MARSHALL DAY Acoustics

TWIN HILLS WIND FARM
DETAILED ACOUSTIC ASSESSMENT

Rp 001 R01 20240044 | 26 February 2026

Marshall Day Acoustics (Australia) Pty Ltd
ABN: 42 687 698 184
6/448 Roberts Road
Subiaco WA 6008
T: +618 9779 9700
www.marshallday.com

Project:	**TWIN HILLS WIND FARM**
Prepared for:	**Twin Hills Wind Farm Pty Ltd Suite 10 19-35 Gertrude St Fitzroy Victoria 3065**
Attention:	**Mikhaela Gray**
Report No.:	**Rp 001 R01 20240044**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	-	-	11 Dec 2025	B. Wilson	J. Adcock
Final	R01	Updated for new layout	26 Feb 2026	J.K. Chong	B. Wilson

SUMMARY

This report presents the results of an assessment of environmental noise associated with the Twin Hills Wind Farm (project) that is proposed to be developed by Twin Hills Wind Farm Pty Ltd (proponent).

The project is proposed to comprise up to 93 wind turbines, a battery energy storage system (BESS), a substation, and related infrastructure.

The development application for the project seeks permission to develop, construct and operate wind turbines with a maximum tip height of 300 m. The actual wind turbine which would be used at the project site would be determined during the detailed design stage, following determination of the project. The final selection would be based on a range of design requirements including achieving compliance with the development consent noise limits at surrounding receivers. In advance of a final selection, the assessment considers a candidate wind turbine model that is a typical example of the size and type of wind turbine that could be used at the site. For this purpose, the Vestas V162 6.8 MW model with a hub height of 138 m has been nominated by the proponent for this assessment.

The *Western Australian Planning Commission's Position Statement: Renewable energy facilities* dated March 2020 (the Position Statement) sets out requirements to support the consistent consideration of renewable energy facilities within Western Australia (WA) and provides guidance on wind farm noise. In relation to wind turbine noise, the Position Statement confirms the *Environmental Protection (Noise) Regulations 1997* (WA Noise Regulations) as the applicable legislation in WA. The Position Statement also states that the *South Australian Environmental Protection Authority – Wind Farms Environmental Noise Guidelines (2009)* should be referenced for assessment purposes, and notes that these guidelines acknowledge the potential for operation in the presence of higher wind-induced background noise levels.

Consistent with the Position Statement, wind farm developments in WA have typically been assessed and approved using an approach based on the WA Noise Regulations and the technical procedures of the South Australian Environmental Protection Authority publication *Wind Farms Environmental Noise Guidelines* issued July 2009 and revised November 2021 (SA Guidelines). The rationale for this approach is that the WA Noise Regulations were developed to address general commercial and industrial noise sources which have very different noise emission characteristics to a wind farm development. As a result, the WA Noise Regulations specifies noise parameters and assessment methodologies which are unsuitable for direct application to a wind farm. The use of the SA Guidelines, as recommended in the Position Statement, therefore provides the benefit of a methodology which is specific to the complexities of wind turbine noise, and is consistent with good practice approaches used throughout Australia and New Zealand.

In lieu of formal guidance, the SA Guidelines have typically been adopted as a procedural framework for the assessment of wind turbine noise, with modifications to key elements in recognition of the WA Noise Regulations. These modifications have typically comprised:

- reduction of base noise level component of the SA Guidelines noise criteria by 5 dB in recognition of the WA Noise Regulations minimum assigned level for the night period
- restriction of wind turbine noise agreements to premises which would host project infrastructure, rather than the approach outlined in the SA Guidelines which enables noise agreements to be reached between wind farm operators and land owners more broadly.

With this approach, wind turbine noise is usually restricted to a single noise assessment criterion at each wind speed in which the wind farm operates. Importantly, this approach to setting noise assessment criterion is based on protection of amenity at night but is applied equally to the day and evening periods. In contrast, the WA Noise Regulations set much higher noise limits during the day and evening, consistent with limits designed for general commercial and industrial noise sources, which are not usually referenced when assessing wind turbine noise in WA.

It is understood that WA noise policy for wind turbine noise is under review and may be subject to change. In advance of this, and in the interests of assessment consistency noted in the Position Statement, the same approach has been used to assess the Twin Hills Wind Farm. Specifically, the assessment has been based on the SA Guidelines with the modifications listed above. However, it is important to note that the wind farm assessment procedures of the SA Guidelines differ from the procedures specified in the WA Noise Regulations that were developed for general industrial noise. A strict application of the WA Noise Regulations would be subject to considerable uncertainty and would indicate different assessment outcomes.

A background noise monitoring survey was undertaken to obtain a representation of typical baseline conditions in the vicinity of the project and derive applicable noise assessment criteria for receivers, as defined by the SA Guidelines. The survey and results are detailed in Rp 002 20240044 *Twin Hills Wind Farm - Background Noise Monitoring* dated 11 December 2025 (Background Noise Report).

Manufacturer specifications for the candidate wind turbine model have been used as the basis for the assessment. The specifications for each wind turbine include noise emission data in accordance with the international standard[1] referenced in the SA Guidelines. The noise emission data used is consistent with the range of values expected for comparable types of multi-megawatt wind turbine models that may be considered for the site.

The noise emission data has been used with international standard ISO 9613-2 to predict wind turbine noise levels at neighbouring receivers.[2] The ISO 9613-2 standard has been applied using well-established input choices and adjustments, based on research and international guidance, that are specific to wind farm noise assessment.

The proponent has nominated a wind turbine noise design objective of 35 dB. An iterative assessment of the proposed wind turbine layout and candidate turbine was carried out to develop an example operating configuration which would achieve the proponent's design objective. The assessment demonstrated that with 2 of the proposed turbines utilising noise control modes for a limited range of wind speeds, the predicted noise levels achieve the 35 dB at all receivers, consistent with the base noise level component of the assessment criterion.

The assessment has also considered operational noise associated with the proposed BESS and substation. Predicted noise levels have been assessed in accordance with the WA Noise Regulations and demonstrate that the BESS and substation are predicted to comply with the most stringent assigned levels at all receivers. Noise from the BESS and substation was shown to have negligible impact on the receiver cumulative noise levels from the project and would not affect the outcomes of the wind turbine noise assessment.

---

1 IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques*

2 ISO 9613-2:2024 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

MARSHALL DAY Acoustics

TABLE OF CONTENTS

APPENDIX A GLOSSARY OF TERMINOLOGY

APPENDIX B DESCRIPTION OF SOUND

APPENDIX C INFRASTRUCTURE COORDINATES

APPENDIX D SITE TOPOGRAPHY

APPENDIX E RECEIVER COORDINATES

APPENDIX F NOISE PREDICTION MODEL

APPENDIX G TABULATED BACKGROUND NOISE LEVELS

APPENDIX H ASSESSMENT CRITERIA – WIND TURBINES

APPENDIX I BESS AND SUBSTATION PREDICTED NOISE LEVEL CONTOURS

APPENDIX J EFFECTS OF WIND TURBINE NOISE

APPENDIX K TABULATED PREDICTED NOISE LEVELS

1.0 INTRODUCTION

Twin Hills Wind Farm Pty Ltd (the proponent) proposes to develop the Twin Hills Wind Farm (project) comprising a large battery energy storage system (BESS) and up to 93 wind turbines near the town of Eneabba, located approximately 300 km north of Perth in the WA Mid West Region. Throughout this report, the term 'project' refers to the BESS, substation and the wind turbines.

This report presents the results of an assessment of operational noise for the proposed project undertaken with reference to the Western Australia *Environmental Protection (Noise) Regulations 1997* (WA Noise Regulations) and South Australia EPA *Wind farms environmental noise guidelines*, issued July 2009 and revised November 2021 (SA Guidelines). This approach is consistent with the Western Australian Planning Commission *Position Statement: Renewable energy facilities*, dated March 2020 (Position Statement).

Noise associated with the operation of the proposed BESS and substation has been assessed in accordance with the WA Noise Regulations.

The noise assessment prepared 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 site layout and a candidate wind turbine model
- predicted noise levels from the BESS and substation, based on assumed noise emission data.

Acoustic terminology used in this report is presented in Appendix A. Throughout this report, the term *receiver* is used to identify any residential premises identified by the Proponent in the vicinity of the project. Receivers are grouped as *host receivers* i.e. host premises where an agreement is in place between the landowners and the proponent to host project infrastructure on their land, or *non-host receivers* which comprise the remaining residential premises that do not have project infrastructure located on their land.

General information about the definition of sound and the ways that different sound characteristics are described is presented in Appendix A. The effects of wind turbine noise on health and amenity are discussed in Appendix J.

2.0 PROJECT OVERVIEW

The project is proposed to be located approximately 30 km northeast of the town of Eneabba in the Shire of Three Springs Local Government Area of Western Australia.

The project would involve the construction, operation and decommissioning of the following key components:

- up to 93 wind turbines with a maximum tip height of 300 metres and a hardstand area at the base of each wind turbine
- one wind farm collector substation comprising 3 high voltage (HV) transformers (280 MVA)
- underground cables from the wind turbines to the collector substation
- BESS comprising:
  - 2 x 3 phase 33/330kV 280MVA transformers.
  - 640 battery units
  - 160 inverters and accompanying medium voltage (MV) transformers
- other permanent on-site related infrastructure:
  - permanent operation and maintenance facilities
  - at least one meteorological mast
- access track network:
  - access and egress points from public roads
  - operational access tracks on private property.

The coordinates of the wind turbines are presented in tabular format in Appendix C and the proposed candidate wind turbine model is shown in Section 7.2.

3.0 STUDY AREA

The study area for the noise assessment extends to 4 km from the proposed locations of the wind turbines. This is a nominal distance selected to enable a complete account of operational noise considerations associated with the project.

The study area is predominantly rural but also includes some nature reserves. A site layout plan illustrating the wind turbine layout, BESS, substation and receivers is provided in Figure 1.

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

A total of 14 receivers have been identified by the Proponent within 4 km of the nearest wind turbine comprising:

- 2 host receivers
- 12 non-host receivers

The coordinates of the receivers identified within 4 km of the nearest wind turbine are tabulated in Appendix E.

Figure 1: Site Layout

4.0 WESTERN AUSTRALIA LEGISLATION, POLICY & RELATED GUIDELINES

The environmental noise assessment for the project has been informed by the following publications:

- *Environmental Protection (Noise) Regulations 1997* (WA Noise Regulations)
- Western Australian Planning Commission *Position Statement: Renewable energy facilities*, dated March 2020 (Position Statement)
- South Australian Environmental Protection Authority publication *Wind Farms Environmental Noise Guidelines* issued July 2009 and revised November 2021 (SA Guidelines)

This section summarises the requirements and guidance of the above publications.

Draft Renewable Energy Planning Code

The Western Australian Planning Commission has released the Draft Renewable Energy Planning Code and Guidelines, which proposes a new planning framework for the assessment of renewable energy infrastructure, with an initial focus on wind farms.

