

APPENDIX G

Noise and Vibration Impact Assessment



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BURRENDONG WIND FARM
EIS NOISE ASSESSMENT
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Project: **Burrendong Wind Farm**

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EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with the Burrendong Wind Farm (the Project) that is proposed to be developed by Burrendong Wind Farm Pty Ltd (the Proponent).

The Project is proposed to comprise of up to seventy (70) Wind Turbine Generators (WTGs) and related infrastructure. The proposed related infrastructure relevant to the environmental noise assessment comprises one (1) collector substation with two (2) location options within the Project site.

The development application for the Project seeks permission to develop, construct and operate WTGs with a maximum tip height of 250 m. The actual WTG 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 noise sensitive locations (receivers). In advance of a final selection, the assessment considers a candidate WTG model that is representative of the size and type of WTG that could be used at the site. For this purpose, the Vestas V162-6.2MW model has been nominated by the Proponent for this assessment.

Operational noise from the proposed WTGs has been assessed in accordance with the NSW Government publication *Wind Energy: Noise Assessment Bulletin* (NSW Noise Assessment Bulletin) as required by the applicable Planning Secretary's Environmental Assessment Requirements (SSD-8950984), dated 13 October 2020.

A background noise monitoring survey was undertaken to obtain a representation of typical baseline conditions at locations in the vicinity of the Project and derive applicable noise limits for receivers, as defined by the NSW Noise Assessment Bulletin. The survey and results are detailed in MDA report Rp 003 r02 20200219 *Burrendong Wind Farm - Background Noise Assessment*, dated 15 September 2023 (Background Noise Report).

Manufacturer specifications for the candidate WTG model have been used as the basis for the assessment. The specifications for each WTG include noise emission data in accordance with the international standard¹ referenced in the NSW Noise Assessment Bulletin. The noise emission data used is consistent with the range of values expected for comparable types of multi megawatt WTG models that may be considered for the site.

The noise emission data has been used with international standard ISO 9613-2² to predict WTG noise levels at neighbouring receivers. 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 results of the noise modelling for the Project demonstrate that the predicted noise levels for the proposed WTG layout achieve the base (minimum) noise limit determined in accordance with the NSW Noise Assessment Bulletin at all but one (1) receiver. At receiver R14-1, WTG noise levels are predicted to be above the applicable noise limits by up to 1.0 dB. An example curtailment strategy has been developed to demonstrate compliance with the NSW Noise Assessment Bulletin, using sound optimised modes for a limited range of wind conditions.

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

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

To assess compliance with the applicable noise limits, the NSW Noise Assessment Bulletin requires consideration of potential adjustments to the predicted WTG noise levels for special noise characteristics, comprising tonality and low frequency. Analysis of the noise emission frequency data for the candidate WTG model indicates the noise of the Project is not expected to be characterised by tonality. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical. Indicative unconstrained noise modelling also demonstrated that the Project is predicted to result in noise levels below 60 dB L_{Ceq} at all assessed non-associated receivers (the threshold defined by the NSW Noise Assessment Bulletin for the presence of low frequency). Accordingly, adjustments for special noise characteristics were not warranted and have therefore not been applied to the predicted noise levels.

The assessment results also demonstrate that cumulative noise considerations between the Project and the nearby Ungula Wind Farm can be practically managed. Specifically, it was demonstrated that cumulative wind farm noise levels do not affect the compliance outcomes for either of the assessed projects.

The assessment has also considered operational noise from the proposed related infrastructure comprising a collector substation with two (2) location options. Predicted noise levels associated with the substation have been assessed in accordance with the NSW EPA *Noise Policy for Industry*. The assessment demonstrates that the related infrastructure is predicted to be substantially below the most stringent night-time project noise trigger level at all receivers.

The findings of the operational noise assessment therefore demonstrated support that the Project can be designed and operated to comply with NSW requirements for both WTG noise and the related infrastructure. Prior to construction of the Project, the predicted noise levels are recommended to be updated for the final Project configuration and equipment selections in order to verify compliance with the criteria.

Consistent with the NSW Noise Assessment Bulletin, compliance is also recommended to be verified by post-construction noise compliance monitoring. The compliance testing procedures should be documented in an operational noise management plan. Given the size of the Project, the compliance testing regime to be documented in the operational noise management plan is recommended to include provisions for early onsite noise emission testing of the WTGs to verify consistency with the design validation modelling.

A preliminary construction noise and vibration assessment has also been conducted, accounting for typical equipment items and work practices, as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the NSW DECC publications *Interim Construction Noise Guideline* and *Assessing Vibration: A Technical Guideline* and confirmed that construction noise and vibration can be appropriately managed using standard good practice measures. An assessment of traffic noise impacts associated with construction operations has been conducted in accordance with the NSW EPA *Road Noise Policy*.

Measures for the management of construction noise and vibration would be implemented via a Construction Noise and Vibration Management Plan to be prepared at a later stage of the Project, when a construction contractor has been selected and specialised construction planning for the Site has been developed. This would comprise a detailed noise and vibration assessment, including consideration for blasting and construction traffic.

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1.0 INTRODUCTION

Burrendong Wind Farm Pty Ltd (the Proponent), proposes to develop the Burrendong Wind Farm (the Project) comprising up to seventy (70) Wind Turbine Generators (WTGs) and related infrastructure. Throughout this report, the term Project refers to both the WTGs and the related infrastructure.

This report presents the results of an assessment of operational and construction noise for the proposed Project undertaken in accordance with the applicable Planning Secretary's Environmental Assessment Requirements (SSD-8950984), dated 13 October 2020 (SEARs), and the publications referenced within.

The assessment of operational noise associated with the WTGs has been undertaken in accordance with the NSW EPA³ *NSW Wind Energy: Noise Assessment Bulletin* dated December 2016 (NSW Noise Assessment Bulletin) as required by the SEARs.

Noise associated with the operation of the proposed related infrastructure has been assessed in accordance with the NSW EPA *Noise Policy for Industry 2017* (NPfI) as required by the SEARs.

The noise assessment presented in this report is based on:

- Operational noise limits determined in accordance with applicable regulatory documentation;
- Predicted WTG noise levels, based on the proposed site layout and a candidate WTG model; and
- Predicted noise levels from the related infrastructure, based on assumed noise emission data.

As required by the NSW Noise Assessment Bulletin, background noise data has been acquired at representative receivers throughout the site. The background noise monitoring was undertaken as an element of the noise studies associated with the Project's development application to obtain a representation of typical baseline conditions at receivers in the vicinity of the Project and derive applicable noise limits.

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

General information about the definition of sound and the ways that different sound characteristics are described is presented in Appendix B.

³ Environment Protection Authority

2.0 PROJECT OVERVIEW

The Project is proposed to be located approximately 30 km south-east of Wellington and to the east of Lake Burrendong in New South Wales.

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

- Up to seventy (70) WTGs with a maximum tip height of 250 metres and a hardstand area at the base of each WTG
- Electrical infrastructure, including:
 - One (1) collector substation with two (2) location options within the Project site; and
 - Combination of underground cabling and overhead powerlines.
- Other permanent on-site ancillary infrastructure:
 - permanent operation and maintenance facilities; and
 - up to four (4) meteorological masts.
- Access track network:
 - access and egress points from public roads; and
 - operational access tracks on private property.
- Temporary construction ancillary facilities:
 - construction compounds;
 - laydown areas; and
 - concrete batching plant.

The coordinates of the WTGs are presented in tabular format in Appendix C and the proposed candidate WTG model is shown in Section 6.2.

A site layout plan illustrating the WTG layout, related infrastructure and receivers is provided in Figure 1.

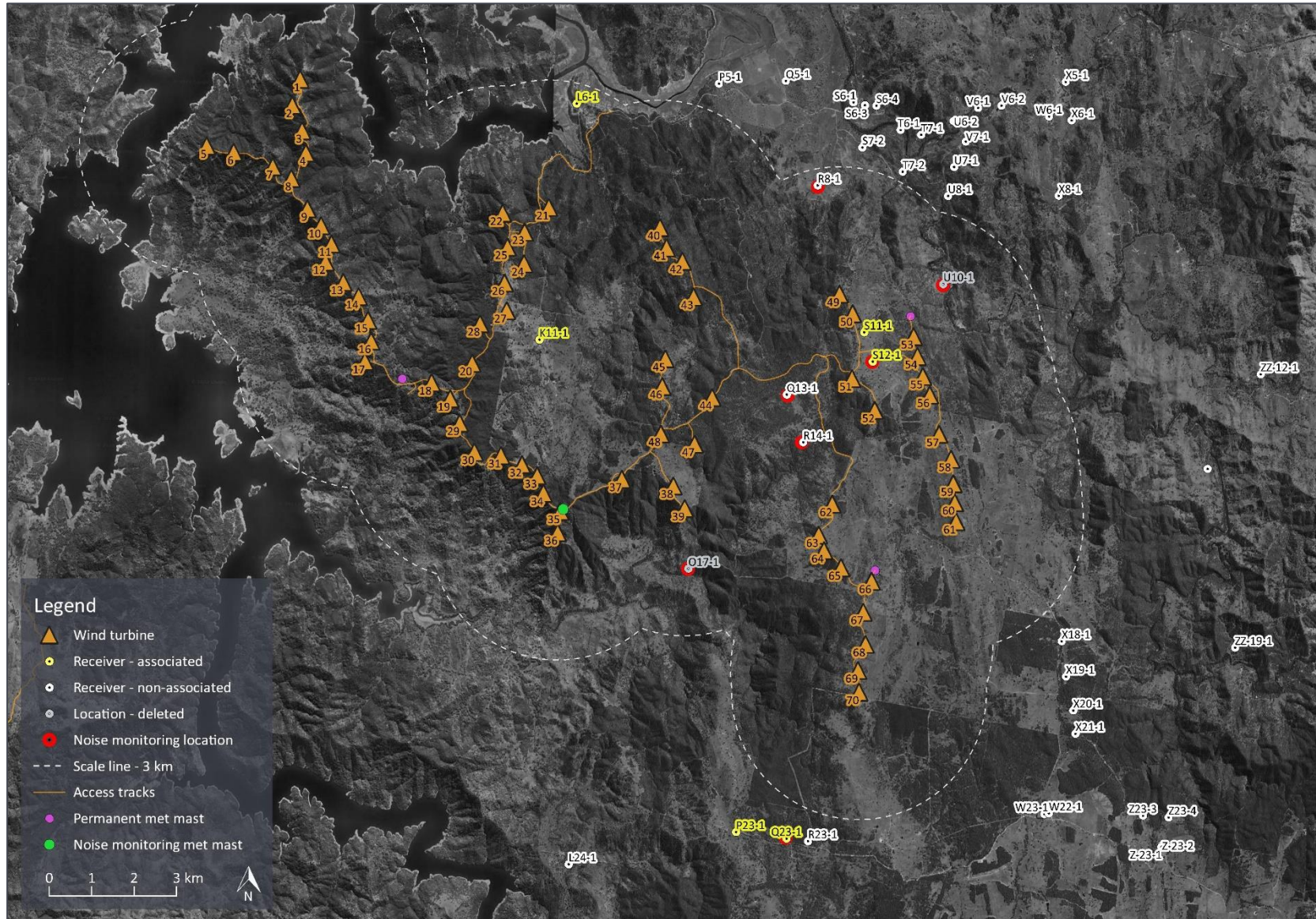
The topography of the site and surrounding area is depicted in the elevation map provided in Appendix D.

A total of seven (7) noise sensitive locations (receivers) have been identified by the Proponent within 3 km of the Project. Four (4) of the receiver are classed as *associated receivers*, where a noise agreement has been formalised between the landowners and the Proponent. The remaining three (3) receivers within 3 km of a WTG, without an agreement with the Proponent, are referred to as *non-associated receivers*.

Locations O17-1 and U10-1 were previously identified as receivers however as part of updated ground truthing these are no longer understood to be dwellings. On this basis these locations are not classed as receivers under the NSW Noise Assessment Bulletin and have been removed from the assessment. The locations are included in Figure 1 for completeness as background noise monitoring has been carried out. Further details are provided in the Background Noise Report.

The coordinates of the receivers identified within 3 km of the Project are tabulated in Appendix E.

Figure 1: Site layout



3.0 NEW SOUTH WALES POLICY & GUIDELINES

Based on the requirements specified in the project SEARs, the following publications are relevant to the assessment of operational and construction noise from proposed wind farm developments in NSW:

- NSW DPE⁴ publication *NSW Wind Energy: Noise Assessment Bulletin*, dated December 2016 (NSW Noise Assessment Bulletin);
- NSW EPA publication *Noise Policy for Industry*, dated 2017 (NPfi);
- NSW DECC⁵ publication *Interim Construction Noise Guideline*, dated 2009 (ICNG);
- NSW DECCW⁶ publication *NSW Road Noise Policy*, dated 2011 (RNP); and
- NSW DECC publication *Assessing Vibration: A Technical Guideline*, dated 2006 (AVTG).

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

3.1 NSW Noise Assessment Bulletin

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

The NSW Noise Assessment Bulletin specifies that the assessment of WTG noise is to be conducted in accordance with the South Australia EPA *Wind farms environmental noise guidelines*, dated July 2009 (SA Guideline), subject to a set of supplementary procedures that are specific to NSW. The variations relate to:

- *Noise limits*: selection of a lower base noise limit in all areas of NSW, in recognition that the regional areas of NSW with high quality wind resources are more populated than the equivalent regions in South Australia;
- *Special noise characteristics*: definition of additional procedures and establishing low frequency as an assessable characteristic; and
- *Noise monitoring*: definition of additional technical procedures, including the use of alternative/intermediate noise monitoring locations for compliance monitoring.

The elements of the NSW Noise Assessment Bulletin that are applicable to the current planning stage assessment are described in further detail below.

⁴ The former Department of Planning and Environment (DPE), now the Department of Planning, Industry and Environment (DPIE)

⁵ The former Department of Environment and Climate Change, now the DPIE

⁶ The former Department of Environment, Climate Change and Water, now the DPIE

3.1.1 Noise limits

In relation to noise limits, the variation defined in the NSW Noise Assessment Bulletin sets the base criterion at a value of 35 dB for all projects, in lieu of the 35 to 40 dB base criterion range defined in the SA Guideline. The criteria in the NSW Noise Assessment Bulletin are subsequently defined as follows:

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

** Determined in accordance with SA 2009, Section 4.*

The NSW Noise Assessment Bulletin notes the following in relation to the types of receivers where the noise limits apply:

The criteria in this Bulletin have been developed to address potential noise impacts on the amenity of residents and other relevant receivers in the vicinity of a proposed wind energy project. Wind energy proponents commonly negotiate agreements with private land owners where applicable noise limits may not be achievable at relevant receiver locations. A negotiated agreement will be considered as part of the assessment of a wind energy project, as will the requirements of SA 2009 and this Bulletin. The proponent's EIS should clearly identify the expected noise levels at all receiver locations including host properties to ensure that affected persons are appropriately informed regarding the development proposal.

Accordingly, the NSW Noise Assessment Bulletin noise limits only apply to non-associated receivers. Associated receivers are discussed in Section 3.1.4.

3.1.2 Tonality

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

The SA Guideline requires that development applications for wind energy projects report the following:

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

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

Under the NSW Noise Assessment Bulletin, in addition to the above requirements, tonality is also assessed using the method described in Annex D of ISO 1996.2: 2007 *Acoustics - Description, measurement and assessment of environmental noise – Determination of environmental noise levels* for the assessment of tonality.

Tonality is defined as when the level of a one-third octave band (with the descriptor in accordance with the SA Guideline), exceeds the level of the adjacent bands on both sides by:

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

If tonality is found to be a repeated characteristic of the candidate WTG, 5 dB is to be added to the predicted or measured WTG noise levels. Note that 5 dB is the maximum penalty that may be applied for special noise characteristics, irrespective of whether one or more characteristics are present.

3.1.3 Low frequency noise

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

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

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

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

In the unlikely event that excessive low frequency noise is found to be a repeated characteristic of the WTG noise, 5 dB is to be added to the predicted or measured WTG noise levels. An assessment of C-weighted WTG noise levels must be undertaken against the 60 dB L_{Ceq} criteria at non-associated receivers in the vicinity of the Project. Note that 5 dB is the maximum penalty that may be applied for special noise characteristics, irrespective of whether one or more characteristics are present.

3.1.4 Associated receivers

The NSW Noise Assessment Bulletin also requires noise levels to be predicted for associated receivers, i.e. host properties and receivers where a noise agreement is in place with the Proponent.

The SA Guideline provides guidance with respect to acceptable levels for *financial stakeholders*, presenting a base reference level of 45 dB L_{Aeq} for associated receivers, in order to provide context to the predicted noise levels for these locations.

Comparisons between the predicted noise levels and the 45 dB reference level are provided for informative purposes only. Noise levels at associated receivers will ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the landowners.

3.2 Noise Policy for Industry

The NPfl is the applicable guideline for assessing operational noise associated with the proposed related infrastructure i.e. the collector substation.

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

The project noise trigger levels are derived from an analysis of the background noise environment and zoning information, accounting for amenity-based criteria and, in the case of residential receivers, intrusiveness criteria. The project noise trigger levels are defined as the minimum of the intrusiveness noise levels and the amenity noise levels.

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

Additional criteria are defined for assessing the potential for sleep disturbance from noise sources that are characterised by transient events which result in brief periods of increased noise levels.

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

3.2.1 Amenity noise levels

The amenity noise assessment is designed to prevent industrial noise continually increasing above an acceptable level. The NPfl provides recommended amenity noise levels based on receiver categories and typical planning zones.

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

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

3.2.2 Intrusiveness noise levels

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

The intrusiveness noise level is the RBL at the nearest noise sensitive location plus 5 dB. Therefore, the noise emissions from the premises are considered to be intrusive if the source noise level ($L_{Aeq, 15 \text{ min}}$) is greater than the background noise level (L_{A90}) plus 5 dB.

3.3 Interim Construction Noise Guideline

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

The ICNG recommended standard hours detailed in Table 1.

Table 1: Interim Construction Noise Guideline recommended standard hours of work

Work type	Recommended standard hours of work
Normal construction	Monday to Friday 0700 to 1800 hrs Saturdays 0800 to 1300 hrs No work on Sundays or public holidays
Blasting	Monday to Friday 0900 to 1700 hrs Saturday 0900 to 1300 hrs No blasting on Sundays or public holidays

The ICNG defines criteria in the form of management levels for both residential and non-residential receiver types.

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

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

Where noise from construction works is above the residential noise affected level, all feasible and reasonable work practices should be applied. Where the noise from construction works is above highly affected level for residential receivers, restrictions to the hours of construction may be required. The ICNG also defines the following five categories of works that might be undertaken outside the recommended standard hours are:

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

The ICNG defines additional assessment and reporting requirements that apply if out of hours work is proposed, including justification of the need to work during these periods.

The ICNG also provides additional criteria for ground borne noise from construction vibration, applicable during the evening and night periods only. As construction is not expected to occur during these periods, ground borne noise is not considered in this assessment.

3.4 Road Noise Policy

The project SEARs indicates that additional traffic on public roads due to construction and operation of the Project must be assessed against the requirements of the NSW *Road Noise Policy* (RNP) and relevant application notes.

The RNP provides noise level criteria for increased traffic flow as a result of a land-use development with the potential to create additional traffic, as detailed in Table 2.

Table 2: Road traffic noise assessment criteria for residential land uses

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

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

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

Where night-time construction traffic is likely to occur, an assessment of sleep disturbance is appropriate. The RNP provides guidance on this matter:

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

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

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

3.5 Assessing Vibration: A Technical Guideline

The Project SEARs stipulate that vibration related to construction and operation of the proposed Project should be assessed in accordance with NSW DECC publication *Assessing Vibration: A Technical Guideline* dated, dated 2006 (AVTG).

The AVTG presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. Preferred and maximum vibration values outlined in the AVTG are taken from British Standard 6472:1992 *Evaluation of human exposure to vibration in buildings (1-80 Hz)* (BS 6472).

The AVTG identifies three vibration categories:

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

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

3.5.1 Intermittent vibration

The vibration characteristics of most construction activities (e.g. excavation and pilling) are considered to be intermittent. Intermittent vibration can be defined as interrupted periods of continuous vibration (e.g. heavy truck pass-bys or rock breaking) or continuous periods of impulsive vibration (e.g. impact pile driving). Higher vibration levels are allowed for intermittent vibration compared with continuous vibration on the basis that the higher levels occur over a shorter time period. Hence, for intermittent vibration, human disturbance vibration levels are assessed on the basis of the Vibration Dose Value (VDV), based on the level and the duration of the vibration events. Vibration criteria applicable to residential receivers for intermittent vibration sources are summarised in Table 3.

Table 3: Preferred and maximum vibration levels for human disturbance limits, VDV ^[2]

Assessment period ^[1]	Preferred value	Maximum value
Daytime	0.20	0.40
Night-time	0.13	0.26

^[1] Daytime is 0700 hr to 2200 hr and night-time is 2200 hr to 0700 hr

^[2] These values are only indicative, and there may be a need to assess to other sensitive areas against the relevant criteria.

3.5.2 Continuous and impulsive vibration

Vibration criteria applicable to the residential receivers in the vicinity of the Site for continuous and impulsive vibration sources, are summarised in Table 4.

Table 4: Preferred and maximum vibration levels for human disturbance limits, m/s^[2]

Vibration type	Assessment period ^[1]	Preferred values		Maximum values	
		Z axis	X and Y axes	Z axis	X and Y axes
Continuous vibration	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Impulsive vibration	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14

^[1] Daytime is 0700 hr to 2200 hr and night-time is 2200 hr to 0700 hr

^[2] The preferred and maximum values are weighted RMS acceleration values. These values are only indicative, and there may be a need to assess to other sensitive areas against the relevant criteria.

3.5.3 Blasting

Blast-induced vibration effects are assessed using the Australian and New Zealand Environment Council report *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, dated September 1990 (ANZEC 1990 Report).

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

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

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

The recommended criteria specified in the report are as follows:

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

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

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

4.0 NOISE PREDICTION METHOD

4.1 Operational noise

Operational Project noise levels are predicted using:

- noise emission data for the WTGs and related infrastructure equipment;
- a 3D digital model of the Site and the surrounding environment; and
- international standards used for the calculation of environmental sound propagation.

The method selected to predict noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by the SA Guideline (referenced in the NSW Noise Assessment Bulletin) and has been shown to provide a reliable method of predicting the typical upper levels of the noise expected to occur in practice.

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

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

Table 5: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.2
Method	<p>International Standard ISO 9613-2:1996 <i>Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation</i> (ISO 9613-2).</p> <p>Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication <i>A good practice guide to the application of ETSU-R-97 for the assessment and rating of WTG noise</i> (the UK Institute of Acoustics guidance).</p> <p>The adjustments are applied within the SoundPLAN modelling software and relate to the influence of terrain screening and ground effects on sound propagation.</p> <p>Specific details of adjustments are noted below and are discussed in Appendix F.</p>
Source characterisation	<p>Each source of operational noise is modelled as a point source of sound.</p> <p>The total sound of the component of the Project being modelled (i.e. the WTGs or the related infrastructure) is then calculated on the basis of simultaneous operation of all elements (e.g. all WTGs) and summing the contribution of each.</p> <p>To model the WTG components of the Project, the following specific procedures are noted:</p> <ul style="list-style-type: none"> • Calculations of WTG 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 WTG. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each WTG. Further discussion of terrain screening effects is provided below.
Terrain data	10 m resolution throughout the Project Site provided by the Proponent.

Detail	Description
Terrain effects (WTG-specific procedures)	<p>Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F.</p> <p>Valley effects: +3 dB is applied to the calculated noise level of a WTG when a significant valley exists between the WTG and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the WTG and calculation point is 50 % greater than would occur if the ground were flat.</p> <p>Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the WTG and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB.</p> <p>The Project is located in a hilly area characterised by significant variations in ground elevation between the WTGs and surrounding receivers. These terrain characteristics were sufficient to result in the application of adjustments to the predicted noise levels. Specifically, based on comparison of predicted noise levels with and without terrain elevation data included, terrain effects are predicted between -1.3 dB and +2.3 dB.</p> <p>For reference purposes, the ground elevations at the WTG and receivers are tabled in Appendix C and Appendix E respectively.</p> <p>The topography of the Site is depicted in the elevation map provided in Appendix D.</p>
Ground conditions	<p>Ground factor of $G = 0.5$ on the basis of the UK IOA Good Practice Guide and research outlined in Appendix F.</p> <p>The ground around the Site corresponds to acoustically soft conditions ($G = 1$) according to ISO 9613-2. The adopted value of $G = 0.5$ assumes that 50 % of the ground cover is acoustically hard ($G = 0$) to account for variations in ground porosity and provide a cautious representation of ground effects.</p>
Atmospheric conditions	<p>Temperature 10 °C and relative humidity 80 %</p> <p>These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance and the SA Guideline.</p> <p>The calculations are based on sound speed profiles⁷ which increase the propagation of sound from each WTG to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point.</p> <p>The primary consideration for wind farm noise assessment is wind speed and direction.</p> <p>The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every WTG at the Site. 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 WTG and the approach is therefore conservative in these instances.</p>

⁷ The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

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

4.2 Construction noise

Predicted noise levels have been calculated in general accordance with the method detailed in Australian Standard 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* (AS 2436). This method enables the prediction of noise levels for sound propagation over hard or soft ground but does not provide the ability to calculate predicted noise levels for mixed ground cover with varied soil conditions. The standard also notes that caution must be applied when considering predicted noise levels at distances beyond 100 m. For these reasons, predicted noise levels have been determined as the arithmetic average of the hard and soft ground prediction methods.

This approach is broadly consistent with the equivalent prediction procedure in British Standard 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites: Noise* (BS 5228, referenced in AS 2436), and provides a margin of caution with respect to ground conditions for the typical magnitude of separating distances between construction activities and neighbouring sensitive receivers.

5.0 EXISTING NOISE ENVIRONMENT

5.1 Policy

5.1.1 NSW Noise Assessment Bulletin

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

The procedures for determining background noise levels for the assessment of WTGs are defined in the SA Guideline, which is adopted by the NSW Noise Assessment Bulletin. Background noise levels are considered in terms of $L_{A90, 10 \text{ min}}$.

The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 3.1 of the SA Guideline 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 Guideline therefore comprises:

- preliminary WTG noise predictions to identify all receivers where predicted noise levels are higher than 35 dB L_{Aeq} ; and
- 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 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 WTGs. This trend defines the value of the background noise for the different wind speeds at which the WTGs will operate. At the wind speeds when the value of the background noise is above 30 dB L_{A90} , the background noise levels are used to set the noise limits for the Project.

5.1.2 Noise Policy for Industry and Interim Construction Noise Guideline

Criteria applicable to related infrastructure noise and construction noise assessment also consider background noise levels measured on Site.

Contrary to the descriptor used for background noise assessment under the NSW Noise Assessment Bulletin, background noise levels in the NPfl and ICNG, referred to as rating background noise levels, are assessed in terms of $L_{A90, 15 \text{ min}}$.

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

5.2 Background noise levels

5.2.1 NSW Noise Assessment Bulletin

Preliminary noise modelling of an earlier Project layout, summarised in MDA report Rp 001 20200219 *Burrendong - Preliminary noise assessment*, dated 6 August 2020 (the preliminary noise report), indicated that background noise monitoring would be required to inform a detailed assessment in accordance with the NSW Noise Assessment Bulletin.

The background noise monitoring locations were proposed based on proximity to WTGs, the location of receivers, and the predicted noise contours detailed in the preliminary noise report. Background noise monitoring was subsequently conducted at seven (7) receivers in the vicinity of the proposed Project between December 2021 and March 2022.

