Appendix 10

Noise Assessment

MARSHALL DAY Acoustics

JUNCTION RIVERS WIND PROJECT
BACKGROUND NOISE ASSESSMENT

Rp 001 20220419 | 22 May 2024

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Report No.: **Rp 001 20220419**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	--	For client information	22 May 2024	Y. Chen O. Wesley-Smith	A. Stoker

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1.0 INTRODUCTION

This report presents the results of background noise monitoring undertaken for the proposed Junction Rivers Wind Project (the Project).

The background noise monitoring was commissioned by Umwelt Australia Pty Ltd (Umwelt) on behalf of Windlab Development Pty Ltd (the Proponent) 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 allows modifications to the base noise limit to be made, where applicable, based on the guidance provided in the NSW EPA *NSW Wind Energy: Noise Assessment Bulletin* (NSW Noise Assessment Bulletin), dated December 2016, and subsequently the South Australia EPA *Wind farms environmental noise guidelines* (SA Guideline), dated July 2009, which is referred to in the NSW Noise Assessment Bulletin. The data collected during background noise monitoring can also play a crucial role in the post-construction compliance assessment.

Generally, background noise results detailed in this document are provided for the purposes of wind turbine noise assessment only. Whilst results in this report are used to provide context to assumptions made for the assessment of ancillary infrastructure and construction noise, minimum assumed background levels are used for assessment. Further details regarding this are provided in Rp 002 20220419 – *Junction Rivers Wind Project – EIS Noise Assessment* (EIS Noise Assessment), dated 22 May 2024.

This report documents both the survey method and the results of the noise monitoring.

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

Wind turbine coordinates and a site layout are detailed in Appendix B and Figure 1 respectively.

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

2.0 BACKGROUND NOISE SURVEY & ANALYSIS METHOD

The background noise survey and analysis has been conducted in accordance with the NSW Noise Assessment Bulletin.

The NSW Noise Assessment Bulletin in turn references the 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 method; and
- A summary of the data analysis procedures.

2.1 Noise monitoring locations

2.1.1 Selection considerations

The NSW Noise Assessment Bulletin does not provide prescribed criteria for the selection of background noise monitoring locations. However, the SA Guideline, referred to in the NSW Noise Assessment Bulletin, provides some commentary as detailed below:

> *Background noise measurements should be carried out at locations that are relevant for assessing the impact of WTG noise on nearby premises (relevant receivers).*
>
> *Relevant receiver locations are premises:*
>
> - *in which someone resides or has a valid development approval to build a residential dwelling*
> - *at which the predicted noise level exceeds the base noise level for the area [35 or 40dB(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.*

Whilst the above provides some guidance, there is a reasonable amount of flexibility afforded to the Proponent allowing noise monitoring locations to be chosen to achieve two primary aims:

- Determining modifications to the base noise limit; and
- Assist with determining compliance with Project consent conditions following construction.

On this basis the following factors are considered when selecting background noise monitoring locations:

- Predicted noise level at the receiver based on preliminary noise modelling;
- Proximity to a wind turbine;
- Topological relationship to wind 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; and
- Proximity to other noise sensitive receivers.

Whilst the above list is not exhaustive, or ordered in terms of priorities, it is clear that selection of background noise monitoring is interpretative and requires careful evaluation to ensure that the most appropriate locations are selected.

2.1.2 Selected locations

Initial noise monitoring locations were selected based on the results of preliminary noise modelling undertaken as part of the preparation of the EIS Noise Assessment.

Based on the preliminary noise modelling results, BALWF58, BALWF123, and BALWF147 were identified as the non-associated receivers at which predicted noise levels were above 30 dB $L_{Aeq.}$

Additionally, to capture a spread of locations across the site, the associated receiver with the highest predicted noise level – BALWF141 - was also selected.

Since the background noise survey was conducted, changes have occurred to the status of BALWF123 and BALWF147, with these receivers now being identified by the Proponent as associated receivers. On this basis three (3) of the four (4) background noise monitoring locations are now categorised as associated with the Project.

On this basis noise monitoring has been conducted at the only non-associated receiver located within 5 km of any wind turbine – BALWF58. Undertaking additional noise monitoring is unlikely to have technical merit.

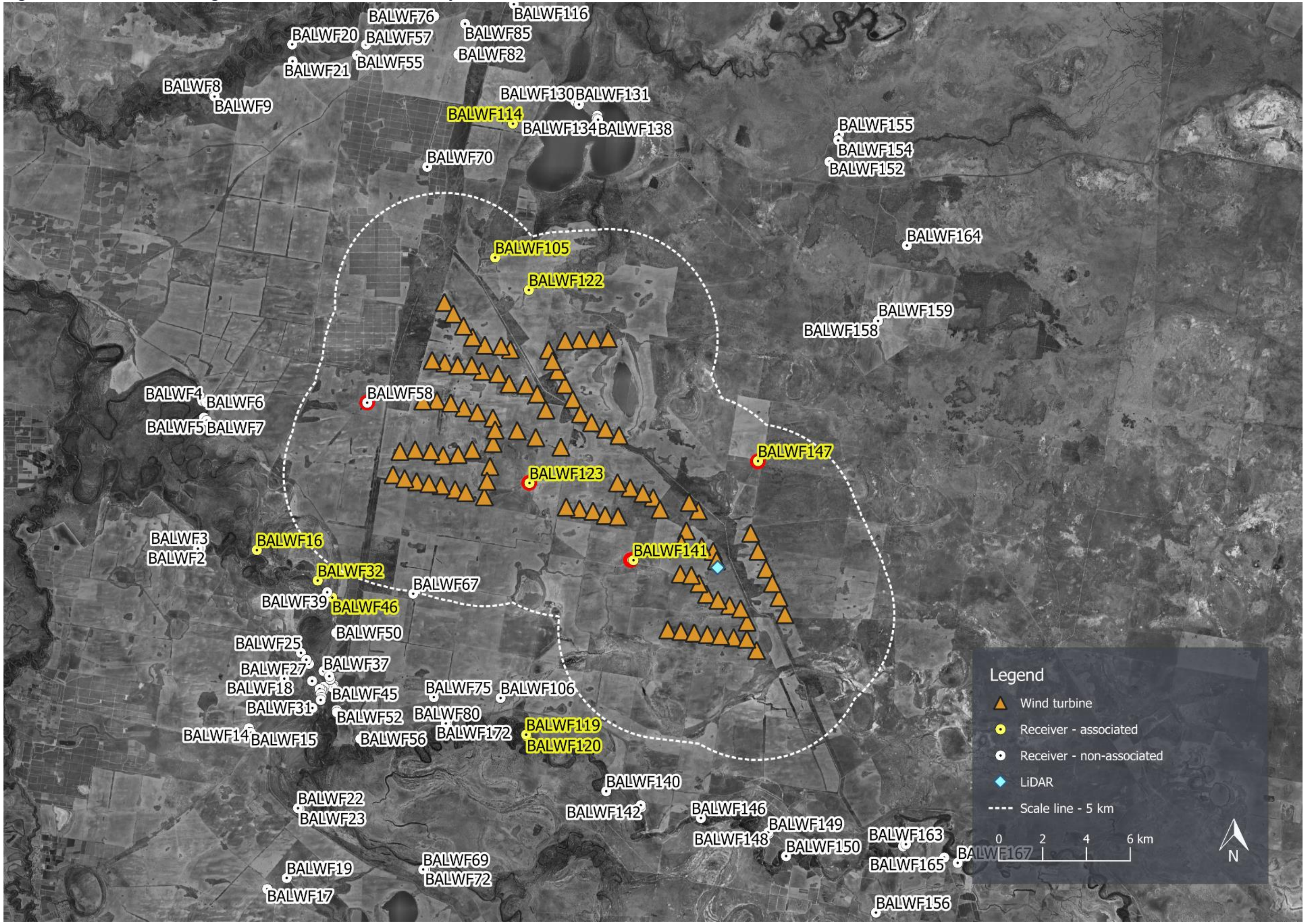
All references to receiver status listed in this report are current as of the date of issue. Accordingly the background noise monitoring locations are summarised in Table 1.

Table 1: Background noise monitoring locations

Receiver	Status	Nearest wind turbine	Direction from wind farm	Approximate distance from nearest wind turbine, m
BALWF58	Non-associated	17	West	2,550
BALWF123	Associated	43	South	1,950
BALWF141	Associated	75	South	2,000
BALWF147	Associated	94	Northeast	3,300

The above noise monitoring locations are shown in Figure 1.

Figure 1: Noise monitoring locations relative to the Project



2.2 Noise monitoring description

The background noise survey comprised unattended noise monitoring for up to eight (8) weeks to measure sound levels for a range of environmental conditions. Site wind speeds and local weather conditions were simultaneously recorded during the survey to enable the relationship between background noise levels and site winds to be assessed. Periodic audio samples were also recorded.

The key elements of the background noise survey are summarised in Table 2. These have been developed considering the NSW Noise Assessment Bulletin and SA Guideline.

Table 2: Summary of key elements of background noise survey

Item	Description
Noise monitoring locations	Four (4) receivers as shown in Section 2.1.
Noise monitoring period	Between 15 February 2023 and 18 April 2023. During this time data was acquired for: • an eight (8) week period at BALWF123, BALWF141, and BALWF147; and • a seven (7) week period for BALWF58. The site wind speed data was available for a seven (7) week period. Further details are provided in Appendix C. The duration of the noise monitoring period was chosen to satisfy the SA Guideline which requires *the collection of 2,000 data points including a minimum of 500 from the worst-case wind direction*. The worst-case direction is defined in Section 4.1 of the SA Guideline as *a wind direction spread of 45° either side of the direct line between the nearest WTG and the relevant receiver*. The NSW Noise Assessment Bulletin recognises *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*. The worst-case wind direction range applied for each receiver location is summarized in Appendix D.
Sound level meters	Class 1 automated sound loggers (most accurate class rating for field usage). 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 Guide[1]. See equipment specifications and calibration records in Appendix C.
Noise measurement data	A-weighted average L_{Aeq} and statistical L_{A90} sound pressure levels. One-third octave band frequency noise levels and a brief audio sample every ten (10) minutes to aid the identification of extraneous noise influences.

[1] 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

Item	Description
Local wind speed and rainfall data	Weather stations were installed beside the noise monitors at locations BALWF58 and BALWF147 to concurrently record rainfall and wind speeds at microphone height. Weather station positions were selected at these two receiver locations to provide information about the spread of local weather conditions across the site. This data was recorded to identify periods when local weather conditions may have resulted in excessive extraneous noise at the microphone (i.e. rainfall occurring at either of the local weather stations).
Site wind speed data	Hub height wind speeds for correlating background noise levels with site wind speeds sourced from a Light Detection and Ranging (LiDAR) monitor (see Figure 1 for location information). Wind speed data aligning with the hub height of the wind turbine models detailed in the EIS Noise Assessment (200 m above ground level) was provided by the Proponent for the period of 22 February 2023 to 18 April 2023. No data was recorded by the LiDAR before 22 February 2023. Noise data acquired at all noise monitoring locations for the period 15 February 2023 to 22 February 2023 was therefore removed from the assessment.

2.3 Data analysis

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	Time stamps for each source of measurement data are reviewed to clarify start or end times and measurement time zone. Measured noise levels, site wind speeds and local weather conditions are then collated for each ten-minute measurement interval.
Local weather data filtering	10-minute intervals are identified and filtered from the analysis if rainfall was identified for any 10-minute measurement interval.
Extraneous noise filtering	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. 10-minute intervals have been identified, and filtered from the analysis, when the following conditions[2] are satisfied: • 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 • the identified one-third octave band A-weighted noise level is greater than a level of 20 dB L_{A90}. • The identified one-third-octave band A-weighted noise level occurs between 1000 Hz and 16 kHz.
Site wind speed data filtering	Lower bound: 10-minute intervals in which site wind speeds are below the operating range of the wind turbines identified in the EIS Noise Assessment (i.e. below cut-in wind speed of 3 m/s) are filtered from the analysis Higher bound: 10-minute intervals in which site wind speeds are above the rated power wind speed of the wind turbines identified in the EIS Noise Assessment (approximately 12 m/s) are filtered from the analysis
Regression analysis	Two datasets are plotted on a chart of noise levels versus wind speeds: • All data points that have been removed from the analysis using the above processes; and • The filtered dataset comprising all retained measurement data. 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). 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.
Time periods	Overall datasets have been processed based on an all-time (24 hour) period, in alignment with the requirements of the NSW Noise Assessment Bulletin.

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

3.0 SURVEY & ANALYSIS RESULTS

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

3.1 Background noise levels

The tabulated data presented in Table 4 summarises the derived background noise levels for the range of wind speeds referenced in Table 3.

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

Background noise level results are illustrated in the graphical data provided for each receiver location in Appendix F to Appendix I.

The background noise levels exhibit variations which are consistent with rural areas and are characterised by lower background noise levels during the night period. This is particularly evident during periods of 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}, All-time (0000 – 2400 hrs)

Receiver	Hub height wind speed, m/s									
	3	4	5	6	7	8	9	10	11	12
BALWF58	24.5	25.7	26.7	27.4	28.0	28.5	28.8	28.9	29.0	- [2]
BALWF123 [1]	22.3	23.7	24.9	25.9	26.6	27.2	27.6	27.8	27.9	- [2]
BALWF141 [1]	26.9	27.5	28.1	28.7	29.2	29.5	29.6	- [2]	- [2]	- [2]
BALWF147 [1]	21.1	22.5	23.7	24.6	25.2	25.6	25.8	25.8	- [2]	- [2]

1 Indicates an associated receiver

2 Outside valid wind speed range of regression analysis

3.2 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 not 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 states that an outdoor level of 45 dB is considered acceptable for financial stakeholders.

On this basis a reference level of 45 dB L_{Aeq} would be used in order to provide context to assessment of wind turbine noise for associated receivers.

3.3 Non-associated receivers

Due to the change in associated status of BALWF123 and BALWF147, from non-associated receivers to associated receivers, background noise monitoring has only been conducted at one (1) receiver that is currently identified as being non-associated.

Review of Figure 1 indicates that BALWF58 is the only non-associated receiver located within 5 km of any wind turbine. On this basis undertaking additional noise monitoring at non-associated receivers located further away is unlikely to have technical merit.

Based on the noise monitoring results documented within this report, it is expected that the base noise limit of 35 dB L_{Aeq} will apply to all non-associated receivers in the vicinity of the Project through the full range of operational wind speeds considered.