At the time of preparation of this report, the Code is in draft form and subject to public consultation and has not been incorporated into any statutory planning instruments. Accordingly, the draft Code and Guidelines have not been applied in the current assessment.

4.1 Environmental Protection (Noise) Regulations

The WA Noise Regulations operate as a prescribed standard under the *Environment Protection Act 1986* and set limits on noise emissions.

The WA Noise Regulations refers to several Australian Standards on the subject of noise and defines assessment procedures for a range of different noise sources including noise generated on industrial, commercial and residential premises. However, the WA Noise Regulations does not define or refer to assessment requirements that are specific to wind turbine noise.

Section 7 of the WA Noise Regulations provides prescribed standards for general noise emissions:

> *7. Prescribed standard for noise emissions*
>
> *(1) Noise emitted from any premises or public place when received at other premises —*
>
> *(a) must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind; and*
>
> *(b) must be free of —*
>
> *(i) tonality; and*
>
> *(ii) impulsiveness; and*
>
> *(iii) modulation,*
>
> *when assessed under regulation 9.*
>
> *(2) For the purposes of subregulation (1)(a), a noise emission is taken to significantly contribute to a level of noise if the noise emission as determined under subregulation (3) exceeds a value which is 5 dB below the assigned level at the point of reception.*
>
> *(3) A level of a noise emission may be determined by —*

> (a) *measurement at its point of reception when, to the extent practicable, other noises that would contribute to the measured noise level are not present; or*
>
> (b) *calculation of the level at its point of reception based on measurement of the noise emission at a reference point determined by the inspector or authorised person to be a point where the relationship between the noise emission as measured at the reference point and at the point of reception can be established.*

Section 8 additionally provides 'assigned levels' which are noise levels that must not be exceeded from the use of a premises when received at other premises. The assigned levels are defined in terms of three descriptors:

- L_{A10} – the sound level exceeded for 10 % of the measurement period, calculated by statistical analysis
- L_{A1} – the sound level exceeded for 1 % of the measurement period, calculated by statistical analysis
- L_{Amax} - the maximum sound level, during a measurement period or a noise event.

Non-host receivers located around the project would be classed as 'highly sensitive area' as described in the regulations. The assigned levels applicable to highly noise sensitive areas have been extracted from the regulation and are reproduced in Table 1.

The WA Noise Regulations deal with noise emission from one premises to another and do not apply where the noise is emitted and received on the same premises. Host receivers therefore may be classified as noise emitters under Section 7 of the Noise Regulations. On this basis, they would be considered part of the project, and the provisions of the Noise Regulations may not be applicable to them.

Table 1: WA Noise Regulations - Assigned levels, dB

Type of premises receiving noise	Time of day	L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + IF	55 + IF	65 + IF
	0900 to 1900 hours Sunday and public holidays	40 + IF	50 + IF	65 + IF
	1900 to 2200 hours All days	40 + IF	50 + IF	55 + IF
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + IF	45 + IF	55 + IF

IF: influencing factor

The above levels include the application of an influencing factor (IF) as described in Schedule 3 of the WA Noise Regulations. The influencing factor is a modification to the assigned level that is developed through consideration of the planning zone for the noise sensitive area and its surrounds as well as traffic volumes on nearby road. Reference to the Local Planning Scheme indicates land surrounding the wind farm is zoned 'Rural' and would be classified as 'Rural premises' under Schedule 1. Road traffic counts provided by Main Roads Western Australia[3] show traffic volumes below the thresholds that affect the influencing factor. On this basis influencing factors are equal to 0.

Regulation 9 defines the requirements in relation to 'intrusive or dominant noise characteristics' which comprises: tonality; impulsiveness; modulation. Adjustment to the noise emission is applied where intrusive or dominant noise characteristics are found to be present. Consideration of these characteristics has been included where relevant in the assessments in Section 7.0 and Section 8.0 below.

4.2 Position Statement: Renewable energy facilities

The Position Statement is a policy outlining the Western Australian Planning Commission requirements to support the consistent consideration and provision of renewable energy facilities within Western Australia. The Position Statement provides guidance on a range of matters that are relevant to the development of renewable energy facilities in Western Australia, which are noted to principally include wind turbines and solar array systems. The Position Statement include guidance for the assessment of noise related to renewable energy projects and states:

> *Noise emissions from renewable energy facilities, including wind turbines, are required to meet the standards prescribed under the Environmental Protection (Noise) Regulations 1997. The South Australian Environmental Protection Authority – Wind Farms Environmental Noise Guidelines (2009) should also be referenced for assessment purposes. These guidelines acknowledge the potential for operation in the presence of higher wind-induced background noise levels.*

The Position Statement refers to the 2009 version of the South Australian Environmental Protection Authority publication *Wind Farms Environmental Noise Guidelines*. In November 2021, after the Position Statement was published, this publication was revised with updated guidance and technical procedures.

Core procedures for both versions of the publication are broadly equivalent in terms of noise limits and assessment requirements. Changes primarily relate to technical procedures, such as the appropriate method of determining a relationship between noise levels and wind speeds. As the 2021 version of the publication is an update of the 2009 version of the publication referenced in the Position Statement, the 2021 version is referenced in this assessment.

4.3 SA Guidelines

On the subject of noise limits applying to new wind farm developments the SA Guidelines state:

> *The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:*
>
> - *35dB(A) at relevant receivers in localities which are primarily intended for rural living*
>
> *OR*
>
> - *40dB(A) at relevant receivers in localities in other zones*
>
> *OR*
>
> - *the background noise ($L_{A90,10}$) by more than 5dB(A).*
>
> *whichever is the greater, at all relevant receivers for wind speeds from cut-in to rated power of the WTG* [Wind Turbine Generator] *and each integer wind speed in between.*

[3] https://trafficmap.mainroads.wa.gov.au/map

These criteria apply for both day and night time hours, but have been based on conservative night time levels.

In relation to rural living the following is included:

A rural living zone is for an area intended as rural-residential 'lifestyle' with high amenity requirements. This area should not be used for primary production purposes other than to produce food, crops or keep animals solely for the occupier's own use, consumption and/or enjoyment. It is expected that these zones have amenity that is quieter than urban residential and land uses that promote primary production.

A review of the Local Planning Scheme map shows that the wind farm site and surrounding land is within a Rural zone. This indicates that the subject area is unlikely to correlate with a rural living zone under the SA Guidelines.

Based on the above, the applicable minimum noise assessment criterion (the base component of the noise limit) in accordance with the SA Guidelines would be 40 dB L_{Aeq}. In the absence of measured background noise levels around the site, the base limit can be used for a conservative assessment in accordance with the SA Guidelines across the range of wind speeds the turbines would operate.

The SA Guidelines acknowledge that different noise limits can apply at the noise sensitive premises where a landowner has entered into an agreement with the proponent to host turbines (host receivers). The SA Guidelines refer to the WHO Guidelines[4] and recommends a 30 dB indoor limit for this scenario. On the basis that the noise reduction from outside to inside with a window open is 15 dB (as per the assumption in the WHO Guidelines referenced in the SA Guidelines), the outdoor noise limit would be 45 dB L_{Aeq}. This is consistent with the 2009 version of the SA Guidelines and the limits for host receivers used in other jurisdictions in Australia. Noise levels at these locations will ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the landowners.

4.4 Proposed wind turbine noise criterion for assessment

The overarching legislative requirement for the assessment of environmental noise is the WA Noise Regulations. While the WA Noise Regulations are not specific to renewable projects, they set general provisions in the form of assigned levels.

The assigned levels represent limits which are applicable to the project, including wind turbines and any ancillary infrastructure. This interpretation is reflected in the Position Statement which reiterates that renewable projects must comply with the requirements of the WA Noise Regulations.

However, operational wind turbine noise characteristics are complex and unique, exhibiting variations in noise levels with both wind speed and direction. Measurement and assessment of background and wind turbine noise across the range of conditions in which a wind farm operates is therefore complex and normally involves the use of dedicated measurement and assessment methods which are specific to wind turbine noise. These complexities are recognised in the Position Statement through the reference to the SA Guidelines for wind turbine noise assessment procedures.

The SA Guidelines provide the benefit of being a publication which is specific to wind turbine noise and provides a comprehensive assessment method for addressing wind turbine noise at each stage of a project's development and operation. The core assessment methods of the SA 2021 Guidelines are consistent with procedures used throughout Australia and New Zealand for wind turbine noise.

However, while the Position Statement recognises the SA Guidelines, there are important procedural differences which are problematic to reconcile directly with the technical requirements of the WA

4 World Health Organization publication *Guidelines for community noise* (1999) (WHO Guidelines)

Noise Regulations. These complications arise from the broad scope of the WA Noise Regulations as a general tool for the assessment of noise from commercial and industry premises. In light of this, it is understood that WA government policy that is specific to wind turbine noise assessment is in development.

Given the above, proposed wind farm developments have been historically assessed and approved by demonstrating compliance with the SA Guidelines, subject to modifications where necessary to reflect the limit structure of the WA Noise Regulations.

In advance of further guidance, the same approach has been adopted for the Twin Hills Wind Farm. This broadly involves the following:

- The use of assessment noise criteria defined by 2 distinct components:
  - A base noise level component which is the minimum noise criterion that could apply at receivers.
  - A background noise dependent component which is set at the background noise plus 5 dB.

  At each hub height integer wind speed, the criterion adopted would be the higher of these 2 components, consistent with the SA Guidelines approach. The background noise dependent component would only be considered at receivers where representative background noise levels have been established. For other receivers the base noise level component would apply across all wind speeds.
- Adoption of a base noise level component set at 35 dB for non-host receivers in lieu of the 40 dB specified in the SA Guidelines. The reduced level is applied to reflect the night period assigned levels of the WA Noise Regulations.
- Restriction of the use of wind turbine noise agreements to premises which would host project infrastructure, in lieu of the approach outlined in the SA Guidelines which enables noise agreements to be reached with other land owners around the wind farm.
- Adoption of a base noise level component set at 45 dB for host receivers, consistent with recommendations in the SA Guideline 2021 for residential land use.
- Application of the noise criteria across all time periods (day, evening and night), consistent with the SA Guidelines.
- Measurement and assessment of background noise levels in accordance with the SA Guidelines.
- Adoption of the predicted L_{Aeq} and measured L_{A90} metric detailed in the SA Guidelines for assessment, based on wind turbine noise being a semi-steady state source and the practical complications of attempting to measure wind turbine noise using general industry parameters (e.g. L_{Aeq}) in a fluctuating ambient noise environment.

The above approach is consistent with assessment approaches historically used in WA for the assessment and approval of wind farm developments. However, it is important to note that the assessment methodology used in this report does not strictly adhere to all the requirements of the WA Noise Regulations. The approach taken does not represent a literal application of the WA Noise Regulations to wind turbine noise.