Analysis and results of the survey are detailed in MDA report Rp 003 r02 20200219 *Burrendong Wind Farm - Background Noise Assessment*, dated 22 August 2023 (Background Noise Report).

Prior to the construction of the Project, background noise monitoring may be undertaken at additional receivers, should this be deemed appropriate.

A summary of background noise levels determined in accordance with the SA Guideline, as adopted by the NSW Noise Assessment Bulletin, 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.

5.2.2 Noise Policy for Industry and Interim Construction Noise Guideline

Review of measured background noise levels for the Project shows that L_{A90} noise levels during the day, evening and night periods are typically below 30 dB L_{A90} for extended periods at low wind speeds.

The NPfl recognises that very low background noise levels, particularly at night, can present challenges with the derivation of reasonable assessment criteria. Table 2.1 of the NPfl provides minimum assumed rating background noise levels which are summarised in Table 6.

These minimum levels are used for derivation of the NPfl project noise trigger levels in Section 7.1 and ICNG management levels in Section 9.0.

Table 6: Minimum assumed rating background noise levels for NPfl and ICNG, dB L_{A90}

Time of day	Minimum assumed RBL
Day	35
Evening	30
Night	30

Time of day is defined as:

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

6.0 WIND TURBINE ASSESSMENT

6.1 Noise limits

6.1.1 Non-associated receivers

At non-associated receivers, the applicable noise limit in accordance with the NSW Noise Assessment Bulletin is 35 dB L_{A90} or background $L_{A90} + 5$ dB, whichever is higher.

Based on the background noise levels detailed in Table 6 of Section 5.1, applicable noise limits at the non-associated receivers where monitoring was undertaken are summarised in Appendix H.

6.1.2 Associated receivers

As detailed in Section 3.1.4, a base reference level of 45 dB L_{Aeq} is applied to all associated receivers. Comparisons between the predicted noise levels and the 45 dB reference level are provided for informative purposes only. Noise levels at these locations will ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the landowners.

6.2 Candidate WTG model

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

Accordingly, to assess the proposed Project at this stage in the Project, it is necessary to consider a candidate WTG model that is representative of the size and type of WTGs being considered. The purpose of the candidate WTG model is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of WTGs being considered for the Site.

For this assessment, the Proponent has considered the candidate WTG model detailed in Table 7.

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

Table 7: Candidate WTG model specifications

Item	Detail
Make	Vestas
Model	V162-6.2MW
Rated power, MW	6.2
Rotor diameter, m	162
Modelled hub height, m	149
Operating mode	PO6200
Serrated trailing edge	Yes
Highest sound power, dB L_{WA}	105.8

Unless specified otherwise, this assessment has been based on all WTG models using unconstrained generation modes (i.e. no sound optimised operating modes) and with blade serrations. Blade serrations are now routinely used to reduce WTG noise emissions, and we understand that their use is now the market standard for WTGs being offered in the Australian market.

A range of sound optimised modes are also available reducing the maximum power output and sound power levels.

6.3 WTG noise emissions

6.3.1 Sound power levels

The noise emissions of a WTG 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 WTG and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the WTG.

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

- 0105-5200_00 *Third octave noise emission EnVentus™ V162-6.2MW* dated 21 April 2021 (unconstrained operation); and
- 0079-5298_01 *V162-5.6MW Third octave noise emission* dated 23 January 2019 (sound optimised modes).

Based on the data sourced from the above specification, the noise modelling conducted for this assessment involved conversion of third octave band levels to octave band levels and adjustment by addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The overall A-weighted sound power levels (including the +1 dB addition) as a function of hub height wind speed are presented in Table 8.

Table 8: Sound power levels versus hub height wind speed, dB L_{WA}

Operating mode	Power output, MW	Hub height wind speed, m/s								
		4	5	6	7	8	9	10	11	≥12
PO6200	6.2	95.1	95.3	97.2	100.2	103.0	105.3	105.8	105.8	105.8
Mode 0	5.6	94.7	95.3	98.3	101.2	103.9	105.0	105.0	105.0	105.0
SO2	5.0	94.7	95.3	98.3	101.2	103.0	103.0	103.0	103.0	103.0
SO3	4.8	94.7	95.3	98.3	101.2	102.0	102.0	102.0	102.0	102.0
SO4	4.6	94.7	95.3	98.3	100.7	101.0	101.0	101.0	101.0	101.0

Note: Other sound optimised modes are available

The reference octave band values used as the basis for this assessment are presented in Table 9 and were adjusted to the overall A-weighted noise levels detailed in Table 8.

Table 9: Octave band sound power levels, dB L_{WA}

Operating mode	Octave band centre frequency, Hz									Total
	31.5	63	125	250	500	1000	2000	4000	8000	
PO6200 ^[1]	76.7	87.1	94.6	99.2	100.9	99.8	95.7	88.8	79.0	105.8

^[1] Based on one-third octave band levels at 10 m/s

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

A review of available sound power data for a range of WTG models has shown that there is no clear relationship between WTG size or power output and the noise emission characteristics of a given WTG model. In practice, the overall noise emissions of a WTG are dependent on a range of factors, including the WTG size and power output, and other important factors such as the blade design and rotational speed of the WTG. Therefore, while WTG sizes and power ratings of contemporary WTGs have increased, the noise emissions of the WTGs are comparable to, or lower than, previous generations of WTGs as a result of design improvements (notably, measures to reduce the speed of rotation of the WTGs, and enhanced blade design features such as serrations for noise control).

6.3.2 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 Guideline) is presently unavailable for the candidate WTG model. However, the occurrence of tonality in the noise of contemporary multi-megawatt WTG designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Further, the third octave band data detailed in the manufacturer's specification has been assessed against the additional tonality test prescribed in the NSW Noise Assessment Bulletin (detailed in Section 3.1.2). This test did not indicate the presence of tonality at any of the available hub height wind speeds.

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

6.3.3 Low frequency noise

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

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

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

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

6.4 Predicted noise levels

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

Predicted noise levels are presented in Table 10 for non-associated receivers and Table 11 for associated receivers.

The predicted noise levels are for conditions when the WTG's noise emissions have reached their highest level (corresponding to hub height wind speeds of 10 m/s for the candidate WTG model) and the wind is directed from the Project to each receiver.

The predicted noise levels include the +1 dB allowance to account for WTG sound power level measurement uncertainty, as described in Section 6.3.1.

Predicted noise levels for each integer wind speed are tabulated in Appendix K.

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 WTG 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 10: Highest predicted noise level at non-associated receivers, dB L_{Aeq}

Receiver	Predicted noise level
Q13-1	35.0
R8-1	26.8
R14-1	36.0

Note: values higher than 35 dB L_{Aeq} are shown in bold for clarity

It can be seen from Table 10 that the predicted WTG noise levels from the proposed Project are below the NSW Noise Assessment Bulletin base (minimum) criterion of 35 dB L_{Aeq} at all but one (1) non-associated receiver.

At receiver R-14, an assessment of compliance requires consideration of the derived noise limits based on the measured background noise levels, as shown in Appendix H. This comparison indicates that the predicted noise levels at this receiver location, per Appendix K, are above the applicable noise limit by 0.5 dB and 1.0 dB at hub height wind speeds of 9 m/s and 10 m/s, respectively.

As such, an example curtailment strategy has been developed to demonstrate compliance with the NSW Noise Assessment Bulletin, using sound optimised modes for a limited range of wind conditions. Details of the example curtailment strategy are presented in Section 6.5.

The above findings support that the Project can be designed and operated to comply with the operational noise requirements of the NSW Noise Assessment Bulletin.

Predicted noise levels at associated receivers are provided in Table 11 for information.

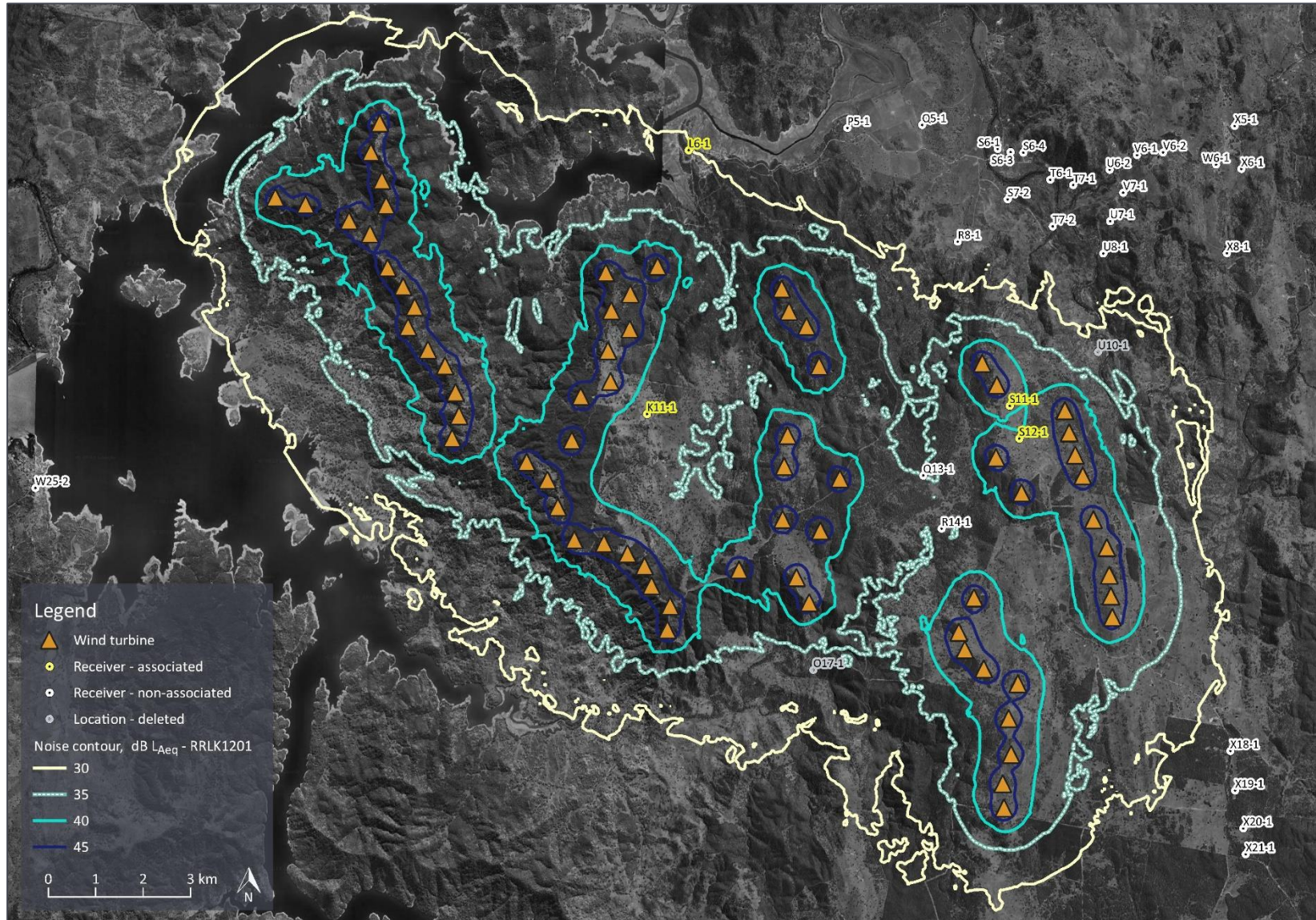
Table 11: Highest predicted noise level at associated receivers, dB L_{Aeq}

Receiver	Predicted noise level
K11-1	37.2
L6-1	31.2
S11-1	40.9
S12-1	40.6

It can be seen from Table 11 that the predicted WTG noise levels from the proposed Project are below the reference level of 45 dB L_{Aeq} for all associated receivers by at least 4.1 dB.

The location of the total predicted 30 dB, 35 dB, 40 dB, and 45 dB L_{Aeq} noise contours is illustrated in Figure 2.

Figure 2: Highest predicted noise level contours



6.5 Example curtailment strategy

Predicted noise levels at the one (1) non-associated receiver, R14-1, at which WTG noise levels were calculated to be above the minimum noise limit of 35 dB L_{Aeq} have been tabulated in Table 12 for the relevant range of wind speeds.

Table 12: Predicted noise levels, dB L_{Aeq}

Receiver	Hub-height wind speed, m/s							
	5	6	7	8	9	10	11	≥12
R14-1	25.5	27.4	30.4	33.2	35.5	36.0	36.0	36.0

Note: Note: values higher than 35 dB L_{Aeq} are shown in bold for clarity

Noise limits applicable at R14-1 during the night period (most stringent noise limits) are tabulated in Table 13 for the relevant range of wind speeds.

Table 13: Applicable noise limits, dB L_{Aeq} – Night period

Receiver	Hub-height wind speed, m/s							
	5	6	7	8	9	10	11	12
R14-1	35.0	35.0	35.0	35.0	35.0	35.0	36.2	39.5

The predicted excess over the applicable noise limits detailed in Table 13 is summarised in Table 14 for each receiver.

Table 14: Predicted excess over the applicable noise limits, dB L_{Aeq}

Receiver	Hub-height wind speed, m/s							
	5	6	7	8	9	10	11	12
R14-1	-9.5	-7.6	-4.6	-1.8	0.5	1.0	-0.2	-3.5

Note: values higher than 35 dB L_{Aeq} are shown in bold for clarity

It can be seen from Table 14 that WTG noise levels are predicted to be above the applicable noise limits at receiver R14-1 at hub height wind speeds of 9 m/s and 10 m/s. To reduce WTG noise levels within this wind speed range, an example curtailment strategy is proposed to be applied to three (3) WTGs, as detailed in Table 15.

Table 15: Example curtailment strategy

WTG	Hub height wind speed, m/s	
	9	10
51	SO4	SO4
52	SO2	SO4
62	-	SO2

Note: The unconstrained operation mode (PO6200) can be used at all other WTGs for all wind speeds and at WTG 51, 52 and 62 for wind speeds other than 9 m/s and 10 m/s.

The example curtailment strategy presented above is only one of the many configurations possible to achieve the required noise reduction. If required, a detailed curtailment strategy accounting for both wind speeds and wind directions would be specified during detailed design once the Project has been approved, the layout finalised, and the WTG model selected.

6.6 Cumulative assessment

The Uungula Wind Farm, located approximately 4 km north of the proposed Project, received development consent in May 2021 for up to ninety-seven (97) WTGs with a tip height of up to 250 m.

In relation to other wind farm developments, the NSW Noise Assessment Bulletin does not make specific recommendations concerning cumulative noise. The SA Guideline does however refer to cumulative noise, noting that the criteria have been specified to allow for other potential development and that any noise criteria which are set relative to background noise levels should not include the influence of other wind farms. While neither document explicitly states a requirement to assess the combined noise levels of multiple wind farm projects, nor do they define criteria that directly applies to cumulative noise, an assessment of cumulative noise from the Project and the neighbouring Uungula Wind Farm is provided herein.

Cumulative operational noise requires consideration in two ways:

- The potential for the Uungula Wind Farm to influence noise levels at receivers near the Project; and
- The potential for the Project to influence noise levels at receivers near the Uungula Wind Farm.

As a visual guide to identify potential cumulative noise considerations, Figure 3 presents the predicted 25 dB L_{Aeq} contours of each project. The 25 dB value corresponds to a level that is 10 dB below the base noise criterion that applies to each project. The noise level contours relate to the separate contribution of each wind farm (i.e. rather than the cumulative predicted noise level from both wind farms).

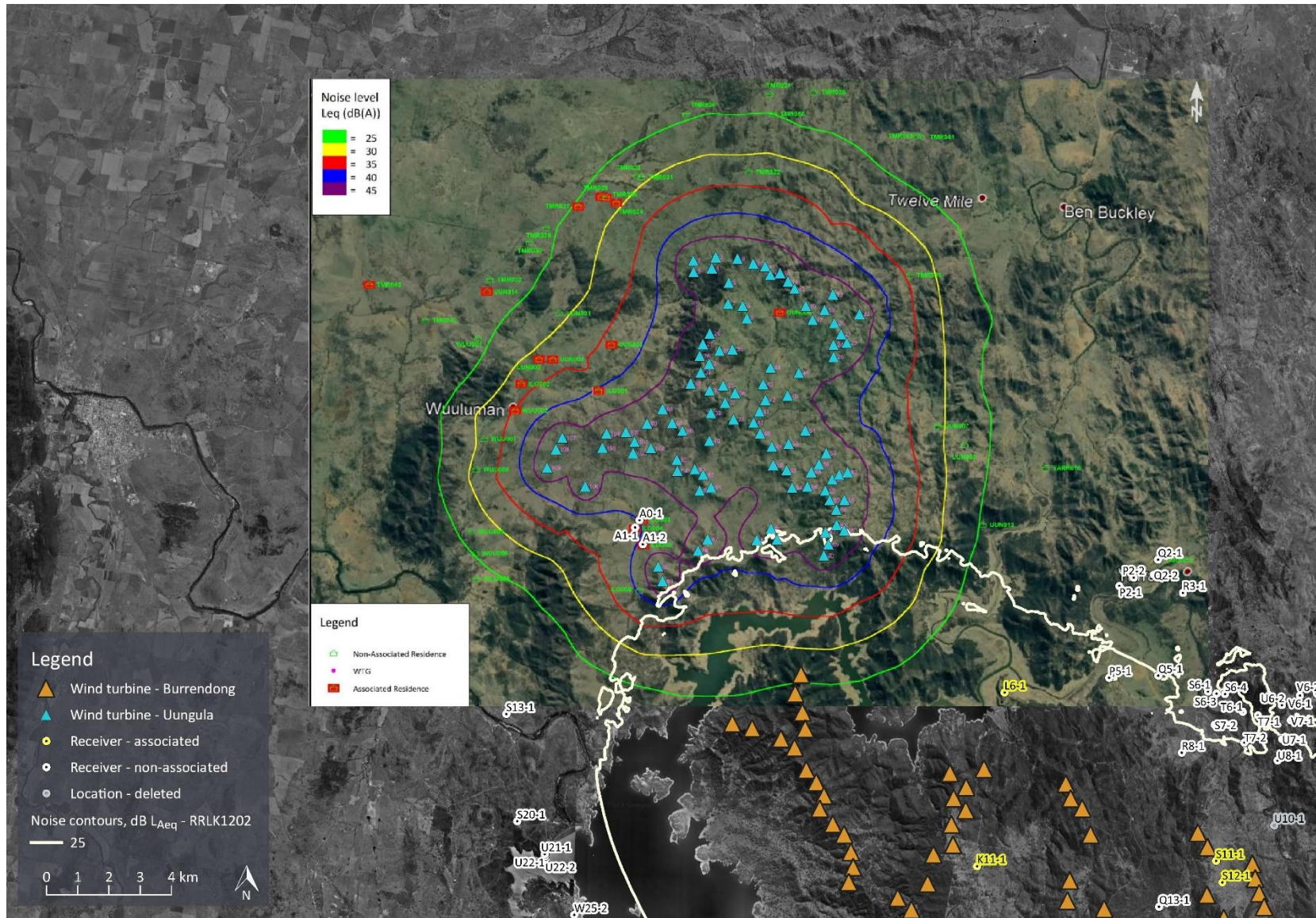
Predicted noise level contours for the Uungula Wind Farm were sourced from the noise assessment report⁸ submitted as part of the Environmental Impact Statement dated May 2020.

It can be seen from Figure 3 that no receivers are located within the area where the 25 dB L_{Aeq} noise contours for each project intersect.

The assessment therefore demonstrates that cumulative noise considerations associated with the Project can be practically managed in terms of receivers near to both projects.

⁸ Sonus report S3958.2C8 *Ungula Wind Farm Noise and Vibration Impact Assessment*, dated May 2020

Figure 3: Predicted 25 dB LAeq noise contour map for the Uungula Wind Farm and the Project



7.0 RELATED INFRASTRUCTURE OPERATIONAL NOISE ASSESSMENT

7.1 Project noise trigger levels

For the purposes of this planning assessment, all receivers have been considered to be Rural in nature, as defined in Table 2.2 of the NPfI. On this basis, and considering the minimum assumed rating background levels detailed in Section 5.2.2, the project noise trigger levels for assessment of related infrastructure have been developed and are summarised in Table 16.

Table 16: NPfI project noise trigger levels, dB L_{Aeq, 15 min}

Time of day	Project noise trigger level
Day	40
Evening	35
Night	35

As the related infrastructure is proposed to operate on a 24-hour basis, the most stringent night-time noise level of 35 dB L_{Aeq, 15 min} will be the controlling factor for compliance.

The noise sources associated with the related infrastructure typically give rise to steady noise levels i.e. transformer noise is not typically characterised by brief momentary increases in noise levels. Accordingly, the additional procedures defined in the NPfI for assessing potential sleep disturbance from brief elevated noise levels associated with transient noise sources are not relevant. The assessment is therefore primarily based on the equivalent noise levels of the plant.

7.2 Infrastructure noise sources

The proposed related infrastructure includes power transmission networks and one (1) collector substation with two (2) location options. Operational noise predictions have been undertaken for both location options, the approximate coordinates of which are detailed in Table 17.

The position of each location option for the collector substation within the Project is shown graphically in Appendix L.

Table 17: Approximate related infrastructure coordinates (GDA 2020 zone 55)

Infrastructure item	Easting, m	Northing, m
Collector substation (east)	712,760	6,379,631
Collector substation (west)	707,625	6,381,342

At this stage in the project, specific details of the transformer make, and model are yet to be determined. However, to provide a basis for assessing the feasibility of the proposed terminal station, the Proponent advised that two (2) transformers rated to 350 MVA are proposed to be installed within the collector substation.

In lieu of measured sound power level data for a specific transformer selection, reference has been made to Australian Standard AS 60076-10:2009 *Power transformers – Part 10: Determination of sound levels* (AS 60076-10:2009) which provides a method for estimating transformer sound power levels. Specifically, Figure ZA1 from AS 60076-10:2009 has been used to determine an estimated standard maximum sound power level of 102 dB L_{WA} for each transformer.

7.3 Predicted noise levels

Noise levels associated with the operation of the collector substation at each of the location options have been predicted at the nearest non-associated and associated receivers based on the method detailed in Section 4.1. As only one location option will be developed, no consideration has been given to cumulative noise levels associated with the concurrent operation of each location.

As equipment selections are not known, the tonality characteristics of the transformers cannot be anticipated. In order to provide a conservative assessment an adjustment of +5 dB (as per the NPfl) has been applied to the predicted noise levels to account for the potential tonal characteristics of transformer noise.

The predicted noise levels at the nearest non-associated and associated receivers are shown in Table 18 and Table 19.

Table 18: Predicted noise levels at the nearest non-associated receivers (including +5 dB tonality penalty), dB L_{Aeq}

Infrastructure item	Nearest non-associated receiver	Distance, m	L _{Aeq}
Collector substation (east)	Q13-1	4,055	14
Collector substation (west)	Q13-1	8,850	< 10

Table 19: Predicted noise levels at the nearest associated receivers (including +5 dB tonality penalty), dB L_{Aeq}

Infrastructure item	Nearest associated receiver	Distance, m	L _{Aeq}
Collector substation (east)	K11-1	3,604	19
Collector substation (west)	K11-1	3,261	17

While the specific equipment selections would not be finalised until the detailed design phase of the Project, noise levels from the transformers are predicted to be below the 35 dB L_{Aeq} night-time project noise trigger level applicable at the nearest receiver by up to 16 dB.

Noise from the ancillary electrical infrastructure is therefore predicted to be below the most stringent applicable noise level criteria, even accounting for any adjustments (if applicable at the receiver) for the potential tonal characteristics associated with transformers.

8.0 RECOMMENDED OPERATIONAL NOISE MANAGEMENT MEASURES

In order to ensure that operational noise from the Project is appropriately managed during subsequent stages of the development, the following is recommended:

- The predicted operational WTG noise levels should be updated with final layout and sound power levels of the final WTG selected for the Site to verify compliance with the criteria in accordance with the NSW Assessment Bulletin;
- Where the updated assessment indicates a continued requirement for curtailment, the curtailment strategy should be updated accordingly;
- The predicted operational related infrastructure noise levels should be updated with the final design and sound power levels of the final equipment selection to verify compliance with the criteria in accordance with the NPfl;
- 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 commencing of operation of the Project; and
- Following construction, compliance monitoring must be conducted to satisfy the NSW Noise Assessment Bulletin including evaluation of special noise characteristics.

In addressing SEARs and assessing operational WTG noise in accordance with the NSW Noise Assessment Bulletin, it is expected that the Project will satisfy the applicable noise limits. Notwithstanding this, consideration has been given to available contingency strategies to reduce noise levels if required.

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

- Procurement contract: the procurement contract for the supply of WTGs to the Site will typically include specifications concerning the allowable total noise emissions from the WTG, and the permissible characteristics of the WTG. In the event that WTG 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 WTGs to be varied according to environmental constraints. Specifically, variable pitch WTGs as proposed for this Site include control functions which enable the noise emissions of the WTGs to be selectively controlled; by adjusting the pitch of blade, the noise emissions of the WTG can be reduced. In addition, where required, the WTGs 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.

9.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

9.1 Overview

The construction of a wind farm project will generate noise and vibration as a result of activities occurring both on and off the Site of the proposed development. As per the SEARs, construction noise is to be assessed in accordance with the ICNG and construction vibration in accordance with the AVTG (see Section 3.0).

Off-site noise generating activities primarily relate to heavy goods vehicle movements to and from the Site and is addressed in the traffic noise assessment in Section 10.0.

On-site works include a range of activities such as construction of access tracks, connection infrastructure, WTG foundations and erection of the WTGs.

Construction of a wind farm mostly occurs at relatively large separating distances from receivers and, as proposed for this Project, the majority of the work is limited to normal working hours. The only exceptions are for potential unavoidable works or low-noise managed-works. Unavoidable works outside of normal hours may comprise the delivery of oversized WTG components at times selected to minimise traffic disruption associated with intersection closures, and potentially WTG installation activities that are sensitive to weather conditions (e.g. installation of rotors or concrete pouring during summer). Should these works be required an out of hours construction noise and vibration assessment should be conducted during the detailed design stage.

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

The following sections provide general information regarding the types of activities that are expected to be associated with the construction of the Project, and reference data that should be considered as part of the preparation of a future CNVMP for the Project.

9.2 Construction activities

Construction of a wind farm project typically involves the following key stages:

- Access road construction;
- Cable trench digging;
- Concrete batching plant;
- Site compound construction;
- Collector substation construction;
- WTG foundations; and
- WTG assembly.

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

The types of equipment associated at different stages of construction typically include excavation plant, pneumatic equipment and lifting equipment.

Appendix L provides a construction site layout denoting key work areas. Appendix M details typical major equipment items associated with the above construction stages, alongside noise levels developed on the basis of reference data from AS 2436 and previous project experience.

As shown in Appendix M, typical construction plant source sound power levels range from approximately 100-120 dB L_{WA} per equipment item.

Based on the groupings of major plant items during key construction tasks, the total aggregated noise emissions for the proposed works stages typically ranges from 115 to 120 dB L_{WA} .

9.3 Construction noise assessment

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

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

Table 20 details the predicted noise level ranges for each of the main construction tasks at the nearest non-associated and associated receivers.