4.0 SUMMARY

Background noise monitoring has been conducted at four (4) receivers in the vicinity of the Project.

The background noise survey and analysis has been conducted with reference to the method in the following:

- NSW Noise Assessment Bulletin which references the SA Guideline 2009.
- Supplementary guidance contained in the UK IOA Best Practice Guide.

The results of the background noise survey provide a representation of typical noise levels in the vicinity of the Project. Accordingly, for all receivers:

- The results can be used to derive noise limits for surrounding receivers; and
- The results of the measurements are to be referenced during the compliance noise monitoring phase of the project as an indication of potential background noise levels contributing to the compliance measurements.

The background noise levels, have been documented for the purposes of informing the EIS Noise Assessment accompanying the development application for the Project.

APPENDIX A GLOSSARY OF TERMINOLOGY

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*. Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report.

For example, sound pressure levels measured using an "A" frequency weighting are expressed as dB L_A.

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

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 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
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 90th 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 WIND TURBINE COORDINATES

Table 5 sets out the coordinates of the current proposed wind turbine layout.

(Layout dated 18 May 2023 as supplied by Umwelt).

Table 5: Proposed wind turbine coordinates – CRS: GDA2020 MGA zone 54

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
1	731,919	6,147,218	65
2	732,326	6,146,691	65
3	732,793	6,146,134	67
4	733,209	6,145,626	65
5	733,768	6,145,264	65
6	734,511	6,145,218	65
7	734,940	6,145,062	65
8	731,358	6,144,560	70
9	731,939	6,144,450	70
10	732,526	6,144,341	68
11	733,171	6,144,337	65
12	733,648	6,144,070	65
13	734,364	6,143,951	65
14	734,878	6,143,490	65
15	735,652	6,143,435	65
16	736,167	6,143,034	65
17	736,559	6,142,302	65
18	739,416	6,145,567	66
19	738,756	6,145,527	61
20	738,098	6,145,489	65
21	737,441	6,145,453	61
22	736,681	6,145,039	65
23	736,861	6,144,537	65
24	737,099	6,144,074	65
25	737,431	6,143,459	65
26	737,788	6,142,789	70
27	738,141	6,142,128	69
28	738,650	6,141,727	67
29	739,285	6,141,428	65
30	739,904	6,141,135	65

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
31	730,932	6,142,712	70
32	731,579	6,142,724	68
33	732,209	6,142,621	65
34	732,817	6,142,404	66
35	733,431	6,142,185	65
36	734,139	6,141,931	69
37	734,240	6,141,388	63
38	735,249	6,141,358	63
39	736,100	6,141,040	65
40	737,245	6,140,607	70
41	729,888	6,140,409	65
42	730,585	6,140,480	67
43	731,293	6,140,416	65
44	731,861	6,140,222	66
45	732,548	6,140,264	65
46	733,192	6,140,477	62
47	734,148	6,140,777	69
48	729,568	6,139,346	67
49	730,103	6,139,166	68
50	730,653	6,139,024	65
51	731,214	6,138,936	62
52	731,775	6,138,845	66
53	732,412	6,138,664	67
54	732,899	6,138,527	65
55	733,744	6,138,337	65
56	733,870	6,139,049	67
57	734,004	6,139,718	66
58	737,487	6,137,866	65
59	738,100	6,137,772	67
60	738,714	6,137,674	65
61	739,272	6,137,486	69
62	739,860	6,137,432	69
63	739,838	6,138,977	64

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
64	740,419	6,138,736	65
65	740,998	6,138,496	65
66	741,469	6,138,293	65
67	741,780	6,137,752	65
68	743,112	6,138,075	65
69	743,533	6,137,692	65
70	742,987	6,136,782	66
71	742,759	6,136,188	70
72	743,687	6,136,057	69
73	744,213	6,135,840	65
74	744,364	6,135,416	65
75	742,704	6,134,807	70
76	743,214	6,134,749	69
77	743,562	6,134,373	70
78	743,906	6,133,878	68
79	744,432	6,133,611	65
80	744,962	6,133,364	68
81	745,468	6,133,213	69
82	745,765	6,132,611	65
83	742,132	6,132,257	70
84	742,736	6,132,185	70
85	743,344	6,132,114	70
86	743,945	6,132,043	65
87	744,546	6,131,970	70
88	745,148	6,131,899	70
89	745,748	6,131,829	69
90	746,196	6,131,312	65
91	745,925	6,136,674	69
92	746,261	6,135,852	65
93	746,627	6,135,032	65
94	746,917	6,134,377	69
95	747,221	6,133,734	65
96	747,493	6,132,956	67

APPENDIX C SURVEY INSTRUMENTATION

Table 6: 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[3]
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 7: Equipment details and calibration

Receiver	Make & model	Serial number	Microphone serial number	Independent calibration date [1]	Calibration drift [2], [3]
BALWF58	01dB CUBE	11296	292451	9/02/2022	-0.47
BALWF123	01dB DUO	10394	144928	23/02/2022	-0.21
BALWF141	01dB DUO	12633	331552c	22/08/2022	-0.20
BALWF147	01dB CUBE	11887	330712	25/08/2021	-0.26

1 Independent (laboratory) calibration date to be within two (2) years of measurement period as per AS 1055:2018[4]
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

Table 8: Local weather data measurement instrumentation

Receiver	Make & model	Serial number
BALWF58	Vaisala WXT520	K1850005
BALWF147	Vaisala WXT520	K4120002

Deployment periods for each of the locations described in Section 2.2 varied as a result of equipment redeployments. The relevant periods for each location are as follows:

- BALWF58 – 23 February 2023 to 18 April 2023 (noise monitor redeployed on 23 February 2023 due to changes in site access conditions)
- BALWF123 – 15 February 2023 to 18 April 2023
- BALWF141 – 15 February 2023 to 18 April 2023
- BALWF147 – 15 February 2023 to 18 April 2023

[3] 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

[4] AS 1055:2018 *Acoustics – Description and measurement of environmental noise*

APPENDIX D DOWNWIND DIRECTIONS

Downwind conditions for each noise monitoring location are defined as directions that are equal to ±45° around a central downwind direction.

The SA Guideline notes that a wind direction spread of 45 degrees either side (i.e. 90 degrees total) of the direct line between the nearest wind turbine and the relevant receiver is considered acceptable for defining downwind conditions (specifically for the purpose of compliance checking).

The downwind direction ranges referenced in the analysis for each noise monitoring location are listed in Table 9.

Table 9: Downwind directions

Location	Central downwind direction, °	Downwind direction range, °
BALWF58	267	222 – 312
BALWF123	249	204 – 294
BALWF141	146	101 – 191
BALWF147	4	319 – 49

APPENDIX E SUMMARY OF BACKGROUND NOISE LEVEL REGRESSION COEFFICIENTS

Regression coefficients arising from the noise level vs wind speed analysis described in Section 2.3 are detailed in Table 10.

Table 10: Regression equation coefficients, All -time (0000 – 2400 hrs)

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
BALWF58	0.0026	-0.1369	2.053	19.49	0.0427	3-11
BALWF123 [1]	0.0015	-0.1303	2.276	16.56	0.0512	3-11
BALWF141 [1]	-0.0104	0.1374	0.0045	25.97	0.0104	3-9
BALWF147 [1]	0.0045	-0.2068	2.748	14.55	0.0395	3-10

1 Indicates an associated receiver.

APPENDIX F RECEIVER BALWF58 DATA

F1 Receiver BALWF58 location data

Table 11: Receiver BALWF58 dwelling and noise monitor coordinates – CRS: GDA2020 MGA zone 54

Location	Easting, m	Northing, m
Dwelling location	728,390	6,142,631
Background noise monitoring location	728,391	6,142,642

Table 12: Receiver BALWF58 noise monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Figure 2: Receiver BALWF58 aerial view – dwelling and noise monitor location

F2 Receiver BALWF58 measurement data summary

Table 13: Receiver BALWF58 background noise level analysis summary

Item	Data point count
Number of data points collected	7,201
Number of data points removed	3,033
Number of data points for analysis (worst case wind direction)	4,168 (1,457)

Figure 3: Receiver BALWF58 background noise level and wind speed time history

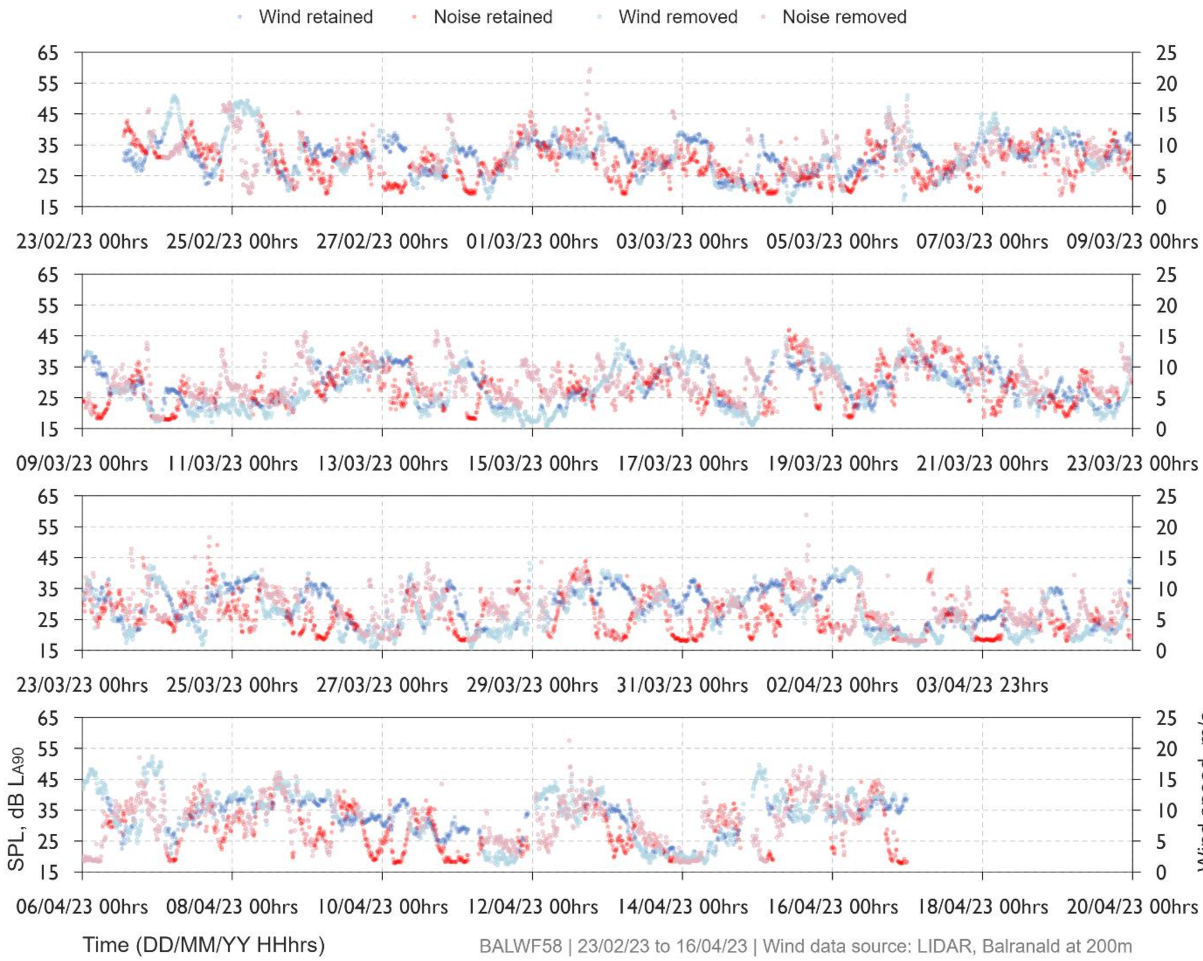
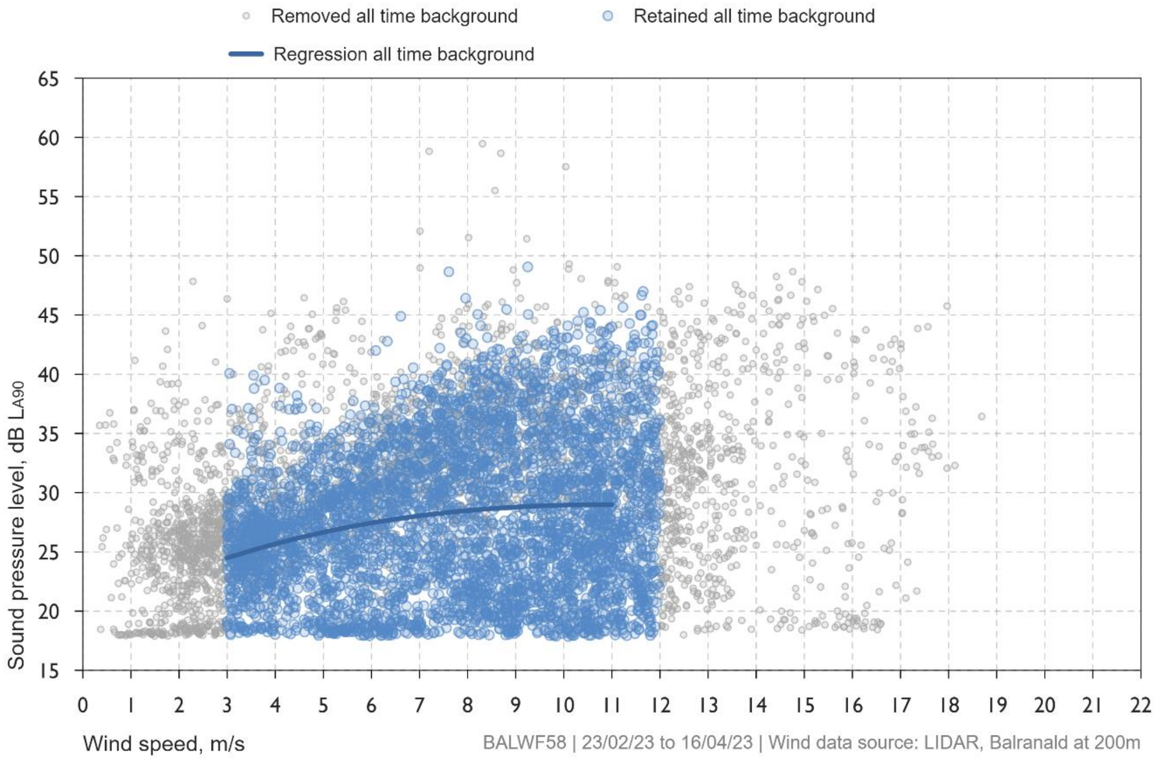