Noise from the BESS and substation are assessed under the WA Noise Regulations using the assigned noise levels outlined in Table 1.

5.0 NOISE PREDICTION METHOD

Operational project noise levels are predicted using:

- noise emission data for the wind turbines, BESS and substation equipment
- a 3D digital model of the Site and the surrounding environment
- international standards used for the calculation of environmental sound propagation.

Key elements of the noise prediction method are summarised in Table 2. Further discussion of the method and the calculation choices is provided in Appendix F

Table 2: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLANnoise version 9.1
Method	International Standard ISO 9613-2:2024 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). The ISO 9613-2:2024 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 9613-2:2024 is nominated as being an acceptable noise prediction method in the SA Guidelines. The adjustments are applied within the SoundPLANnoise modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below. The prediction method is consistent with the guidance provided by the SA Guidelines (referenced in the Position Statement) and has been shown to provide a reliable method of predicting the typical upper levels of the wind turbine noise expected to occur in practice.
Source characterisation	Each wind turbine is modelled as a point source of sound. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each. 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. 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. Source heights are set at 2 m for batteries and inverters and 5 m for transformers.
Terrain data	Elevation contours in 2 m vertical resolution provided by the Proponent.

Detail	Description
Terrain effects (wind turbine-specific procedures)	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance *Valley effects*: +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 was flat. *Terrain screening effects*: 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. The project is located in a hilly area characterised by significant variations in ground elevation between the wind turbines and surrounding receivers. Based on comparison of predicted noise levels with and without terrain elevation data included, calculated terrain effects range between -1.0 dB and +0.1 dB for receivers within 4 km of the proposed wind turbines For reference purposes, the ground elevations at the wind turbine and receivers are tabled in Appendix C and Appendix E respectively. The topography of the Site is depicted in the elevation map provided in Appendix D.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK IOA Good Practice Guide and research outlined in Appendix F. The ground around the project corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 ^{o}C and relative humidity 80 % as required by the SA Guidelines. These represent conditions which result in relatively low levels of atmospheric sound absorption. The calculations are based on sound speed profiles[5] which increase the propagation of sound from each wind turbine to each receiver location, whether as a result of thermal inversions or wind directed toward each calculation point. The primary consideration for wind farm noise assessment is wind speed and direction. 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.
Receiver heights	4 m above ground level based on the recommendations of ISO 9613-2:2024 Annex D.

6.0 EXISTING NOISE ENVIRONMENT

Background noise level data is used to establish appropriate noise limits when assessing wind turbine noise in accordance with the SA Guidelines. The approach allows variations in both background noise and wind turbine noise under different wind conditions to be taken into account. Additionally, background noise information provides context for understanding the broader environmental noise

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

environment and is potentially needed for future compliance assessment purposes (an important step in the compliance checking process under the SA Guidelines is the adjustment for background noise).

The procedures for determining background noise levels for the assessment of wind turbines are defined in the SA Guidelines, as referenced in the Position Statement. Background noise levels are considered in terms of $L_{A90,\ 10\ min}$.

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:*
>
> - *where someone resides or has development approval to build a residential dwelling;*
> - *where 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 surveys involve measurements of background noise levels at receivers and simultaneous measurement of wind speeds at the project site. 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 site 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 SA Guidelines assessment criteria.

Preliminary noise modelling indicates that background noise monitoring may be required to inform a detailed assessment and for future compliance checking purposes. Proposed background noise monitoring locations have been selected based on proximity to wind turbines, the location of receivers, and the predicted noise contours.

A summary of background noise levels determined in accordance with the SA Guidelines, as referenced in the Position Statement, are tabulated in Appendix G for the range of surveyed wind speeds. The results are illustrated in the graphical data provided for each receiver in the appendices of the Background Noise Report.

7.0 OPERATIONAL NOISE ASSESSMENT – WIND TURBINES

7.1 Assessment basis

7.1.1 Non-host receivers

At non-host receivers, the applicable noise limit in accordance with the SA Guidelines is 40 dB L_{Aeq} or background L_{A90} + 5 dB, whichever is higher. However, to reflect the limit structure of the WA Nosie Regulations, the base noise level component of the assessment criteria is reduced to from 40 dB to 35 dB L_{Aeq}.

Based on the background noise levels detailed in Appendix G, the derived assessment criteria at the non-host receivers where monitoring was undertaken are summarised in Appendix H.

The background noise levels in Appendix G generally show an increase in noise with wind speed. However, in some instances, there are anomalous results where noise levels decrease with wind speed across selected wind speed bins. It should be noted that these outcomes are not a true representation of the noise environment but instead a consequence of the binning analysis based on the data available. There may be options to resolve these anomalies however none are specifically defined in SA Guidelines. So, for purposes of this report, all data is presented based on a literal interpretation of the SA Guidelines analysis method.

Notwithstanding the assessment criteria outlined above, the proponent has nominated a wind turbine noise design objective of 35 dB, consistent with the base noise level component of the assessment criterion.

7.1.2 Host receivers

As detailed in Section 4.4, the base noise level component of the of the assessment criteria is set at 45 dB L_{Aeq} for all host receivers. Comparisons between the predicted noise levels and the 45 dB base noise level are provided for informative purposes only. Noise levels at these locations would ultimately need to be managed in accordance with the commercial agreements established between the proponent and the landowners.

7.2 Candidate wind turbine model

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

Accordingly, to assess the proposed project at this stage, it is necessary to assess compliance by using a candidate wind turbine model that is representative of the size and type of wind turbines that would be considered for procurement. The purpose of the candidate wind turbine model is to assess the viability of achieving compliance with the applicable noise criterion, based on noise emission levels that are typical of the size of wind turbines being considered for the project.

For this assessment, the proponent has nominated the candidate wind turbine model detailed in Table 3.

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

Table 3: Candidate wind turbine model specifications

Item	Details
Make	Vestas
Model	V162
Rated power, MW	6.8
Rotor diameter, m	162
Modelled hub height, m	138
Operating mode	PO6800 [1]
Blade serrations	Yes
Highest sound power[2], dB L_{WA}	105.5
Highest sound power level wind speed, m/s	15
Cut-in wind speed (hub height), m/s	3
Rated power wind speed (hub height), m/s	13
Cut-out wind speed (hub height), m/s	25

1 'PO6800' is a manufacturer designation which indicates an unconstrained, Power Optimised mode of operation to achieve a rated power of 6.8 MW (i.e. without noise curtailment)

2 Specification sound power level, including a 1 dB margin to account for uncertainties.

The candidate wind turbine model is considered appropriate to represent the class of wind turbine being considered for the project.

The modelled hub height detailed above is suitable for noise assessment purposes however the final hub height of the selected wind turbine model may differ slightly. The magnitude of any changes is expected to be minor and inconsequential with respect to predicted noise levels at receivers. Irrespective, revised noise modelling would be conducted for the final wind turbine layout, model selection and hub height to verify compliance. The results of the revised noise modelling would be documented in the noise management plan.

Unless specified otherwise, this assessment has been based on all wind turbine models using unconstrained generation modes (i.e. no sound optimised operating modes) and with blade serrations. Blade serrations are now routinely used to reduce wind turbine noise emissions, and we understand that their use is now the market standard for wind turbines being offered in the Australian market. A range of sound optimised modes are also available reducing the maximum power output and sound power levels.

7.3 Wind turbine noise emissions

7.3.1 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 Vestas document 0111-1246_03 *Third octave noise emission EnVentus™ V162-6.8MW 50/60 Hz* dated 13 January 2023.

Based on the data sourced from the manufacturer's documentation, the noise modelling undertaken for this assessment involved conversion of third octave band levels to octave band levels (where applicable), and adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The wind farm configuration considered in this assessment utilises a combination of full power and sound reduced modes of operation, referred to as operating modes PO6800 and S02 respectively.

The overall A-weighted sound power levels (including the +1 dB addition) as a function of hub height wind speed are presented in Table 4. Data are presented for the normal operating mode (mode PO6800) and for available sound optimised modes.

Table 4: Sound power levels versus hub height wind speed, dB L_{WA}

Operating mode	Hub height wind speed, m/s										
	≤5	6	7	8	9	10	11	12	13	14	15
PO6800	95.0	96.0	99.3	102.5	104.3	104.3	104.4	104.8	105.1	105.3	105.5
SO1	95.0	96.0	99.3	102.5	104.3	104.3	104.4	104.5	104.5	104.5	104.5
SO2	95.0	96.0	99.3	102.3	103.0	103.0	103.0	103.0	103.0	103.0	103.0
SO3	95.0	96.0	99.2	101.8	101.9	102.0	102.0	102.0	102.0	102.0	102.0
SO4	95.0	96.0	99.2	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
SO5	95.0	96.0	99.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
SO6	95.0	96.0	98.8	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0

The reference octave band values used as the basis for this assessment are presented in Table 5 and were adjusted to the overall A-weighted noise levels detailed in Table 4.

Table 5: Octave band sound power levels, dB L_{WA}

	Octave band centre frequency, Hz								
Operating mode[1]	31.5	63	125	250	500	1000	2000	4000	8000	Total
PO6800	76.0	88.5	96.4	99.7	100.2	98.7	94.2	86.7	76.0	105.5
SO1	75.1	87.5	95.4	98.7	99.2	97.7	93.3	85.8	75.2	104.5
SO2	73.7	86.1	93.9	97.2	97.7	96.2	91.8	84.4	73.9	103.0
SO3	72.9	85.1	92.9	96.2	96.6	95.2	90.9	83.4	73.1	102.0
SO4	72.8	84.6	91.8	94.9	95.7	94.4	90.1	82.7	72.4	101.0
SO5	72.0	83.7	90.8	93.9	94.7	93.4	89.1	81.8	71.5	100.0
SO6	71.1	82.7	89.8	92.9	93.7	92.4	88.1	80.9	70.6	99.0

Note: [1] Based on one-third octave band levels at 15 m/s

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.[6] In practice, the overall noise emissions of a wind turbine are dependent on a range of factors, including the wind turbine size and power output, and other important factors such as the blade design and rotational speed of the wind turbine. Therefore, 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 as 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).

7.3.2 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.

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, and again following the construction.

7.3.3 Wind farm configuration

Preliminary noise modelling indicated that a curtailment strategy involving the use of sound reduced modes would be required to achieve the proponent's design objective.

An iterative assessment of the proposed wind turbine layout and candidate turbine was therefore carried out to develop an example operating configuration which would achieve a level of 35 dB, consistent with the base component of the assessment criteria.

The example wind farm configuration detailed in Table 6 has been used as the basis for the noise assessment.