Table 20: Indicative range of construction noise predictions at non-associated receivers, dB L_{Aeq}

Construction task	Nearest receiver	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
WTG foundations	Q13-1	40-45	45	-	75	-
WTG assembly	Q13-1	35-40	45	-	75	-
Construction of hardstands	Q13-1	40-45	45	-	75	-
Access road construction	Q13-1	50-55	45	5-10	75	-
Substation construction	Q13-1	25-30	45	-	75	-
Connection switchyard construction	R14-1	10-15	45	-	75	-
O&M and site (temporary and permanent) compounds construction	Q13-1	40-45	45	-	75	-
Construction of overhead transmission lines	R14-1	30-35	45	-	75	-
Permanent meteorological masts of footing construction	Q13-1	30-35	45	-	75	-
Underground transmission lines (cable trench digging)	Q13-1	50-55	45	5-10	75	-
Concrete batching plant	Q13-1	35-40	45	-	75	-
Temporary laydown areas & construction compounds	Q13-1	40-45	45	-	75	-
Temporary and permanent meteorological masts footing	R14-1	25-30	45	-	75	-

Table 21: Indicative range of construction noise predictions at associated receivers, dB L_{Aeq}

Construction task	Nearest receiver	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
WTG foundations	S11-1	50-55	45	5-10	75	-
WTG assembly	S11-1	45-50	45	0-5	75	-
Construction of hardstands	S11-1	50-55	45	5-10	75	-
Access road construction	S11-1	60-65	45	15-20	75	-
Substation construction	K11-1	30-35	45	-	75	-
Connection switchyard construction	K11-1	10-15	45	-	75	-
O&M and site (temporary and permanent) compounds construction	S12-1	60-65	45	15-20	75	-
Construction of overhead transmission lines	K11-1	30-35	45	-	75	-
Permanent meteorological masts of footing construction	S11-1	45-50	45	0-5	75	-
Underground transmission lines (cable trench digging)	S11-1	60-65	45	15-20	75	-
Concrete batching plant	S12-1	50-55	45	5-10	75	-
Temporary laydown areas & construction compounds	S11-1	55-60	45	10-15	75	-
Temporary and permanent meteorological masts footing	K11-1	30-35	45	-	75	-

The following can be seen from Table 20:

- Construction noise levels are predicted to be above the noise affected management levels at some of the nearest non-associated receivers, during the construction of access roads and laydown areas and during cable trench digging.
- Construction noise levels are predicted to be below the highly noise affected management levels at all non-associated receivers for all assessed construction activities.
- Construction noise levels are predicted to be above the noise affected management levels at some of the nearest associated receivers, during the construction of access roads and laydown areas and during cable trench digging.
- Construction noise levels are predicted to be below the highly noise affected management levels at all associated receivers for all assessed construction activities.

Exceedances above the noise affected management levels are not unique to this Project and are characteristic of most construction assessments due to the typically high source noise levels of construction equipment. Based on previous project experience the predicted noise levels are typical of the range expected for the construction of a wind farm.

Due to the proximity of certain receivers to the proposed construction activities, the highest predicted noise levels are noted to occur during the construction of access roads, cable trench digging activities, and the use of temporary laydown areas.

9.3.1 Discussion – Access road construction

The construction activity that would typically occur nearest to receivers is the construction of access roads.

This activity involves a brief period of elevated noise while work is carried out to improve existing roads (where required), create new intersections at Site access points, and initiate Site access tracks.

During these initial works, construction noise levels of up to 60-65 dB L_{Aeq} could be expected for brief periods when road and access work is carried out at distances within less than 200 m from a receiver. It is expected that during site access works, one (1) associated receiver (S11-1) and no non-associated receivers would be located less than 200 m from this type of construction activities.

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

9.3.2 Discussion – Cable trench digging

Similar to the construction of access roads, cable trench digging activities will generally move along the intended routes reasonably quickly, with activities moving throughout the Project Site. On this basis trench digging activities are unlikely to be a feature of any one receiver for an extended period of time.

During these initial works, construction noise levels of the order of 60-65 dB L_{Aeq} could be expected for brief periods when cable trench digging activities are carried out at distances within 200 m from a receiver.

It is expected that during this stage of works, one (1) associated receiver (S11-1) and no non-associated receivers would be located less than 200 m from this type of construction activities.

9.3.3 Discussion – General

The majority of the remainder of construction activities occurs in proximity to the WTG locations and related infrastructure locations. These works therefore typically occur at larger separating distances from receivers. As a result, construction noise levels are then lower. However, depending on background noise levels and wind directions, construction noise associated with more distant works

would still be audible at surrounding receivers at times. In particular, given the low background noise levels that occur in rural environments at low wind speeds, construction noise could be higher than background noise levels on some occasions.

The ICNG indicates:

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

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

Feasible and reasonable work practices, as well as a structured approach to community consultation, should be developed as part of a future detailed CNVMP.

9.4 Construction vibration assessment

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

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

9.4.1 Intermittent vibration

The AVTG indicates that intermittent vibration should be assessed in terms of the Vibration Dose Value (VDV). These values for intermittent construction activities are highly specific to site conditions, equipment selections and operational durations. As such, calculation of VDV levels is not typical or practical at the planning stage but will need to be considered as part of a later detailed vibration assessment.

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

9.4.2 Continuous vibration

Vibration due to some construction operations can be considered continuous depending on the duration and nature of the works. Since the guide values for continuous vibration are independent of exposure duration, indicative safe working distances can be developed. Section 7.1 of the NSW RMS *Construction Noise & Vibration Guideline* (CNVG) sets out minimum working distances from sensitive receivers for typical items of vibration intensive plant. The minimum distances, reproduced in Table 22, are quoted for effects relating to human comfort.

Table 22: Recommended minimum working distances for human response limits for vibration intensive plant

Plant item	Rating / description	Minimum working distance, m
Vibratory roller	< 50 kN (typically 1-2 tonnes)	15 to 20

Plant item	Rating / description	Minimum working distance, m
	< 100 kN (typically 2-4 tonnes)	20
	< 200 kN (typically 4-6 tonnes)	40
	< 300 kN (typically 7-13 tonnes)	100
	> 300 kN (typically 13-18 tonnes)	100
	> 300 kN (> 18 tonnes)	100
Small hydraulic hammer	(300 kg – 5 to 12 t excavator)	7
Medium hydraulic hammer	(900 kg – 12 to 18 t excavator)	23
Large hydraulic hammer	(1600 kg – 18 to 34 t excavator)	73
Vibratory pile driver	Sheet piles	20
Pile boring	≤ 800 mm	4
Jackhammer	Handheld	2

Note: Reproduced from Table 2 of Section 7.1 of the CNVG

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

9.4.3 Blasting

The excavation methods that will be needed in order to prepare the foundations of the WTGs and other on-site infrastructure are yet to be determined. However, low level blasting could potentially be required in some instances.

The accurate estimation of airblast and ground vibration is complex and subject to considerable uncertainty. The blasting process is highly non-linear and the variability of ground and rock also contributes to the difficulty in accurate predictions.

As the need for blasting is yet to be determined, it is not possible provide an estimate of potential airblast and ground vibration levels. However, in the event that blasting is ultimately required, the activities would need to be addressed in a blasting plan which sets out the management and monitoring measures to be implemented, including identification of the locations where blasting could be conducted, if required, in accordance with the ANZEC 1990 Report.

Once further information is known it may be feasible to establish general indications of airblast overpressure and ground vibration levels at the nearest receivers to the proposed blasting areas, by undertaking a high-level assessment in accordance with AS 2187-2:2006 *Explosives—Storage, transport and use, Part 2: Use of explosives (AS 2187-2)*.

9.5 Decommissioning

Similar construction activities to those detailed in Section 9.2 are expected to be required during the decommissioning of the Project.

9.6 Construction noise and vibration recommendations

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

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

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

- Universal work practices;
- Consultation and notification;
- Plant and equipment;
- On-site controls;
- Work scheduling; and
- Transmission path and at-receiver considerations.

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

Generally, it is likely to be feasible for a majority of works to be restricted to normal working hours, i.e. the ICNG recommended standard construction hours detailed in Section 3.3. This will assist in limiting noisy activities to times of the day when intrusive impacts or adverse reactions may be less likely.

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

Where out of hours works are proposed, the ICNG advises:

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

General experience of wind farm developments has indicated that construction noise tends to represent a limited risk factor. With reasonable and feasible work practices implemented it is expected that noise associated with the construction and decommissioning of the Project can be acceptably managed.

10.0 TRAFFIC NOISE ASSESSMENT

Noise criteria for the assessment of traffic associated with the construction and operation of the Project are laid out in Section 3.4.

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

The estimated construction traffic flows on public roads have been provided by Cardno in correspondence dated 11 February 2022 and reproduced in Table 23.

Table 23: Construction traffic and base traffic flows on public roads – vehicles (% heavy vehicles)

Road category	Existing traffic		Future: existing traffic + construction traffic	
	Day ^[1]	Night ^[1]	Day ^[1]	Night ^{[1],[2]}
Local roads				
Twelve Mile Road	15 (5 %) ^[3]	2 (0 %) ^[3]	50 (12 %) ^[3]	4 (50 %) ^[3]
Yarrabin Road	15 (5 %) ³	2 (0 %) ³	69 (13 %) ^[3]	4 (50 %) ^[3]
Burrendong Dam Road	15 (5 %) ³	2 (0 %) ³	104 (13 %) ^[3]	4 (50 %) ^[3]
Freeways/arterial/sub-arterial roads				
Mitchell Highway	2,327 ^[4] (12 %)	243 ^[5] (36 %)	2,373 ^[4] (13 %)	255 ^[5] (39 %)
Castlereagh Highway	3,354 ^[4] (9 %)	264 ^[5] (23 %)	3,517 ^[4] (11 %)	276 ^[5] (26 %)
Golden Highway	1,948 ^[4] (19 %)	143 ^[5] (65 %)	<i>No change</i>	155 ^[5] (68 %)
Goolma Road	798 ^[4] (10 %)	89 ^[5] (20 %)	903 ^[4] (15 %)	101 ^[5] (30 %)
Hill End Road	1,404 ^[4] (8 %)	156 ^[5] (20 %)	1,579 ^[4] (12 %)	<i>No change</i>
Saxa Road	445 ^[4] (20 %)	50 ^[5] (30 %)	<i>No change</i>	62 ^[5] (44 %)

Notes:

^[1] Day is 0700 - 2200 hrs; Night is 2200 - 0700 hrs

^[2] An average of six (6) return OSOM (Over Size Over Mass) journeys per night during periods of delivery phase of the Project

^[3] Peak 1 hr AADT (Annual Average Daily Traffic) / Heavy vehicle (%)

^[4] Total 15 hr AADT / Heavy vehicle (%)

^[5] Total 9 hr AADT / Heavy vehicle (%)

In considering feasible and reasonable mitigation measures, the RNP states that an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. On this basis, to assess noise impacts from construction traffic, an initial screening test is undertaken in the following section to evaluate whether existing road traffic noise levels would increase beyond this threshold. Where the predicted traffic noise increase is 2 dB or less, no further assessment is conducted, as impacts will be barely perceptible. However, where the road traffic noise levels are predicted to increase by more than 2 dB as a result of additional traffic, consideration is given to the actual noise levels associated with the construction traffic and whether or not these levels comply with the following road traffic noise criteria detailed in Table 2 of Section 3.4.

10.1 Screening assessment

For the freeway / arterial / sub-arterial roads listed in Table 23, the increase in road traffic is relatively minor compared to the existing traffic flows, less than a 25 % increase in all cases. Based on the estimated construction traffic flows presented in the previous section, the relative increase in traffic noise level associated with construction activities is predicted below the 2 dB threshold during the day and night periods. Therefore, further detailed noise level predictions and assessments at receivers along the identified freeways / arterial / sub-arterial roads are not carried out herein.

However, the local roads listed in Table 23 all have very low existing traffic flows and, as such, any increase in flow, for example from 2 vehicles to 4 vehicles, may give rise to a large relative increase. The relative traffic noise level increase due to the proposed construction activities is predicted to be above the 2 dB threshold. Therefore, further detailed noise level predictions and assessments at receivers along the identified local roads are provided in the following section.

10.2 Construction traffic predictions

It is noted that the traffic volumes for the local roads under assessment are very low in absolute levels, particularly the existing volumes. The Calculation of Road Traffic Noise (CoRTN) prediction method, preferred by Transport for NSW, Roads and Maritime Services (RMS) and the EPA, is not typically applied where traffic flows are less than 50 vehicles per hour. A correction factor for low traffic volumes, applicable when considering traffic flows lower than 200 vehicles per hour, has been applied in accordance with CoRTN. It should be noted that CoRTN does not provide corrections for flows of less than 50 vehicles per hour. As such, the predicted levels below may be overly conservative (i.e. higher) than those expected to be experienced on site.

From the traffic data in Table 23 and a review of receivers adjoining the affected local roads, traffic noise levels have been predicted to the nearest identified receivers on each road using the following method and assumptions:

- Traffic speed assumed at 50 km/h;
- Roads assessed as local roads as defined in the RNP;
- Predicted noise levels include an additional +2.5 dB correction for facade reflection as required by the RNP;
- $L_{Aeq, 1h}$ levels are calculated as CoRTN $L_{A10(1hr)}$ - 3 dB, per RMS practice; and
- Grass or cultivated fields assumed between the road and receivers.

Modifying corrections for Australian conditions (e.g. per Australian Road Research Board report ARR 121 dated 1983) or for road surface conditions have not been applied as applicable data for the local road surfaces in question are not available.

The additional vehicle flows during construction, particularly on roads carrying very little existing traffic, may result in a noticeable increase for some residents. However, the total vehicle flows are still low (less than 105 vehicles per hour in all cases) in an absolute sense. It is also noted that the assessments presented for local roads are based on the peak 1 hr AADT traffic data which is considered a worst-case scenario.

Table 24 shows a summary of the minimum setback distance from the local roads, beyond which compliance with the RNP criteria is predicted to be achieved during the day and night periods.

Table 24: Construction traffic and base traffic flows on local public roads

Road	Minimum setback for compliance, m		Identified receivers within minimum setback zone
	Day	Night	
Twelve Mile Road	15	10	None
Yarrabin Road	25	10	None
Burrendong Dam Road	30	10	None

It can be seen from the above table that no receivers were identified within the minimum setback distance, where traffic noise are predicted above the RNP criteria.

As noted above, although the absolute noise levels are predicted to comply with the RNP criteria at relevant receivers, the increase in traffic levels, from very low existing levels, may result in a noticeable increase in noise during some periods of construction. We recommend residents on these local roads be included in consultation prior to commencement of construction.

10.3 Sleep disturbance due to construction traffic

The majority of construction traffic movements are expected to occur during the day period only. However, during some construction stages, oversize/over mass vehicles (OSOM) will be required for the delivery of larger items. Movements on local roads during the night period are more likely to be associated with the OSOM deliveries during a particular phase of the construction works. The night-time OSOM deliveries are expected to occur only during approximately seven (7) months of the program as opposed to the life of the construction works. During that period, approximately six (6) return OSOM journeys are estimated.

For freeways / arterial / sub-arterial roads identified in Table 23, the number of night period heavy vehicle movements generated by the proposed construction works is expected to be small compared to the existing heavy vehicle numbers on these roads. On this basis, the number of maximum noise events that could disturb sleep is unlikely to increase noticeably. However, an assessment of sleep disturbance is provided for receivers along the local roads.

Based on the traffic sleep disturbance criteria established in Section 3.4, an external noise level screening threshold of 65 dB L_{Amax} is established to assess the potential for sleep disturbance due to construction traffic during the periods of OSOM delivery. A maximum external noise level of 65 dB L_{Amax} or higher, is predicted at receivers within 40 m of the OSOM vehicle movements.

Based on an aerial review of receivers along the subject local roads, no receivers within 40 m of Burrendong Dam Road were identified. However, up to two (2) receivers along Yarrabin Road and up to two (2) receivers along Twelve Mile Road were identified within 40 m of the relevant roads. The affected receivers are identified as:

- 59 Twelve Mile Road, Wuuluman
- 3601 Twelve Mile Road, Twelve Mile
- 3360 Yarrabin Road, Twelve Mile
- 2985 Yarrabin Road, Yarrabin

Sleep disturbance impacts are not anticipated under the typical working hours during construction. However for occasions where OSOM deliveries must be carried out during night periods, reasonable and feasible noise mitigations should be considered. Potential mitigation could include:

- Alternate traffic routes;
- Reducing the maximum number of movements to once or twice each night; and
- Planning for times when there is a clear change in the noise environment.

Consultation with the four (4) potentially impacted residences above should be carried out prior to any OSOM deliveries scheduled during the night period.

11.0 SUMMARY

An assessment of operational and construction noise for the proposed Project has been carried out in accordance with the requirements of the applicable Planning Secretary's Environmental Assessment Requirements (SEARs). The assessment is based on the proposed Project layout comprising seventy (70) WTGs and related infrastructure.

Operational noise associated with the proposed WTGs has been assessed in accordance with the NSW EPA *NSW Wind Energy: Noise Assessment Bulletin* (NSW Noise Assessment Bulletin) as required by the SEARs.

Noise modelling was carried out based on a candidate WTG model (Vestas V162-6.2MW) which has been selected by the Proponent as being representative of the size and type of WTGs that could be used for this Project. The results demonstrate that the proposed WTGs are predicted to achieve compliance with the applicable base noise limits specified in the NSW Noise Assessment Bulletin at all but one (1) assessed non-associated receiver, R14-1. For this receiver, WTG noise levels are predicted to be above the applicable noise limits by up to 1.0 dB. An example curtailment strategy has been developed to demonstrate compliance with the NSW Noise Assessment Bulletin, using sound optimised modes for a limited range of wind conditions.

The assessment results demonstrate that cumulative noise considerations associated with the Project can be practically managed for receivers near to both the proposed Project and the nearby approved Uungula Wind Farm. In particular, it was demonstrated that cumulative wind farm noise levels do not affect the compliance outcomes for either of the assessed projects.

As required by the NSW Noise Assessment Bulletin, consideration was also given to the potential for special noise characteristics. Based on review of the manufacturer specification and prediction of C-weighted noise levels, adjustments for special noise characteristics have not been applied to the predicted noise levels presented in this assessment.

The assessment has also considered operational noise associated with the proposed related infrastructure comprising one (1) collector substation with two location options. Predicted noise levels have been assessed in accordance with the NSW EPA *Noise Policy for Industry* and demonstrated that the related infrastructure complied with the most stringent night-time project noise trigger level at all receivers.

A preliminary construction noise and vibration assessment has also been conducted, including assumptions for typical equipment items and work practices as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the NSW DECC publications *Interim Construction Noise Guideline* and *Assessing Vibration: A Technical Guideline* and confirmed that a construction noise and vibration can be appropriately managed using standard good practice measures.

An assessment of traffic noise impacts associated with construction operations has also been conducted in accordance with the NSW EPA *Road Noise Policy*.

Once a more detailed schedule of equipment and plant items, construction method, construction traffic and construction work areas are known, a detailed Construction Noise and Vibration Management Plan should be prepared. It should include site and process specific noise management work practices designed to mitigate the noise and vibration impact of construction activities, including blasting and traffic.

The findings of this noise assessment indicates that with appropriate work practices, feasible and reasonable mitigation, planning and management techniques, the proposed Project can be designed, constructed, operated, and decommissioned to satisfy the requirements specified in the Project SEARs.

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90 th 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. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.	L _{Aeq(t)}
A-weighted maximum noise level	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.	L _{Amax}
C-weighting	The process by which noise levels are corrected to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).	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.	-
Peak Particle Velocity	The measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment	PPV
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L _w
Sound pressure level	A measure of the level of sound expressed in decibels.	L _p
Special Audible Characterises	A term used to define a set group of Sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics comprise tonality, impulsiveness and amplitude modulation.	SAC
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.

APPENDIX B DESCRIPTION OF SOUND

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

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

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

B1 Definition of sound

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

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

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

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

B2 Physical description of sound

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

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

- sound pressure; and
- sound frequency.

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

B2.1 Sound pressure

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

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

To provide some context, Table 25 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 25: Atmospheric pressure versus sound pressure – example values of pressure

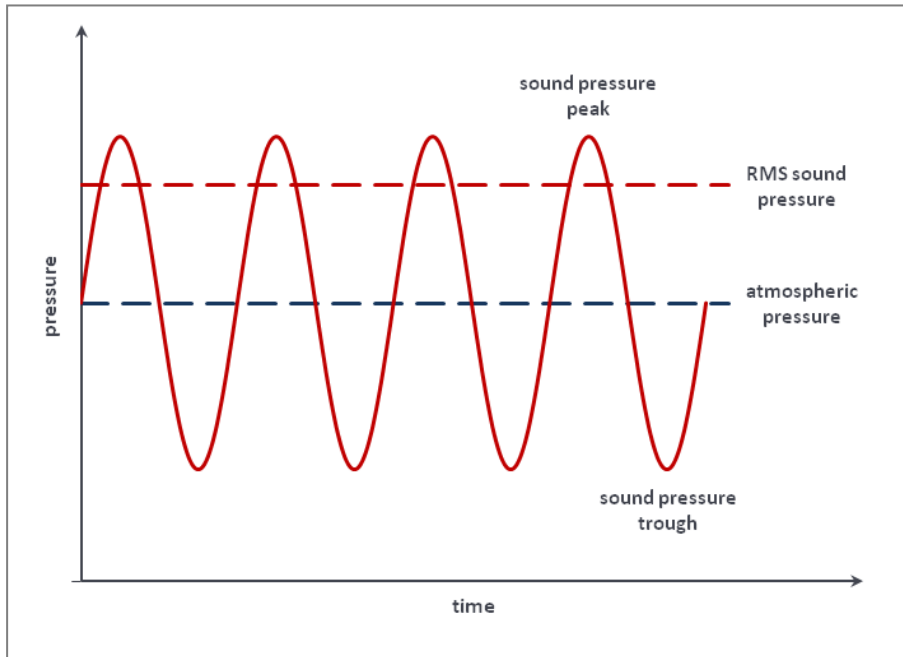
Example	Pascals	Bars	Pounds per Square Inch (PSI)
Atmospheric pressure	100,000	1	14.5
Pressure change due to weather front	10,000	0.1	1.5
Pressure change associated with sound at the threshold of pain	20	0.0002	0.003
Pressure change associated with sound at the threshold of hearing	0.00002	0.000000002	0.000000003

The pressure values in Table 25 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

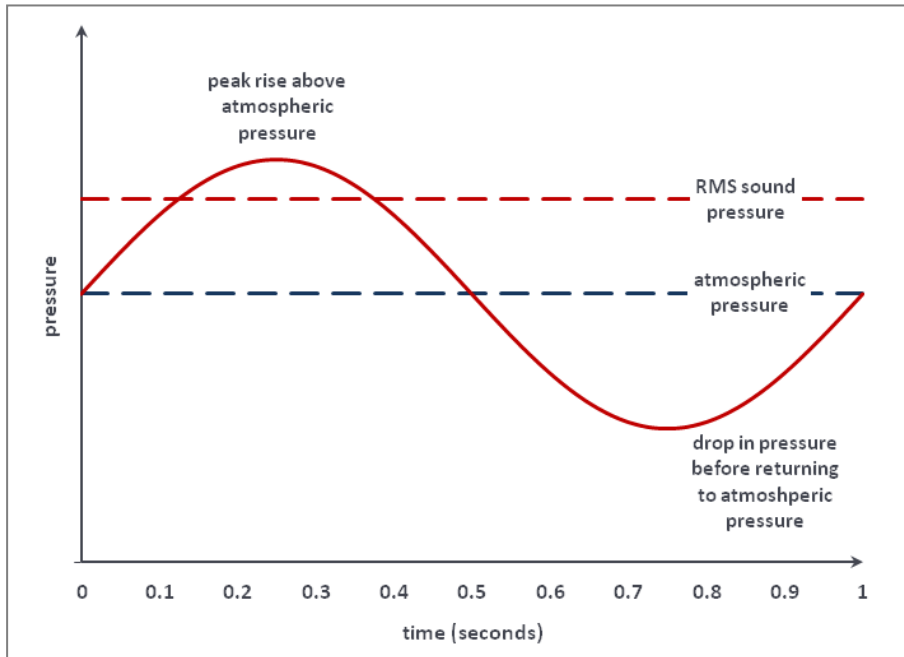
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period. The rate of change in pressure is an important feature that determines whether it can be perceived as a sound by the human ear.

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.

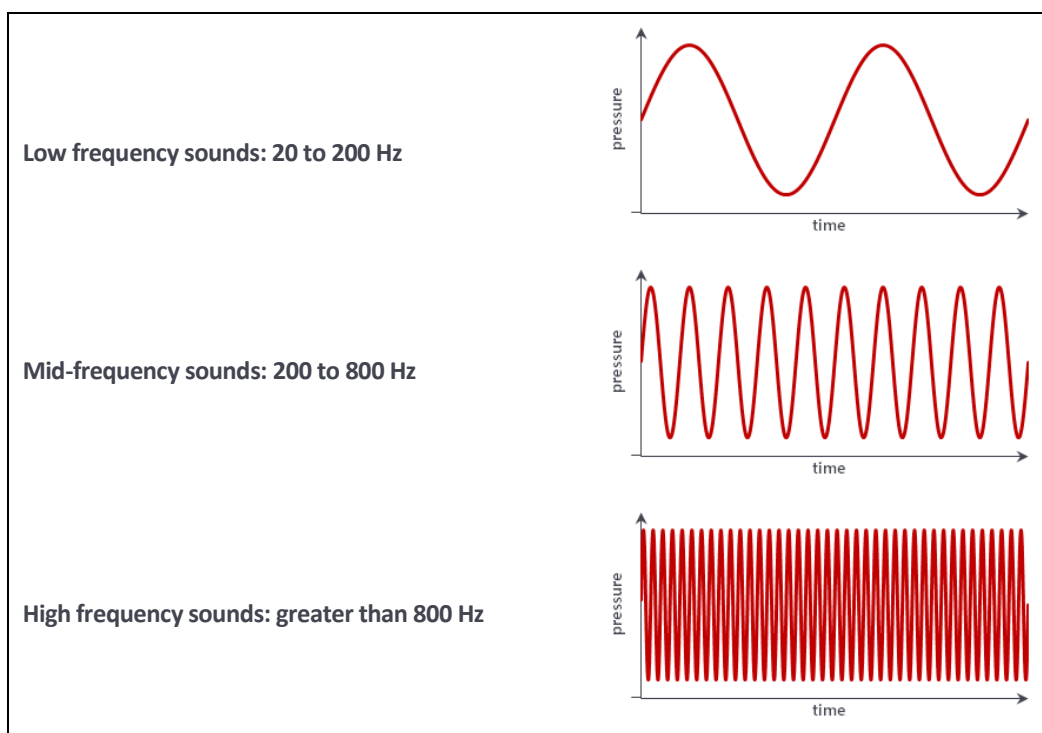
The rate of fluctuation is numerically described in terms of the number of pressure fluctuations that occur in a single second. Specifically, it is the number of cycles per second of the pressure rising above, falling below, and then returning to atmospheric pressure. The number of these cycles per second 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



B2.3 Sound pressure and frequency variations

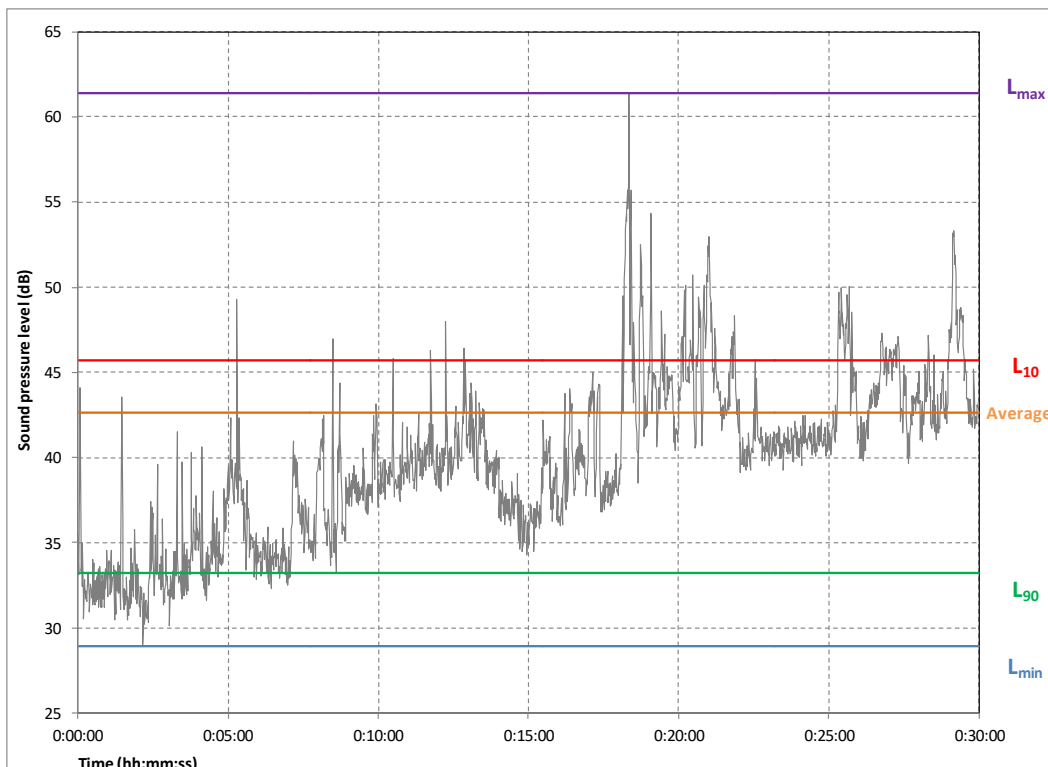
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

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; and
- The relationship between sound frequency and human hearing.