Figure 4: Receiver BALWF58 derived background noise levels



APPENDIX G RECEIVER BALWF123 DATA

G1 Receiver BALWF123 location data

Table 14: Receiver BALWF123 dwelling and noise monitor coordinates – CRS: GDA2020 MGA zone 54

Location	Easting, m	Northing, m
Dwelling location	735,810	6,138,962
Background noise monitoring location	735,796	6,138,971

Table 15: Receiver BALWF123 noise monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Figure 5: Receiver BALWF123 aerial view – dwelling and noise monitor location

G2 Receiver BALWF123 measurement data summary

Table 16: Receiver BALWF123 background noise level analysis summary

Item	Data point count
Number of data points collected	7,371
Number of data points removed	2,831
Number of data points for analysis (worst case wind direction)	4,540 (1,987)

Figure 6: Receiver BALWF123 all-time background noise level and wind speed time history

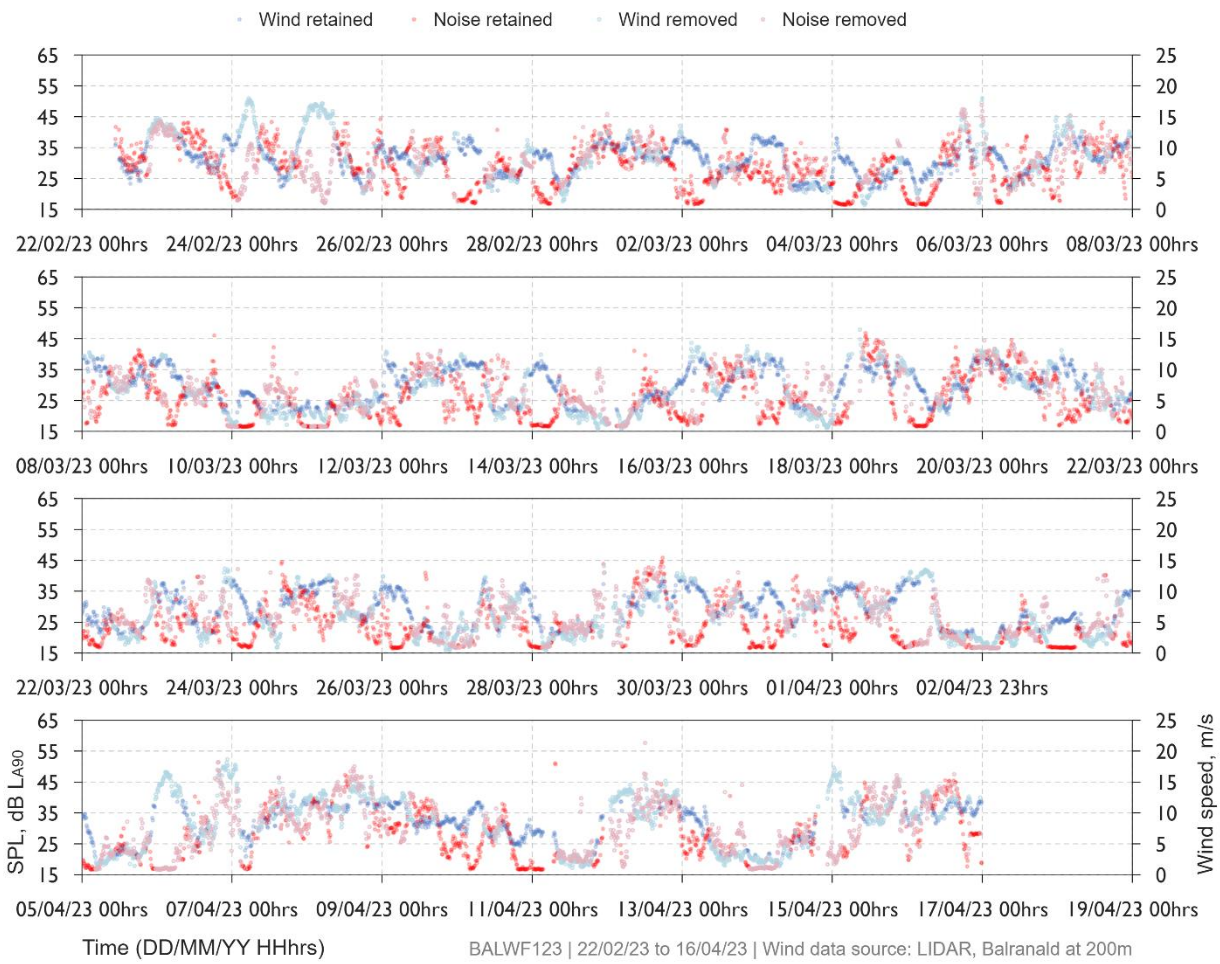
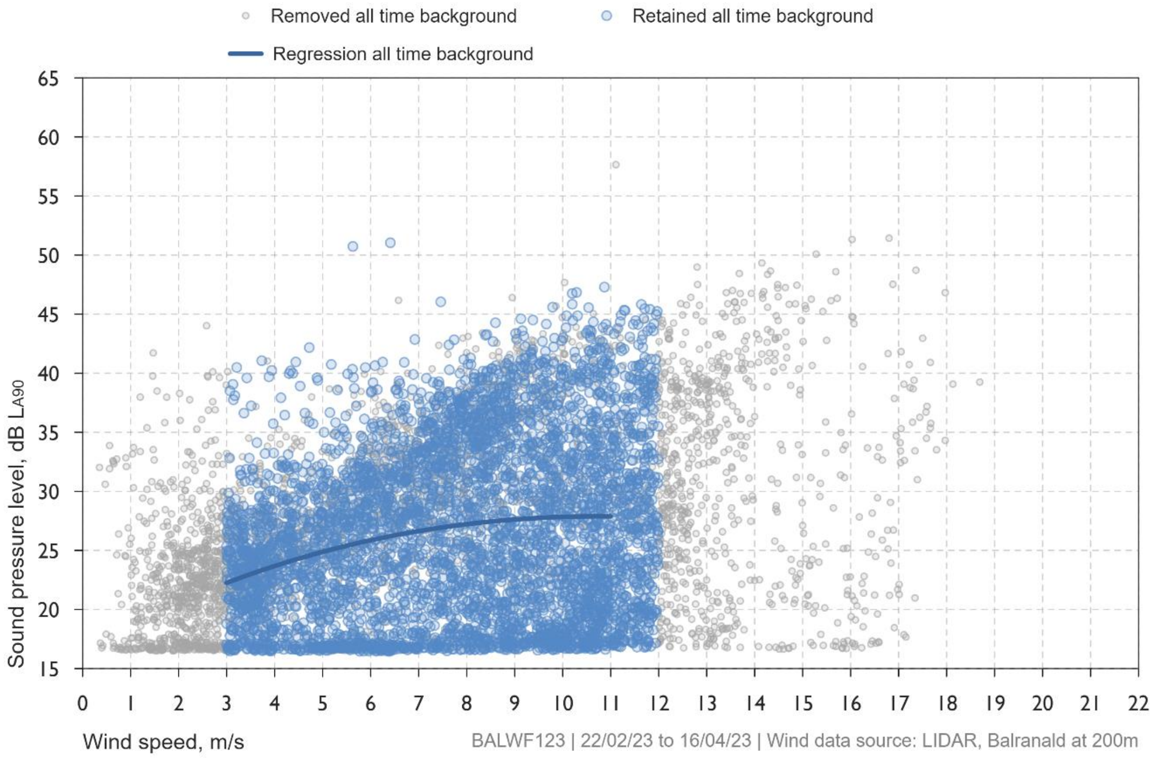


Figure 7: Receiver BALWF123 derived background noise levels



APPENDIX H RECEIVER BALWF141 DATA

H1 Receiver BALWF141 location data

Table 17: Receiver BALWF141 dwelling and noise monitor coordinates – CRS: GDA2020 MGA zone 54

Location	Easting, m	Northing, m
Dwelling location	740,567	6,135,437
Background noise monitoring location	740,448	6,135,444

Table 18: Receiver BALWF141 noise monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Figure 8: Receiver BALWF141 aerial view – dwelling and noise monitor location

H2 Receiver BALWF141 measurement data summary

Table 19: Receiver BALWF141 background noise level analysis summary

Item	Data point count
Number of data points collected	7,404
Number of data points removed	3,162
Number of data points for analysis (worst case wind direction)	4,242 (1,194)

Figure 9: Receiver BALWF141 all-time background noise level and wind speed time history

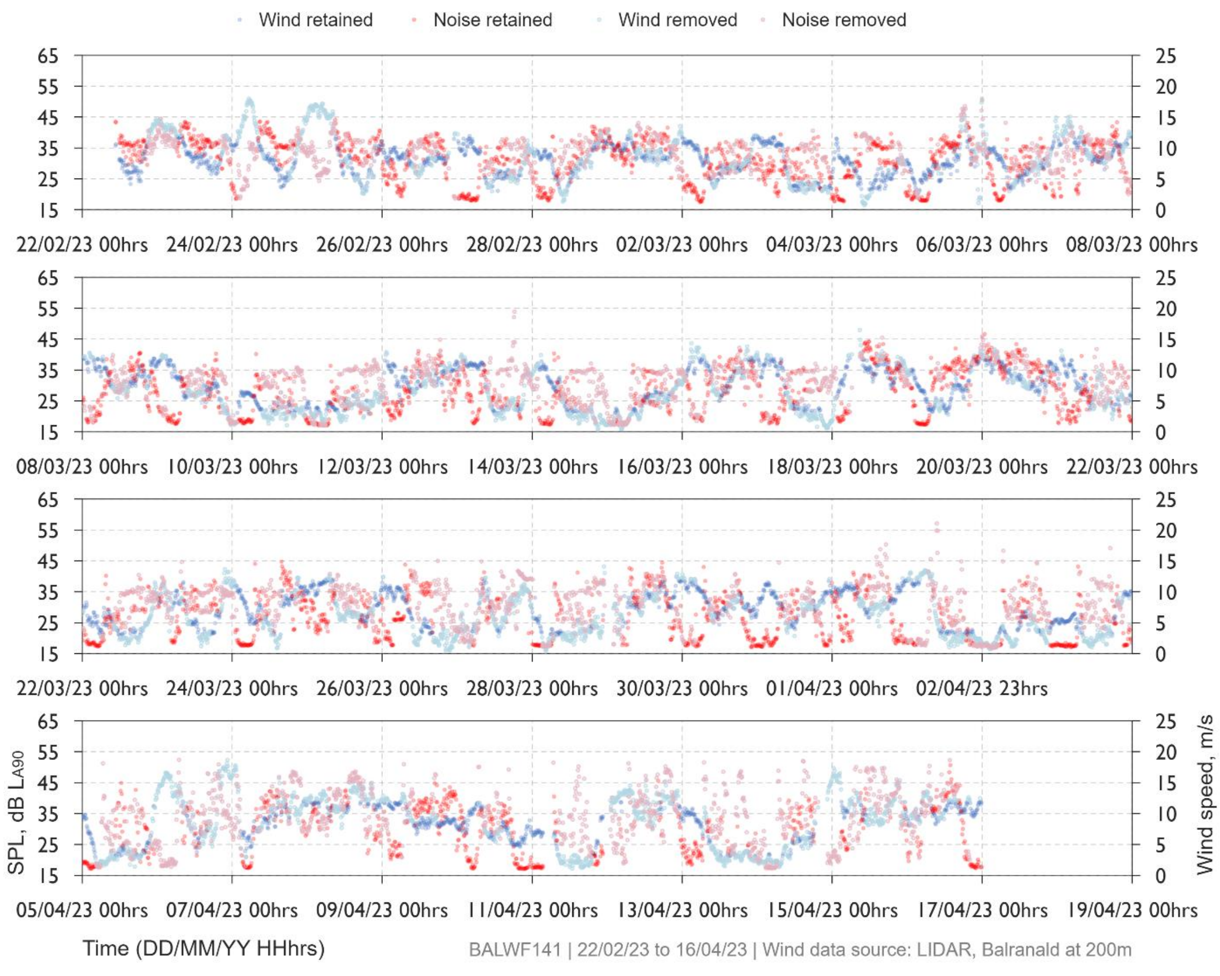
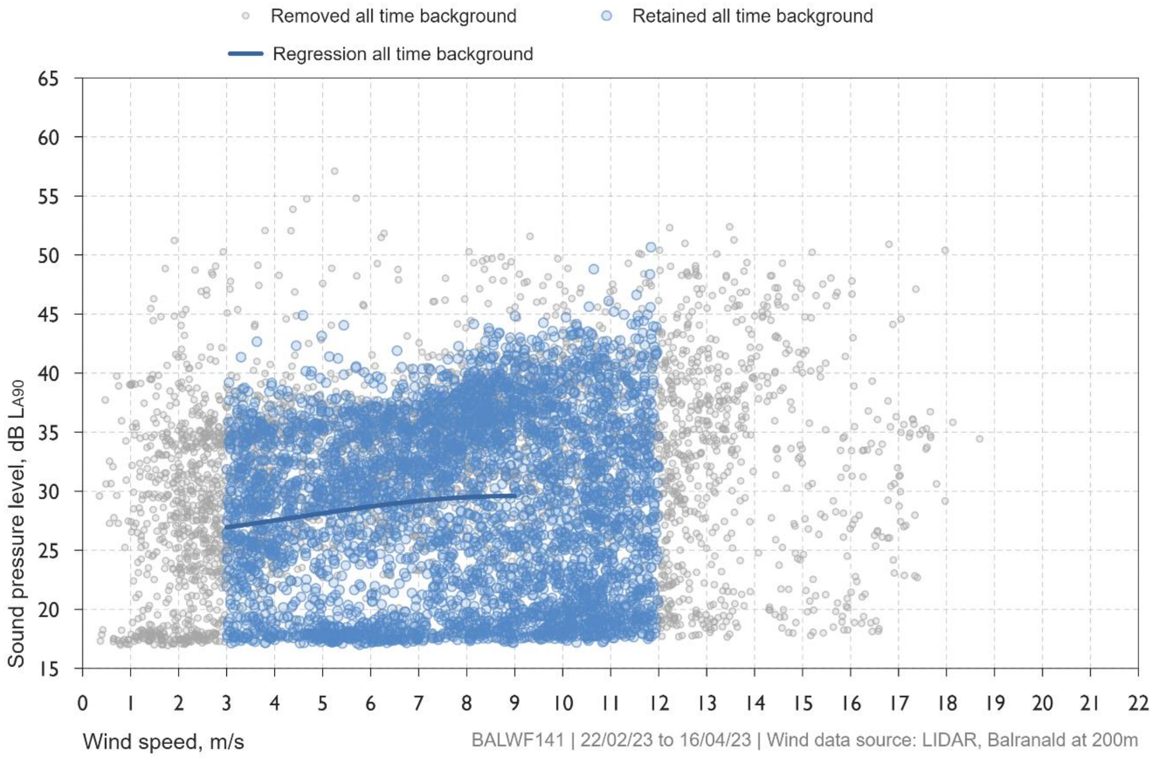