Table 6: Example wind farm configuration (assessment basis)

Turbine ID	Vestas V162 operating mode
T1	SO2 (sound reduced mode)
T4	SO2 (sound reduced mode)
T6	SO3 (sound reduced mode)
T7	SO3 (sound reduced mode)
T8	SO2 (sound reduced mode)
T9	SO1 (sound reduced mode)
T10	SO2 (sound reduced mode)
T11	SO2 (sound reduced mode)
T12	SO5 (sound reduced mode)

6 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

Turbine ID	Vestas V162 operating mode
T13	SO4 (sound reduced mode)
T14	SO2 (sound reduced mode)
T15	SO1 (sound reduced mode)
T16	SO2 (sound reduced mode)
T18	SO1 (sound reduced mode)
T23	SO1 (sound reduced mode)
T25	SO1 (sound reduced mode)
All other turbines	PO6800 (full power operation)

7.4 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 criterion.

Wind turbine noise levels have been predicted using the selected candidate turbine model and sound power level data detailed in Section 7.3.1 for the wind speed which results in the highest predicted noise levels (15 m/s).

Predicted noise levels, based on the wind farm configuration detailed in Section 7.3.3, are presented in Table 7 for non-host receivers and Table 8 for host receivers and tabulated in Appendix K for each integer wind speed.

The location of the total predicted 30 dB, 35 dB, 40 dB, and 45 dB L_{Aeq} noise contours is illustrated in Figure 2, for the 15 m/s wind speed.

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 project 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. It is for this reason that the levels presented in this section are reported to one decimal place.

Table 7: Highest predicted wind turbine noise levels at non-host receivers with predicted levels 30 dB L_{Aeq} or above

Receiver	Predicted noise level
D20	35.0
D84	35.0
D78	32.4
D6	32.2
D96	31.8
D48	31.8
D19	31.6
D2	30.8
D95	30.7

On the basis that the predicted L_{Aeq} noise levels are used for assessment purposes, as described in Section 4.4, the results in Table 7 show that the predicted wind turbine noise levels from the project meet the assessment criterion applicable for all non-host receivers.

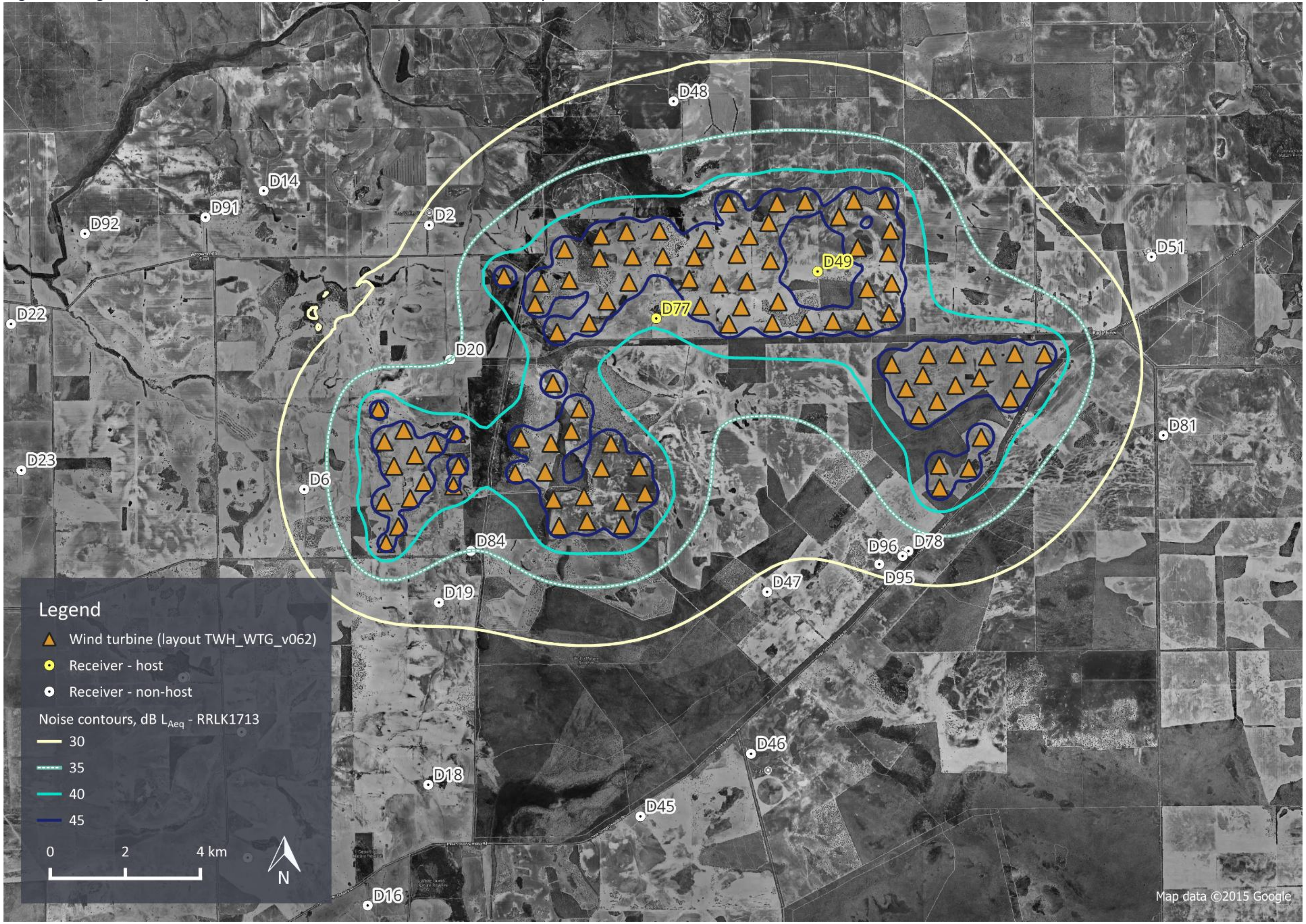
Predicted noise levels at host receivers are provided in Table 8 for information.

Table 8: Highest predicted noise level at host receivers, dB L_{Aeq}

Receiver	Predicted noise level
D49	41.6
D77	40.8

The result in Table 8 show that the predicted wind turbine noise levels from the project are below the assessment criterion applicable for all host receivers.

Figure 2: Highest predicted noise level contours (assessment basis)



7.5 Cumulative wind farm assessment

We are not aware of any nearby existing or approved wind farms within 10 km of the project. On this basis, cumulative wind turbine noise is not a matter that requires further consideration or investigation at this stage. Cumulative noise of the different elements of the project are considered separately in Section 9.0.

8.0 BESS & SUBSTATION OPERATIONAL NOISE ASSESSMENT

This section presents an assessment of operational noise from the wind farm collector substation and BESS facility associated with the wind farm. The substation and the BESS facility are both located within the project boundary. A site layout plan illustrating the wind farm substation and BESS facility and receivers is provided in Figure 1 of Section 2.0. The terminal station used for the grid connection will not include any transformers.

8.1 Assessment criteria

The relevant criteria for the assessment of noise from the BESS and substation are the assigned levels under the WA Noise Regulations as defined in Table 1.

The noise sources associated with the BESS and substation typically give rise to steady noise levels i.e. transformer and battery noise is not typically characterised by brief momentary increases in noise levels. Accordingly, the relevant assessment metric is the L_{A10} assigned level.

8.2 Noise emissions

8.2.1 Wind farm collector substation

The high voltage (HV) transformers and any associated cooling equipment would be the main sources of noise located within the substation.

At this stage in the project, specific details of the transformer make and model are yet to be determined. However, the proponent has indicated that 3 transformers, each with a rating of 280 MVA, would be representative.

8.2.2 BESS

The concept design comprises a layout of separate inverters, medium voltage (MV) transformers, and battery modules. Two HV transformers will be located alongside the BESS equipment. The concept layout indicating the number and position of each equipment item is shown in Figure 3. A summary of the relevant information is shown in Table 9.

Table 9: BESS equipment details

Equipment item	Quantity
Battery	640
Inverter	160
MV transformer	160
HV transformer	2

8.2.3 Sound power level data

Sound power levels for individual equipment items, as used in the noise model, are detailed in Table 10. Data is provided as un-weighted (linear) octave band spectra and A-weighted overall sound power level.

Manufacturer sound power level data for battery and inverter units has been taken from MDA's noise database. Noise associated with transformers has been derived considering appropriate technical standards. Further detail is provided in Table 11.

Table 10: Sound power levels for each individual equipment item, dB L_W

Item	Octave band centre frequency, Hz							
	63	125	250	500	1,000	2,000	4,000	L_{WA}
Wind farm collector substation								
HV transformer (280 MVA)	103	105	100	100	94	89	84	100
BESS								
Battery	98	96	85	81	82	76	71	86
Inverter	88	85	82	75	70	77	85	87
MV transformer	77	79	74	74	68	63	58	75
HV transformer (280 MVA)	103	105	100	100	94	89	84	100