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

B3.1 Sound pressure and the decibel

Previous sections discussed the wide range of small pressure fluctuations that the ear can detect as sound. Owing to the wide range of these fluctuations, the way we hear sound is more practically described using 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 26 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

Table 26: 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 27 provides some examples of how changes in sound pressure levels, for a sound with the same character, can be perceived.

Table 27: 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 27 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.

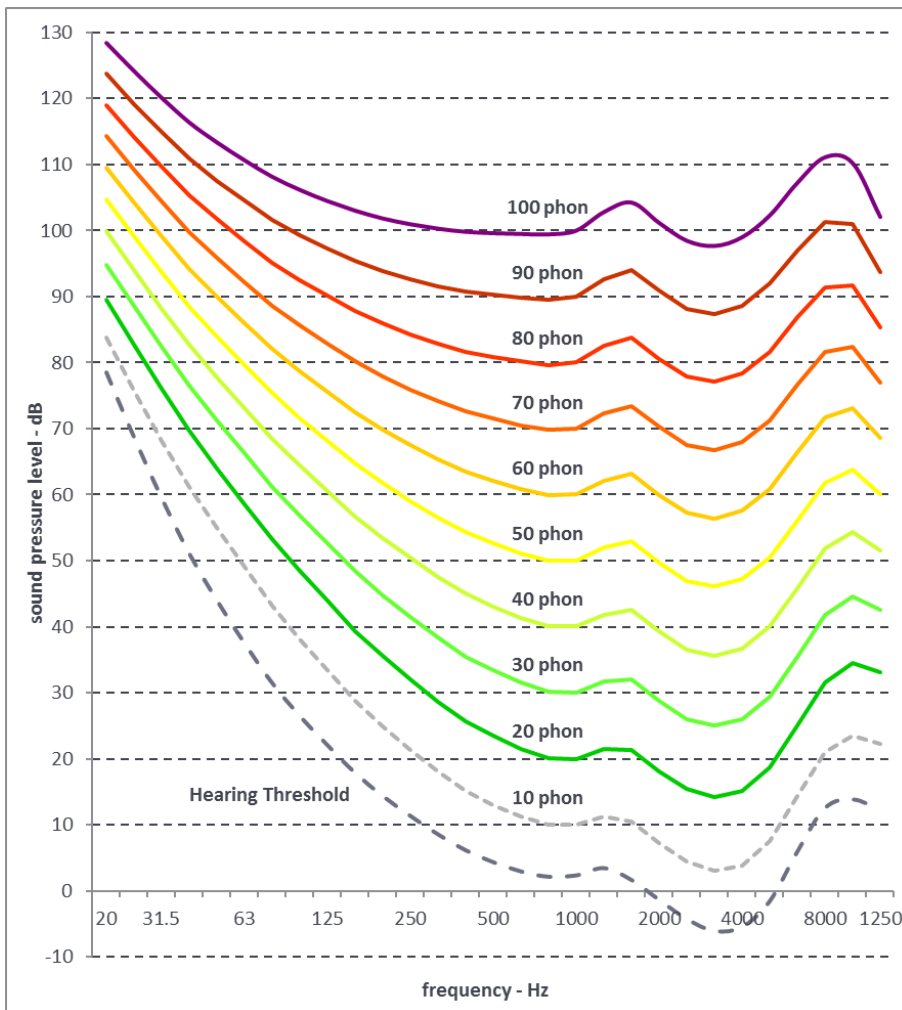
B3.2 Sound frequency and loudness

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 standard⁹ 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.

⁹ ISO 226:2003 *Acoustics - Normal equal-loudness-level contours*, 2003

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; and
- 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 WTG COORDINATES

Table 28 sets out the coordinates of the proposed WTG layout.

(Layout dated 20 April 2023 as supplied by the Proponent).

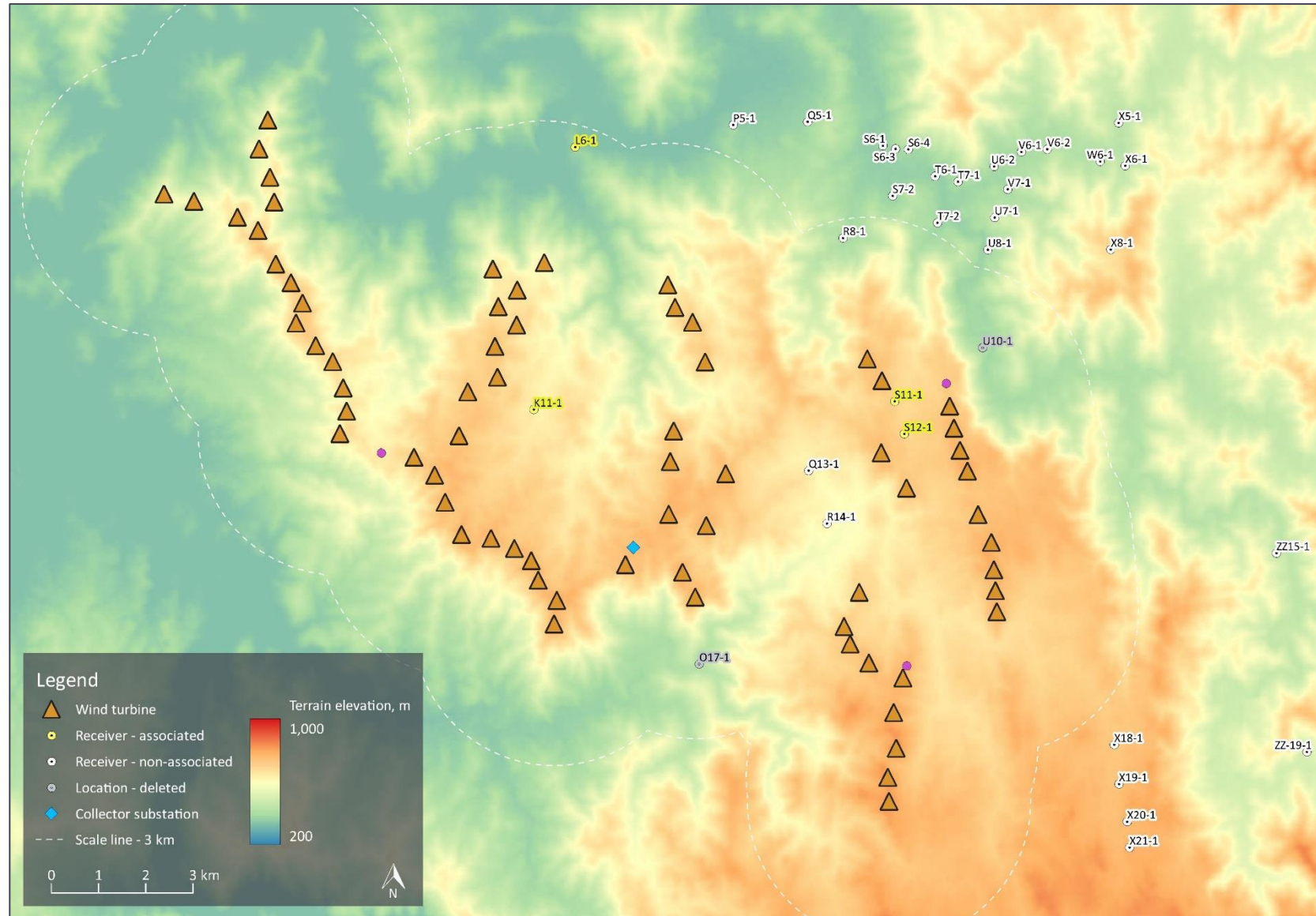
Table 28: Proposed WTG coordinates – GDA 2020 Zone 55

WTG	Easting, m	Northing, m	Terrain elevation, m
1	705,019	6,388,684	614
2	704,833	6,388,073	635
3	705,065	6,387,475	670
5	702,820	6,387,116	601
6	703,455	6,386,966	600
7	704,375	6,386,629	694
8	704,813	6,386,349	699
9	705,188	6,385,635	730
10	705,510	6,385,239	720
11	705,755	6,384,808	730
12	705,617	6,384,386	741
13	706,034	6,383,906	705
14	706,395	6,383,567	710
15	706,616	6,383,010	660
16	706,689	6,382,518	675
17	706,546	6,382,043	679
19	708,552	6,381,162	769
20	709,069	6,381,998	750
21	710,874	6,385,666	613
22	709,786	6,385,531	665
23	710,302	6,385,085	660
24	710,289	6,384,344	690
25	709,901	6,384,732	670
26	709,831	6,383,889	740
27	709,882	6,383,239	730
28	709,255	6,382,927	735
29	708,775	6,380,588	764
30	709,121	6,379,906	774
31	709,746	6,379,824	764
32	710241	6379611	742

WTG	Easting, m	Northing, m	Terrain elevation, m
33	710599	6379350	785
34	710747	6378937	775
35	711140	6378511	795
36	711082	6378010	780
37	712593	6379269	760
38	713,803	6,379,108	774
39	714,071	6,378,580	779
40	713,491	6,385,192	650
41	713,644	6,384,719	664
42	714,015	6,384,401	720
43	714,281	6,383,561	725
44	714,717	6,381,192	765
45	713,616	6,382,100	740
46	713,543	6,381,450	740
47	714,306	6,380,093	768
48	713,510	6,380,333	775
49	717,717	6,383,624	763
50	718,027	6,383,164	745
51	718,009	6,381,637	759
52	718,546	6,380,891	745
53	719,461	6,382,625	755
54	719,551	6,382,158	765
55	719,679	6,381,689	770
56	719,838	6,381,250	805
57	720,061	6,380,325	770
58	720,344	6,379,739	781
59	720,396	6,379,159	800
60	720,430	6,378,716	768
61	720,460	6,378,269	800
62	717,545	6,378,681	705
63	717,225	6,377,956	735
64	717,352	6,377,586	755
65	717,750	6,377,183	763

WTG	Easting, m	Northing, m	Terrain elevation, m
66	718,470	6,376,868	788
67	718,275	6,376,135	795
68	718,327	6,375,379	825
69	718,151	6,374,763	830
70	718,176	6,374,253	815

APPENDIX D SITE TOPOGRAPHY



APPENDIX E RECEIVER COORDINATES

The Proponent Table 29 sets out the seven (7) receivers identified by the Proponent within 3 km of the proposed WTGs considered in the environmental noise assessment, together with their respective distance to the nearest WTG.

This includes four (4) associated receivers where a noise agreement has been formalised between the landowners and the Proponent.

(Data supplied by the Proponent on 27 July 2023)

Table 29: Receivers within 3 km of the proposed WTGs – GDA 2020 Zone 55

Receiver	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest WTG, m	Nearest WTG
<i>Non-associated receivers</i>					
Q13-1	716,474	6,381,259	629	1,587	51
R8-1	717,203	6,386,186	420	2,618	49
R14-1	716,862	6,380,138	620	1,617	62
<i>Associated receivers</i>					
K11-1	710,652	6,382,554	639	1,041	27
L6-1	711,530	6,388,112	385	2,538	21
S11-1	718,297	6,382,726	701	535	50
S12-1	718,499	6,382,037	707	651	51

APPENDIX F NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods.

The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2) has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in the South Australia EPA *Wind farms environmental noise guidelines*, NZS 6808:2010 *Acoustics – Wind farm noise* and AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators*.

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

To calculate far-field noise levels according to the ISO 9613-2, the noise emissions of each WTG 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 receivers.

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

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of $G = 0.5$ for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all WTGs operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 °C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

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

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

A range of measurement and prediction studies^{10, 11, 12} for wind farms in which Marshall Day Acoustics' staff have been associated in have provided further support for the use of ISO 9613-2 and $G = 0.5$ as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613-2 method to predict the propagation of WTG noise for:

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

¹⁰ Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

¹¹ Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

¹² Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

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

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

The adjustments detailed above are implemented in the WTG calculation procedure of the SoundPLAN 8.2 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the Site to evaluate the path between each WTG and receiver pairing, and then subsequently applies the adjustments to each WTG's predicted noise contribution where appropriate.

APPENDIX G TABULATED BACKGROUND NOISE LEVELS

Table 30: Background noise levels, dB LA90 – Day period

Receiver	Hub height wind speed ^[1] , m/s									
	3	4	5	6	7	8	9	10	11	12
O17-1 ^[4]	-	-	-	-	39.0	39.1	39.4	40.1	41.0	42.2
Q13-1	-	-	32.4	32.8	33.3	34.2	35.2	36.4	37.7	39.1
Q23-1 ^{[2][3]}	31.4	32.2	33.2	34.3	35.4	36.6	37.9	39.2	40.7	42.2
R8-1	31.9	32.3	32.6	32.8	33.1	33.5	33.9	34.6	35.5	36.7
R14-1	36.7	36.8	37.0	37.4	38.0	38.6	39.3	40.1	40.9	41.7
S12-1 ^[2]	-	31.5	31.6	31.8	32.4	33.1	34.1	35.3	36.6	38.1
U10-1 ^[4]	33.1	33.0	33.3	34.0	34.9	36.0	37.1	38.2	39.0	39.6

^[1] BDG1 met mast at 711,209 E / 6,378,562 N (GDA 2020 Zone 55)

^[2] Background noise levels measured at associated receivers are provided for information only.

^[3] This receiver was selected for assessment purposes as part of a legacy WTG layout that has since been superseded. At that time Q23-1 was within 3 km of a WTG. Following update of the WTG layout this receiver is now greater than 3 km from a WTG and is no longer considered within the EIS assessment due to its distance from a WTG. Further information is provided in the Background Noise Report.

^[4] Background noise levels provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per the Background Noise Report.

Table 31: Background noise levels, dB LA90 – Night period

Receiver	Hub height wind speed ^[1] , m/s									
	3	4	5	6	7	8	9	10	11	12
O17-1 ^[4]	-	-	-	-	-	31.0	31.6	33.1	35.8	40.1
Q13-1	30.8	30.8	30.9	31.1	31.4	31.8	32.3	32.9	33.6	34.4
Q23-1 ^{[2][3]}	-	-	-	27.2	27.8	29.2	31.1	33.5	36.1	38.9
R8-1	-	-	25.4	25.6	26.3	27.4	28.8	30.4	32.2	34.1
R14-1	-	-	-	22.8	23.3	24.4	26.1	28.4	31.2	34.5
S12-1 ^[2]	-	-	26.3	26.6	27.5	28.9	30.4	31.9	33.3	34.2
U10-1 ^[4]	29.8	30.2	30.6	31.1	31.7	32.4	33.2	34.0	34.9	35.9

^[1] BDG1 met mast at 711,209 E / 6,378,562 N (GDA 2020 Zone 55)

^[2] Background noise levels measured at associated receivers are provided for information only.

^[3] This receiver was selected for assessment purposes as part of a legacy WTG layout that has since been superseded. At that time Q23-1 was within 3 km of a WTG. Following update of the WTG layout this receiver is now greater than 3 km from a WTG and is no longer considered within the EIS assessment due to its distance from a WTG. Further information is provided in the Background Noise Report.

^[4] Background noise levels provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per the Background Noise Report.

APPENDIX H TABULATED NOISE LIMITS

Table 32: Noise limits, dB L_{Aeq} – Day period

Receiver	Hub height wind speed ^[1] , m/s									
	3	4	5	6	7	8	9	10	11	12
Q13-1	37.4	37.4	37.4	37.8	38.3	39.2	40.2	41.4	42.7	44.1
Q23-1 ^{[2][3]}	36.4	37.2	38.2	39.3	40.4	41.6	42.9	44.2	45.7	47.2
R8-1	36.9	37.3	37.6	37.8	38.1	38.5	38.9	39.6	40.5	41.7
R14-1	41.7	41.8	42.0	42.4	43.0	43.6	44.3	45.1	45.9	46.7
S12-1 ^[2]	36.5	36.5	36.6	36.8	37.4	38.1	39.1	40.3	41.6	43.1

^[1] BDG1 met mast at 711,209 E / 6,378,562 N (GDA 2020 Zone 55)

^[2] Background noise levels measured at associated receivers are provided for information only.

^[3] This receiver was selected for assessment purposes as part of a legacy WTG layout that has since been superseded. At that time Q23-1 was within 3 km of a WTG. Following update of the WTG layout this receiver is now greater than 3 km from a WTG and is no longer considered within the EIS assessment due to its distance from a WTG. Further information is provided in the Background Noise Report.

Table 33: Noise limits, dB L_{Aeq} – Night period

Receiver	Hub height wind speed ^[1] , m/s									
	3	4	5	6	7	8	9	10	11	12
Q13-1	35.8	35.8	35.9	36.1	36.4	36.8	37.3	37.9	38.6	39.4
Q23-1 ^{[2][3]}	35.0	35.0	35.0	35.0	35.0	35.0	36.1	38.5	41.1	43.9
R8-1	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.4	37.2	39.1
R14-1	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.2	39.5
S12-1 ^[2]	35.0	35.0	35.0	35.0	35.0	35.0	35.4	36.9	38.3	39.2

^[1] BDG1 met mast at 711,209 E / 6,378,562 N (GDA 2020 Zone 55)

^[2] Background noise levels measured at associated receivers are provided for information only.

^[3] This receiver was selected for assessment purposes as part of a legacy WTG layout that has since been superseded. At that time Q23-1 was within 3 km of a WTG. Following update of the WTG layout this receiver is now greater than 3 km from a WTG and is no longer considered within the EIS assessment due to its distance from a WTG. Further information is provided in the Background Noise Report.

APPENDIX I C-WEIGHTING ASSESSMENT RESULTS

I1 Introduction

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

I2 Assessment requirement

Comments and guidance with respect to C-weighted WTG is provided in the NSW Noise Assessment Bulletin and discussed in Section 3.1.3 and reproduced below:

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

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

I3 Prediction method

As highlighted in Section 6.3.3, there are no commonly used, practical methods to accurately predict the WTG low frequency noise levels at receivers. The predictions are carried out using a simplified approach based on the same noise modelling methods for A-weighted levels described in Section 4.0, but with the following modifications:

- Unconstrained sound power levels;
- The range of band frequencies has been expanded to include bands down to the 16 Hz frequency band; and
- The ground factor has been set to $G = 0$ (hard ground) to account for the increased influence of ground reflections at low frequencies.

C-weighted noise levels have been predicted for the worst-case hub height wind speed of 10 m/s.

I4 Results

Table 34 presents the results of the preliminary C-weighted noise predictions. Results at associated receivers are provided for information only.

Table 34: Predicted C-weighted noise levels for receivers within 3 km of WTGs, dB L_{Ceq}

Receiver	Predicted noise level
<i>Non-associated receivers</i>	
Q13-1	56.0
R8-1	50.5
R14-1	56.5
<i>Associated receivers</i>	
K11-1	57.7
L6-1	53.2
S11-1	59.5
S12-1	59.5

15 Discussion

The results in Table 34 show that preliminary C-weighted noise levels are predicted to be below the most stringent criteria of 60 dB L_{Ceq} at all assessed non-associated receivers by a margin of at least 3.5 dB.

While there are limitations on the accuracy of the prediction method used, the approach is considered sufficiently conservative for the purposes of this study. On the basis of the results above, it is considered that risk of low-frequency noise exceeding the criteria is low and therefore it is not appropriate to apply penalty adjustment to account for low-frequency noise.

APPENDIX J EFFECTS OF WIND TURBINE NOISE

In terms of the effect of WTG 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 reviews¹³ and public statements^{14, 15} 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 WTGs. The following conclusions¹⁶ 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).*

¹³ *Systematic review of the human health effects of wind farms 2013*, Adelaide University, commissioned by the NMRC

¹⁴ NHMRC Information Paper: *Evidence on Wind Farms and Human Health*, February 2015, National Health and Medical Research Council

¹⁵ AMA Position Statement – *Wind Farms and Health 2014*, Australian Medical Association

¹⁶ <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*¹⁷ 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*¹⁸, 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 New South Wales, which are intended to provide reasonable protection of health and amenity at noise sensitive locations.

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

J2 Low frequency noise, infrasound and ground vibration

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

However, consistent with noise policies applied to other forms of development, the criteria are not intended to restrict wind farm noise to inaudible levels. Accordingly, a wind farm which achieves compliance with the criteria may still be audible at surrounding receivers on some occasions; this will depend on a range of factors such as the time of day, the speed and direction of the wind, the proximity to WTGs, 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.

¹⁷ <https://www.euro.who.int/en/health-topics/environment-and-health/noise/environmental-noise-guidelines-for-the-european-region>

¹⁸ <http://tinyurl.com/WTN2019-Delaire>

In common with many other sources of noise, WTGs 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 WTGs 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 WTGs. However, Dr Leventhall has regularly made clear statements to assert that there is no significant infrasound from current designs of WTGs 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 2009¹⁹. 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.

¹⁹ 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 WTGs 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 WTGs on the seismic detection array at Eskdalemuir, Scotland. The results of this work were widely misinterpreted and resulted in a statement²⁰ 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^{21, 22} 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 WTGs, 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

²⁰ Keele University Rejects Renewable Energy Foundation’s Low Frequency Noise Research Claims

²¹ 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

²² 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 report²³ 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 document²⁴ 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 paper²⁵ 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.

²³ Health Protection Agency UK – *Health Effects of Exposure to Ultrasound and Infrasound – Report of the independent Advisory Group on Non-ionising Radiation* - 2010

²⁴ [Public Statement: Wind Turbines and Health - July 2010](#)

²⁵ *Information Paper - Evidence on Wind Farms and Human Health*, February 2015

The NSW *Noise Assessment Bulletin* issued in December 2016 refers to this advice and states the following in its section on Noise and Health:

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

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

APPENDIX K TABULATED PREDICTED NOISE LEVELS

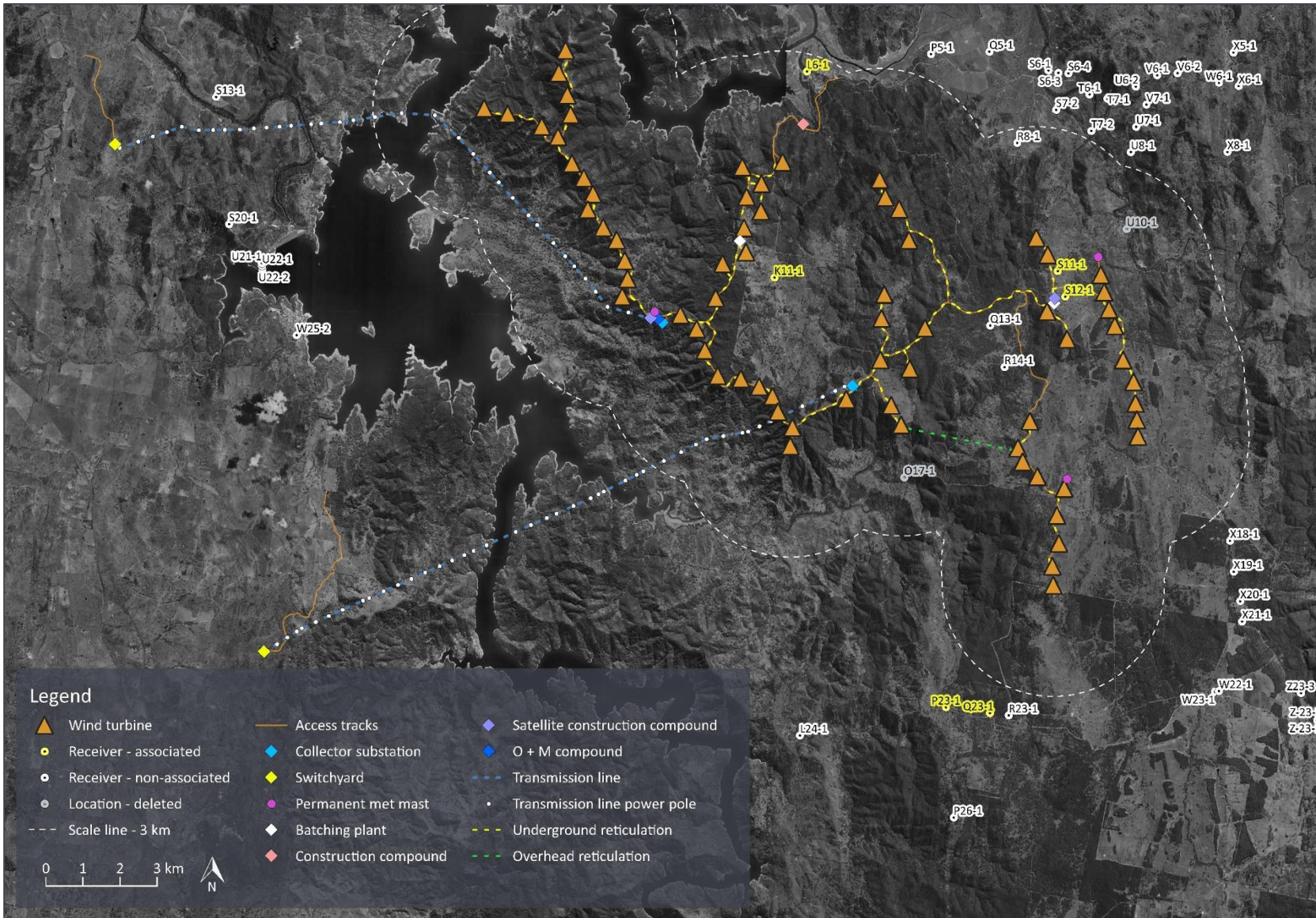
Table 35: Predicted noise levels at non-associated receivers, dB LAeq

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
Q13-1	24.3	24.5	26.4	29.4	32.2	34.5	35.0	35.0	35.0
R8-1	16.1	16.3	18.2	21.2	24.0	26.3	26.8	26.8	26.8
R14-1	25.3	25.5	27.4	30.4	33.2	35.5	36.0	36.0	36.0

Table 36: Predicted noise levels at associated receivers, dB L_{Aeq}

Receiver	Hub-height wind speed, m/s								
	4	5	6	7	8	9	10	11	≥12
K11-1	26.5	26.7	28.6	31.6	34.4	36.7	37.2	37.2	37.2
L6-1	20.5	20.7	22.6	25.6	28.4	30.7	31.2	31.2	31.2
S11-1	30.2	30.4	32.3	35.3	38.1	40.4	40.9	40.9	40.9
S12-1	29.9	30.1	32.0	35.0	37.8	40.1	40.6	40.6	40.6

APPENDIX L CONSTRUCTION LAYOUT PLAN



APPENDIX M CONSTRUCTION EQUIPMENT, WORK STAGES AND ACOUSTIC DATA

It is anticipated that a variety of construction equipment would be used for this Project.