Figure 10: Receiver BALWF141 derived background noise levels



APPENDIX I RECEIVER BALWF147 DATA

I1 Receiver BALWF147 location data

Table 20: Receiver BALWF147 dwelling and noise monitor coordinates – CRS: GDA202 MGA zone 54

Location	Easting, m	Northing, m
Dwelling location	746,261	6,139,965
Background noise monitoring location	746,253	6,139,950

Table 21: Receiver BALWF147 noise monitor installation photos

Looking North	Looking East
	
Looking South	Looking West
	

Figure 11: Receiver BALWF147 aerial view – dwelling and noise monitor location

I2 Receiver BALWF147 measurement data summary

Table 22: Receiver BALWF147 background noise level analysis summary

Item	Data point count
Number of data points collected	7,345
Number of data points removed	2,627
Number of data points for analysis (worst case wind direction)	4,718 (518)

Figure 12: Receiver BALWF147 background noise level and wind speed time history

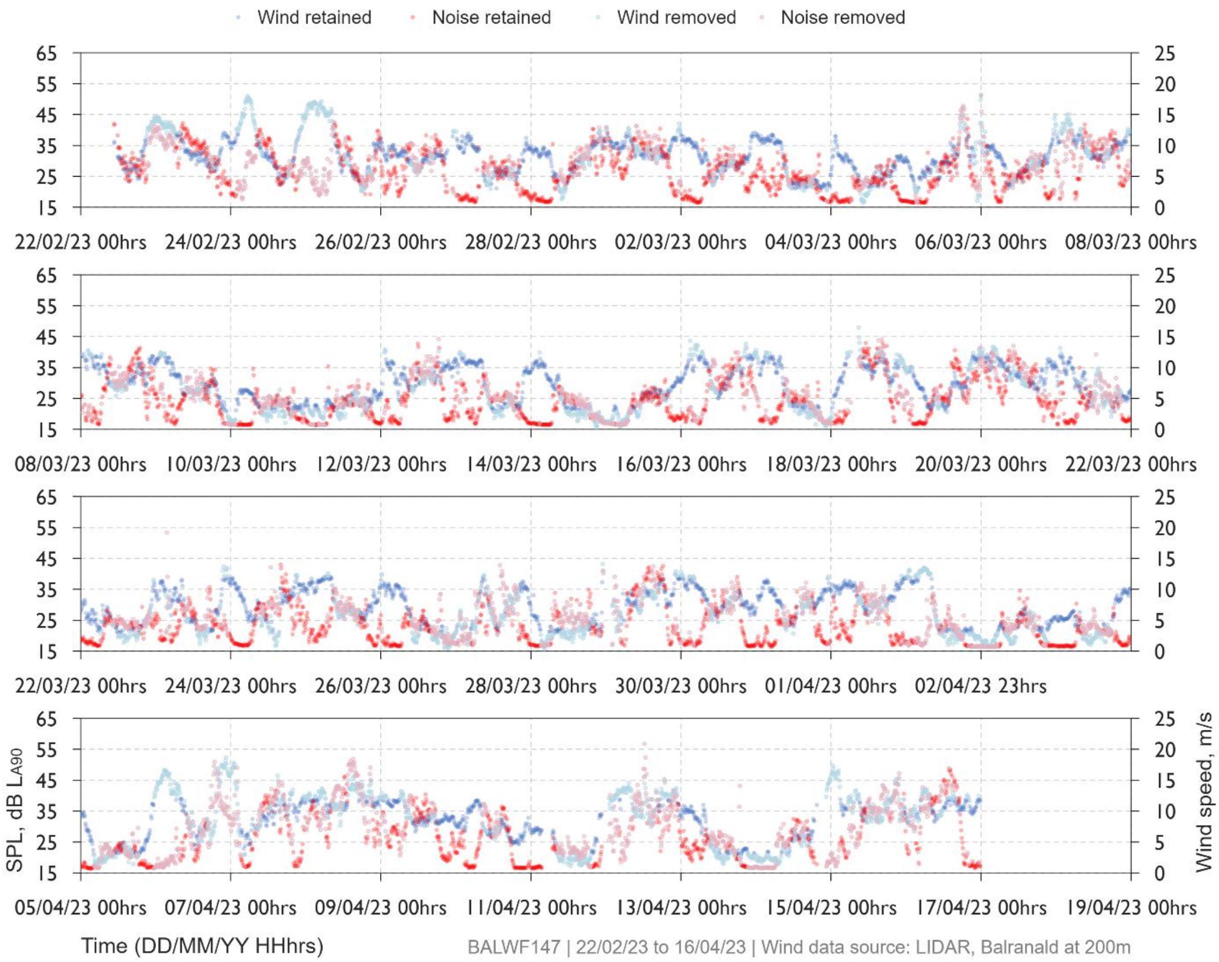
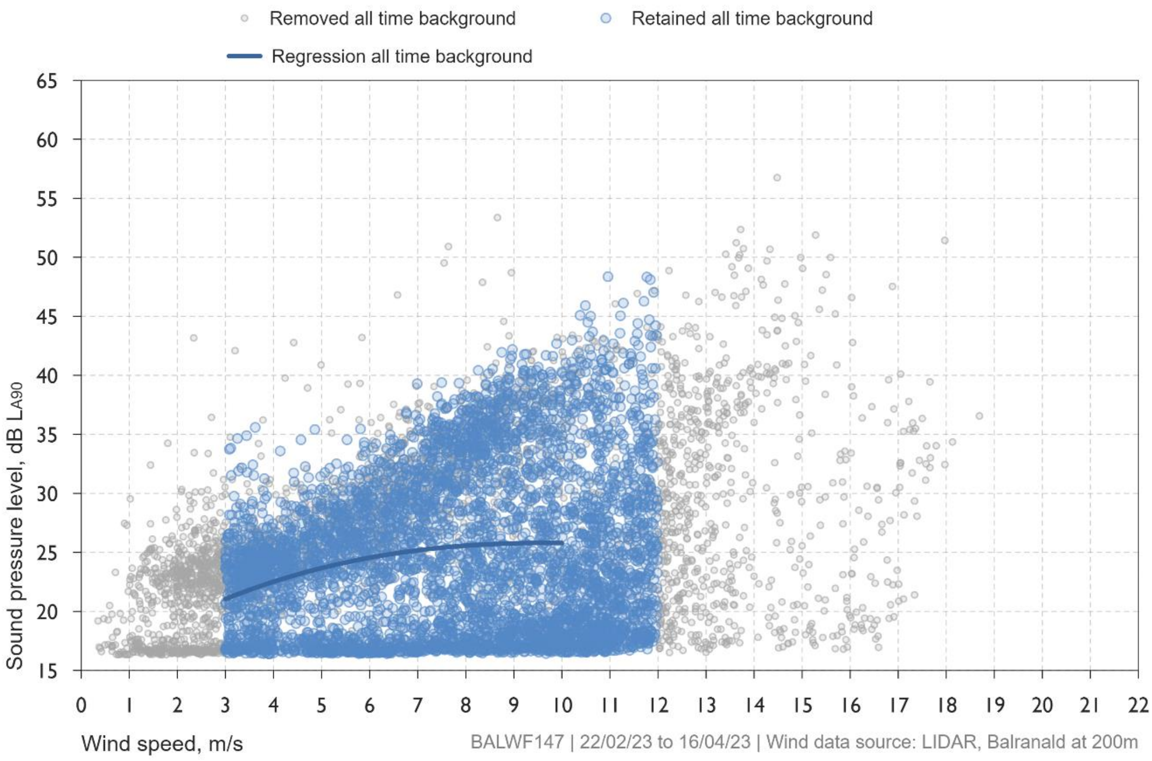


Figure 13: Receiver BALWF147 derived background noise levels



MARSHALL DAY Acoustics

JUNCTION RIVERS WIND PROJECT
EIS NOISE ASSESSMENT

Rp 002 20220419 | 22 May 2024

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Report No.: **Rp 002 20220419**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Complete	--	For client information	22 May 2024	Y. Chen O. Wesley-Smith	A. Stoker

EXECUTIVE SUMMARY

This report presents the results of an assessment of environmental noise associated with Junction Rivers Wind Project (the Project), as an element of the noise studies associated with the Project's Environmental Impact Statement (EIS).

Windlab Development Pty Ltd (the Proponent) is the applicant for the development application. The assessment was commissioned by Umwelt Australia Pty Ltd (Umwelt) on behalf of the Proponent.

The assessment is based on the proposed Project layout comprising ninety-six (96) multi-megawatt wind turbines and associated site infrastructure.

The development application for the Project seeks permission to develop wind turbines with a maximum tip height of 300 m. The actual wind turbine that would be used at the site would be determined at a later stage in the Project, after planning approval has been granted. 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 multiple candidate wind turbine models that are representative of the size and type of wind turbine that could be used for the Project. For this purpose, two (2) candidate wind turbine models have been nominated by the Proponent, comprising the two (2) noise modelling scenarios that have been considered within this assessment.

Operational noise from the wind turbines has been assessed in accordance with the NSW Department of Planning and Environment[1] *NSW Wind Energy: Noise Assessment Bulletin* (NSW Noise Assessment Bulletin), as required by the applicable Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-30448824) dated 19 December 2023.

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

A background noise monitoring survey was undertaken to obtain a representation of typical baseline conditions at receivers in the vicinity of the Project and derive applicable noise limits. The results are detailed in MDA report Rp 001 20220419 - *Junction Rivers Wind Project - Background Noise Assessment* (Background Noise Assessment), dated 22 May 2024.

Manufacturer specification data provided by the Proponent for the candidate wind turbine models has been used as the basis for the assessment. These specifications provide noise emission data in accordance with the international standard[2] referenced in the NSW Noise Assessment Bulletin. The noise emission data is consistent with the range of values expected for comparable types of multi megawatt wind turbine models that may be considered for the site.

The noise emission data has been used with international standard ISO 9613-2[3] to predict the level of noise expected to occur at neighbouring receivers. The ISO 9613-2 standard has been applied based on well-established input choices and adjustments, based on research and international guidance, that are specific to wind farm noise assessment. ISO 9613-2 (without reference to a specific version of the standard) is nominated as being an acceptable noise prediction method in the SA Guidelines 2009.

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1 Now under the purview of the NSW Department of Planning, Housing and Infrastructure (DPHI)

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

3 ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

The results of the noise modelling for the Project demonstrate that the predicted noise levels for the proposed wind turbine layout are below the base noise limit determined in accordance with the NSW Noise Assessment Bulletin for one (1) of the candidate wind turbine models.

For the second candidate wind turbine model, predicted noise levels are above the base noise limit at receiver BALWF58, by up to 1.6 dB. An example curtailment strategy has been developed to demonstrate compliance with the NSW Noise Assessment Bulletin, using sound optimised modes for limited range of wind conditions.

To assess compliance with the applicable noise limits, the NSW Noise Assessment Bulletin also requires consideration of potential adjustments to the predicted wind turbine noise levels for special noise characteristics, comprising tonality and low frequency. Analysis of the noise emission frequency data for the proposed wind turbine models indicates that the noise from the Project is not expected to be characterised by tonality.

This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical. Indicative unconstrained noise modelling also demonstrated 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 has also considered operational noise from the proposed battery energy storage systems (BESS) or static synchronous compensator (STATCOM) facilities, and ancillary infrastructure, including substations. The predicted noise levels have been assessed in accordance with the NSW EPA *Noise Policy for Industry* (NPfI). At this stage of the Project, limited information is available with respect to specific BESS or STATCOM design, including layouts and proposed equipment items. A simplified noise modelling method has been adopted, including conservative assumptions relating to noise emissions and the application of modifying factor corrections for tonality, per the NPfI.

The ancillary infrastructure noise assessment indicates that noise level predictions are below the 35 dB L_{Aeq} night-time project noise trigger level at all receivers with the exception of BALWF141. For BALWF141 predicted ancillary infrastructure noise levels are above the night-time project noise trigger level for two possible delivery scenarios, by up to 3 dB.

The assessment demonstrates that the Project will need to undertake detailed design at a later stage, once Project delivery options, and ancillary infrastructure equipment selection/arrangement and site design have been completed. A review of potential detailed design options indicates that reduction of noise levels in the order of 3 dB is comfortably in the range of engineering noise controls that may be accommodated into the Project design.

On this basis it is expected that with refinement of the noise modelling to reflect a more detailed method, and appropriate detailed design of the ancillary infrastructure locations during procurement / tender stages, the Project can be designed to be capable of complying with the requirements of the NPfI.

The predicted noise levels for all components of the operational noise assessment will need to be updated for the final Project configuration and equipment selections, in order to verify compliance with the applicable noise 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 a compliance test plan. Given the size of the Project, the compliance testing regime to be documented in a future noise compliance test plan is recommended to include provisions for early onsite noise emission testing of the wind turbines 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 Department of

Environment and Climate Change NSW[4] publication *Interim Construction Noise Guideline* (ICNG) and the NSW Department of Environment and Conservation[5] publication *Assessing Vibration: A Technical Guideline* (AVATG). The assessment confirmed that construction noise and vibration can be appropriately managed using standard good practice measures. An assessment of traffic noise impacts associated with construction activities has been conducted in accordance with the Department of Environment, Climate Change and Water NSW[6] *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, specialised construction planning for the site has been developed and prior to construction occurring. This would comprise a detailed noise and vibration assessment, including consideration for blasting (if required) and construction traffic, as well as Project specific noise mitigating work practices and physical noise controls (where required).