Figure 3: BESS layout

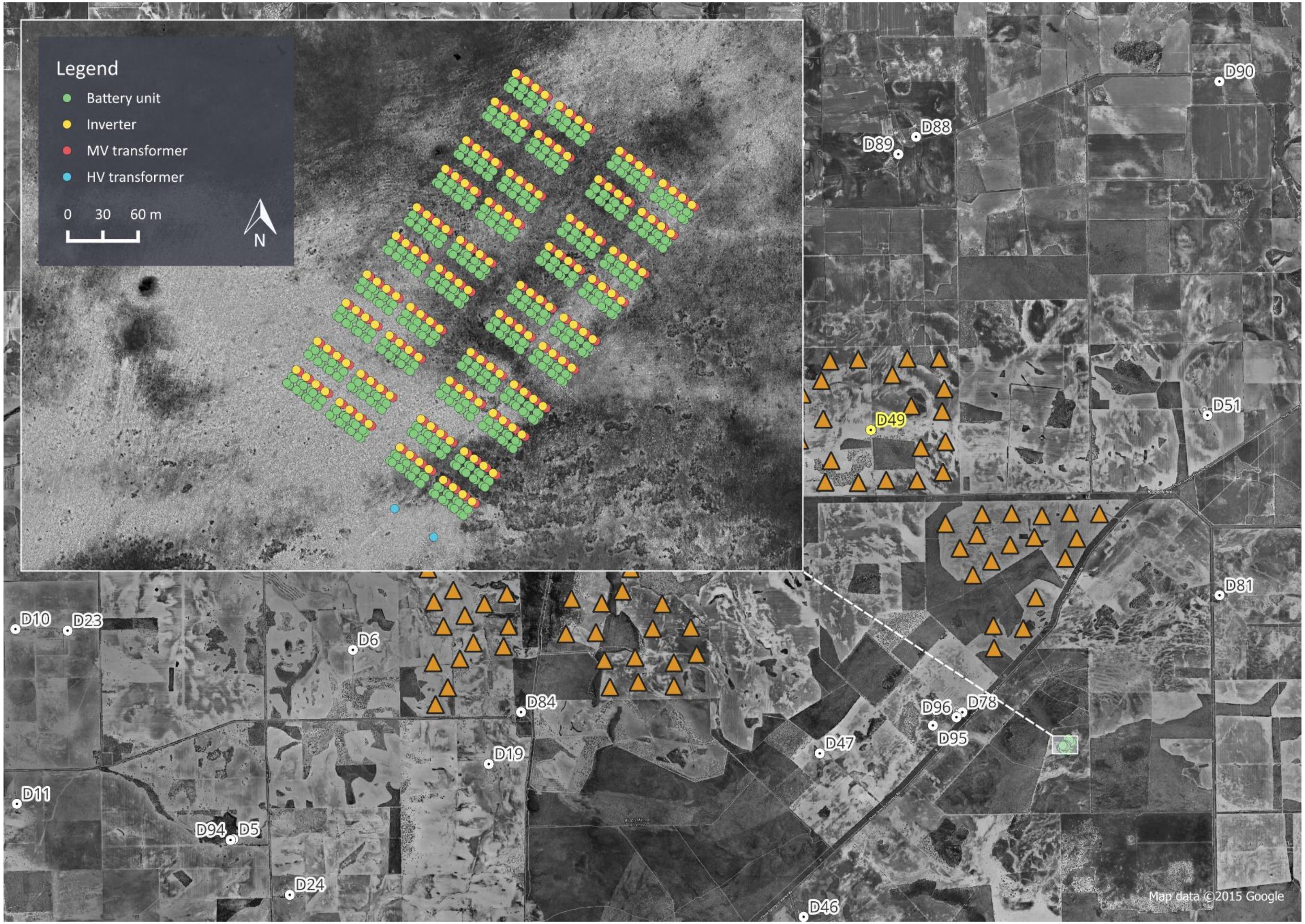


Table 11: Sound power level data description

Item	Description
Substation station	
HV transformer (280 MVA)	At this stage of the project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by the proponent, MDA understands that 3 HV transformers are proposed for the project, each expected to be rated at 280 MVA. In the absence of measured sound power level data for a specific transformer model, standard maximum sound power levels have been estimated, based on the nominated power rating, using the method described in Annex ZA of AS 60076-10:2009. Octave band spectral data for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (*Location 1a for outdoor transformer noise*) to the determined overall sound power level.
BESS	
Battery	Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 associated with a containerised battery system have been sourced from MDA library data.[7] The noise data aligns with 100% operation of the subject battery, i.e. worst-case sound power level. Noise data associated with the selected battery unit is towards the lower end of the range of sound power levels exhibited on the market.
Inverter	Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 have been sourced from MDA library data. The noise data aligns with 100% operation of the subject inverter, i.e. worst-case sound power level and is inclusive of an OEM noise attenuation kit. Noise data associated with the selected inverter is at the lower end of the range of sound power levels exhibited on the market.
MV transformer	At this stage of the project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by the proponent, MDA understands that the MV transformers proposed for the project are expected to be rated at approximately 4.2 MVA. 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 60076-10:2009.[8] Octave band spectral data for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (*Location 1a for outdoor transformer noise*) to the determined overall sound power level. [9]

7 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*

8 AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels*

9 *Bies, D. H. & Hansen, C. H. (2009). Engineering noise control: theory and practice (Fourth edition.). p. 601*

Item	Description
Item	Description
HV transformers	Based on information provided by the proponent, MDA understands that 2 HV transformers are proposed for the BESS facility, each expected to be rated at 280 MVA. Sound power data has been derived as per the Internal substation transformers.

Due to commercial sensitivities specific manufacturers and models are not detailed in this report, however, the proponent has confirmed the equipment to be representative of the specification required for the project.

8.3 Predicted noise levels

Noise levels associated with the operation of the BESS and substation have been predicted at the nearest non-host and host receivers based on the method detailed in Section 5.0..

The predicted noise levels at the nearest receivers within 4 km of the BESS and substation are shown in Table 12.

Table 12: Predicted noise levels at receivers within 4 km, dB L_{Aeq}

Receiver	Nearest item	Distance to nearest item, m	Predicted noise level, dB
Non-host receivers			
D78	BESS	2770	28
D95	BESS	3435	25
D96	BESS	2877	27
Host receivers			
D49	Substation	3557	11
D77	Substation	1093	29

It is noted that the sound power is provided as equivalent continuous noise levels (L_{Aeq}). Since noise from transformers, inverters, and battery units can be characterised as being steady state, for assessment purposes, the L_{Aeq} noise level metric has been used for comparison with the L_{AS10} assigned levels.

While the specific equipment selections would not be finalised until the detailed design phase of the project, noise levels from the BESS and substation are predicted to be below the assigned levels including the most stringent 35dB L_{A10} night period limit at all nearby host receiver and non-host receivers.

In accordance with the WA Noise Regulations, a +5 dB adjustment applies where noise levels at the receiver are found to have tonal characteristics. Noting the separation distances between the proposed BESS and substation and receivers, and the magnitude of the predicted noise levels, it is considered unlikely that tonality would be present at receivers.

Notwithstanding the above, should tonality present at receivers and a +5 dB adjustment was applied, compliance would still be demonstrated at all non-host receivers.

Other intrusive or dominant characteristics (modulation and impulsiveness) are not typically associated with BESS and substation equipment. In consideration of this and the other factors listed above, it is unlikely that these characteristics would be present at receivers and no adjustment have been applied.

9.0 PROJECT CUMULATIVE NOISE ASSESSMENT

The calculated noise levels due to the BESS and substation are more than 7 dB below the calculated noise levels from the wind turbines at all receivers. Cumulative noise from the project is therefore predominantly due to the noise of wind turbines, and the impact from the BESS and substation on the total received noise levels would be negligible in most cases.

The predicted cumulative noise levels at the nearest receivers within 4 km of BESS and substation are shown in Table 13.

Table 13: Predicted cumulative noise levels, receivers within 4 km, dB L_{Aeq}

Nearest receiver	Predicted noise level
Non-host receivers	
D78	33.7
D96	33.1
D95	31.8
Host receivers	
D77	41.1
D49	41.6

On the basis that the predicted L_{Aeq} noise levels are used for assessment purposes, as described in Section 4.4, the results in Table 13 shows that the predicted cumulative noise levels from the project are below the assessment criterion applicable for all receivers.

10.0 RECOMMENDED OPERATIONAL NOISE MANAGEMENT MEASURES

In order to appropriately manage operational noise from the project during subsequent stages of development, the following is recommended:

- The noise assessment criteria applicable to wind turbine noise should be reviewed and clarified, based on the policy requirements which apply at the detailed design stage of the project.
- The predicted operational wind turbine noise levels should be updated with final layout and sound power levels of the final wind turbine selected for the project to verify compliance with the nominated criteria.
- Where the updated assessment indicates a continued requirement for curtailment, the curtailment strategy should be updated accordingly.
- The predicted operational BESS and substation noise levels should be updated with the final site selection, design and sound power levels of the final equipment selection to verify compliance with the limits in accordance with the WA Noise Regulations.
- An operational noise management plan should be prepared which identifies how compliance with the project's operational noise limits will be demonstrated, including details of testing procedures and reporting time frames following commencement of operation of the project.
- Following construction, compliance monitoring should be conducted in accordance with the procedure outlined in the operational noise management plan including sound power testing of selected wind turbines and evaluation of tonality.

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

- Procurement contract: the procurement contract for the supply of wind turbines to the project will typically include specifications concerning the allowable total noise emissions from the wind turbine, and the permissible 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 turbines to be varied according to environmental constraints. Specifically, variable pitch wind turbines as proposed for the project include control functions which enable the noise emissions to be selectively controlled; by adjusting the pitch of the blade, the noise emissions 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.

11.0 CONCLUSION

An assessment of operational noise has been carried out for the proposed Twin Hill Wind Farm being developed by Twin Hills Wind Farm Pty Ltd. The assessment is based on the proposed project layout comprising 93 wind turbines, a BESS, and a substation.

Noise modelling was carried out based on a candidate wind turbine model (Vestas V162 6.8MW) which has been selected by the proponent as a typical example of the size and type of wind turbines that could be used for this project. The results demonstrate the predicted wind turbine noise levels from the project can achieve the proponents design objective and are below the base noise level component assessment criterion of 35 dB L_{ae} at all non-host receivers.

The assessment has also considered operational noise associated with the proposed BESS and substation. Predicted noise levels have been assessed in accordance with the WA Noise Regulations and demonstrate that the BESS and substation are predicted to comply with the most stringent assigned levels at all receivers. Noise from the BESS and substation was shown to have negligible impact on the receiver cumulative noise levels from the project and would not affect the outcomes of the wind turbine assessment.

The findings of this noise assessment indicates that it is feasible for the project to be designed and operated to satisfy the nominated criteria. The final noise limits applicable to the wind farm, based on the policy requirements which apply at the detailed design stage of the project, will need to be confirmed by the proponent. An updated assessment of compliance should then be conducted based on the final equipment selections and layout to assess compliance and inform the noise management plan for the wind farm, including any required noise mitigation strategies.

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
A-weighted 10th centile	The sound level exceeded for 10 % of the measurement period, calculated by statistical analysis	L_{A10}
A-weighted 1st centile	the sound level exceeded for 1 % of the measurement period, calculated by statistical analysis	L_{A1}
A-weighted 90th 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_{A90}
A-weighted average noise level	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.	L_{Aeq}
A-weighted maximum noise level	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.	L_{Amax}
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.
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.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Annoying characteristics	Annoying characteristics that are not fundamental to a typical well-maintained wind farm, as defined in the SA Guidelines. Such characteristics may include adverse mechanical noise (tonality), or higher degrees of amplitude modulation or low frequency noise.	-
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_A. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report, unless as part of direct quotes of external documents.

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
- 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 14 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 14: Atmospheric pressure versus sound pressure – example values of pressure

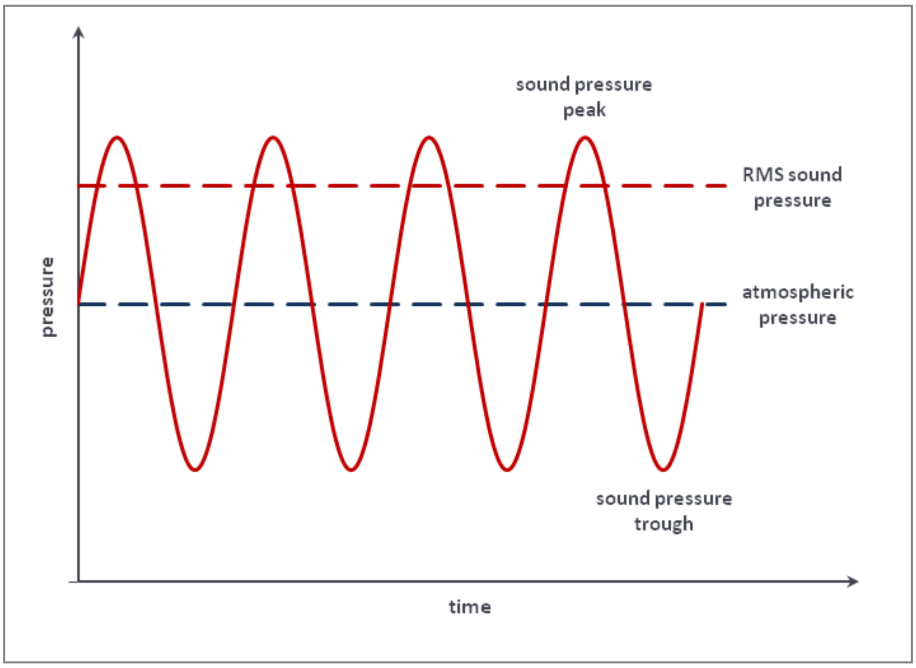
Example	Pascals	Bars	Pounds per Square Inch (PSI)
Atmospheric pressure	100,000	1	14.5
Pressure change due to weather front	10,000	0.1	1.5
Pressure change associated with sound at the threshold of pain	20	0.0002	0.003
Pressure change associated with sound at the threshold of hearing	0.00002	0.0000000002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

The pressure values in Table 14 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 decibels or dB.