Sound power levels for the types of equipment used to construct a wind farm have been determined from guidance and data sources including Australian Standard AS 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* (AS 2436), and noise level data from previous projects of a similar nature.

Table 37 summarises the noise emissions used to represent key items of plant associated with construction.

Table 37: Construction noise sources sound power data, dB L_{WA}

Noise source	Sound power level
Excavator fitted with pneumatic breaker	118
Excavator (100 to 200 kW)	107
Tracked loaders	115
Crane (200 t)	105
Crane (500 t)	110
Crane (1,200 t)	115
Delivery Trucks	107
Concrete trucks	108
Dump truck	117
Concrete pump	108
Generator	99
Grader	110
Bulldozer	108
Rock Crusher	120
Batching Plant	110
Cone crusher	116
Impact crusher	118
Jaw crusher	116
Screening plant	109
Water truck	107

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

The overall total aggregated sound power levels for each of the key construction tasks are detailed in Table 38, and assume that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

Table 38: Overall sound power levels of key construction tasks, dB L_{wa}

Construction task	Plant/Equipment	Approximate overall sound power level
WTG foundations	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Excavator fitted with pneumatic breaker, 1 x Generator	120
WTG assembly	1 x Crane (1200 t), 2 x Crane (200t), 1 x Crane (500t), 1 x Generator	115
Construction of hardstands	1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Excavator fitted with pneumatic breaker, 1 x Generator	120
Access road construction	1 x Bulldozer, 2 x Dump truck, 2 x Excavator (100 to 200 kW), 1 x Grader, 1 x Tracked loader	120
Substation construction	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (500 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Generator	115
Connection switchyard construction	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (500t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Generator	115
O&M and site (temporary and permanent) compounds construction	1 x Bulldozer, 1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Generator, 1 x Rock crusher	120
Construction of overhead transmission lines	1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Generator	115
Permanent meteorological masts of footing construction	1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Excavator fitted with pneumatic breaker, 1 x Generator	120
Underground transmission lines (cable trench digging)	1 x Bulldozer, 1 x Dump truck, 1 x Excavator (100 to 200 kW), 1 x Generator	120
Concrete batching plant	1 x Batching Plant, 1 x Concrete pump, 1 x Concrete truck	115
Temporary laydown areas & construction compounds	1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Excavator fitted with pneumatic breaker, 1 x Generator	120
Temporary and permanent meteorological masts footing	1 x Concrete pump, 1 x Concrete truck, 1 x Crane (200 t), 1 x Delivery Trucks, 1 x Excavator (100 to 200 kW), 1 x Excavator fitted with pneumatic breaker, 1 x Generator	120W

APPENDIX N NSW NOISE ASSESSMENT BULLETIN – INFORMATION REQUIREMENTS

The NSW Noise Assessment Bulletin specifies the minimum information to be provided in a noise report accompanying an Environmental Impact Statement. The requirements and the location within this report where the requirement is addressed, are summarised in Table

Table 39: NSW Noise Assessment Bulletin – information requirements

Information requirement	Location of relevant content
<ul style="list-style-type: none"> the model used to predict the wind energy project noise levels and input assumptions and factors used in the model, noting that noise management mode or sector management (i.e. stopping individual WTGs or combinations, or operating in low noise mode, during identified meteorological conditions) should not be used in the primary modelling or predicting of noise levels. Any modelling and predictions which incorporate noise management mode or sector management must be reported separately; 	Section 4.1 / Appendix F
<ul style="list-style-type: none"> background noise measurement locations including time and duration of the background noise monitoring program; 	Figure 1 See also Background noise report ²⁶
<ul style="list-style-type: none"> wind speed monitoring locations within the Project area, heights above ground and graphical correlation plot of hub height wind speed versus background noise level data; 	See Background noise report
<ul style="list-style-type: none"> a summary of the environmental noise criteria for the Project at each integer wind speed based on the above correlation; 	Appendix H See also Background noise report
<ul style="list-style-type: none"> make and model of the representative WTG(s) along with the positions of the WTGs; 	Figure 1 / Section 6.2 / Appendix C
<ul style="list-style-type: none"> predicted noise levels at the closest non-associated dwellings to the wind energy project at each integer wind speed; 	Section 6.4 / Appendix K
<ul style="list-style-type: none"> a comparison of the predicted noise levels against the criterion at each integer wind speed for the closest non-associated dwellings to the wind energy project; and 	Section 6.4
<ul style="list-style-type: none"> modifications or operating strategy that would be employed to address any unforeseen non-compliances. The error margins of the noise model used should be considered in developing such modifications or strategies. 	Section 8.0

²⁶ MDA report Rp 003 r02 20200219 Burrendong Wind Farm - Background Noise Assessment, dated 15 September 2023



MARSHALL DAY
Acoustics 

BURRENDONG WIND FARM
BACKGROUND NOISE ASSESSMENT

Rp 003 r02 20200219 | 15 September 2023

Project: **BURRENDONG WIND FARM**

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Report No.: **Rp 003 r02 20200219**

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APPENDIX M LOCATION U10-1 DATA

1.0 INTRODUCTION

This report presents the results of background noise monitoring undertaken for the proposed Burrendong Wind Farm (subsequently referred to as the Project herein).

The background noise monitoring was commissioned by Eco Logical Australia (ELA) on behalf of Burrendong Wind Farm Pty Ltd (referred to as the Proponent herein) as an element of the noise studies associated with the Project's Environmental Impact Statement (EIS). The background noise monitoring was undertaken to obtain a representation of typical baseline conditions at receivers in the vicinity of the Project.

This report documents the survey methodology, the results of the monitoring, and the derived noise limits that apply to the Project.

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

Wind Turbine Generator (WTG) coordinates and a site layout are detailed in Appendix B and Appendix C respectively.

Throughout this report, the term receiver is used to identify any dwelling identified by the Proponent in the vicinity of the proposed Project. Receivers are grouped as *associated receivers* i.e. host properties or receivers where a noise agreement is proposed between the landowners and the Proponent, or *non-associated receivers* which comprises the remaining receivers without an agreement with the Proponent.

The background noise survey detailed in this report was designed considering the preliminary noise assessment, Rp 001 20200219 *Burrendong Wind Farm – Preliminary Noise Assessment* (Preliminary Noise Assessment), dated 6 August 2020.

Since that time, the Proponent has made various changes to the WTG layout (primarily the removal of a cluster of thirty-five (35) WTG to the south of the Project) and provided progressive updates to the identification of receivers in the vicinity of the Project.

Based on these updates, a number of the locations at which background noise monitoring has been conducted are no longer classed as receivers (as they are not dwellings) or are located a significant distance from the Project, due to the changes in WTG layout.

Further details are provided in this report.

2.0 BACKGROUND NOISE SURVEY & ANALYSIS METHODOLOGY

The background noise survey and analysis has been conducted in accordance with the NSW Environment Protection Authority *NSW Wind Energy: Noise Assessment Bulletin*, dated December 2016 (NSW Noise Assessment Bulletin).

The NSW Noise Assessment Bulletin in turn references the South Australia Environmental Protection Authority *Wind Farms Environmental Noise Guidelines*, dated July 2009 (SA Guideline), the requirements of which have also been considered.

This section of the report presents:

- Details of the selected noise monitoring locations;
- An overview of the survey methodology; and
- A summary of the data analysis procedures.

2.1 Noise monitoring locations

Development of the noise monitoring strategy for the Project was originally based on the results of the Preliminary Noise Assessment, with locations selected based on the following considerations:

- Predicted noise level at the receiver based on preliminary noise modelling
- Proximity to a wind turbine
- Topological relationship to turbines
- Whether the receiver is associated or non-associated / existing or proposed
- Noise generating sources that may be near the receiver e.g. industrial/agricultural buildings, foliage, or watercourses
- Proximity to other noise sensitive receivers

Following changes made to the WTG layout by the proponent, MDA conducted additional noise modelling, presented in MDA report Rp 002 20200219 *Burrendong Wind Farm - EIS Noise Assessment* (EIS Noise Assessment), dated 4 April 2022¹. Based on the results of the updated noise modelling additional monitoring locations, Q13-1, and U10-1, were added to the noise monitoring plan.

On this basis background noise monitoring was conducted at the following locations:

- O17-1;
- Q13-1;
- Q23-1;
- R8-1;
- R14-1;
- S12-1; and
- U10-1.

¹ This report has since been superseded by MDA report Rp 002 r02 20200219 *Burrendong Wind Farm - EIS Noise Assessment* dated 15 September 2023

Following completion of the background noise monitoring, the Proponent provided further updates to the WTG layout as well as the list of associated and non-associated receivers relating to the Project.

Changes to the WTG layout (primarily the removal of a cluster of thirty-five (35) WTG to the south of the Project) means that Q23-1, identified as an associated receiver, is now more than 3.8 km from a WTG. At this distance Q23-1 would not ordinarily be considered pertinent for inclusion in a background noise survey designed for the updated WTG layout.

For the purposes of consistency Q23-1 has been retained in this report with associated noise limits derived in full. The receiver is also referenced in the appendices of the EIS Noise Assessment but is not generally considered for noise level predictions.

As part of the updates to receiver identification provided by the Proponent, two locations, O17-1 and U10-1, were identified as not being dwellings and thus not classed as receivers. For these locations background noise monitoring information has been provided for completion, as these works have already been carried out in full, however, noise limits are not derived or applicable.

Noise monitoring locations at recognised receivers are detailed in Table 1 and also presented in Figure 1 of Appendix C.

Table 1: Receivers at which background noise monitoring has been conducted

Location	Nearest WTG	Distance from nearest WTG, m	Direction to nearest WTG, °
Q13-1	51	1,581	76
Q23-1 ^[1]	70	3,848	26
R8-1	49	2,613	169
R14-1	62	1,609	155
S12-1 ^[1]	51	633	231

^[1] Indicates an associated receiver. Background noise levels measured at this receiver are provided for information only.

2.2 Survey description

The background noise survey comprised unattended monitoring over a number of weeks to measure sound levels for a range of environmental conditions. Site wind speeds and local weather conditions were simultaneously recorded during the survey, along with periodic audio samples, to enable the relationship between background noise levels and site winds to be assessed.

The key elements of the background noise survey are summarised in Table 2.

Table 2: Summary of key elements of background noise survey

Item	Description
Monitoring locations	Seven (7) locations as described in Section 2.1. Only five (5) of these locations are recognised associated or non-associated receivers.
Monitoring Period	<p>Monitoring periods for each of the locations described in Section 2.1 varied as a result of both equipment redeployments and additional locations selected following updated WTG layouts. The relevant periods for each location are as follows;</p> <ul style="list-style-type: none"> - 14 December 2020 to 5 February 2021 (O17-1, Q23-1, R8-1, R14-1, S12-1) <p>During that survey, S12-1 was observed to have been adversely affected by lightning strike / electrical storms and no viable data was retrieved.</p> <ul style="list-style-type: none"> - 5 February to 8 April 2021 (redeployment at S12-1). - 23 September 2021 to 24 January 2022 (Q13-1, U10-1) <p>No data was recorded during that period at U10-1 due to equipment issues.</p> <ul style="list-style-type: none"> - 24 January to 14 March 2022 (redeployment at U10-1). <p>The duration of the monitoring period was chosen to satisfy the SA Guideline which requires <i>the collection of 2,000 data points including a minimum of 500 from the worst-case wind direction.</i></p> <p>The worst-case direction is defined in Section 4.1 of the SA Guideline as <i>a wind direction spread of 45° either side of the direct line between the nearest WTG and the relevant receiver.</i></p> <p>The NSW Noise Assessment Bulletin recognises <i>in NSW, the worst-case wind direction rarely occurs. Therefore, if it appears impractical to collect 500 valid data points under the worst-case conditions, data collection should continue for up to six weeks.</i></p>
Sound level meters	<p>Class 1 automated sound loggers (most accurate class rating for field usage).</p> <p>Microphones mounted at approximately 1.5 m above ground level and fitted with enhanced wind shielding systems based on the design recommendations detailed in the UK IOA Good Practice Guide².</p> <p>See equipment specifications and calibration records in Appendix D.</p>
Noise measurement data	<p>A-weighted average and statistical sound pressure levels.</p> <p>One-third octave band frequency noise levels and a brief audio sample every ten (10) minutes to aid the identification of extraneous noise influences.</p>
Local wind speed and rainfall data	<p>Weather stations were installed beside the noise monitors at locations Q13-1, R14-1, and U10-1 to concurrently record rainfall and wind speeds at microphone height.</p> <p>This data was recorded to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone (i.e. rainfall).</p>
Site wind speed data	<p>Hub height wind speeds for correlating background noise levels with site wind speeds sourced from a meteorological mast (BDG1). The subject location is referred to as the 'met mast' in this report.</p> <p>Hub height wind speed data (150 m above ground level) was provided based on analysis conducted by the Proponent to extrapolate 110 m height anemometer wind speed data to 150 m using site-specific wind shear calculations.</p> <p>Documentation summarising the analysis process is reproduced in Appendix E.</p>

² UK Institute of Acoustics *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*, dated May 2013

2.3 Data analysis

2.3.1 General method

The analysis of the survey data has been conducted in accordance with the NSW Noise Assessment Bulletin, and consequently the SA Guideline.

This broadly involves:

- Collating the measured noise levels, site wind speeds and local weather data into a single dataset;
- Filtering the data set to remove measurement results affected by extraneous or atypical noise;
- Filtering the data where necessary to account for site wind directions; and
- Plotting a chart of noise levels versus wind speeds and conducting a best fit regression analysis of the filtered data.

A summary of the key steps in the analysis of the data is presented in Table 3.

Table 3: Background noise data analysis

Process	Description
Data collation	<p>Time stamps for each source of measurement data are reviewed to clarify start or end times and measurement time zone.</p> <p>Measured noise levels, site wind speeds and local weather conditions are then collated for each ten-minute measurement interval.</p>
Local weather data filtering	<p>10-minute intervals are identified and filtered from the analysis if rainfall was identified for any 10-minute measurement interval.</p>
Extraneous noise filtering	<p>The measured sound frequencies (one-third octave bands) in each 10-minute interval are used to identify periods that are significantly affected by bird or insect sounds.</p> <p>10-minute intervals have been identified, and filtered from the analysis, when the following conditions³ are satisfied:</p> <p>the highest A-weighted one-third octave band noise level is within 5 dB of the broadband A-weighted background noise level for that interval; and</p> <p>the identified one-third octave band A-weighted noise level is greater than a level of 20 dB L_{A90}.</p> <p>At locations where insect noise was found to be prevalent, an additional method was applied, comprising the objective method detailed in Annex K of ISO 1996-2:2017⁴. Specifically, if this method identified the presence of a tone, the corresponding 10-minute was considered to have been significantly affected by bird or insect sounds and filtered from the analysis.</p>
Site wind speed data filtering	<p>Lower bound: 10-minute intervals in which site wind speeds are below the operating range of the wind WTGs (i.e. below cut-in wind speed of 3 m/s) are filtered from the analysis</p> <p>Higher bound: 10-minute intervals in which site wind speeds are above the wind WTGs' rated power wind speed (12 m/s) are filtered from the analysis</p>
Regression analysis	<p>Two datasets are plotted on a chart of noise levels versus wind speeds:</p> <ul style="list-style-type: none"> • All data points that have been removed from the analysis using the above processes • The filtered dataset comprising all retained measurement data. <p>The chart of filtered noise levels versus wind speed is reviewed to determine if there are any distinctive trends or gaps in the data which could warrant separation of the measurement results into subgroups (e.g. subgroups for time of day or wind direction).</p> <p>A line of best fit is determined for the filtered data and, where applicable, any subgroups of the filtered data. The line of best fit is determined using a regression analysis of the range of noise levels and wind speeds or, where necessary, analysis of noise levels at individual wind speeds.</p>

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

⁴ ISO 1996-2:2017 *Acoustics - Description, measurement and assessment of environmental noise -, Part 2: Determination of sound pressure levels*

Process	Description
Time periods	<p>Large scatter was observed in the datasets. Further analysis indicated that night-time data at some locations featured periods in which low background noise levels are measured during periods of high hub height wind speeds.</p> <p>Overall datasets were separated into component Day (0700 - 2200 hrs) and Night (2200 - 0700 hrs) subsets. This improved the analytical distortion that would otherwise occur with the incorporation of this night period trend into correlation of datasets considering both time periods, however some residual scatter remained.</p>
Listening tests	<p>To identify additional extraneous events and provide improved correlations between background noise and hub height wind speeds, selected audio samples were reviewed at each receiver and for various data subsets.</p> <p>Based on our review of selected audio samples it has been found that residual scatter appeared to be generated by localised sources that are part of the normal environment in a rural and/or farming environment, including chainsaws, radios, operation of heavy equipment and animal noise.</p>
Noise limits	<p>Noise limits, applicable at non-associated receivers, are defined at each wind speed in accordance with the NSW Noise Assessment Bulletin by a value of 35 dB or the background plus 5 dB, whichever is higher. The value of the background noise level at each integer wind speed is defined by the line of best fit to the measurement results.</p>

2.3.2 Analysis specific to location O17-1

Review of audio samples for location O17-1 identified data points adversely affected by suspected rain or hydrological noise impacts. These data points were not captured by the standard correlation of local weather station data. This is expected to be due to meteorological variances across the Project site and / or the location of O17-1 within a forested valley close to a water course. These data points, identified as those typically occurring when background noise levels were measured above 44 dB L_{A90} , have been removed from the regression analysis.

Following these eliminations the datasets for receiver O17-1 are still subject to broad noise level variation, randomised noise events and significant residual scatter. Whilst a variety of practical and feasible filtering methods have been employed it is not possible to wholly identify and eliminate all extraneous samples due to the limitations of automatic filtering and the practical limits of listening tests and manual deletions.

3.0 SURVEY & ANALYSIS RESULTS

This section presents a summary of the background noise measurement results, analysed in accordance with the methodology described in Section 2.3.

The analysis results include the noise limits, applicable at non-associated receivers, determined in accordance with the NSW Noise Assessment Bulletin.

It should be noted that for certain receivers, regression lines indicate an increase of background noise levels as hub height wind speed decreases. As this feature is deemed to be an artifact of the regression analysis process due to the large scatter of points at low hub height wind speeds, the regression lines have been truncated at their lowest values. The associated noise limits were extended based on that lowest value. This is a conservative approach as it results in lower noise limits.

3.1 Background noise levels

The tabulated data presented in Table 4 and Table 5 summarise the derived background noise levels for the surveyed wind speeds, based on Day and Night subsets.

A summary of the background noise level regression coefficients is provided in Appendix F.

Background noise level results are illustrated in the graphical data provided for each monitoring location in Appendix G to Appendix M.

The background noise levels exhibit variations which are consistent with rural areas and are characterised by lower background noise levels during the night period (particularly during periods of increased wind shear which result in lower wind speeds near ground level, and consequently lower background noise levels from wind disturbance of vegetation).

Table 4: Background noise levels, dB L_{A90} – Day period (0700 - 2200 hrs)

Location	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
O17-1 ^[3]	-	-	-	-	39.0	39.1	39.4	40.1	41.0	42.2
Q13-1	-	-	32.4	32.8	33.3	34.2	35.2	36.4	37.7	39.1
Q23-1 ^{[1][2]}	31.4	32.2	33.2	34.3	35.4	36.6	37.9	39.2	40.7	42.2
R8-1	31.9	32.3	32.6	32.8	33.1	33.5	33.9	34.6	35.5	36.7
R14-1	36.7	36.8	37.0	37.4	38.0	38.6	39.3	40.1	40.9	41.7
S12-1 ^[1]	-	31.5	31.6	31.8	32.4	33.1	34.1	35.3	36.6	38.1
U10-1 ^[3]	33.1	33.0	33.3	34.0	34.9	36.0	37.1	38.2	39.0	39.6

^[1] Indicates an associated receiver. Background noise levels measured at this receiver are provided for information only.

^[2] See comments regarding Q23-1 in Section 2.1

^[3] Background noise levels provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per Section 2.1.

Table 5: Background noise levels, dB LA90 – Night period (2200 - 0700 hrs)

Receiver	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
O17-1 ^[3]	-	-	-	-	-	31.0	31.6	33.1	35.8	40.1
Q13-1	30.8	30.8	30.9	31.1	31.4	31.8	32.3	32.9	33.6	34.4
Q23-1 ^{[1][2]}	-	-	-	27.2	27.8	29.2	31.1	33.5	36.1	38.9
R8-1	-	-	25.4	25.6	26.3	27.4	28.8	30.4	32.2	34.1
R14-1	-	-	-	22.8	23.3	24.4	26.1	28.4	31.2	34.5
S12-1 ^[1]	-	-	26.3	26.6	27.5	28.9	30.4	31.9	33.3	34.2
U10-1 ^[3]	29.8	30.2	30.6	31.1	31.7	32.4	33.2	34.0	34.9	35.9

^[1] Indicates an associated receiver. Background noise levels measured at this receiver are provided for information only.

^[2] See comments regarding Q23-1 in Section 1.0

^[3] Background noise levels provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per Section 2.1.

3.2 Noise limits

Noise limits derived considering the background noise levels detailed in Section 3.1 are provided in Table 6 and Table 7 for the key wind speeds relevant to the assessment of wind farm noise, separated into Day and Night subsets. Noise limits derived at associated receivers are provided as reference for nearby non-associated receivers.

The derived noise limits for all surveyed wind speeds are illustrated in the graphical data provided for each non-associated receiver in Appendix G to Appendix M.

Table 6: Operational wind farm noise limits, dB LA90 – Day period (0700 – 2200 hrs)

Receiver	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Q13-1	37.4	37.4	37.4	37.8	38.3	39.2	40.2	41.4	42.7	44.1
Q23-1 ^{[1][2]}	36.4	37.2	38.2	39.3	40.4	41.6	42.9	44.2	45.7	47.2
R8-1	36.9	37.3	37.6	37.8	38.1	38.5	38.9	39.6	40.5	41.7
R14-1	41.7	41.8	42.0	42.4	43.0	43.6	44.3	45.1	45.9	46.7
S12-1 ^[1]	36.5	36.5	36.6	36.8	37.4	38.1	39.1	40.3	41.6	43.1

^[1] Indicates an associated receiver. Noise limits provided as reference for nearby non-associated receivers only

^[2] See comments regarding Q23-1 in Section 1.0

Table 7: Operational wind farm noise limits, dB LA90 – Night period (2200 – 0700 hrs)

Receiver	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
Q13-1	35.8	35.8	35.9	36.1	36.4	36.8	37.3	37.9	38.6	39.4
Q23-1 ^{[1][2]}	35.0	35.0	35.0	35.0	35.0	35.0	36.1	38.5	41.1	43.9
R8-1	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.4	37.2	39.1
R14-1	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	36.2	39.5
S12-1 ^[1]	35.0	35.0	35.0	35.0	35.0	35.0	35.4	36.9	38.3	39.2

^[1] Indicates an associated receiver. Noise limits provided as reference for nearby non-associated receivers only

^[2] See comments regarding Q23-1 in Section 1.0

3.3 Associated receivers

Noise limits derived in accordance with the NSW Noise Assessment Bulletin only apply to non-associated receivers i.e. host properties and receivers where a noise agreement is in place with the Proponent.

Noise levels at associated receivers will ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the landowners, however, the SA Guideline (referred to in the NSW Noise Assessment Bulletin) states that an outdoor level of 45 dB is considered acceptable for financial stakeholders.

On this basis a reference level of 45 dB LAeq would be used in order to provide context to assessment of WTG noise for associated receivers.

3.4 C-Weighted background noise levels

The NSW Noise Assessment Bulletin does not provide a specific direction to measure C-weighted background noise levels as part of pre-construction noise monitoring, noting:

Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted criteria applied by this Bulletin.

Notwithstanding the above, the NSW Noise Assessment Bulletin does however indicate that C-weighted low frequency noise should be evaluated for compliance purposes.

In order to provide clarity to the Proponent and any stakeholders with respect to any future post-construction compliance assessment, C-weighted background noise levels have been recorded during the monitoring period for comparison to future operational C-weighted noise levels (if required). The C-weighted background noise levels are not presented in this report but are available upon request.

4.0 SUMMARY

Background noise monitoring has been conducted at seven (7) locations in the vicinity of the proposed Project. Only five (5) of these locations are classed as receivers; three (3) non-associated receivers and two (2) associated receivers.

The survey and analysis have been carried out on the basis of the NSW Noise Assessment Bulletin, which in turn references the SA Guideline.

The results have been analysed to derive noise limits for surrounding receivers only at integer hub height wind speeds as the greater of a 35 dB L_{A90} base level and the background level (L_{A90}) plus 5 dB.

Noise limits have been derived for the two (2) associated receivers for the purposes of providing reference for nearby non-associated receivers only. Noise limits applicable at associated receivers ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the landowners, however, the SA Guideline (referred to in the NSW Noise Assessment Bulletin) states that an outdoor level of 45 dB is considered acceptable for financial stakeholders.

The background noise levels, and derived noise limits applicable at non-associated receivers have been documented for the purposes of the environmental noise assessment accompanying the development application for the project.

APPENDIX A GLOSSARY

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.

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear’s varied sensitivity to different frequencies of sound.	--
A-weighted 90 th 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}
C-weighting	The process by which noise levels are corrected to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).	--
C-weighted 90 th centile	The C-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 _{C90}
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 pressure level	A measure of the level of sound expressed in decibels.	L _p

APPENDIX B WTG COORDINATES

Table 8 sets out the coordinates of the current proposed WTG layout.
(Layout dated 20 April 2023 as supplied by the Proponent).