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4 Now under the purview of the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW)

5 Now under the purview of the DCCEEW

6 Now under the purview of NSW Environment Protection Authority (EPA)

TABLE OF CONTENTS

1.0 INTRODUCTION

Umwelt Australia Pty Ltd (Umwelt) is assisting Windlab Developments Pty Ltd (Windlab, identified herein as the Proponent) with the development of Junction Rivers Wind Project (the Project). The Project comprises up to ninety-six (96) wind turbines, battery energy storage systems (BESS) or static synchronous compensator (STATCOM), and ancillary infrastructure. Throughout this report, the term Project refers to both the wind turbines and the ancillary 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 (SEARs) (SSD-30448824) dated 19 December 2023, and the publications referenced within.

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

Noise associated with the operation of the proposed BESS or STATCOM, and ancillary 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 wind turbine noise levels, based on the proposed Project layout and three (3) candidate wind turbine models; and
- Predicted noise levels from the ancillary 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 Project. 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 allow adjusted noise limits to be determined. The background noise survey is summarised in MDA report Rp 001 20220419 - *Junction Rivers Wind Project - Background Noise Assessment* (Background Noise Assessment), dated 22 May 2024.

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.

2.0 PROJECT OVERVIEW

2.1 Description

The Project is proposed to be located approximately 15 km south of Balranald, 140 km west of Hay and 20 km northeast of the NSW and Victorian border within the southern section of the Murray-Darling Basin. The Project is within the Murray River Local Government Area (LGA) and immediately east of Balranald Shire LGA. The Project is located within the South-West Renewable Energy Zone (SW REZ), which the NSW Government has identified as a target area for renewable energy development in its Transmission Infrastructure Strategy (NSW Government, 2023) and Electricity Infrastructure Roadmap (NSW Government, 2023).

The Project will have a generating capacity of up to approximately 750 MW and would connect to the existing 220 kV transmission line that traverses the Project and / or the approved Project EnergyConnect transmission line.

The key components of the Project include:

- Up to ninety-six (96) 3 blade wind turbines with a maximum height (tip height) of 300 m;
- electrical connections between the proposed wind turbines and substations/switching stations consisting of a combination of underground cables and overhead powerlines;
- substations / switching stations and transmission connections to connect to the existing 220 kV transmission line and / or the proposed Project EnergyConnect transmission line;
- up to four (4) BESS facilities, to a total of 200 MW with a 4 hour delivery capacity i.e. 800 MWh, or up to four (4) STATCOM facilities;
- other associated infrastructure including access roads and tracks, operation and maintenance buildings and construction facilities;
- temporary on-site concrete batching plants and rock crushing facilities during the construction phases; and
- targeted road network upgrades to facilitate delivery of wind turbine components to the site as required.

The Project may be constructed in two stages. Stage 1 may see the construction of up to thirty (30) wind turbines, 75 MW of BESS capacity or STATCOM facilities, and required ancillary infrastructure. Stage 2 would then see the construction of the remaining wind turbines, BESS or STATCOM facilities and required ancillary infrastructure. The construction period would be approximately four (4) years for the full project.

The coordinates of the wind turbines are presented in tabular format in Appendix C.

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

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

2.2 Delivery staging

As is typical of projects of this scale, the delivery of the wind farm may be staged. The decision to construct the wind farm in stages will depend on a number of factors, including but not limited to:

- Access scheme arrangements for the SW REZ;
- Availability of offtake and other energy market considerations; and
- Financing arrangements and other commercial considerations.

2.2.1 Stage 1

If the Project is constructed in stages, Stage 1 would connect into the existing TransGrid 220kV line. Wind turbines, BESS or STATCOM, and ancillary infrastructure located in the northern part of the site closest to the transmission line i.e. the northern BESS or STATCOM and ancillary infrastructure location only, would therefore be used for Stage 1.

The final configuration for Stage 1 will depend on the wind turbine model selected and the outcome of detailed grid studies. However, initial studies indicate that Stage 1 may comprise up to thirty (30) wind turbines and a BESS of up to 75MW, located in the northern BESS or STATCOM and ancillary infrastructure location.

2.2.2 Stage 2

Stage 2 would connect into Project Energy Connect, and will depend on the access scheme defined in the *Renewable Energy Zone (South West) Access Scheme Order* (April 2024). The balance of the wind turbines, BESS or STATCOM facilities, and ancillary infrastructure would be used for Stage 2.

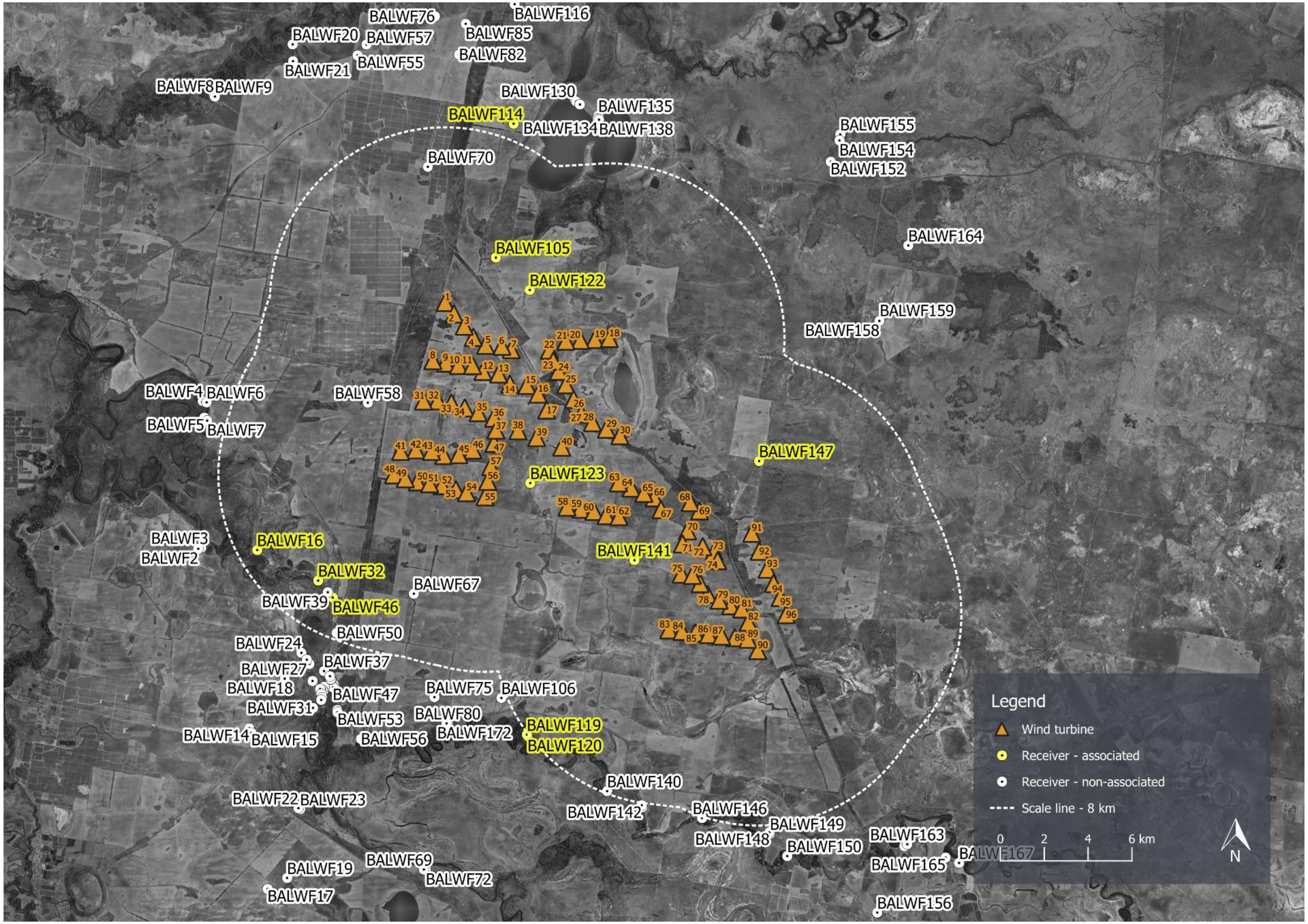
2.3 Receivers

Throughout this report, the term receiver is used to identify any dwelling identified by the Proponent in the vicinity of the proposed Project.

A total of fourteen (14) receivers have been identified by the Proponent within 8 km of a Project wind turbine and are considered in this noise assessment. This includes eight (8) *associated receivers* i.e. host properties or receivers where a noise agreement is in place between the landowners and the Proponent. The remaining six (6) receivers, without an agreement with the Proponent, are referred to as *non-associated receivers*.

The coordinates of the receivers identified within 8 km of the Project are tabulated in Appendix E.

Figure 1: Project layout



3.0 NEW SOUTH WALES POLICY & GUIDELINES

Based on the requirements specified in the Project SEARs (SSD-30448824), the following publications are relevant to the assessment of operational and construction noise from proposed wind farm developments in NSW:

- *NSW Wind Energy: Noise Assessment Bulletin*, dated December 2016 (NSW Noise Assessment Bulletin);
- *Noise Policy for Industry*, dated 2017 (NPfI);
- *Interim Construction Noise Guideline*, dated 2009 (ICNG);
- *NSW Road Noise Policy*, dated 2011 (RNP); and
- *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 (SSD). 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 wind turbine noise is to be conducted in accordance with the SA Guidelines 2009, 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.

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 Guidelines 2009. The criteria in the NSW Noise Assessment Bulletin are subsequently defined as follows:

> *The predicted equivalent noise level ($L_{Aeq,10\ minute}$)*, adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed 35 dB(A) or the background noise ($L_{A90(10\ minute)}$) 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 wind turbines are generally related to rotational equipment in the wind turbine nacelle and can have a specific pitch dependent on the speed of rotation. This can cause the noise to be more annoying or noticeable. These tonal characteristics (as defined below) typically do not occur in well designed and well-maintained wind turbines.

The SA Guidelines 2009 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 Guidelines 2009 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* (ISO 1996-2:2007) 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 Guidelines 2009), exceeds the level of the adjacent bands on both sides by:

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

If tonality is found to be a repeated characteristic of the candidate wind turbine, 5 dB is to be added to the predicted or measured wind turbine noise levels. 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 wind turbine noise when it complies with the A-weighted noise limits.

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

> *The presence of excessive low frequency noise that is a repeated characteristic* [i.e. noise from the wind farm that is repeatedly greater than 60 dB(C)] will incur a 5 dB(A) penalty, to be added to the measured noise level for the wind farm, unless a detailed low frequency noise assessment to the satisfaction of the Secretary demonstrates compliance with the proposed criteria for the assessment of low frequency noise disturbance (UK Department for Environment, Food and Rural Affairs (DEFRA, 2005)) for a steady state noise source.*
>
> ** The descriptor shall be in accordance with SA 2009, Section 4*

In the unlikely event that excessive low frequency noise is found to be a repeated characteristic of the wind turbine noise, 5 dB is to be added to the predicted or measured wind turbine noise levels. An assessment of C-weighted wind turbine 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 Guidelines 2009 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 NPfI is the applicable guideline for assessing operational noise associated with the proposed BESS / STATCOM and ancillary infrastructure i.e. substations.

The NPfI 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 NPfI 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 $L_{Aeq,\ 15\ min}$, as opposed to the $L_{Aeq,\ 10\ min}$ used for wind turbine 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. This criteria is applicable during the night-time period only.

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 ancillary 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 NPfI provides recommended amenity noise levels based on receiver categories and typical planning zones.

The recommended amenity noise levels outlined in the NPfI 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 NPfI 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 NPfI.

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 ($L_{Aeq,\ 15\ min}$) 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 are detailed in Table 1.

Table 1: ICNG recommended standard hours of work

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

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

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

The AVTG presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. Preferred and maximum vibration values outlined in the AVTG are taken from 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.

3.4.1 Intermittent vibration

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

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

Table 2: Preferred and maximum vibration levels for human disturbance limits, VDV [1]

Assessment period [2]	Preferred value	Maximum value
Daytime	0.20	0.40
Night-time	0.13	0.26

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

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

3.4.2 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 3.

Table 3: Preferred and maximum vibration levels for human disturbance limits, m/s [1]

Vibration type	Assessment period [2]	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 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.

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

3.4.3 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.

3.5 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 RNP and relevant application notes.

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

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

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

4.0 NOISE PREDICTION METHOD

4.1 Operational noise

Operational Project noise levels are predicted using:

- Noise emission data for the wind turbines, BESS / STATCOM, and ancillary infrastructure equipment;
- A 3D digital model of the Project 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 9613-2:1996). The prediction method is consistent with the guidance provided by the SA Guidelines 2009 (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 wind turbine and ancillary infrastructure noise levels. For example, for both types of sources, equivalent ground and atmospheric conditions are used for the calculations. However, when applied to wind turbine noise, additional and specific input choices apply, as detailed below.

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

Table 5: Noise prediction elements

Detail	Description
Software	Proprietary noise modelling software SoundPLANnoise version 9.0
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2:1996). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of WTG noise* (UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLANnoise modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix F.

Detail	Description
Source characterisation	To model the operational wind turbine noise associated with the Project, the following specific procedures are noted: • Calculations of wind turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the wind turbine. • Each wind turbine is modelled as a point source of sound. • The total wind turbine noise associated with the operation of the Project is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution from each. • Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each wind turbine. Further discussion of terrain screening effects is provided below. To model the noise resulting from the operation of the BESS or STATCOM and ancillary infrastructure, the following specific procedures are noted: • A cumulative sound power level is derived based on the assumed concurrent operation of all equipment items proposed as part of the BESS or STATCOM and ancillary infrastructure, for each subject location. • Calculations of BESS or STATCOM and ancillary infrastructure to receiver distances and average sound propagation heights are made on the basis of the point source being located at the centroid of the subject location boundary.
Terrain data	Contours with a vertical resolution of 5 m throughout the Project and surrounds, provided by Umwelt.
Terrain effects (wind turbine-specific procedures)	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F. *Valley effects*: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the wind turbine and calculation point is 50 % greater than would occur if the ground were flat. *Terrain screening effects*: only calculated if the terrain blocks line of sight between the maximum tip height of the wind turbine and the calculation point. The value of the screening effect is limited to a maximum value of -2 dB. For reference purposes, the ground elevations at the wind turbine and receivers are tabled in Appendix C and Appendix E, respectively. The topography of the Project is depicted in the elevation map provided in Appendix D.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix F. The ground around the Project corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.