To illustrate the pressure variation associated with sound, Figure 4 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 4: Pressure changes relative to atmospheric pressure associated with sound



B2.2 Frequency

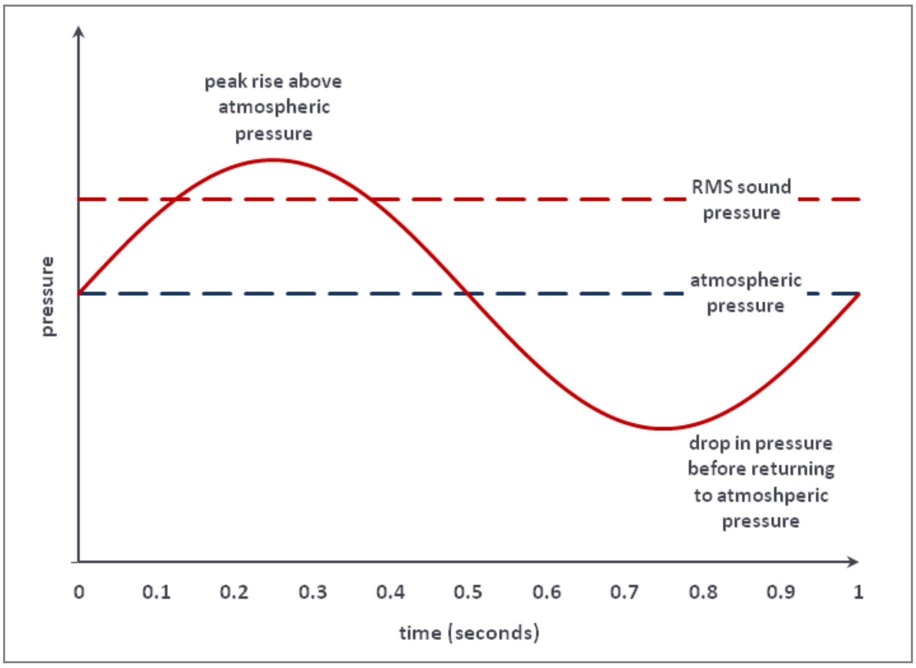
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period. The rate of change in pressure is an important feature that determines whether it can be perceived as a sound by the human ear.

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 Hertz (Hz). This concept of cycles per second is illustrated in Figure 5 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 5: Illustration of a pressure fluctuation with a frequency of 1 Hz



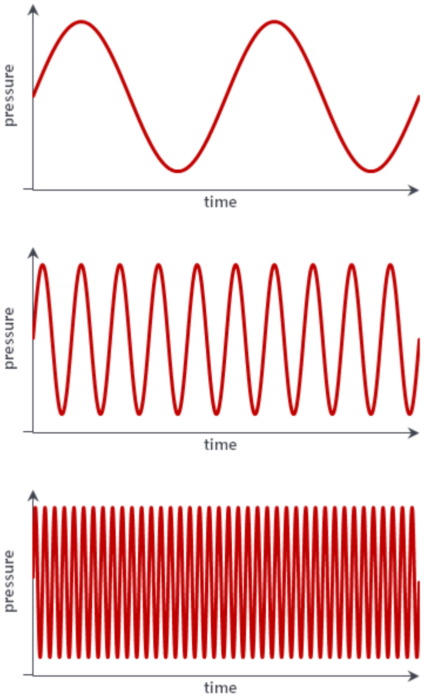
The rate that sound pressure rises and falls will vary depending on the source of the sound. For example, the surface of a tuning fork vibrates at a specific rate, in turn causing the pressure of the adjacent air to fluctuate at the same rate. Recalling the idea of pressure fluctuations from someone 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 6 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 6: Examples of the rate of change in pressure fluctuations for low, mid and high frequencies

Low frequency sounds: 20 to 200 Hz

Mid-frequency sounds: 200 to 800 Hz

High frequency sounds: greater than 800 Hz



B2.3 Sound pressure and frequency variations

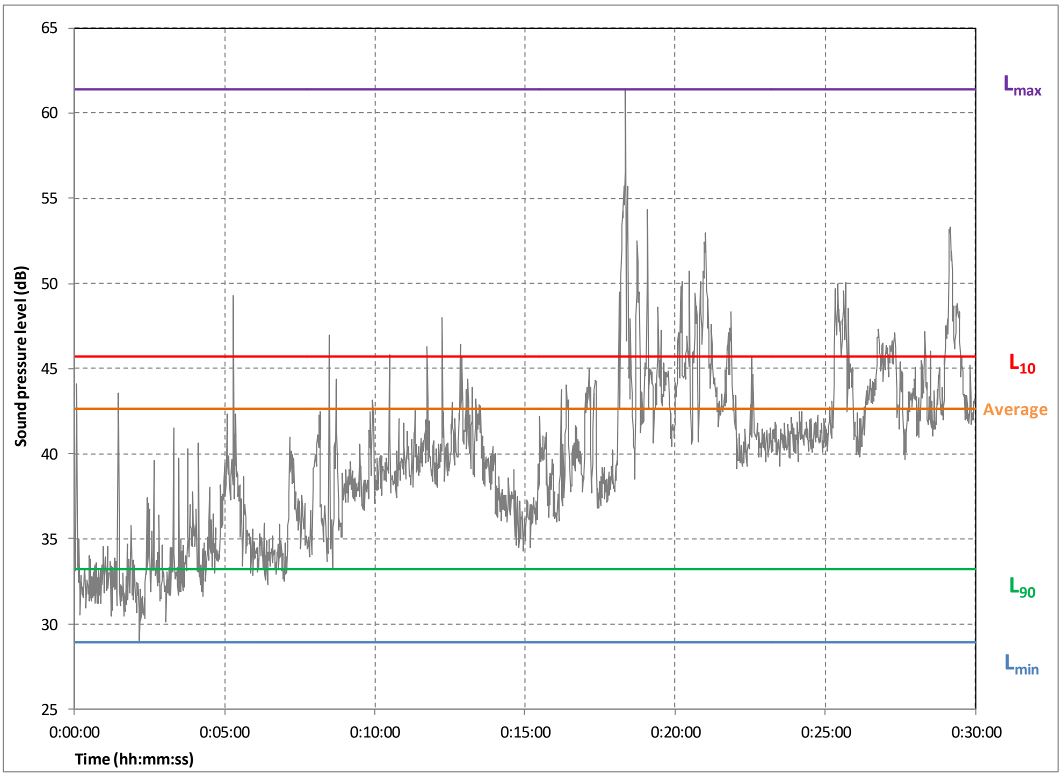
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

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 'broad band'. Common examples of broad band 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 7 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 7: 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
- 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 the decibel (dB). The decibel 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 decibel 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 15 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

Table 15: Example sound pressure levels that might be experienced in different environments

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

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 16 provides some examples of how changes in sound pressure levels, for a sound with the same character, can be perceived.

Table 16: Perceived changes in sound pressure levels

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

The example sound pressure level changes in Table 16 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.

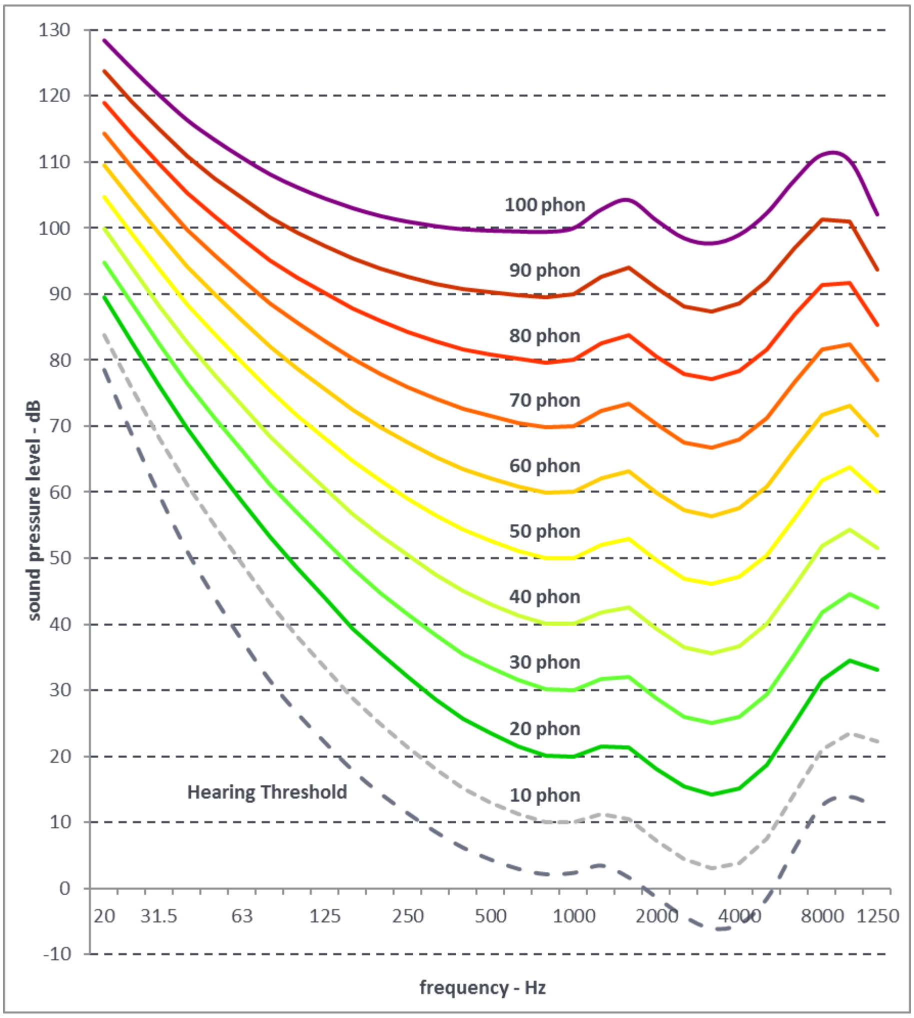
B3.2 Sound frequency and loudness

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 8. 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[10] that defines equal loudness levels for sounds comprising individual frequencies. 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 8 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.