Table 8: Proposed WTG co-ordinates – MGA 2020 zone 55

WTG	Easting, m	Northing, m	Terrain elevation, m
1	705,019	6,388,684	614
2	704,833	6,388,073	635
3	705,065	6,387,475	670
5	702,820	6,387,116	601
6	703,455	6,386,966	600
7	704,375	6,386,629	694
8	704,813	6,386,349	699
9	705,188	6,385,635	730
10	705,510	6,385,239	720
11	705,755	6,384,808	730
12	705,617	6,384,386	741
13	706,034	6,383,906	705
14	706,395	6,383,567	710
15	706,616	6,383,010	660
16	706,689	6,382,518	675
17	706,546	6,382,043	679
19	708,552	6,381,162	769
20	709,069	6,381,998	750
21	710,874	6,385,666	613
22	709,786	6,385,531	665
23	710,302	6,385,085	660
24	710,289	6,384,344	690
25	709,901	6,384,732	670
26	709,831	6,383,889	740
27	709,882	6,383,239	730
28	709,255	6,382,927	735
29	708,775	6,380,588	764
30	709,121	6,379,906	774
31	709,746	6,379,824	764

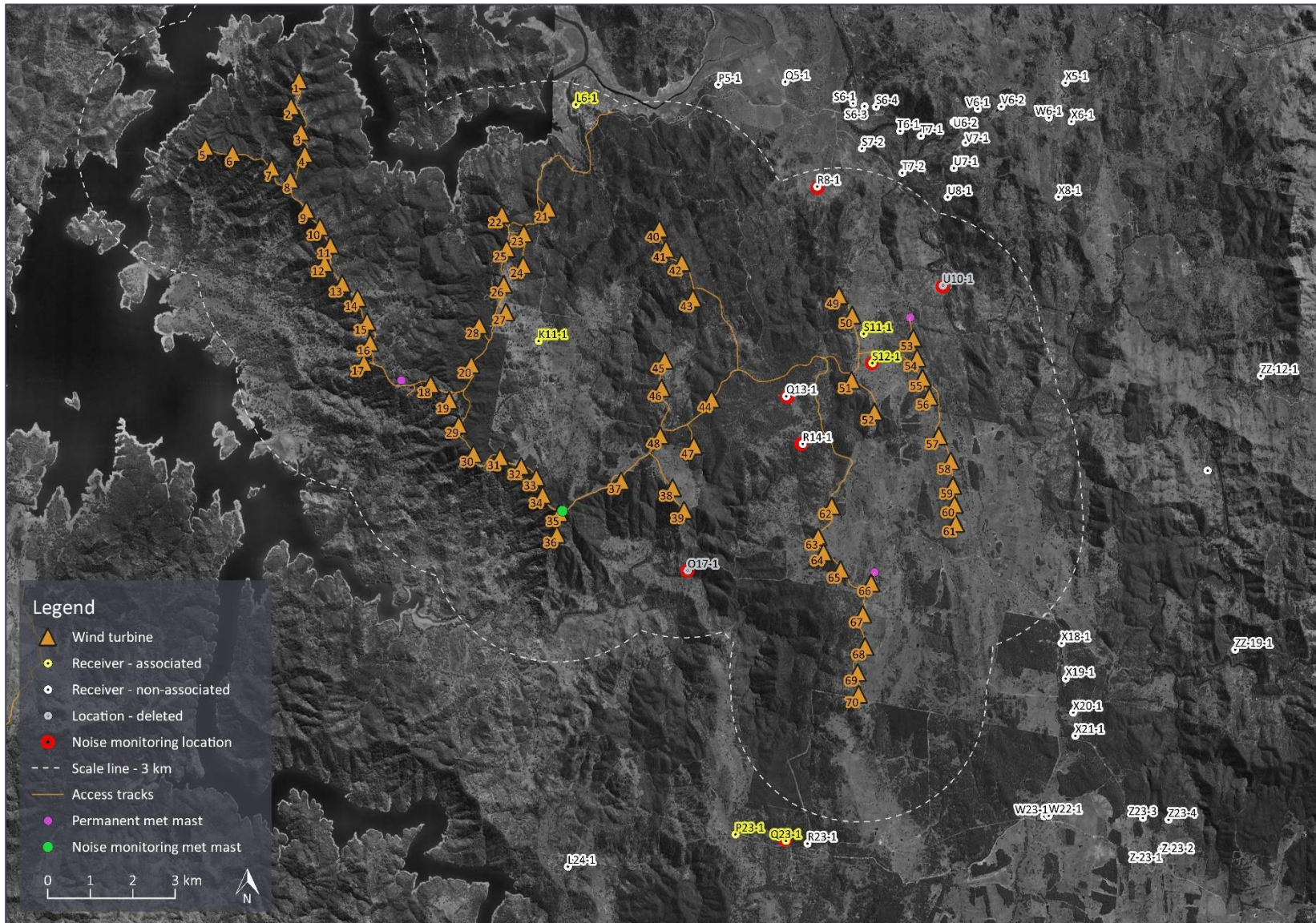
WTG	Easting, m	Northing, m	Terrain elevation, m
32	710241	6379611	742
33	710599	6379350	785
34	710747	6378937	775
35	711140	6378511	795
36	711082	6378010	780
37	712593	6379269	760
38	713,803	6,379,108	774
39	714,071	6,378,580	779
40	713,491	6,385,192	650
41	713,644	6,384,719	664
42	714,015	6,384,401	720
43	714,281	6,383,561	725
44	714,717	6,381,192	765
45	713,616	6,382,100	740
46	713,543	6,381,450	740
47	714,306	6,380,093	768
48	713,510	6,380,333	775
49	717,717	6,383,624	763
50	718,027	6,383,164	745
51	718,009	6,381,637	759
52	718,546	6,380,891	745
53	719,461	6,382,625	755
54	719,551	6,382,158	765
55	719,679	6,381,689	770
56	719,838	6,381,250	805
57	720,061	6,380,325	770
58	720,344	6,379,739	781
59	720,396	6,379,159	800
60	720,430	6,378,716	768
61	720,460	6,378,269	800
62	717,545	6,378,681	705
63	717,225	6,377,956	735
64	717,352	6,377,586	755

WTG	Easting, m	Northing, m	Terrain elevation, m
65	717,750	6,377,183	763
66	718,470	6,376,868	788
67	718,275	6,376,135	795
68	718,327	6,375,379	825
69	718,151	6,374,763	830
70	718,176	6,374,253	815

APPENDIX C NOISE MONITORING LOCATIONS

The locations where background noise monitoring was undertaken is illustrated in Figure 1 together with an overall site layout indicating candidate WTG locations.

Figure 1: Monitoring locations relative to the proposed Burrendong Wind Farm



APPENDIX D SURVEY INSTRUMENTATION

Table 9: Sound level measurement instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound levels
Make & model	01dB CUBE/DUO
Instrumentation class	Certified to Type 1 / Class 1 (precision grade) standards in accordance with AS/IEC 61672.1:2019 ⁵
Instrumentation noise floor	Less than 20 dB
Time synchronisation	Internal GPS clocks
Wind shielding	Enhanced wind shielding system based on the design recommendations detailed in the UK IOA Good Practice Guide. The system comprises an inner solid primary wind shield and an outer secondary large diameter hollow wind shield

Table 10: Equipment details and calibration

Location	Make & model	Serial number	Microphone serial number	Independent calibration date ^[1]	Calibration drift ^{[2] [3]}
<i>Noise monitoring equipment</i>					
O17-1	01dB Cube	10421	260714	04/08/2020	-0.05
Q13-1	01dB Duo	10497	144850	17/08/2020	+0.10
Q23-1	01dB Cube	11887	330712	28/08/2019	-0.07
R8-1	01dB Cube	10516	161879	31/07/2020	-0.24
R14-1	01dB Cube	11877	331800	12/4/2019	-0.35
S12-1	01dB Cube	11877	331800	12/4/2019	-0.35
U10-1	01dB Cube	10511	255808	16/11/2020	-0.78
<i>Calibrator</i>					
-	01dB Cal 21	34164984	-	9/8/2019	-
-	Brüel & Kjær 4231	3027271	-	28/07/2021	-

^[1] Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055:2018⁶

^[2] Difference between reference level checks during deployment and collection of instruments

^[3] Calibration drift should not be greater than 1 dB as specified in AS 1055:2018

⁵ AS/IEC 61672.1-2019 *Electroacoustics - Sound level meters – Specifications* which is identical to IEC 61672.1:2.0 *Electroacoustics - Sound Level Meters - Part 1: Specifications* published in 2013

⁶ AS 1055:2018 *Acoustics – Description and measurement of environmental noise*

Table 11: Local weather data measurement instrumentation

Receiver	Make & model	Serial number
Q13-1	Vaisala WXT520	M4511088
R14-1	Vaisala WXT520	H5020012
U10-1	LSI WSV601	215521

APPENDIX E SITE WIND SPEED DATA

E1 Wind monitoring location

Wind monitoring was carried out by the Proponent at the met mast identified as BDG1 during the noise monitoring survey. Coordinates for the met mast is detailed in Table 12.

Table 12: Wind monitoring location coordinates – GDA 1994 Zone 55

Reference	Easting, m	Northing, m	Elevation, m
BDG1	711,209.4	6,378,562.2	790

E1 Wind speed data derivation

Hub height wind speed and direction data (150 m above ground level) for the duration of the background noise monitoring periods has been provided by the Proponent.

The process for generating the wind data set for this project was provided to MDA by the Proponent in an email dated 28 March 2022. The relevant extract is reproduced below.

- *Values are recorded at 10 min intervals, with intervals denoted by the time at which they end*
- *The mast is 110 m tall so the 110 m values are directly measured*
- *The 150 m values are estimated by shearing up the measured data. The following is a simplified explanation for how this is achieved:*
 - *Calculate the shear exponent for each timestamp, using the wind speeds from the other mast elevations (60, 80, 100, 110)*
 - *Divide these exponents into bins based on Wind direction/time of day/time of year*
 - *Calculate the average shear exponent for each bin, then use these to synthesize the 150 m wind speeds*

APPENDIX F SUMMARY OF BACKGROUND NOISE LEVEL REGRESSION COEFFICIENTS

Table 13: Regression equation coefficients (Day period)

Location	Regression equation coefficients for background noise equation of best fit					
	$L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					
	a	b	c	d	R ²	Valid wind speed range
O17-1 ^[3]	0.00346	0.0413	-1.09	43.38	0.0073	7-12
Q13-1	-0.0066	0.2573	-1.914	36.39	0.2191	5-12
Q23-1 ^{[1][2]}	--	0.04044	0.601	29.19	0.3082	3-12
R8-1	0.00929	-0.1573	1.137	29.68	0.0602	3-12
R14-1	-0.004	0.135	-0.716	37.73	0.0519	3-12
S12-1 ^[1]	-0.0032	0.1835	-1.438	34.56	0.2509	4-12
U10-1 ^[3]	-0.0173	0.4325	-2.5	37.18	0.2576	3-12

^[1] Indicates an associated receiver. Noise limits provided as reference for nearby non-associated receivers

^[2] See comments regarding Q23-1 in Section 1.0

^[3] Regression equation coefficients provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per Section 2.1.

Table 14: Regression equation coefficients (Night period)

Location	Regression equation coefficients for background noise equation of best fit					
	$L_{A90} = ax^3+bx^2+cx+d$, where x = windspeed in m/s					
	a	b	c	d	R ²	Valid wind speed range
O17-1 ^[3]	0.05281	-0.9674	5.555	21.44	0.0788	8-12
Q13-1	---	0.04812	-0.3201	31.31	0.049	3-12
Q23-1 ^{[1][2]}	-0.0232	0.8469	-7.437	46.37	0.2022	6-12
R8-1	-0.0138	0.4917	-3.948	34.54	0.2112	5-12
R14-1	-0.0029	0.3644	-3.877	33.61	0.2327	6-12
S12-1 ^[1]	-0.0334	0.9002	-6.524	40.55	0.1842	5-12
U10-1 ^[3]	---	0.03699	0.1197	29.09	0.1046	3-12

^[1] Indicates an associated receiver. Noise limits provided as reference for nearby non-associated receivers

^[2] See comments regarding Q23-1 in Section 1.0

^[3] Regression equation coefficients provided for information only. Noise limits have not been derived for these locations as they are not classed as receivers per Section 2.1.

APPENDIX G LOCATION O17-1 DATA

G1 Location O17-1 location data

Table 15: Location O17-1 and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Location	714,157	6,377,163
Background noise monitoring location	714,150	6,377,156

Table 16: Location O17-1 monitor installation photos

Looking North



Looking East



Looking South



Looking West



Figure 2: Location O17-1 aerial view – dwelling and noise monitor location



G2 Location O17-1 measurement data summary

Table 17: Location O17-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	4,582
Number of data points removed	2,636
Number of data points for analysis (worst case wind direction)	1,946 (461)

Table 18: Location O17-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	2,754
Number of data points removed	1,944
Number of data points for analysis (worst case wind direction)	810 (210)

Figure 3: Location O17-1 background noise level and wind speed time history

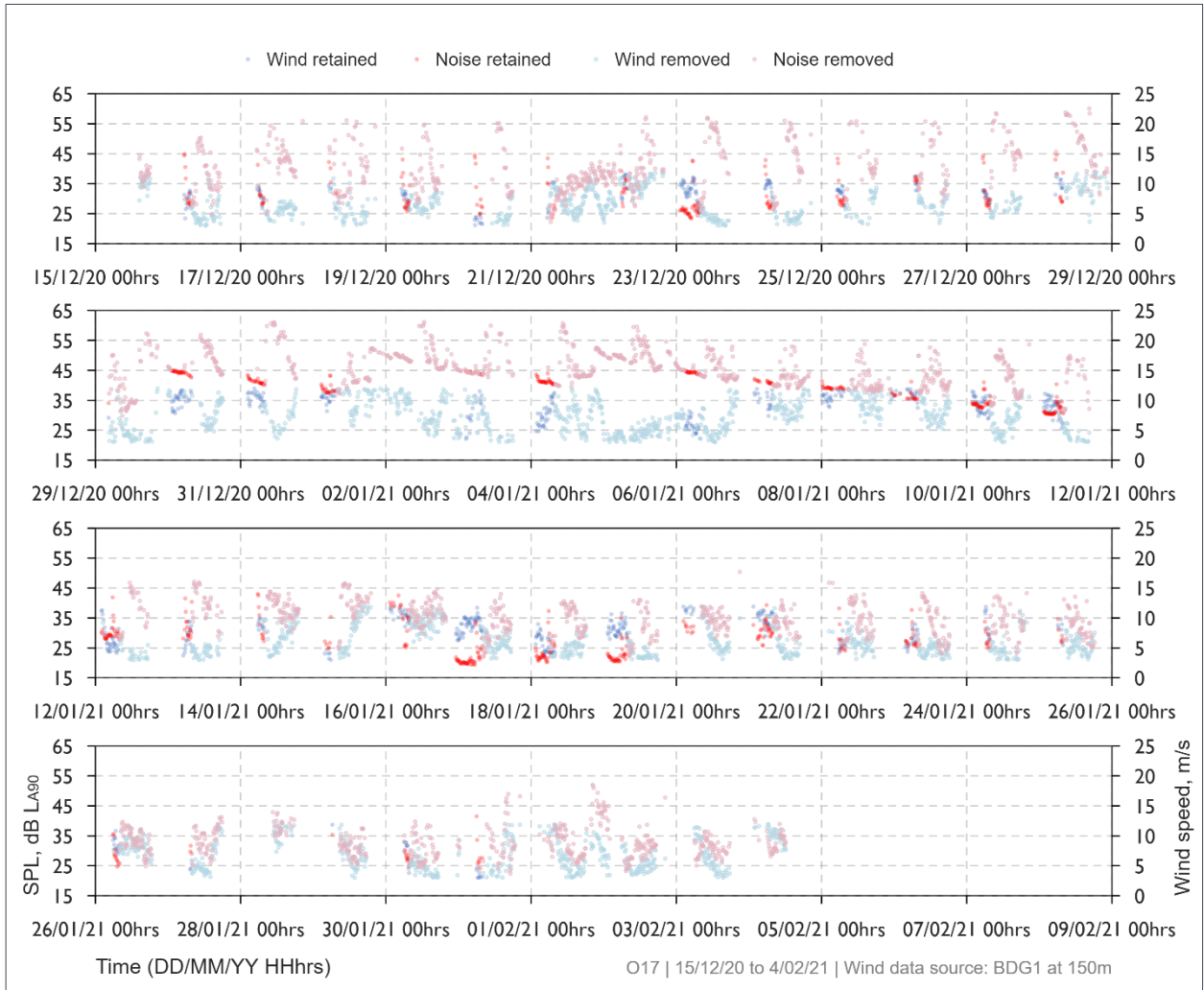
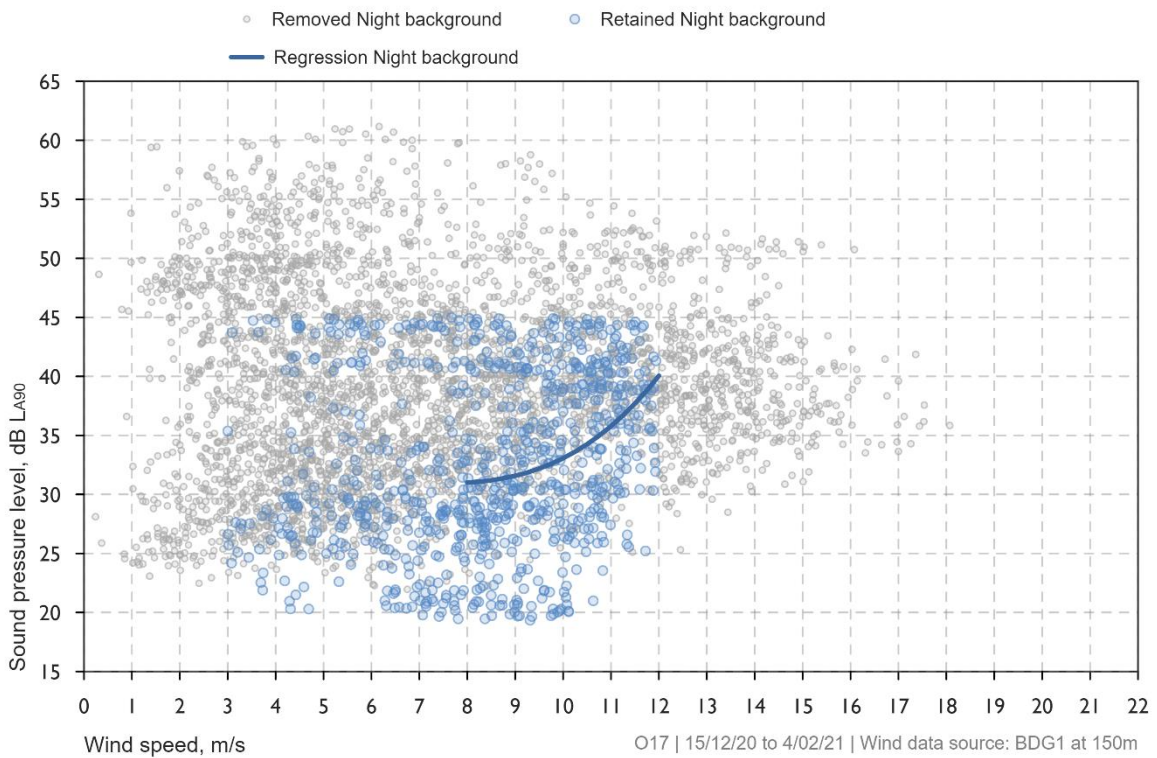
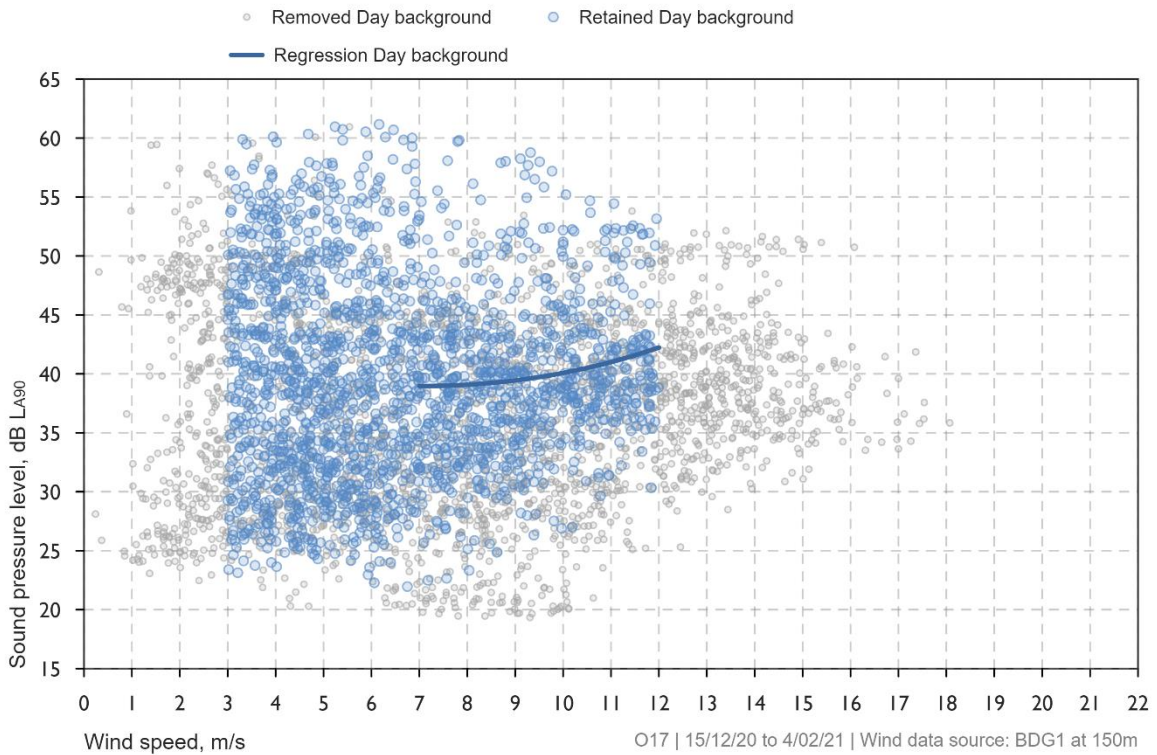


Figure 4: Location O17-1 derived background noise levels



APPENDIX H RECEIVER Q13-1 DATA

H1 Receiver Q13-1 location data

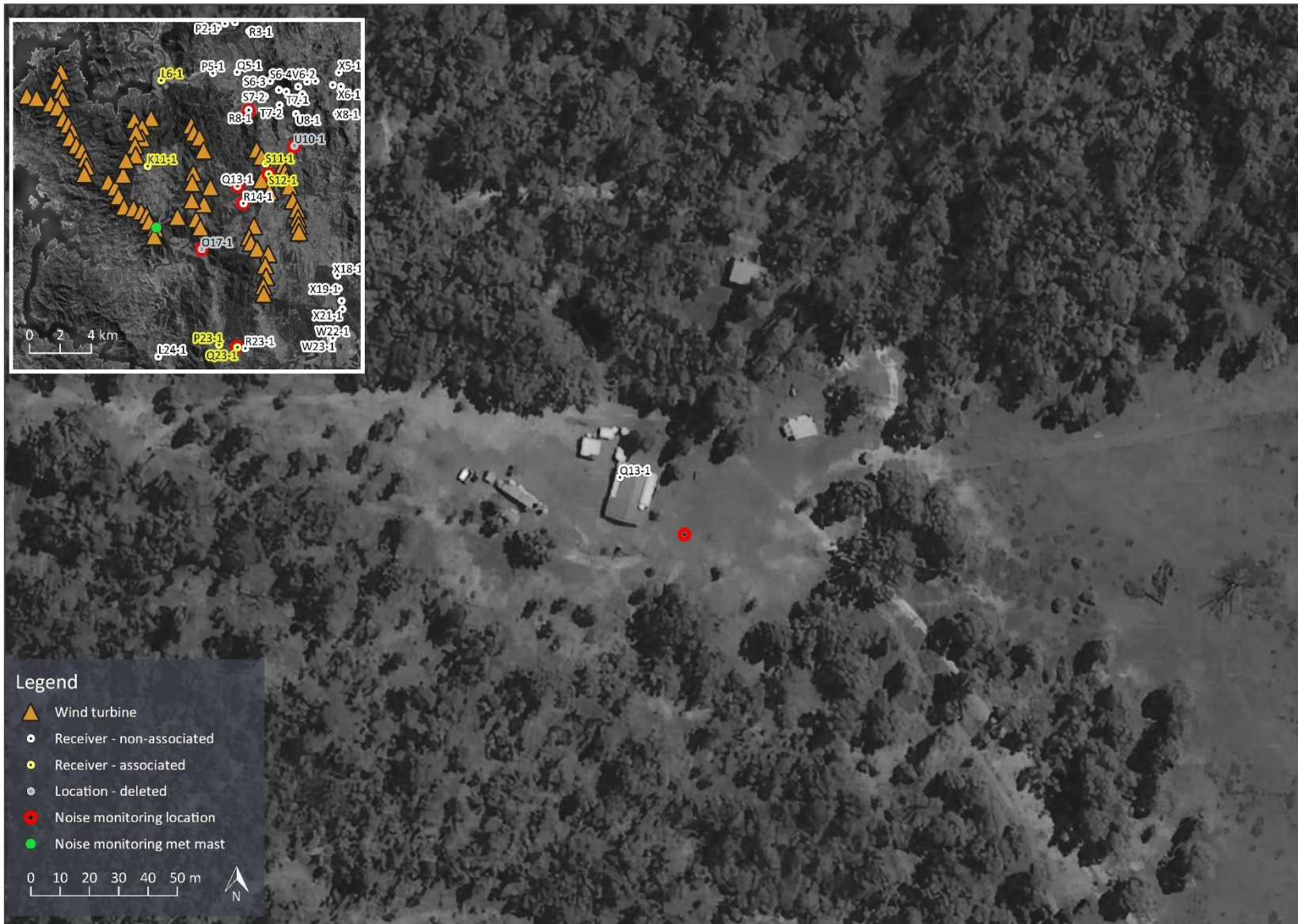
Table 19: Receiver Q13-1 dwelling and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Dwelling location	716,474	6,381,259
Background noise monitoring location	716,496	6,381,239

Table 20: Receiver Q13-1 monitor installation photos



Figure 5: Receiver Q13-1 aerial view – dwelling and noise monitor location



H2 Receiver Q13-1 measurement data summary

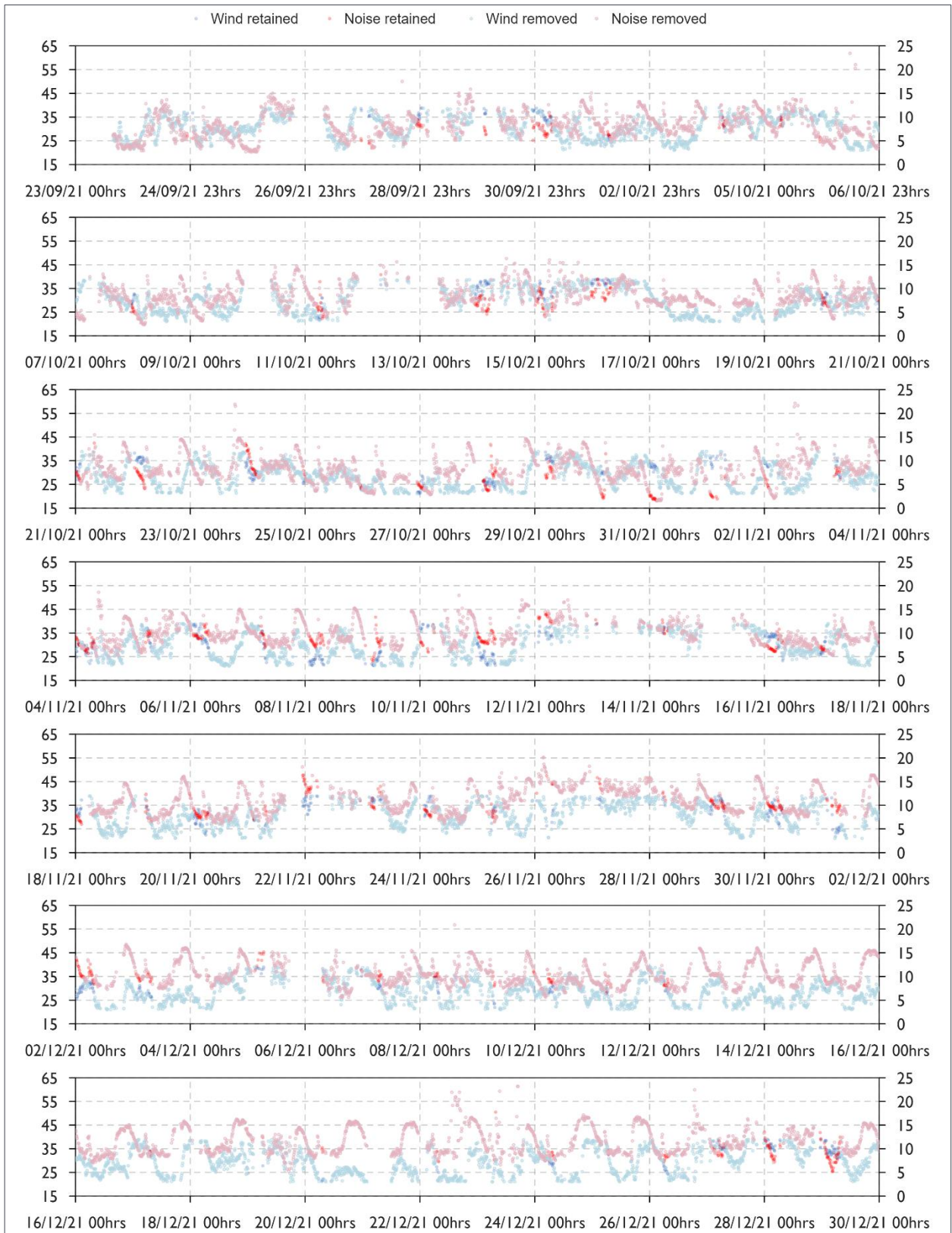
Table 21: Receiver Q13-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	11,067
Number of data points removed	7,530
Number of data points for analysis (worst case wind direction)	3,537 (1,528)