Detail	Description
Atmospheric conditions	Temperature 10 °C and relative humidity 80 % These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance and SA Guidelines 2009. The calculations are based on sound speed profiles[7] which increase the propagation of sound from each wind turbine to each receiver, whether as a result of thermal inversions or wind directed toward each calculation point. The primary consideration for wind farm noise assessment is wind speed and direction. The noise level at each calculation point is assessed on the basis of being simultaneously downwind of every wind turbine at the Project. Other wind directions in which part or the entire wind farm is upwind of the receiver will result in lower noise levels. In some cases, it is not physically possible for a receiver to be simultaneously downwind of each wind turbine and the approach is therefore conservative in these instances.
Receiver heights	1.5 m above ground level. 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. 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).

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.

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

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 wind turbine noise under the NSW Noise Assessment Bulletin. This is due to the need to consider the changes in background noise levels and wind turbine noise levels for different wind conditions.

The procedures for determining background noise levels for the assessment of wind turbines are defined in the SA Guidelines 2009, which is adopted by the NSW Noise Assessment Bulletin. Background noise levels are considered in terms of $L_{A90,\ 10\ min}$.

The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 3.1 of the SA Guidelines 2009 provides the following guidance:

> *Background noise measurements should be carried out at locations that are relevant for assessing the impact of WTG noise on nearby premises (relevant receivers).*
>
> *Relevant receiver locations are premises:*
>
> - *where someone resides or has development approval to build a residential dwelling;*
> - *where the predicted noise level exceeds the base noise level for the area [35 or 40 dB(A)] for wind speeds up to the speed of the rated power;*
> - *that are representative of the worst-case situation when considering the range of premises, e.g. a house located among a group of nearby houses within a residential zone.*

The initial stage of a background noise monitoring program in accordance with the SA Guidelines 2009 therefore comprises:

- preliminary wind turbine 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 Project. The survey typically extends over a period of several weeks to enable a range of wind speeds and directions to be measured. Data adversely affected by extraneous noise such as insect noise, rain and other considerations is filtered.

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

5.1.2 Noise Policy for Industry and Interim Construction Noise Guideline

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

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

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

5.2 Background noise levels

5.2.1 NSW Noise Assessment Bulletin

The NSW Noise Assessment Bulletin specifies that the Proponent will need to have undertaken monitoring to determine the background noise levels in the vicinity of the Project as part of the EIS submission.

To meet this requirement, background noise monitoring locations were proposed based on proximity to wind turbines, the location of receivers, and the predicted noise contours detailed in the preliminary noise report.

Background noise monitoring was subsequently conducted at four (4) receivers in the vicinity of the proposed Project between February and April 2023, of which three (3) are associated with the Project. The one (1) non-associated receiver at which background noise monitoring was conducted is the closest non-associated receiver to the Project.

Analysis and results of the survey are detailed in MDA report Rp 001 20220419 - *Junction Rivers Wind Project - Background Noise Assessment* (Background Noise Assessment), dated 22 May 2024.

A summary of background noise levels determined in accordance with the SA Guidelines 2009, 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 Assessment.

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 NPfI 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 NPfI provides minimum assumed rating background noise levels which are summarised in Table 6.

These minimum levels are used for derivation of the NPfI 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 NPfI 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 NOISE 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 Appendix G, 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 wind turbine model

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

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

For this assessment, the Proponent has considered the two (2) candidate wind turbine models detailed in Table 7.

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

Table 7: Candidate wind turbine model specifications

Item	Details	
Make	Vestas	Goldwind
Model	V162-6.2	GW165-6.0
Rated power, MW	6.2	6.0
Rotor diameter, m	162	165
Modelled hub height, m	200	200
Operating mode	PO6200	Standard
Serrated trailing edge	Yes	Yes
Highest sound power, dB L_{WA}	105.8	111.1
Wind speed for highest sound power, m/s	11	11.5

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

A range of sound optimised modes are also available to reduce the maximum power output and sound power levels, if required.

6.3 Wind turbine noise emissions

6.3.1 Sound power levels

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

Sound power level data for the candidate wind turbine models, including sound frequency characteristics, has been sourced from the following documents provided to MDA by Umwelt:

- Vestas Power Solutions document 0105-5200_01 *Third octave noise emission EnVentus™ V162-6.2 MW 50/60Hz*, dated 12 May 2023.
- Goldwind International Holdings (HK) Limited document *Description of GW165-6.0MW Acoustic Performance Specification,* dated 15 May 2023.

Based on the data sourced from the above specifications, the noise modelling conducted for this assessment involved conversion of third octave band levels to octave band levels and adjustment by addition of an additional margin at each wind speed for test uncertainty. The uncertainty margin for GW165-6.0 is explicitly specified to be +2.1 dB in the abovementioned document, while a +1.0 dB margin is used for the V162-6.2 typical value of test uncertainty.

The overall A-weighted sound power levels (including uncertainty margin) 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}

Wind turbine model	Hub height wind speed, m/s						
	6	7	8	9	10	11	≥12
V162-6.2	97.2	100.2	103.0	105.3	105.8	105.8	105.8
GW165-6.0 [1]	102.8	106.2	108.6	110.1	110.9	110.9	111.1

1 Sound power level data is provided by the manufacturer in terms of 0.5 m/s hub height wind speed intervals. For reporting convenience, only integer wind speeds are reproduced in the above table.

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}

Model	Octave band centre frequency, Hz										
	16	31.5	63	125	250	500	1000	2000	4000	8000	L_{WA}
V162-6.2 [1]	60.0	75.2	87.9	95.7	100.6	101.0	98.3	93.9	86.7	76.4	105.8
GW165-6.0 [2]	65.8	80.5	93.0	101.4	106.1	106.3	104.0	96.5	82.4	69.1	111.1

1 Based on one-third octave band levels at 11 m/s

2 Based on one-third octave band levels at 11.5 m/s

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

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

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 2009) is presently unavailable for the candidate wind turbine models.

Notwithstanding the above, the occurrence of tonality in the noise of contemporary multi-megawatt wind turbine designs is unusual. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receivers is atypical.

Additionally, 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. The potential for tonality would be subject to further review and controls (i.e. contractual performance specifications) during the wind turbine procurement stage of the Project, following approval of the Project, and again following the construction of the Project.

6.3.3 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 wind turbines.

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

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

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

6.4 Predicted noise levels

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

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

Predicted noise levels are for conditions when the wind turbine's noise emissions have reached their highest level (corresponding to hub height wind speeds of 11 m/s and above for V162-6.2 and 11.5 m/s and above for GW165-6.0) and the wind is directed from the Project to each receiver.

The predicted noise levels include the allowance to account for wind turbine sound power level measurement uncertainty, as described in Section 6.3.1.

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

6.4.1 Non-associated receivers

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

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

Receiver	Predicted noise level, dB L_{Aeq}		Distance to the nearest wind turbine, m	Below the 35 dB base criterion for all wind turbine models?
	V162-6.2	GW165-6.0		
BALWF39	22.8	28.2	6,163	Yes
BALWF50	21.5	26.9	7,688	Yes
BALWF58	31.1	**36.6**	2,552	**No**
BALWF67	25.8	31.2	5,087	Yes
BALWF70	21.7	27.1	6,248	Yes
BALWF140	20.8	26.2	7,898	Yes

It can be seen from Table 10 that the predicted wind turbine noise levels from the proposed Project are below the NSW Noise Assessment Bulletin base (minimum) criterion of 35 dB L_{Aeq} at:

- All non-associated receivers for the V162-6.2 scenario; and
- All but one (1) non-associated receiver – BALWF58 – for the GW165-6.0 scenario.

Based on the above assessment and the currently indicated non-associated receivers, the V162-6.2 candidate wind turbine could be adopted for the Project without a requirement for sound optimised modes or other operational restrictions.

For the GW165-6.0 candidate wind turbine, the predicted noise level at BAWLF58 is up to 1.6 dB above the base noise limit. Therefore, it is necessary to consider the derived noise limits, as shown in

Appendix H. This comparison indicates that the predicted noise levels, as per Appendix K, are above the applicable noise limit by up to 1.6 dB for all hub height wind speeds greater than 9 m/s.

On this basis, additional investigation is required to establish whether the Project can achieve the applicable noise limits for the GW165-6.0 candidate wind turbine option.

GW165-6.0 - Conceptual curtailment

Should the status of BALWF58 change from non-associated to associated, noise from the Project adopting the GW165-6.0 model can be managed in accordance with the noise provisions of any commercial agreement that is established between the Proponent and the landowner.

For the purposes of this assessment, a preliminary conceptual curtailment strategy has been developed considering data for sound optimised modes provided by Goldwind. The most stringent mode available i.e. the mode offering the most significant noise reduction, is identified as SOPM5S. This offers a reduction of up to 4.5 dB to the overall sound power level of the wind turbine. The application of SOPM5S to eight (8) relevant wind turbines would result in a reduced predicted noise level of 34.9 dB L_{Aeq}.

With the adoption of this example curtailment strategy, predicted noise levels for the GW165-6.0 would be below the base noise limit at all receivers.

We note that various alternative curtailment strategies may be feasible. Detailed consideration of the requirement for curtailment and specific methods will be conducted during the detailed design stage once the final wind turbine model is selected.

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, pending specific candidate wind turbine selection.

6.4.2 Associated receivers

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

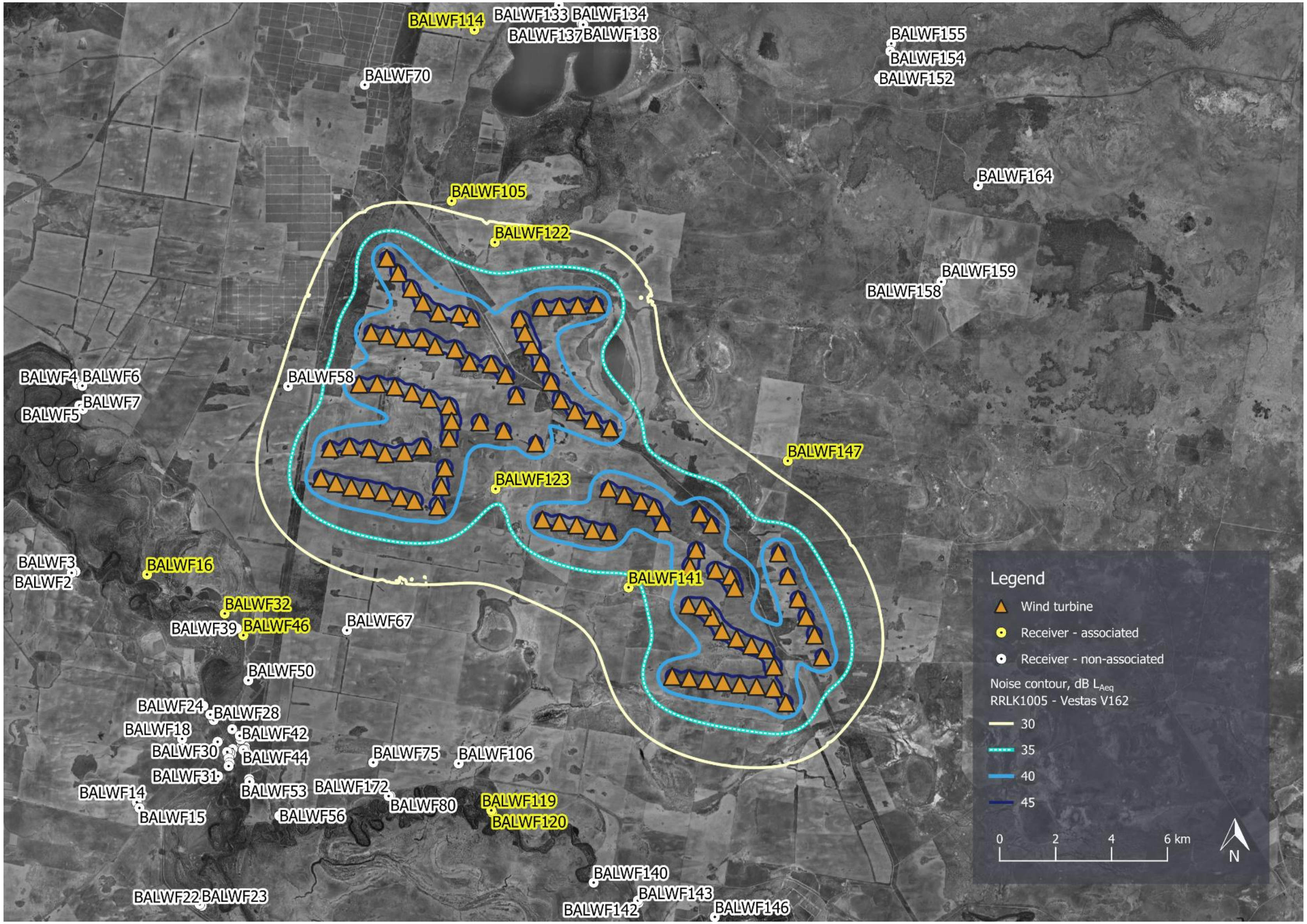
Table 11: Highest predicted noise level at associated receivers, dB L_{Aeq}

Receiver	Predicted noise level, dB L_{Aeq}		Distance to the nearest wind turbine, m	Below the 45 dB base criterion for all wind turbine models?
	V162-6.2	GW165-6.0		
BALWF16	21.1	26.5	7,119	Yes
BALWF32	22.9	28.3	5,945	Yes
BALWF46	22.8	28.2	6,270	Yes
BALWF105	35.6	41.1	1,952	Yes
BALWF122	34.2	39.6	2,125	Yes
BALWF123	28.5	34.0	3,315	Yes
BALWF141	21.1	26.5	7,119	Yes
BALWF147	22.9	28.3	5,945	Yes

It can be seen from Table 11 that the predicted wind turbine noise levels from the proposed Project are below the reference level of 45 dB L_{Aeq} at all associated receivers by at least 3.9 dB.