[10] ISO 226:2003 *Acoustics - Normal equal-loudness-level contours*

Figure 8: Equal loudness contours for pure tone sounds



The noise curves in Figure 8 demonstrate that human hearing is most sensitive at frequencies from 500 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 INFRASTRUCTURE COORDINATES

C1 Wind turbine coordinates

Table 17 sets out the coordinates of the proposed wind turbine layout (Layout v056)

Table 17: Wind turbine coordinates (Layout v062) – CRS: GDA2020 MGA zone 50

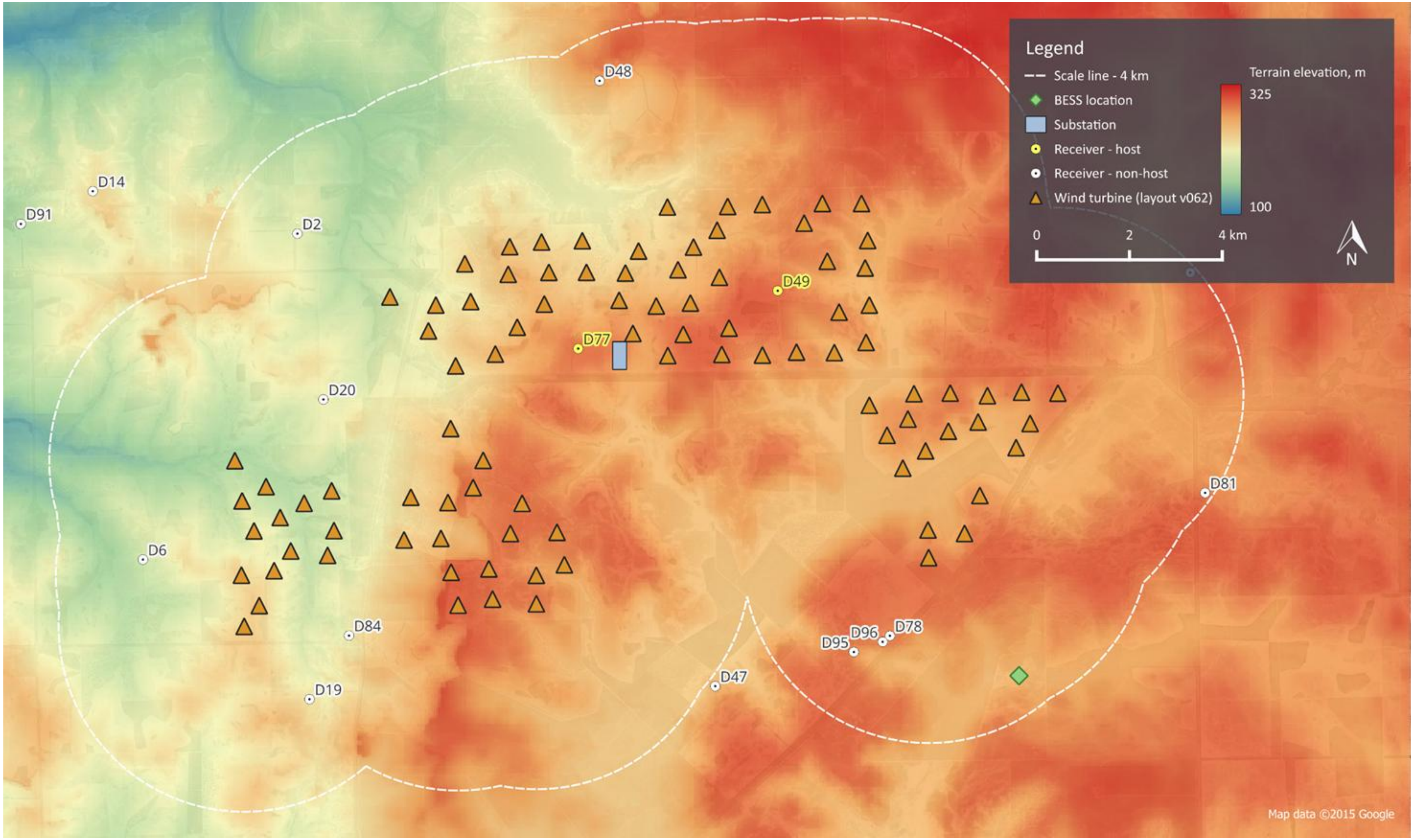
Turbine	Easting	Northing	Terrain elevation
T1	343,661	6,718,702	164
T2	343,803	6,716,231	236
T3	343,818	6,717,834	194
T4	343,863	6,715,127	238
T5	344,074	6,717,187	211
T6	344,187	6,715,574	242
T7	344,334	6,718,141	174
T8	344,507	6,716,329	220
T9	344,638	6,717,475	193
T10	344,866	6,716,753	197
T11	345,155	6,717,781	179
T12	345,661	6,716,657	192
T13	345,748	6,718,051	184
T14	345,797	6,717,191	196
T15	347,003	6,722,234	191
T16	347,308	6,716,991	241
T17	347,454	6,717,912	239
T18	347,834	6,721,500	221
T19	347,993	6,722,058	220
T20	348,102	6,717,025	249
T21	348,255	6,717,798	263
T22	348,312	6,719,394	243
T23	348,322	6,716,294	298
T24	348,420	6,720,746	223
T25	348,473	6,715,584	298
T26	348,618	6,722,949	233
T27	348,744	6,722,133	222
T28	348,796	6,718,120	288
T29	349,013	6,718,707	277

Turbine	Easting	Northing	Terrain elevation
T30	349,135	6,716,367	292
T31	349,216	6,715,715	289
T32	349,275	6,721,000	257
T33	349,553	6,722,721	254
T34	349,585	6,723,317	243
T35	349,601	6,717,130	292
T36	349,748	6,721,580	255
T37	349,853	6,717,781	291
T38	350,159	6,716,228	276
T39	350,160	6,715,613	286
T40	350,272	6,723,416	233
T41	350,331	6,722,080	263
T42	350,429	6,722,763	246
T43	350,605	6,717,155	286
T44	350,763	6,716,456	274
T45	351,150	6,723,445	227
T46	351,240	6,722,764	240
T47	351,943	6,722,161	262
T48	352,078	6,722,749	242
T49	352,240	6,721,445	274
T50	352,361	6,723,223	238
T51	352,744	6,722,037	272
T52	352,984	6,724,173	233
T53	352,992	6,720,967	283
T54	353,212	6,722,820	254
T55	353,325	6,721,425	295
T56	353,480	6,722,101	271
T57	353,546	6,723,309	250
T58	354,055	6,723,672	258
T59	354,105	6,722,656	273
T60	354,156	6,720,993	295
T61	354,283	6,724,185	266
T62	354,312	6,721,561	294

Turbine	Easting	Northing	Terrain elevation
T63	355,029	6,724,228	271
T64	355,032	6,720,978	276
T65	355,767	6,721,042	282
T66	355,931	6,723,825	281
T67	356,324	6,724,248	290
T68	356,430	6,723,003	279
T69	356,582	6,721,032	261
T70	356,684	6,721,905	279
T71	357,168	6,724,249	282
T72	357,246	6,722,858	263
T73	357,266	6,721,252	272
T74	357,300	6,723,451	268
T75	357,336	6,722,056	261
T76	357,336	6,719,895	257
T77	357,718	6,719,249	274
T78	358,058	6,718,540	260
T79	358,168	6,719,599	279
T80	358,298	6,720,145	265
T81	358,548	6,718,912	268
T82	358,600	6,717,206	275
T83	358,615	6,716,609	288
T84	359,039	6,719,336	269
T85	359,079	6,720,159	288
T86	359,388	6,717,131	277
T87	359,681	6,719,535	265
T88	359,718	6,717,949	278
T89	359,881	6,720,103	270
T90	360,498	6,718,982	261
T91	360,615	6,720,178	281
T92	360,801	6,719,502	274
T93	361,400	6,720,158	290

APPENDIX D SITE TOPOGRAPHY

Figure 9: Site topography (layout v062)



APPENDIX E RECEIVER COORDINATES

Table 18 sets out the 12 receivers identified by the Proponent within 4 km of the proposed wind turbines considered in the environmental noise assessment, together with their respective distance to the nearest wind turbine.

This includes 2 host receivers where a noise agreement has been formalised between the landowners and the Proponent to host turbines.

Data supplied by the Proponent on 29 January 2025 (LAN_TWH_Dwellings_v029.shp).

Table 18: Receivers within 4 km of the proposed wind turbines – GDA2020 MGA Zone 50

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Nearest wind turbine	Distance to the nearest wind turbine, m
Non-host receiver					
D2	345,008	6,723,597	200	T15	2,420
D6	341,681	6,716,566	191	T2	2,153
D19	345,270	6,713,554	227	T4	2,115
D20	345,569	6,720,021	209	T13	1,982
D48	351,521	6,726,894	266	T52	3,093
D51	364,253	6,722,756	299	T93	3,862
D78	357,779	6,714,922	283	T83	1,888
D81	364,573	6,718,006	285	T93	3,836
D84	346,121	6,714,926	216	T12	1,796
D95	357,002	6,714,573	279	T83	2,601
D96	357,624	6,714,791	281	T83	2,075
Host receiver					
D49	355,362	6,722,366	295	T68	1,251
D77	351,061	6,721,117	290	T41	1,216

APPENDIX F NOISE PREDICTION MODEL

In Australia, wind turbine noise predictions are typically calculated using ISO 9613-2:2024, Annex D.[11] The use of this ISO 9613-2 is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in NZS 6808:2010 Acoustics – Wind farm noise, the South Australian EPA Wind farms environmental noise planning guideline and the Queensland State code 23: Wind farm development – Planning guideline.

A computer model was created in the environmental noise modelling program SoundPLANnoise v9.1 to predict noise levels from the proposed development to relevant receptors in the vicinity of the subject site. The noise model has been used to calculate noise levels at the nearest receptors in accordance with ISO 9613-2.

The noise model enables the calculation of noise levels over a wide area, and accounts for key considerations including site arrangement, terrain, and atmospheric conditions.

The ISO 9613-2 standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions that are favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the wind blows from the source to the noise-affected premises within an angle of +/-45 degrees from a line connecting the source to the receptors, 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 the source to the receiver.

Accordingly, predictions based on ISO 9613-2 account for the instances when local atmospheric conditions at the site favour the propagation of sound to surrounding receptor locations. Under alternative atmospheric conditions, such as when the wind is blowing from a noise-affected premises location to the development site, the noise levels would be lower than calculated.

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

- geometric divergence;
- air absorption;
- reflecting obstacles;
- screening;
- vegetation; and
- ground reflections.

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 noise sensitive receptors.

[11] 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).

