed that are likely to exceed the 35 dB(A) base objective</i></li> </ul>                                                                                                                                                                                                                                                                                                                                      | Section 6.2/Appendix K                  |
| <ul style="list-style-type: none"> <li><i>a comparison of the predicted noise levels against the criterion at each integer wind speed for the most affected non-associated residences to the wind energy project that are likely to experience noise level higher than the 35 dB(A) base limit.</i></li> </ul>                                                                                                                                                                                                                                                            | Section 6.2/Appendix K                  |
| <ul style="list-style-type: none"> <li><i>modifications or operating strategy that would address unforeseen non-compliances, considering the error margins of the noise</i></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                    | Section 9.0                             |