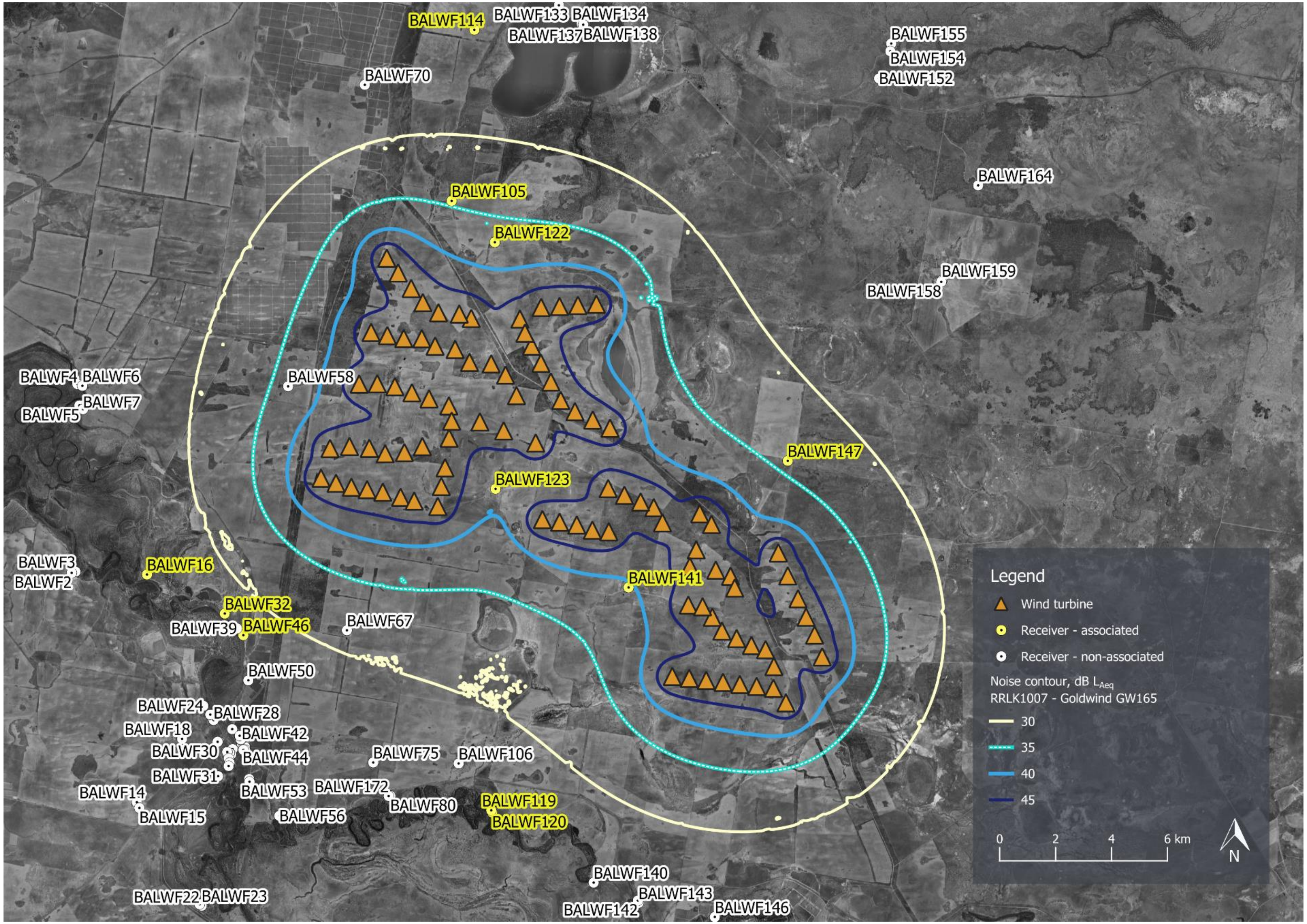
Predicted noise contours associated with each candidate wind turbine model are shown in Figure 2 to Figure 3.

Figure 2: Highest predicted noise level contours for Vestas V162-6.2 (corresponding to hub height wind speeds of 11 m/s)



MARSHALL DAY Acoustics

Figure 3: Highest predicted noise level contours for Goldwind GW165-6.0 (corresponding to hub height wind speeds of 11.5 m/s)



6.4.3 Cumulative wind turbine noise

Assessment of cumulative wind turbine noise would typically consider noise from other wind turbines within 10 km of the Project boundary i.e. wind turbines associated with adjacent or nearby wind farms, within 10 km.

Review of information provided by the Proponent indicates that the nearest other known wind farm project is Keri Keri Wind Farm which is located approximately 20 km from the Project area.

6.5 Conclusion

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.

7.0 BESS / STATCOM AND ANCILLARY INFRASTRUCTURE OPERATIONAL NOISE ASSESSMENT

7.1 Project noise trigger levels

For the purposes of this planning assessment, all receivers have been considered to be Rural 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 that are relevant for assessment of the BESS or STATCOM and ancillary infrastructure have been developed and are summarised in Table 12.

Table 12: 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 assessed infrastructure is proposed to be able to operate at any time of day, 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 BESS or STATCOM and ancillary infrastructure typically give rise to steady noise levels and are not typically characterised by brief momentary increases in noise levels. Accordingly, the additional procedures defined in the NPfI for assessing potential sleep disturbance from brief elevated noise levels associated with transient noise sources are not relevant. The assessment is therefore solely based on noise levels of the plant assessed in terms of the $L_{Aeq\ 15\ min}$ descriptor, which is adopted by the NPfI for the assessment of average noise energy over a 15 minute period.

It is noted that all but one (1) of the receivers located within 5 km of any wind turbine are associated with the Project. When conducting the operational wind turbine noise assessment in accordance with the NSW Noise Assessment Bulletin, the status of these receivers provides a mechanism by which the compliance assessment can be conducted to an adjusted noise criteria of 45 dB L_{Aeq}.

The NPfI does not contain the same mechanism, meaning that noise levels at all receivers are assessed to the same project noise trigger levels, regardless of the status of any landowner agreement that may be in place.

7.2 Noise modelling scenarios

Based on information provided by the Proponent, BESS or STATCOM and ancillary infrastructure noise sources that are proposed to be developed as part of the Project are limited to:

- substations / switching stations and transmission connections to connect to the existing 220 kV TransGrid transmission line and / or the approved 330 kV Project EnergyConnect transmission line; and
- up to four (4) BESS facilities, totalling 200 MW with 4 hr delivery capacity i.e. up to 800 MWh, or up to four (4) static synchronous compensator (STATCOM) facilities.

MDA has been advised that the Project would only comprise either BESS or STATCOM facilities. There is no scenario currently being considered in which both facilities would be constructed.

Through review of other STATCOM noise assessments conducted by MDA, it is understood that the noise levels associated with the operation of these facilities is typically of a lower level than those associated with the operation of a BESS of the capacity proposed for the Project. For this reason, and to provide a conservative, worst-case assessment, noise from a BESS of the proposed capacity has been assessed. In practical terms a STATCOM facility could alternatively be adopted with noise levels at receivers being lower than that predicted in this assessment.

For brevity, and to minimise repetition in this section, where BESS is referred, this could, operationally, be interchangeable with a STATCOM facility.

The information provided to MDA indicates that there are three (3) current conceptual options for the configuration and distribution of the BESS and ancillary infrastructure. It is understood that the finalised selection of these options will be determined based on the Project delivery staging options (summarised in Section 2.2) chosen for the Project. These options are understood to include:

- Scenario 1 – based on the construction of Stage 1 alone;
- Scenario 2 – based on the staged construction of the Project (i.e. Stage 1 and Stage 2); and
- Scenario 3 – based on the uninterrupted construction of the complete Project (i.e. not staged).

Conceptual information regarding the BESS and ancillary infrastructure configurations associated with each delivery staging option scenario was provided to MDA in the following documents:

- ref: *10015508-01* dated 1 November 2023; and
- ref: *10015519-01* dated 25 August 2023.

The above documents provide high-level information regarding the proposed electrical configuration of the substation and BESS options, such as transformer ratings and BESS nameplate capacity.

At this stage of the project, specific details regarding equipment selection and site layout for the BESS and ancillary infrastructure is not available. In the absence of these details, MDA has conducted a simplified assessment, based on the information provided in the above documents. Further information regarding the simplified assessment is provided in Section 7.4.

To form the basis for the simplified assessment, MDA have also been provided with proposed locations for the BESS and ancillary infrastructure.

The centroid coordinates for each of the proposed BESS and ancillary infrastructure locations is shown in Table 13.

The BESS and ancillary infrastructure locations are presented graphically within the context of the Project site in Figure 4

Table 13: Approximate BESS and ancillary infrastructure location centroid coordinates - GDA2020 MGA zone 54

Location	Easting, m	Northing, m
Northern	736,597	6,145,431
Central	737,847	6,140,794
Western	734,498	6,141,294
Southern	741,404	6,136,813

Based on Table 13, and in consultation with the Proponent, a noise modelling scenario has been developed to represent the worst-case BESS and ancillary infrastructure configuration that could occur for each delivery staging option. The derivation of these scenarios has considered:

- The proximity of each BESS and ancillary infrastructure location to any receiver location;
- The capacity (and associated equipment counts) of the BESS proposed to be developed; and
- The proposed electrical configurations for each delivery staging option, as detailed in *10015508-01* and *10015519-01.*

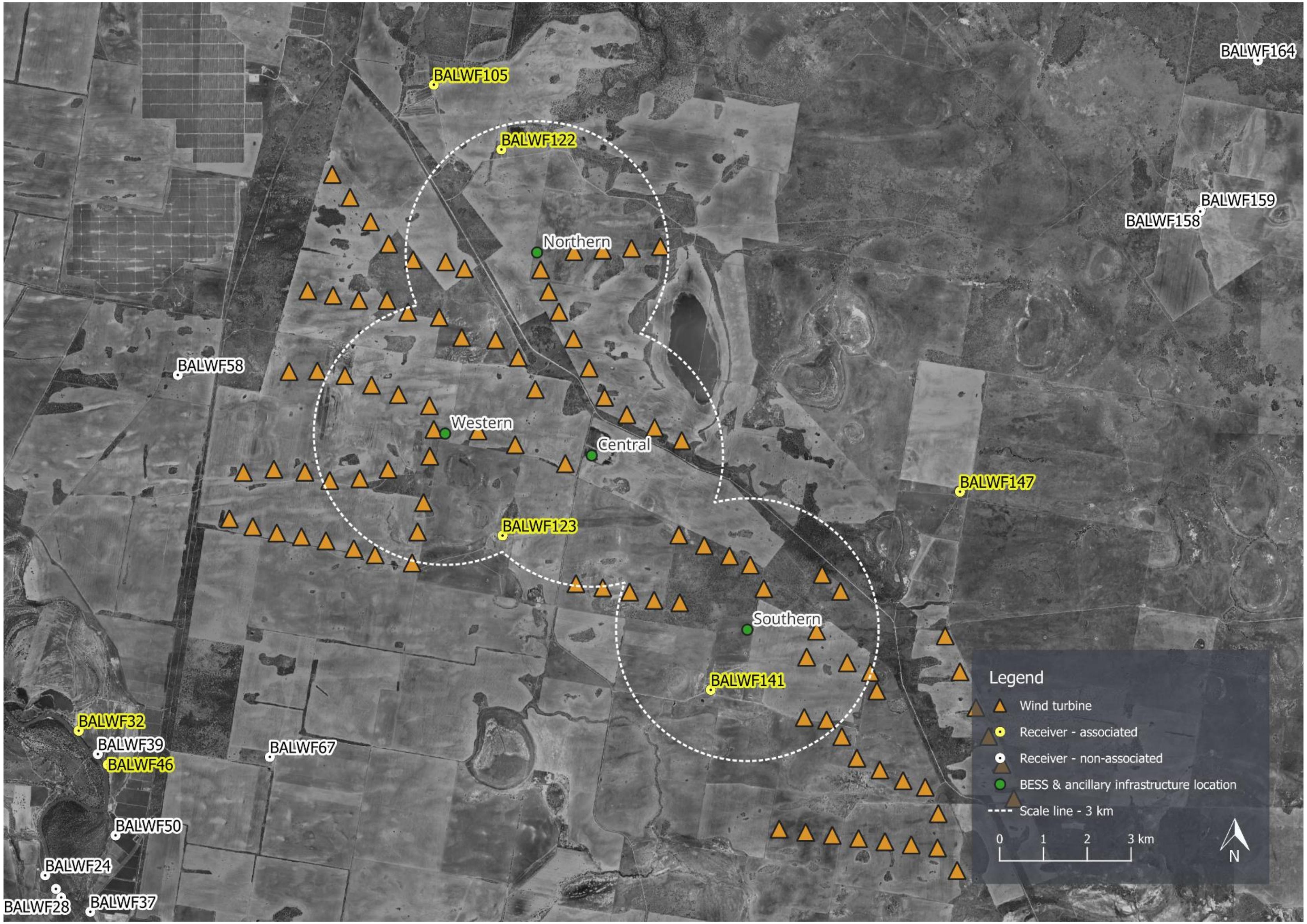
Specific details regarding each of the noise modelling scenarios included within this assessment are provided in Table 14.

Table 14: BESS and ancillary infrastructure operational noise modelling scenarios

Location	Scenario 1	Scenario 2 [1]	Scenario 3 [1]
Northern	**75 MW BESS** 75 x Inverter 75 x Battery unit 10 x 8 MVA Transformer 2 x 160 MVA Transformer	**75 MW BESS** 75 x Inverter 75 x Battery unit 10 x 8 MVA Transformer 2 x 160 MVA Transformer	-
Central	-	-	**125 MW BESS** - 125 x Inverter 125 x Battery unit 16 x 8 MVA Transformer 4 x 200 MVA Transformer
Southern	-	**125 MW BESS** 125 x Inverter 125 x Battery unit 16 x 8 MVA Transformer 4 x 220 MVA Transformer	**75 MW BESS** 75 x Inverter 75 x Battery unit 10 x 8 MVA Transformer 2 x 220 MVA Transformer
Western	-	-	-

1 This assessment has considered the worst-case (in terms of noise) equipment locations that could occur for each scenario. In practical terms, alternative configurations, such as those in which equipment is sited at the Western location are likely to be feasible, however every permutation of deployment has not been specifically modelled.

Figure 4: BESS and ancillary infrastructure layout



7.3 Sound power level data

Sound power levels for individual ancillary infrastructure equipment items, as used in the noise model, are detailed in Table 15. Data is provided as un-weighted (linear) octave band spectra and A-weighted overall sound power level.

Table 15: Sound power levels for BESS and ancillary infrastructure equipment items, dB L_W

Item	Octave band centre frequency, Hz							
	63	125	250	500	1000	2000	4000	L_{WA}
Inverter	92	92	93	87	84	83	88	93
Battery Unit	93	90	79	75	76	70	65	81
MV Transformer (8 MVA)	81	83	78	78	72	67	62	79
HV Transformer (160 MVA)	99	101	96	96	90	85	80	97
HV Transformer (200 MVA)	101	103	98	98	92	87	82	98
HV Transformer (220 MVA)	101	103	98	98	92	87	82	99

Additional information with respect to the source of the data is provided in Table 16.