APPENDIX G TABULATED BACKGROUND NOISE LEVELS

Table 19: Background noise levels, dB L_{A90} – All-time period

Location	Hub height wind speed[1], m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D6 int	19.1	19.1	19.5	20.1	20.6	21.5	21.6	22.6	22.2	22.9	23.9	25.9	25.6
D20	20.1	20.3	21.7	24.1	26.5	28.5	28.7	29.6	30.2	32.4	34.3	36.6	35.4
D81 proxy	18.2	18.1	18.9	20.0	20.5	22.1	22.4	23.6	22.7	23.7	24.4	27.4	27.0
D84 proxy	25.4	26.4	26.0	26.8	27.8	29.7	29.8	30.4	30.6	31.0	32.7	34.3	32.8

[1] TWH02met mast at 351,867 E / 6,721,676N (GDA2020 MGA Zone 50)

Table 20: Background noise levels, dB L_{A90} – Night period

Location	Hub height wind speed[1], m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D6 int	18.7	18.5	18.7	19.0	19.0	19.1	19.4	19.6	20.2	21.4	22.2	22.0	22.5
D20	18.1	18.8	18.9	20.1	22.1	24.5	24.7	24.5	28.2	31.3	33.5	35.1	33.1
D81 proxy	16.9	17.1	16.8	17.1	17.1	17.6	19.2	19.6	19.6	21.6	22.2	23.7	25.1
D84 proxy	26.1	26.5	25.2	26.5	26.1	25.9	26.1	27.0	28.5	29.1	31.2	30.5	28.7

[1] TWH02met mast at 351,867 E / 6,721,676N (GDA2020 MGA Zone 50)

APPENDIX H ASSESSMENT CRITERIA – WIND TURBINES

The derived assessment criteria at the non-host receivers where monitoring was undertaken are summarised in Table 21.

While the assessment is based on the all-time period noise assessment criteria above, derived noise assessment criteria for the night period have been provided for reference in Table 22.

Assessment criteria have not been presented for the intermediate location (D6 int) on the basis that this monitoring location was not intended to be a proxy for receiver D6. Regardless, review of the background noise levels at this intermediate location (see Table 19 and Table 20 above) shows that the derived values would not exceed the base component of the assessment criteria anyway.

Table 21: Noise assessment criteria, dB L_{Aeq} – All-time period

Location	Hub height wind speed[1], m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D20	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.2	37.4	39.3	41.6	40.4
D81 proxy	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
D84 proxy	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.4	35.6	36.0	37.7	39.3	37.8

[1] TWH02met mast at 351,867 E / 6,721,676N (GDA2020 MGA Zone 50)

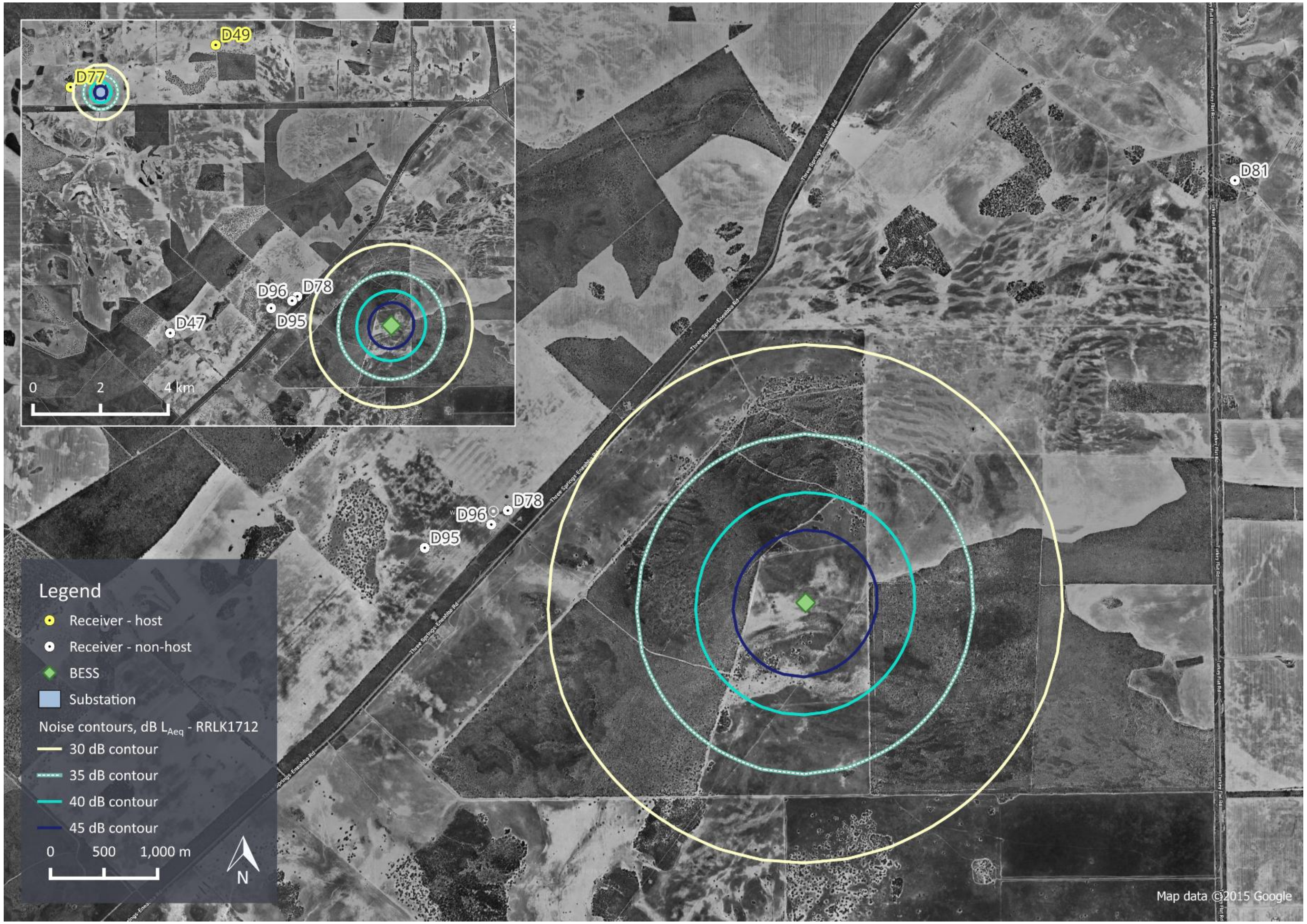
Table 22: Noise assessment criteria, dB L_{Aeq} –Night period

Location	Hub height wind speed[1], m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	15
D20	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.3	38.5	40.1	38.1
D81 proxy	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
D84 proxy	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.2	35.5	35.0

[1] TWH02met mast at 351,867 E / 6,721,676N (GDA2020 MGA Zone 50)

APPENDIX I BESS AND SUBSTATION PREDICTED NOISE LEVEL CONTOURS

Figure 10: BESS and substation predicted noise level contours



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[12] and public statements[13, 14] 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. 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[15] were made from this research.

> *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).*

12 *Systematic review of the human health effects of wind* farms 2013, Adelaide University, commissioned by the NMRC

13 NHMRC Information Paper: *Evidence on Wind Farms and Human Health*, February 2015, National Health and Medical Research Council

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

15 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*[16] which concluded:

> *In accordance with the prioritization process, the GDG set a guideline exposure level of 45.0 dB L_{den} 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 nighttime.*

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*[17], achieving compliance with NZS 6808 corresponds to noise levels that are consistent with the recommendations of the 2018 WHO European Noise Guidelines.

These findings lend support to the suitability of the wind farm noise controls applied in SA Guidelines, 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.

---

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

17 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 NSW Noise Assessment Bulletin states the following concerning infrasound:

> *there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans relating to infrasound.*

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[18]. 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 20Hz. 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 20Hz to 200Hz 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 120dB. 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.*

[18] 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[19] from Professor Styles:

> *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[20, 21] 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:

> *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*

---

19 *Keele University Rejects Renewable Energy Foundation's Low Frequency Noise Research Claims*

20 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

21 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

In 2010, the UK Health Protection Agency published a report[22] 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:

> *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 recent State Government of Victorian Department of Health document[23] concludes the following in relation to infrasound from wind farms:

> *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[24] addressing human health effects of wind farms which includes consideration of noise.

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.*

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.

---

[22] Health Protection Agency UK – *Health Effects of Exposure to Ultrasound and Infrasound – Report of the independent Advisory Group on Non-ionising Radiation* - 2010

[23] Public Statement: Wind Turbines and Health - July 2010

[24] *Information Paper - Evidence on Wind Farms and Human Health*, February 2015

APPENDIX K TABULATED PREDICTED NOISE LEVELS

Table 23: Predicted noise levels at non-host receivers within 4 km, dB L_{Aeq}

Receiver	Hub-height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	≥15
D2	20.3	20.3	20.3	21.3	24.6	27.8	29.6	29.6	29.7	30.1	30.4	30.6	30.8
D6	21.7	21.7	21.7	22.7	26.0	29.2	31.0	31.0	31.1	31.5	31.8	32.0	32.2
D19	21.1	21.1	21.1	22.1	25.4	28.6	30.4	30.4	30.5	30.9	31.2	31.4	31.6
D20	24.5	24.5	24.5	25.5	28.8	32.0	33.8	33.8	33.9	34.3	34.6	34.8	35.0
D48	21.3	21.3	21.3	22.3	25.6	28.8	30.6	30.6	30.7	31.1	31.4	31.6	31.8
D51	16.9	16.9	16.9	17.9	21.2	24.4	26.2	26.2	26.3	26.7	27.0	27.2	27.4
D78	21.9	21.9	21.9	22.9	26.2	29.4	31.2	31.2	31.3	31.7	32.0	32.2	32.4
D81	17.3	17.3	17.3	18.3	21.6	24.8	26.6	26.6	26.7	27.1	27.4	27.6	27.8
D84	24.5	24.5	24.5	25.5	28.8	32.0	33.8	33.8	33.9	34.3	34.6	34.8	35.0
D95	20.2	20.2	20.2	21.2	24.5	27.7	29.5	29.5	29.6	30.0	30.3	30.5	30.7
D96	21.3	21.3	21.3	22.3	25.6	28.8	30.6	30.6	30.7	31.1	31.4	31.6	31.8
D2	20.3	20.3	20.3	21.3	24.6	27.8	29.6	29.6	29.7	30.1	30.4	30.6	30.8

Table 24: Predicted noise levels at host receivers within 4 km, dB L_{Aeq}

Receiver	Hub-height wind speed, m/s												
	3	4	5	6	7	8	9	10	11	12	13	14	≥15
D49	31.1	31.1	31.1	32.1	35.4	38.6	40.4	40.4	40.5	40.9	41.2	41.4	41.6
D77	30.3	30.3	30.3	31.3	34.6	37.8	39.6	39.6	39.7	40.1	40.4	40.6	40.8