Table 22: Receiver Q13-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	6,642
Number of data points removed	5,013
Number of data points for analysis (worst case wind direction)	1,629 (876)

Figure 6: Receiver Q13-1 background noise level and wind speed time history



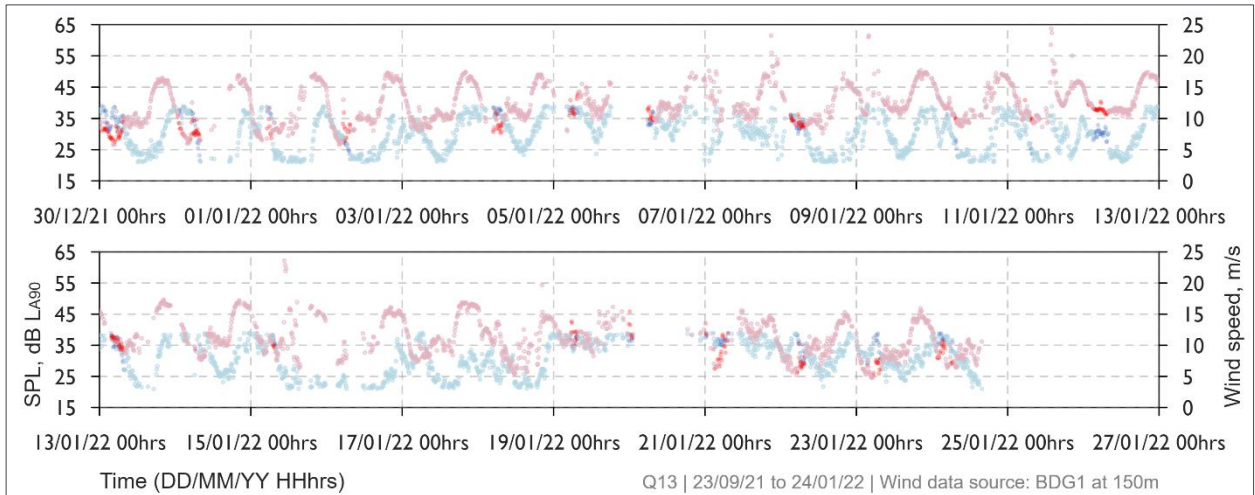
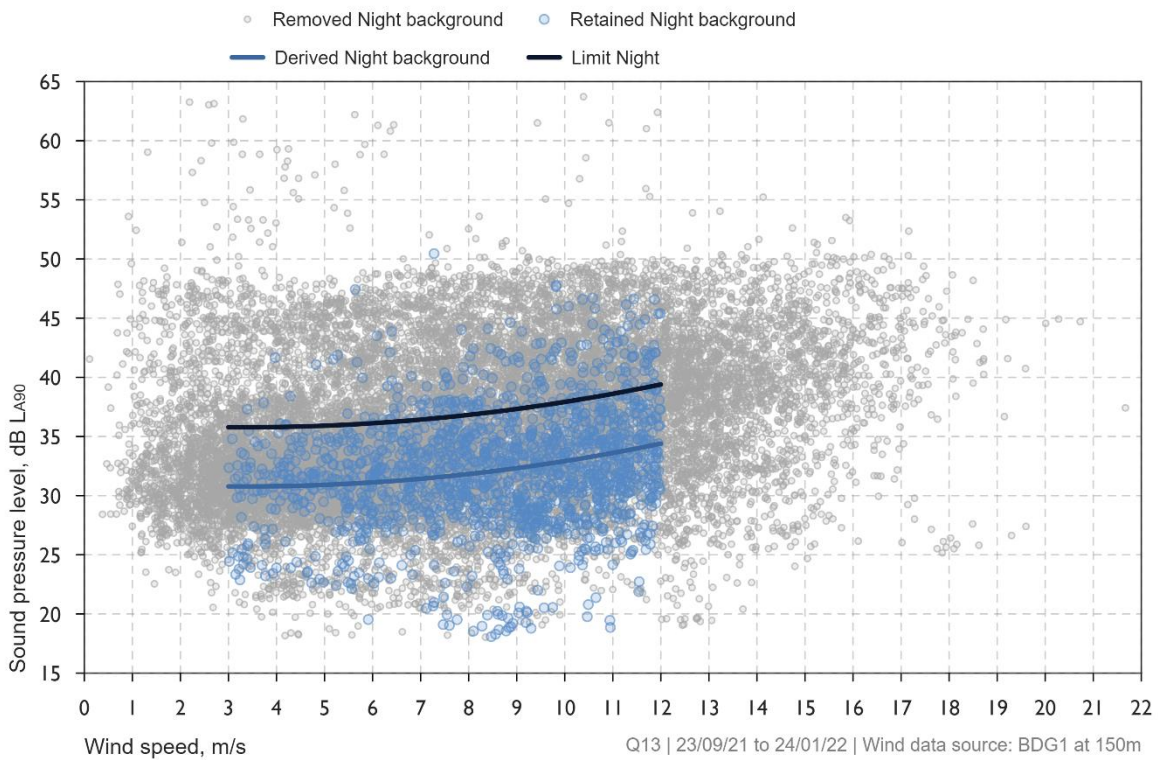
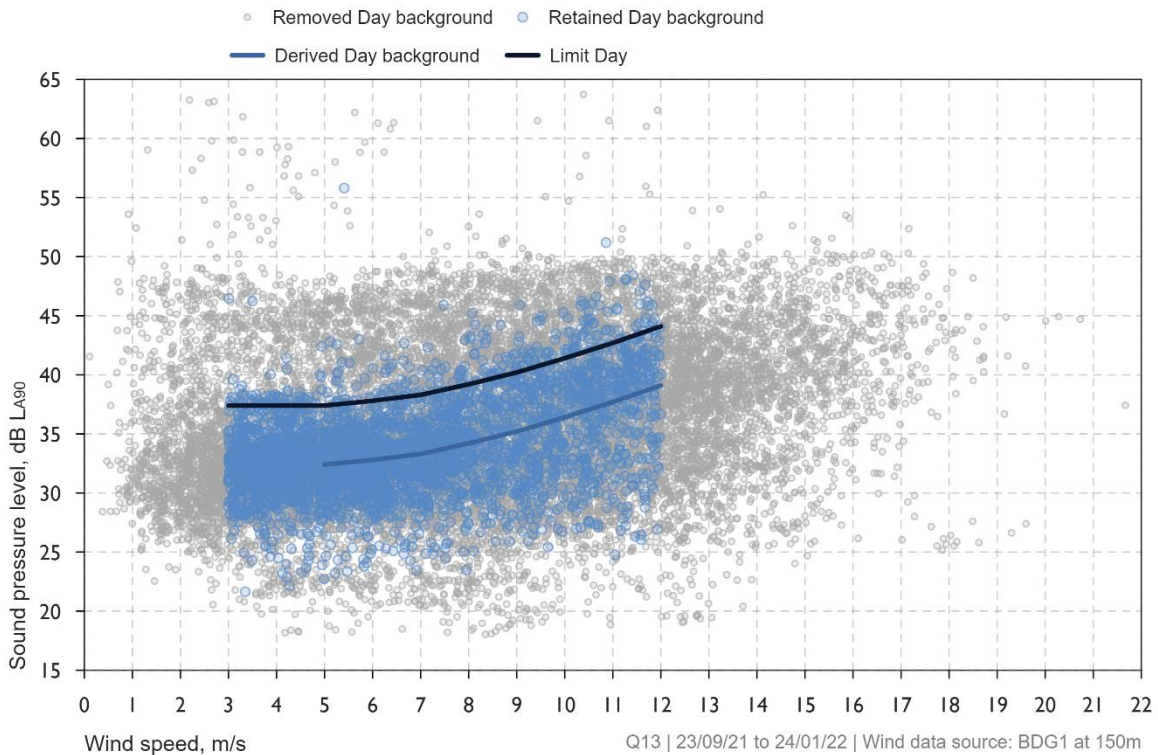


Figure 7: Receiver Q13-1 derived background noise levels and reference noise limits



APPENDIX I RECEIVER Q23-1 DATA

I1 Receiver Q23-1 location data

See comments regarding Q23-1 in Section 1.0.

Table 23: Receiver Q23-1 dwelling and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Dwelling location	716,467	6,370,805
Background noise monitoring location	716,449	6,370,828

Table 24: Receiver Q23-1 monitor installation photos

Looking North



Looking East



Looking South



Looking West



Figure 8: Receiver Q23-1 aerial view – dwelling and noise monitor location



I2 Receiver Q23-1 measurement data summary

Table 25: Receiver Q23-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	4,676
Number of data points removed	3,034
Number of data points for analysis (worst case wind direction)	1,642 (464)

Table 26: Receiver Q23-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	2,808
Number of data points removed	1,607
Number of data points for analysis (worst case wind direction)	1,201 (131)

Figure 9: Receiver Q23-1 background noise level and wind speed time history

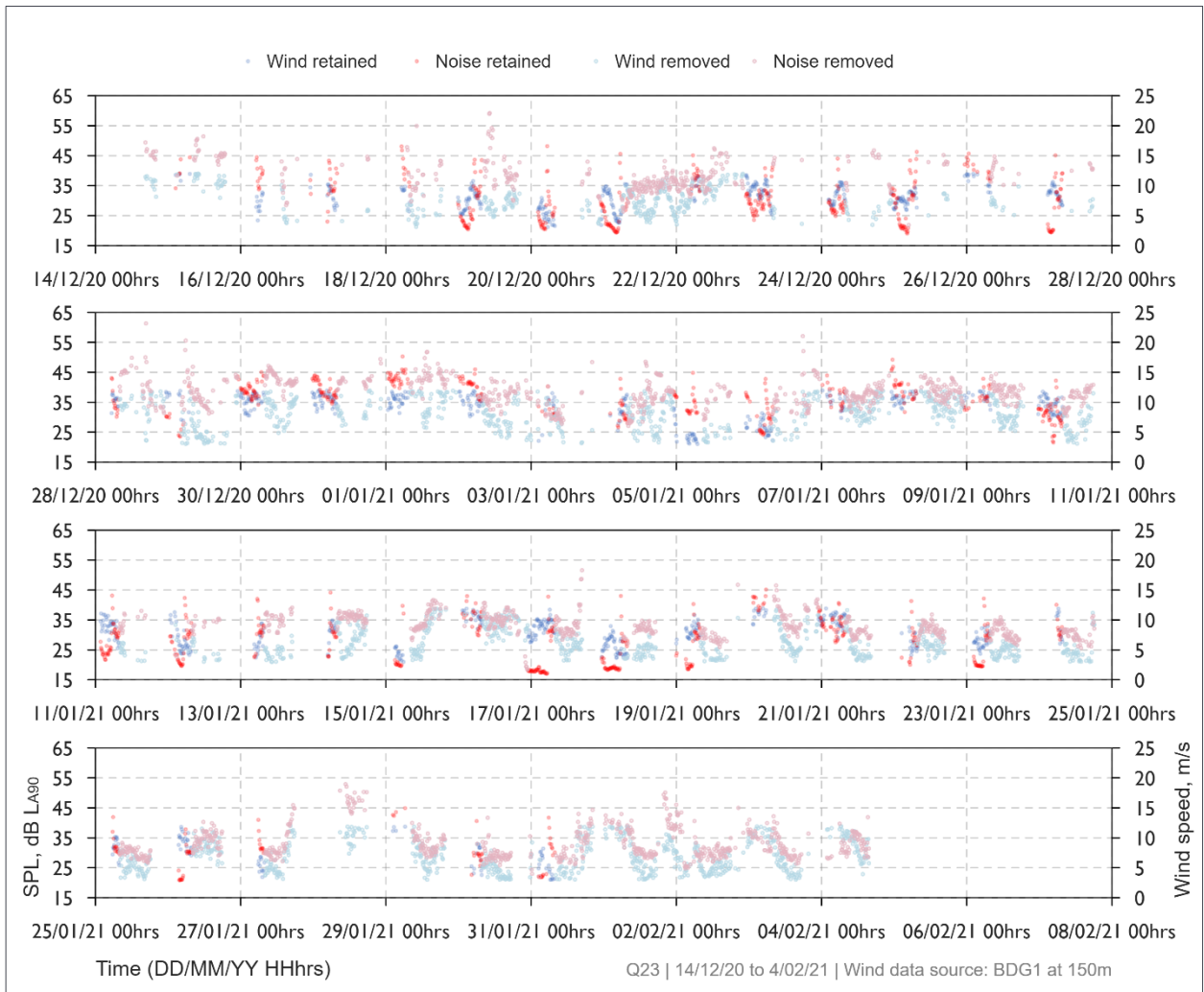
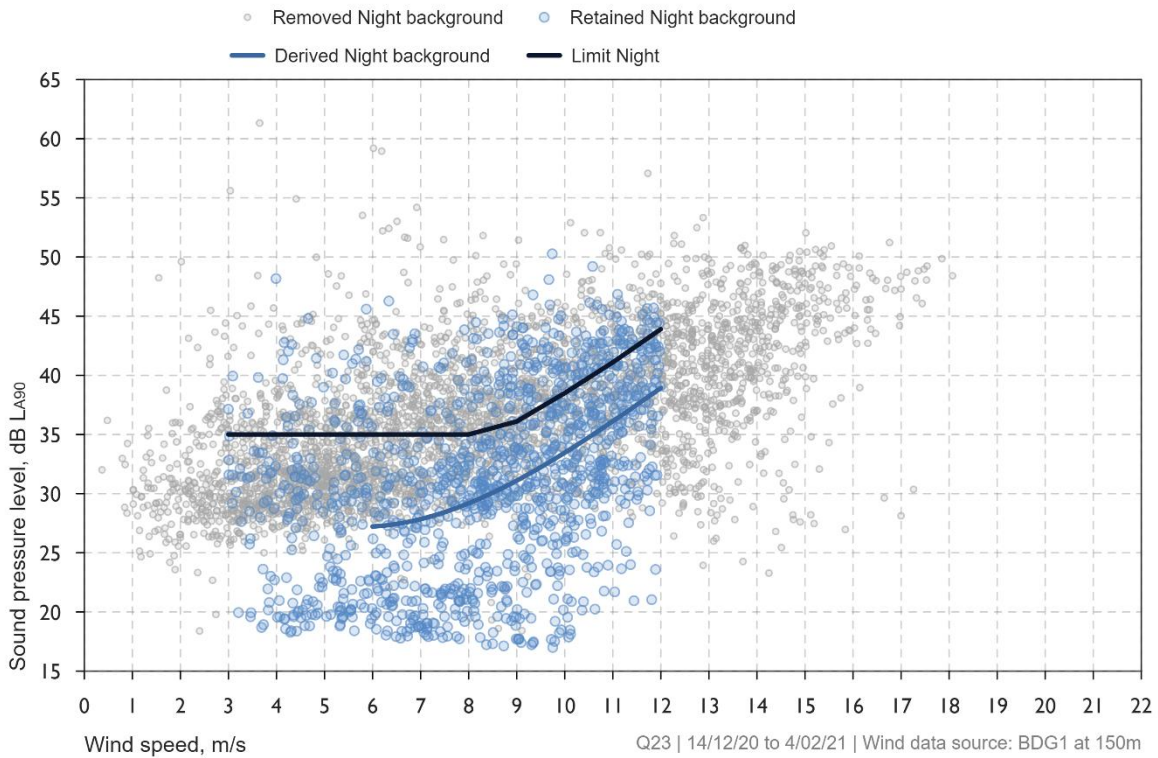
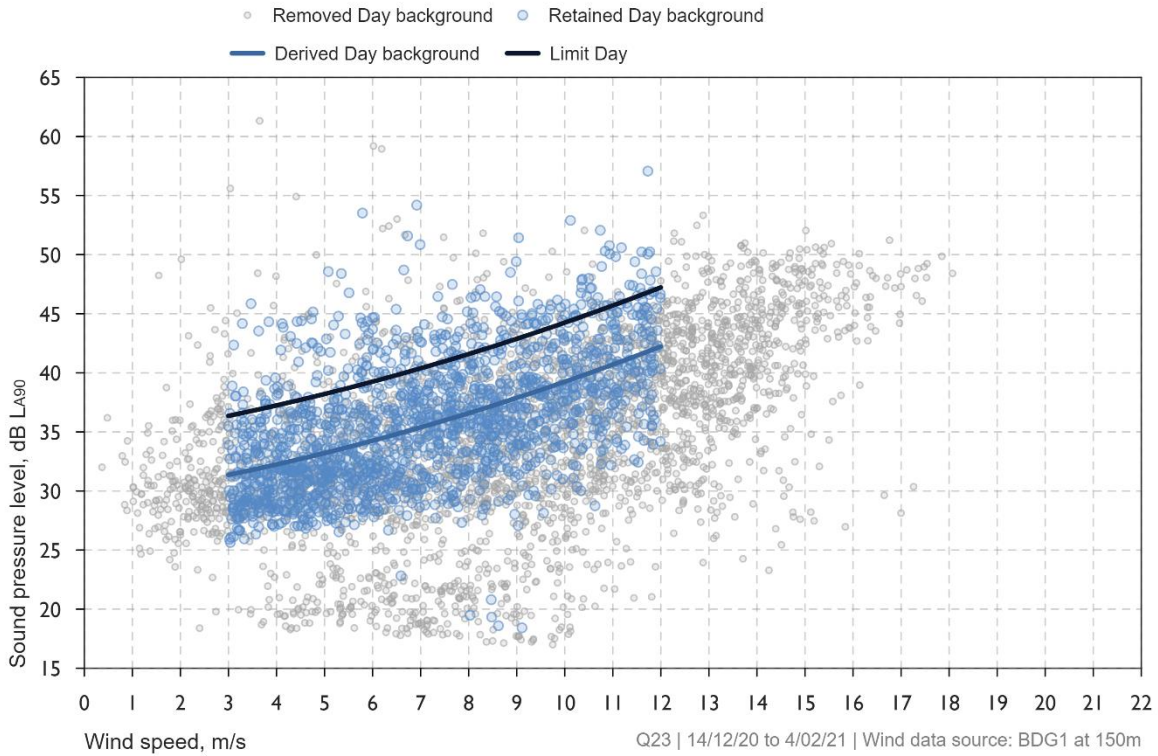


Figure 10: Receiver Q23-1 derived background noise levels.



APPENDIX J RECEIVER R8-1 DATA

J1 Receiver R8-1 location data

Table 27: Receiver R8-1 dwelling and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Dwelling location	717,203	6,386,186
Background noise monitoring location	717,205	6,386,152

Table 28: Receiver R8-1 monitor installation photos



Figure 11: Receiver R8-1 aerial view – dwelling and noise monitor location



J2 Receiver R8-1 measurement data summary

Table 29: Receiver R8-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	4,758
Number of data points removed	2,334
Number of data points for analysis (worst case wind direction)	2,424 (695)

Table 30: Receiver R8-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	2,862
Number of data points removed	1,595
Number of data points for analysis (worst case wind direction)	1,267 (148)

Figure 12: Receiver R8-1 background noise level and wind speed time history

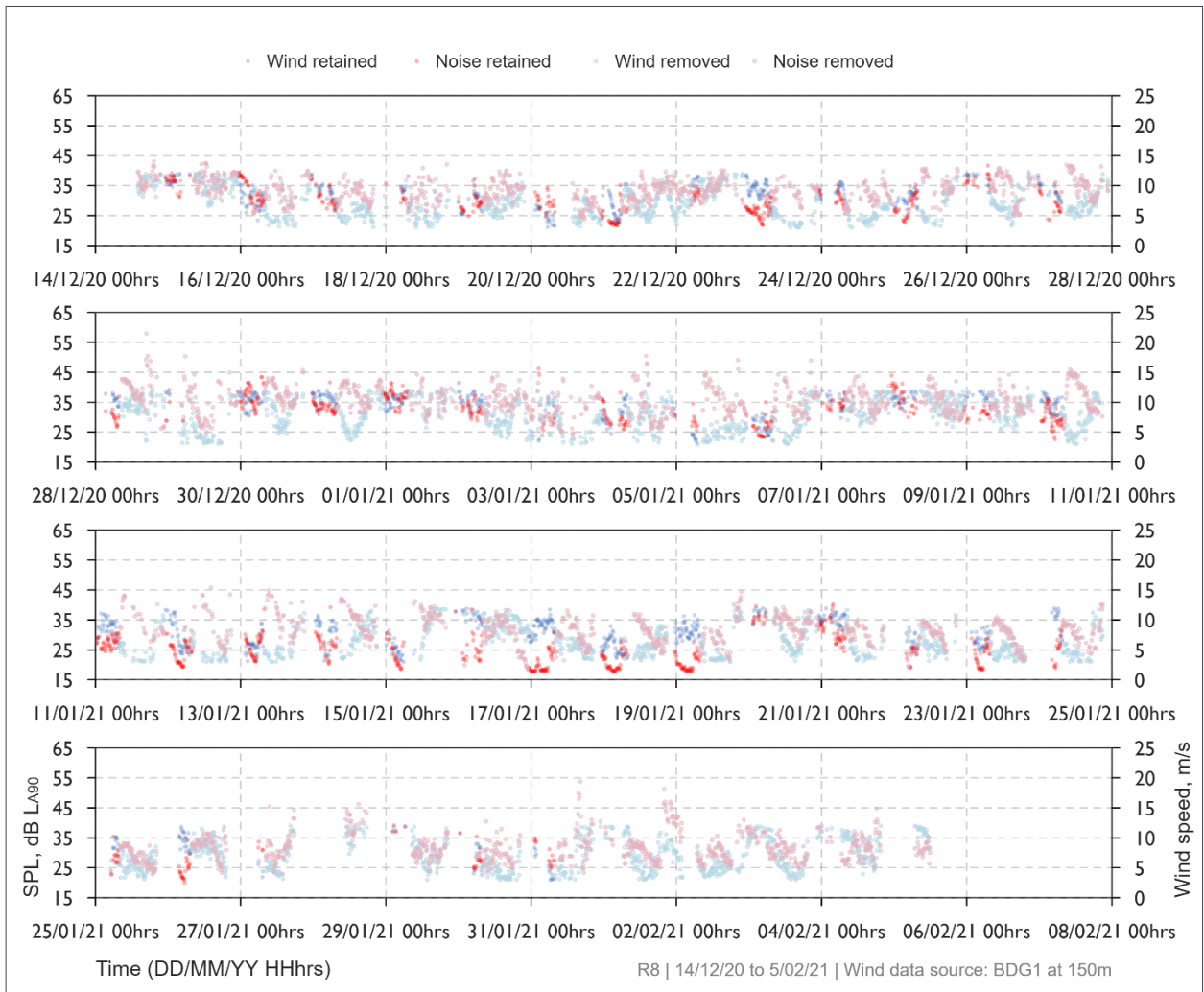
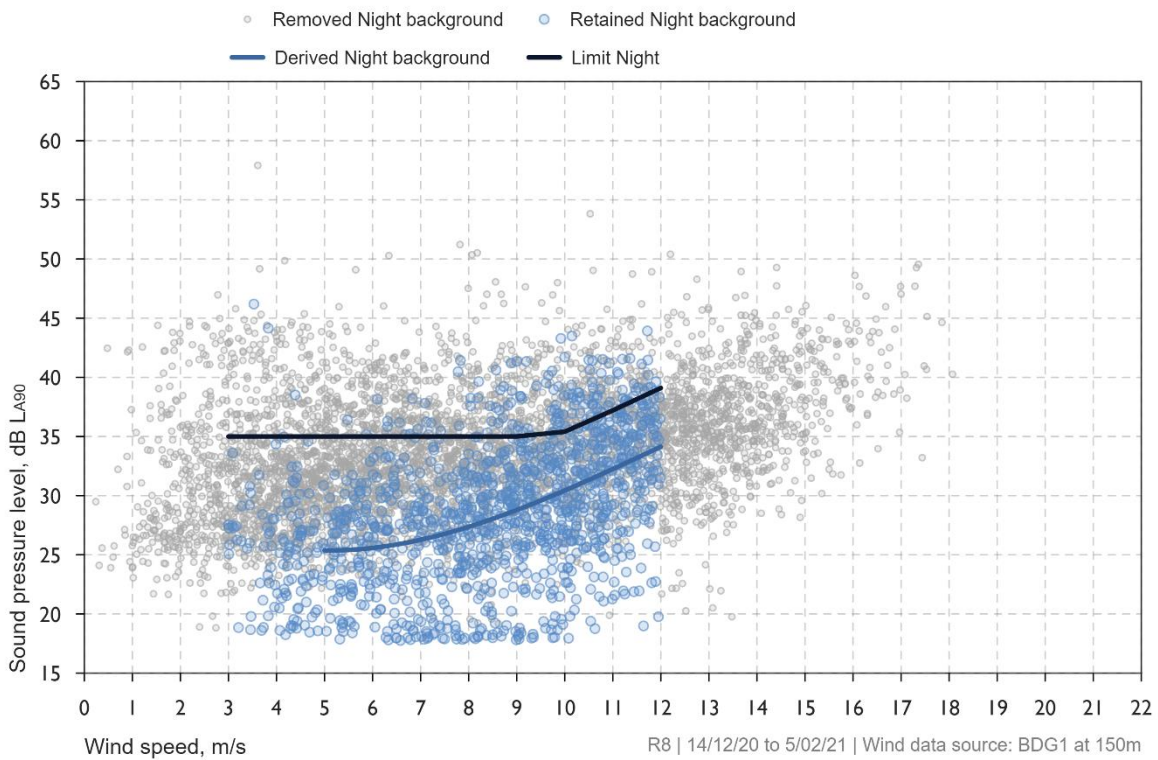
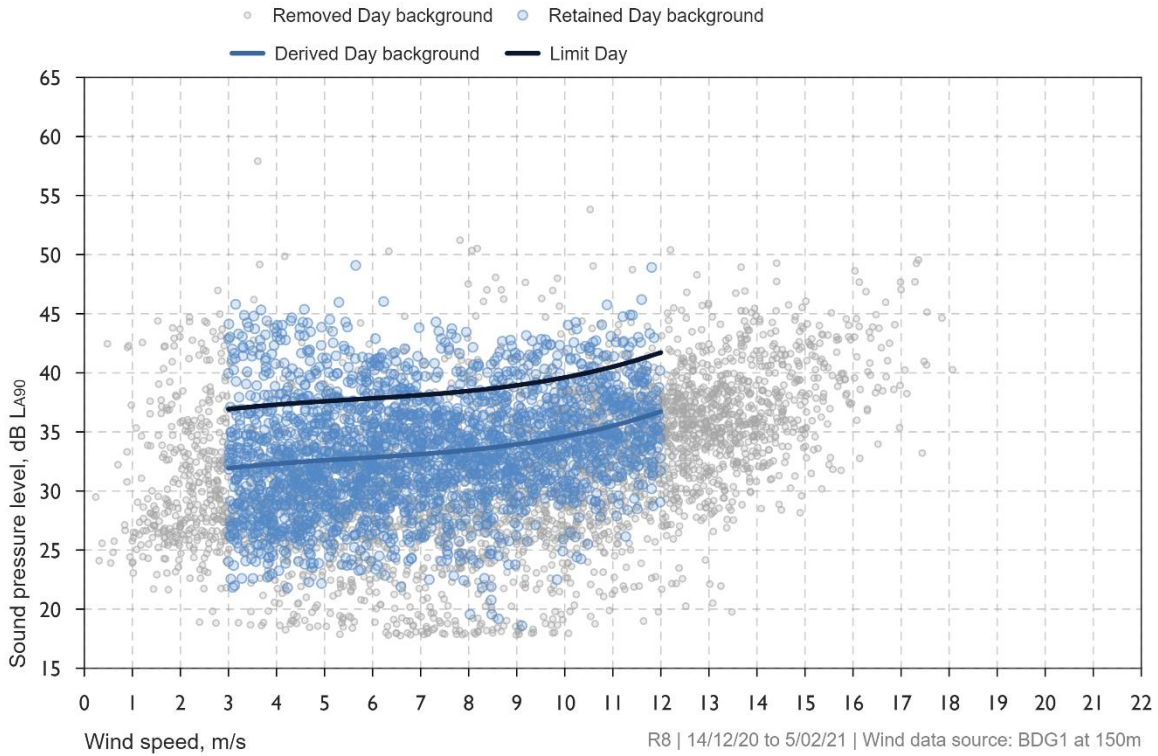


Figure 13: Receiver R8-1 derived background noise levels and reference noise limits



APPENDIX K RECEIVER R14-1 DATA

K1 Receiver R14-1 location data

Table 31: Receiver R14-1 dwelling and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Dwelling location	716,862	6,380,138
Background noise monitoring location	716,829	6,380,134

Table 32: Receiver R14-1 monitor installation photos

Looking North



Looking East



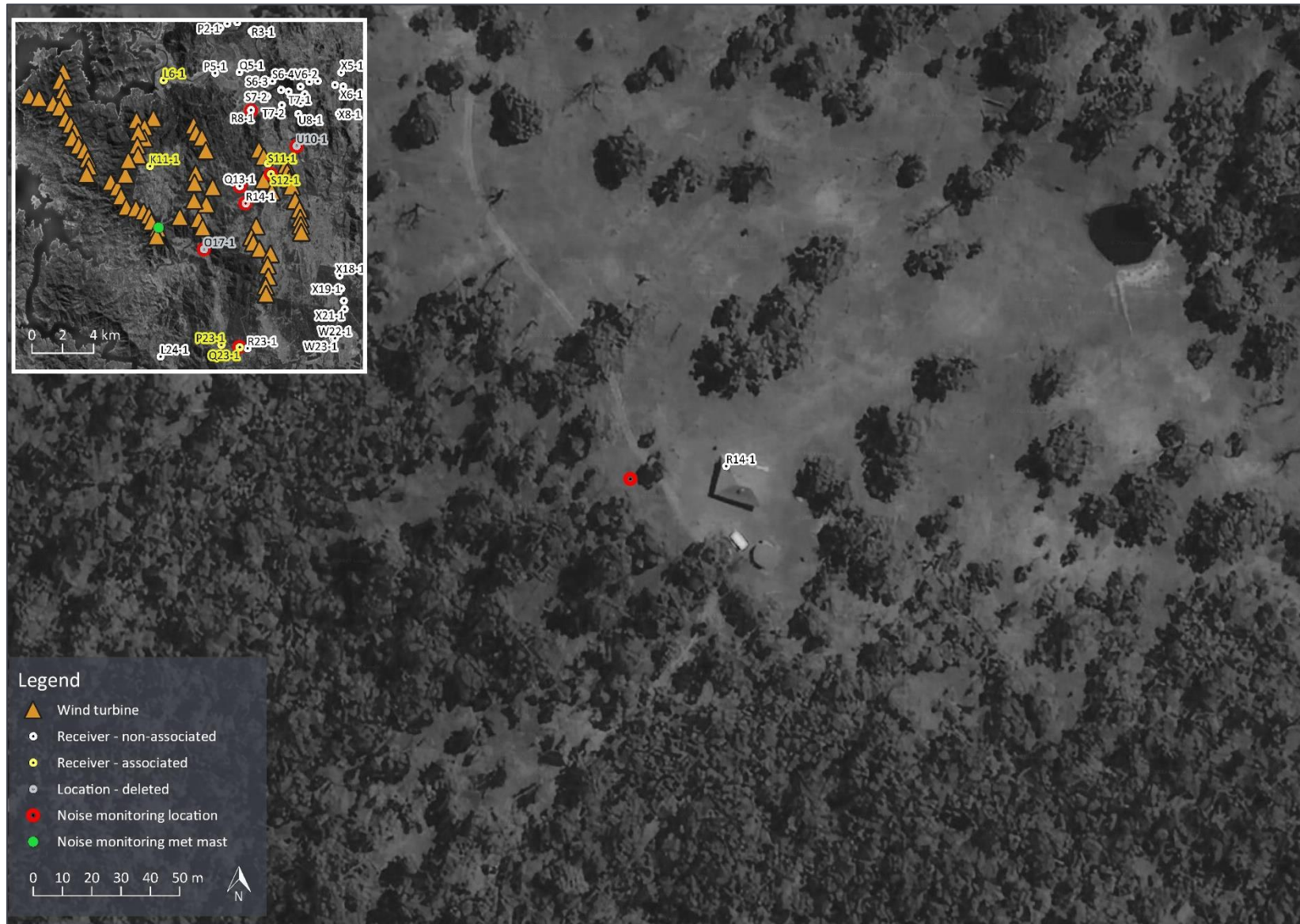
Looking South



Looking West



Figure 14: Receiver R14-1 aerial view – dwelling and noise monitor location



K2 Receiver R14-1 measurement data summary

Table 33: Receiver R14-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	4,691
Number of data points removed	2,864
Number of data points for analysis (worst case wind direction)	1,827 (587)

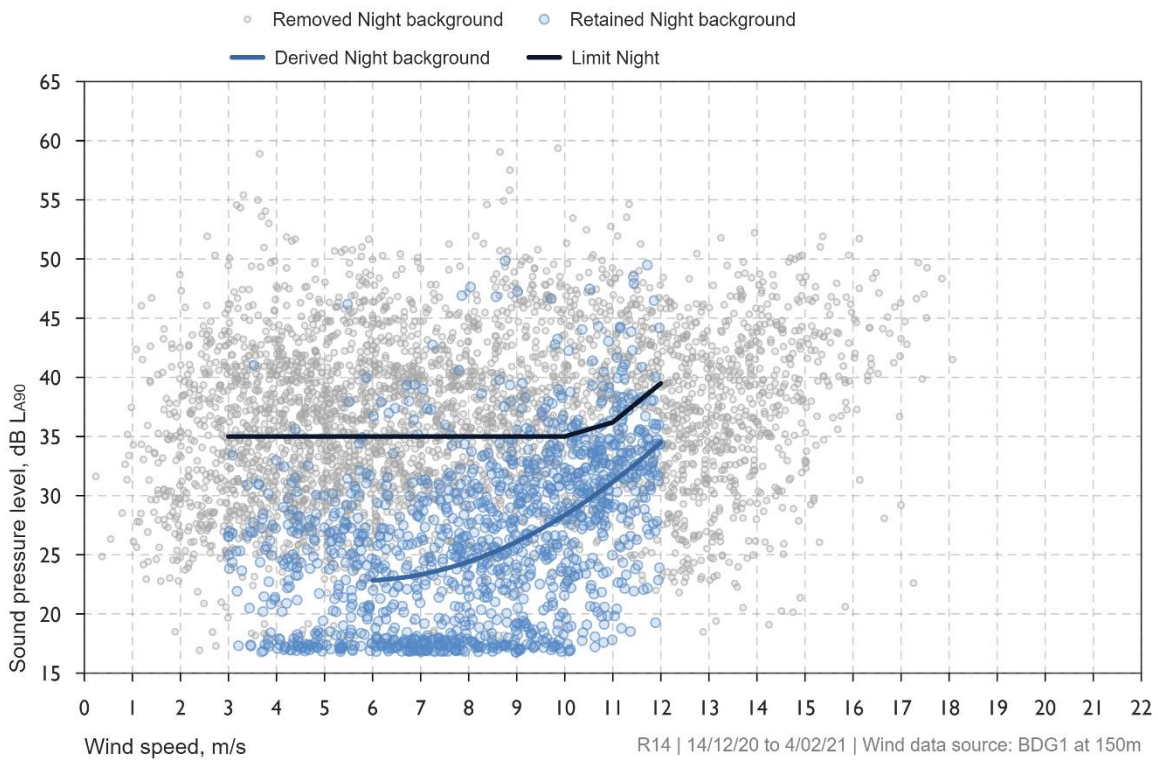
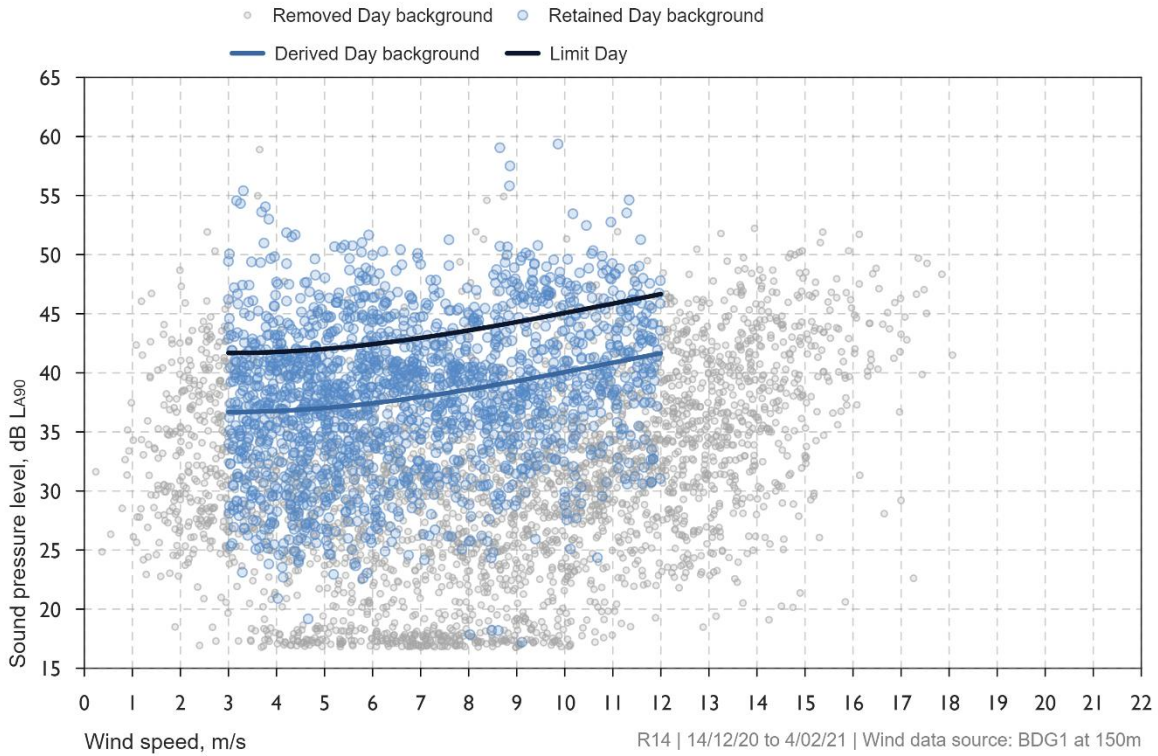
Table 34: Receiver R14-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	2,808
Number of data points removed	1,538
Number of data points for analysis (worst case wind direction)	1,270 (534)

Figure 15: Receiver R14-1 background noise level and wind speed time history



Figure 16: Receiver R14-1 derived background noise levels and reference noise limits



APPENDIX L RECEIVER S12-1 DATA

L1 Receiver S12-1 location data

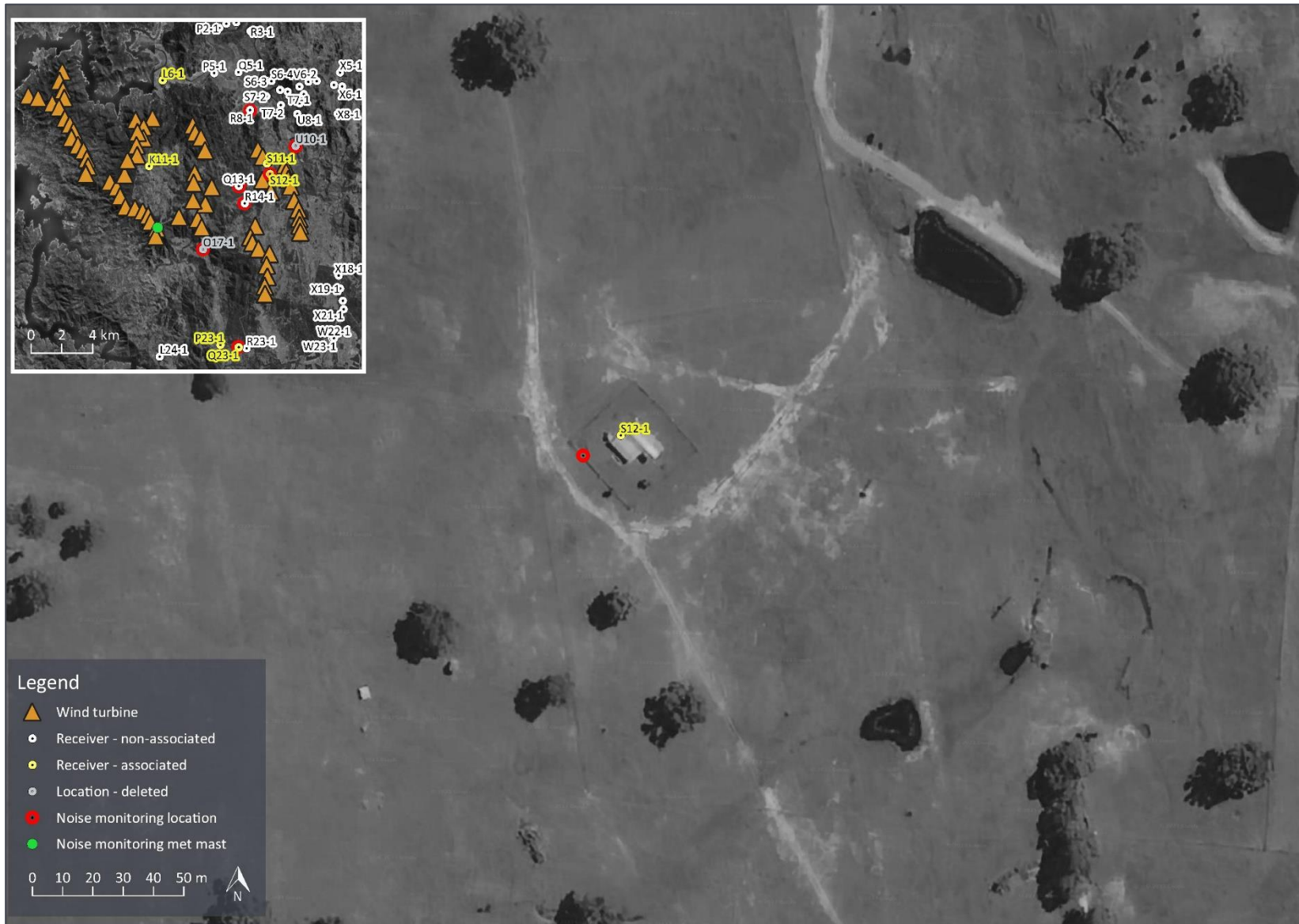
Table 35: Receiver S12-1 dwelling and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Dwelling location	718,499	6,382,037
Background noise monitoring location	718,486	6,382,029

Table 36: Receiver S12-1 monitor installation photos



Figure 17: Receiver S12-1 aerial view – dwelling and noise monitor location



L2 Receiver S12-1 measurement data summary

Table 37: Receiver S12-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	5,654
Number of data points removed	2,467
Number of data points for analysis (worst case wind direction)	3,187 (829)

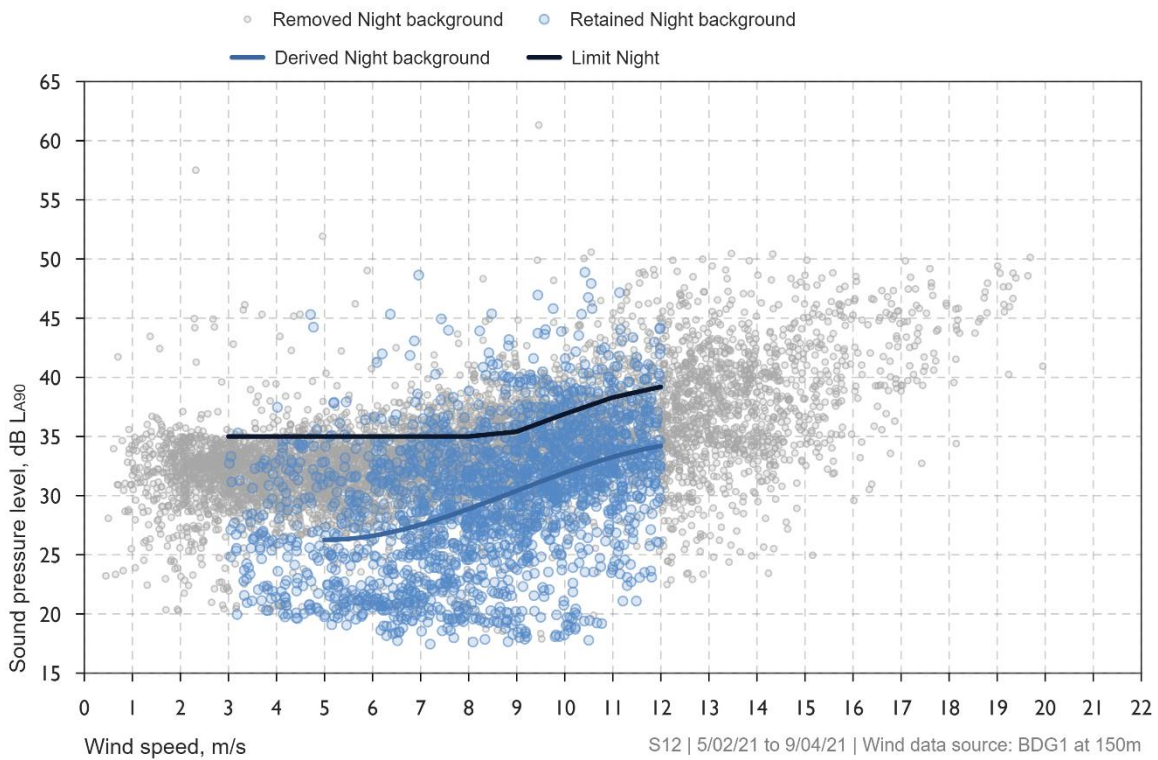
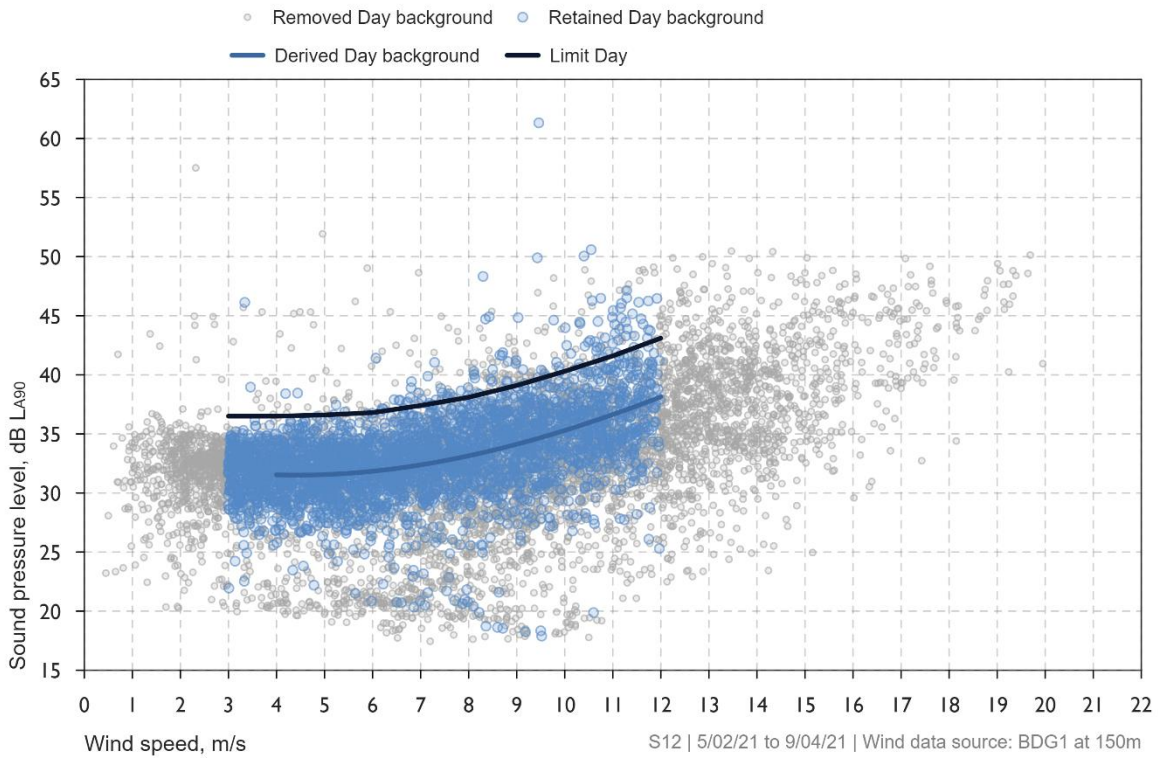
Table 38: Receiver S12-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	3,382
Number of data points removed	1,301
Number of data points for analysis (worst case wind direction)	2,081 (182)

Figure 18: Receiver S12-1 background noise level and wind speed time history



Figure 19: Receiver S12-1 derived background noise levels



APPENDIX M LOCATION U10-1 DATA

M1 Location U10-1 location data

Table 39: Location U10-1 and noise monitor coordinates – MGA 2020 Zone 55

Location	Easting, m	Northing, m
Location	720,158	6,383,862
Background noise monitoring location	720,151	6,383,834

Table 40: Location U10-1 monitor installation photos

Looking North



Looking East



Looking South



Looking West



Figure 20: Location U10-1 aerial view – location and noise monitor location



M2 Location U10-1 measurement data summary

Table 41: Location U10-1 background noise level analysis summary (Day period)

Item	Data point count
Number of data points collected	4,379
Number of data points removed	2,145
Number of data points for analysis (worst case wind direction)	2,234 (309)

Table 42: Location U10-1 background noise level analysis summary (Night period)

Item	Data point count
Number of data points collected	2,646
Number of data points removed	1,947
Number of data points for analysis (worst case wind direction)	699 (5)

Figure 21: Location U10-1 background noise level and wind speed time history

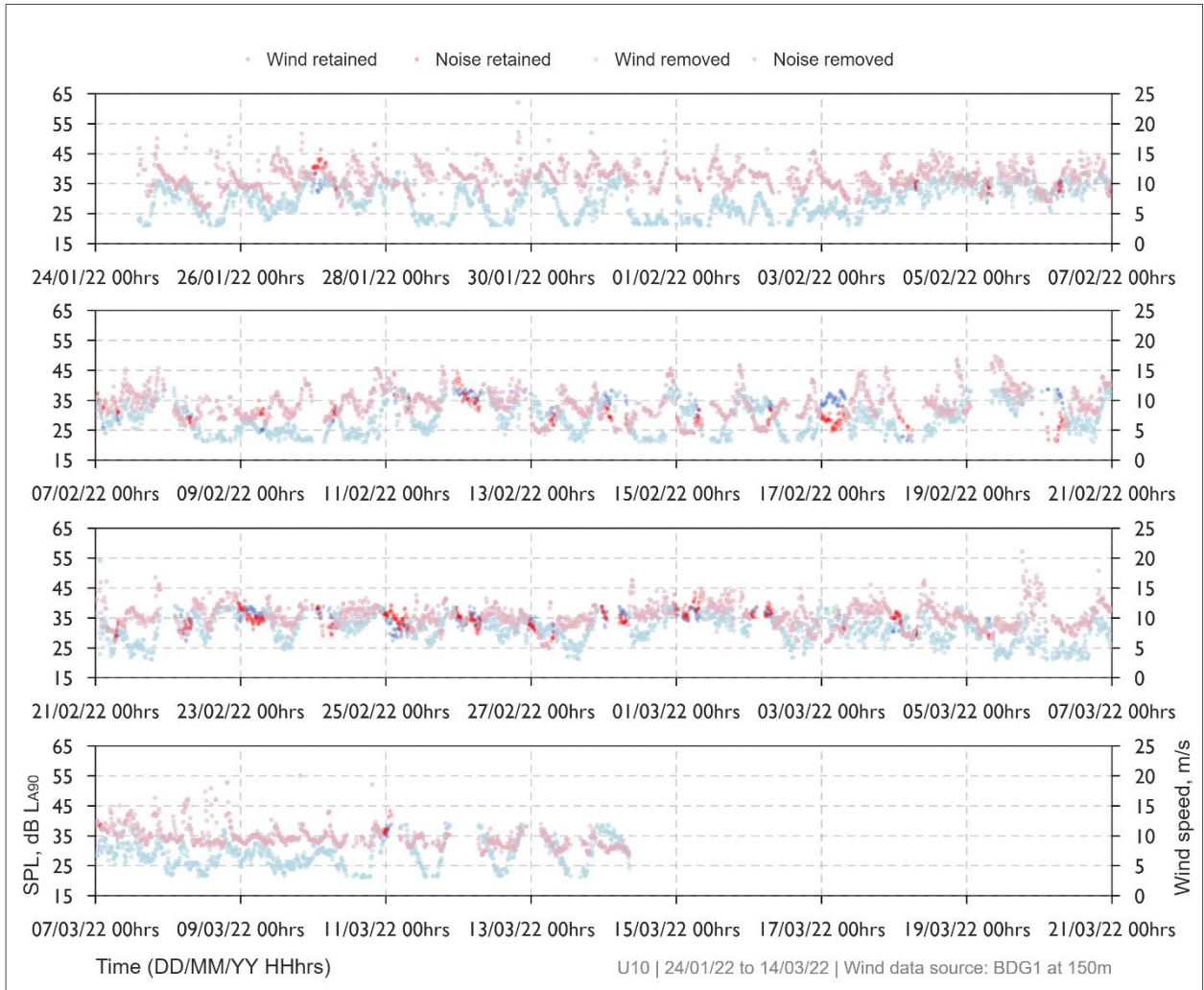


Figure 22: Location U10-1 derived background noise levels