Table 16: Noise data description

Item	Description
Inverter	Third octave band sound power levels measured in accordance with EN ISO 9614-2 have been sourced from MDA library data. Extensive specific operating conditions for the test were described in the supplied data sheet but included all fans running at 100 %. Due to commercial sensitivities the specific inverter manufacturer and model is not detailed in this report but has been confirmed by the Proponent to be representative of the specification required for the Project.
Battery Unit	Third octave band sound power levels measured in accordance with ISO 3744:2010 associated with a typical 20 ft containerised battery unit have been sourced from MDA library data. Due to commercial sensitivities the specific battery unit manufacturer and model is not detailed in this report but has been confirmed by the Proponent to be representative of the specification required for the Project.
HV / MV Transformer	At this stage of the project, specific details of the transformer makes and models are yet to be finalised. Based on information provided in *10015508-01,* MDA understands that the HV and MV transformers would have a capacity of between 160-220 MVA and 8 MVA, respectively. In the absence of measured sound power level data for a specific transformer model, reference has been made to the method for estimating overall transformer sound power levels for a given power rating described in AS 60076-10:2009 [8]. Spectral data for each transformer was then estimated by applying Bies & Hansen[9] corrections from Table 11.27, (Location 1a for outdoor transformer noise) to the determined overall sound power level.

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

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

7.4 Noise modelling method

The information provided in Table 14 has been used in conjunction with the sound power level data shown in Table 15 to derive an overall cumulative sound power level for each of the BESS and ancillary infrastructure locations in the noise modelling scenarios. This is summarised in Table 17.

Table 17: Overall sound power level for each BESS and ancillary infrastructure location, dB L_{WA}

Location	Scenario 1	Scenario 2	Scenario 3
Northern	112	112	-
Central	-	-	115
Southern	-	115	112
Western	-	-	-

Noise modelling has therefore been conducted on the basis of a single point source, located at the centroid of the proposed related infrastructure locations provided to MDA by the Proponent. Each point source represents the cumulative sound emissions from the total noise generating equipment proposed for each BESS and ancillary infrastructure location, per scenario.

It is noted that this is a simplified approach, reflecting the limits of the information currently available for ancillary infrastructure.

It is recommended that ancillary infrastructure noise modelling is revised and updated once the delivery staging option is known, and specific ancillary infrastructure equipment and layouts are determined.

7.5 Tonality

As finalised equipment selections are not known, the tonality characteristics of the specific equipment items cannot be anticipated. To provide a conservative assessment, a modifying factor correction of +5 dB (as per the NPfI) has been applied to the predicted noise levels to account for the potential tonal characteristics of the noise from both the substation transformers and BESS equipment.

It should be noted that, in practice, the +5 dB correction is not applicable based on the source noise characteristics but would only be applied if the tonality was measurable at the subject receiver. As tonality at a receiver cannot readily be predicted, this correction has been included to provide a conservative assessment.

7.6 Cumulative ancillary infrastructure noise

Based on information provided by the Proponent, Limondale Solar Farm and Sunraysia Solar Farm are located within 5 km from the Project area.

The NPfI project amenity noise level is designed '*to protect against cumulative noise impacts from industry*' with modifications made to the recommended amenity noise level to account for noise contributions for existing industry, as described in Section 3.2 and Section 7.1.

Further, the NPfI states:

> *Where the project amenity noise level applies and it can be met, no additional consideration of cumulative industrial noise is required.*

On this basis no further consideration is given to noise from Limondale Solar Farm or Sunraysia Solar Farm or other approved or proposed developments, and assessment of cumulative industrial noise under the NPfI is considered satisfied.

7.7 Predicted noise levels

Noise levels resulting from the operation of the BESS and ancillary infrastructure have been predicted at all receivers located within 3 km of any proposed related infrastructure location, as per the method described in Section 4.1.

The results of these predictions are shown in Table 18.

Table 18: Predicted noise levels at receivers within 3 km (including +5 dB tonality correction), dB L_{Aeq}

Receiver	Scenario 1	Scenario 2	Scenario 3
BALWF122	21 (26)	21 (26)	< 10
BALWF123	< 10	16 (21)	23 (28)
BALWF141	< 10	33 (38)	31 (36)

The results shown in Table 18 demonstrate that:

- Noise level predictions are below the 35 dB L_{Aeq} night-time project noise trigger level at all receivers with the exception of BALWF141.
- For BALWF141 predicted ancillary infrastructure noise levels are above the night-time project noise trigger level for both Scenario 2 and Scenario 3, by up to 3 dB, when applying the + 5 dB tonality correction.

7.8 Conclusion

For the purposes of wind turbine noise assessment, the receivers shown in Table 18 are considered to be associated with the Project, however, the NPfI does not provide a mechanism for the applicable noise criteria to be adjusted on this basis.

Notwithstanding the specifics of any noise agreement that may be established between BALWF141 and the Proponent, additional noise controls and mitigation measures should be investigated during the procurement / tender stage.

Based on the noise predictions shown in Table 18, a reduction of noise levels in the order of 3 dB or more will be required to establish compliance with the NPfI. This is comfortably in the range of engineering noise controls that may be accommodated into the Project design.

Engineering noise controls, or future refinement of the noise levels predictions may include:

- Repeat noise modelling based on a more detailed noise modelling method.

  i.e. establishing specific positions of equipment items, and their positions within the ancillary infrastructure locations. This would eliminate the conservatism associated with the current simplified method.

- Appropriate selection of inverters and other ancillary infrastructure equipment items to preference quieter equipment.

  Based on MDA's review of currently available equipment reductions to noise predictions in the order of 5 dB may be achieved.

- Provision of physical noise control barriers at the subject ancillary infrastructure location, should detailed noise modelling indicate this may be beneficial.
- More detailed review of the application of a modifying factor correction for tonality

  Noting that tonality at the indicated distances of 1.6 km from the nearest ancillary infrastructure location to BALWF141 may be unlikely in practice. The conservative application of a modifying *factor correction for tonality may not be required with detailed review of manufacturer data for preferred equipment selections.*

With refinement of the noise modelling to reflect a more detailed method, and appropriate detailed design of the ancillary infrastructure locations during procurement / tender stages, the Project is expected to be capable of complying with the requirements of the NPfI.

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 wind turbine noise levels should be updated with final layout and sound power levels of the final wind turbine selected for the Project to verify compliance with the criteria in accordance with the NSW Noise Assessment Bulletin;
- The predicted operational ancillary 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 NPfI;
- 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 the SEARs and assessing operational wind turbine noise in accordance with the NSW Noise Assessment Bulletin, it is expected that the Project will satisfy the applicable noise limits. Notwithstanding this, consideration should be 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 wind turbines to the Project will typically include specifications concerning the allowable total noise emissions from the wind turbine, and the permissible characteristics of the wind turbine.

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

- *Noise reduction management strategy*

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

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

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 (see Section 3.3) and construction vibration in accordance with the AVTG (see Section 3.4).

Off-site noise generating activities considered within this assessment are limited to heavy goods vehicle movements to and from the site. These have been addressed separately in the traffic noise assessment, documented in Section 10.0.

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

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

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 relevant 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;
- Substation construction;
- BESS construction;
- Wind turbine foundations; and
- Wind turbine 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 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}. These predictions are based on the assumption that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period thus providing a conservative approach that is unlikely to occur in practice.

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.

The predicted noise level ranges for each of the main construction tasks are provided in Table 19 and Table 20 for non-associated and associated receivers, respectively.

Table 19: Indicative range of construction noise predictions at non-associated receivers, dB L_{Aeq}

Construction phase	Nearest receiver (distance, m)	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
Wind turbine foundations	BALWF58 (2,540)	35-40	45	-	75	-
Wind turbine assembly	BALWF58 (2,540)	30-35	45	-	75	-
Construction of hardstands	BALWF58 (2,540)	35-40	45	-	75	-
Access road construction	BALWF58 (870)	45-50	45	0-5	75	-
Substation construction	BALWF58 (6,150)	20-25	45	-	75	-
BESS construction	BALWF58 (6,150)	20-25	45	-	75	-
O&M/construction compounds	BALWF58 (6,140)	25-30	45	-	75	-
Cable trench digging	BALWF58 (2,620)	35-40	46	-	76	-
Construction of overhead transmission lines	BALWF58 (6,260)	20-25	45	-	75	-
Temporary met mast construction	BALWF58 (6,210)	25-30	45	-	75	-
Concrete batching plant	BALWF58 (6,080)	20-25	45	-	75	-
Temporary laydown areas	BALWF58 (6,140)	25-30	45	-	75	-
Power performance mast construction	BALWF58 (4,990)	30-35	45	-	75	-

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

Construction phase	Nearest receiver (distance, m)	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
Wind turbine foundations	BALWF123 (1,940)	40-45	45	-	75	-
Wind turbine assembly	BALWF123 (1,940)	35-40	45	-	75	-
Construction of hardstands	BALWF123 (1,940)	40-45	45	-	75	-
Access road construction	BALWF141 (1730)	40-45	45	-	75	-
Substation construction	BALWF141 (1,480)	35-40	45	-	75	-
BESS construction	BALWF141 (1,480)	35-40	45	-	75	-
O&M/construction compounds	BALWF141 (1,780)	40-45	45	-	75	-
Construction of overhead transmission lines	BALWF141 (1,630)	40-45	46	-	76	-
Cable trench digging	BALWF141 (1,270)	35-40	45	-	75	-
Temporary met mast construction	BALWF141 (2,280)	35-40	45	-	75	-
Concrete batching plant	BALWF123 (3,060)	30-35	45	-	75	-
Temporary laydown areas	BALWF141 (2,020)	40-45	45	-	75	-
Power performance mast construction	BALWF123 (4,080)	30-35	45	-	75	-

The following can be seen from the construction noise predictions shown in Table 19 and Table 20:

- Construction noise levels are predicted to be below both the noise affected and highly noise-affected management levels at all but one (1) non-associated receiver during all assessed construction activities.
- Construction noise levels are predicted to be below both the noise affected and highly noise-affected management levels at all associated receivers during all assessed construction activities.
- Noise levels associated with the construction of access roads are predicted to be above the noise affected management level at the nearest non-associated receiver – BALWF58 – by a maximum margin of 5 dB.

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 construct new site access tracks.

There is one (1) non-associated receiver located within 1000 m of the access road construction work. The highest predicted noise level at this receiver is expected to be up to 5 dB above the noise affected management level.

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 – General

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

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

The ICNG indicates:

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

The predicted noise levels summarised in Table 19 and Table 20 indicate that the noise affected management levels are expected to be exceeded at one (1) non-associated receiver by up to 5 dB, during the construction of access roads. Therefore, in accordance with the ICNG, it is expected that the proponent will apply all feasible and reasonable work practices to meet the noise affected level and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as relevant contact details.

9.4 Construction vibration assessment

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

The AVTG provides guidance with respect to the assessment of human comfort due to vibration from construction works. This guideline distinguishes intermittent, impulsive, and continuous vibration sources, which can be generated by construction activities. For the purposes of this planning risk assessment only residences 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 21, are quoted for effects relating to human comfort.

Table 21: Recommended minimum working distances for human response limits for vibration intensive plant

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

No associated or non-associated receivers are located within the above indicated minimum working distances.

9.4.3 Blasting

The specific excavation methods that will be needed in order to prepare the foundations of the wind turbines and other on-site infrastructure are not likely to be determined at this stage of the Project. 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. On this basis no further assessment has been conducted.

9.6 Construction noise and vibration recommendations

At this stage of the Project, 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 (if required).

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 wind turbine assembly which must occur in still wind conditions for safety reasons.

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

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

General experience of wind farm developments has indicated that construction noise tends to represent a limited risk factor. 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 detailed in Section 3.5.

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

The estimated construction traffic flows on public roads have been provided by Umwelt in correspondence dated 19 January 2024.

The information provided by Umwelt refers to construction traffic on the basis of the Project delivery staging referred to in Section 2.2. From review of the traffic data, it is understood that the traffic associated with the Stage 2 construction represents the higher of the two and as such has been selected as the worst-case scenario.

The traffic volumes associated with the Stage 2 construction that have been provided to MDA by Umwelt are reproduced in Table 22.

Based on the definitions in the RNP, Yanga Way is considered to be a freeway / arterial / sub-arterial road, and Balranald Road is a local road. The assessment has therefore been based on the relevant RNP criteria for each road category.

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

Where the predicted traffic noise increase is 2 dB or less, no further assessment is conducted, as impacts will be barely perceptible. However, where the road traffic noise levels are predicted to increase by more than 2 dB as a result of additional traffic, consideration is given to the actual noise levels associated with the construction traffic and whether or not these levels comply with the road traffic noise criteria detailed in Table 4 of Section 3.5.

Table 22: Construction traffic and base traffic flows on public roads – data provided by Umwelt

ROAD SECTION	STAGE 2 [1]																	
	2027 BACKGROUND						PROJECT TRAFFIC						2027 IN CONST					
	Gazettal		A-Gazettal		Both Directions		Gazettal		A-Gazettal		Both Directions		Gazettal		A-Gazettal		Both Directions	
	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV
Yanga Way (NE of Balranald Road) – Daily [2]	279	102	281	102	560	205	93	20	93	20	186	40	372	122	374	122	746	245
Balranald Road – Daily [2]	17	11	17	17	33	28	141	62	141	62	282	124	158	73	158	79	315	152
Yanga Way (SW of Balranald Road) – Daily [2]	279	102	281	102	560	205	48	60	48	60	96	120	327	162	329	162	656	325
Balranald Road - AM Project Peak (6-7AM) [3]	2	1	2	1	4	2	141	6	0	6	141	12	143	7	2	7	145	14
Balranald Road - PM Project Peak (5-6PM) [3]	1	1	1	2	2	3	0	6	191	6	191	12	1	7	192	8	193	15

1 LV: Light vehicle. HV: Heavy vehicle
2 Total 24 hr AADT (Annual Average Daily Traffic)
3 Peak 1 hr AADT

10.1 Screening assessment

For both sections of Yanga Way listed in Table 22, the increase in road traffic is approximately 28-30% when compared to the existing traffic flows. The relative increase in traffic noise level associated with construction activities is predicted to be below the 2 dB threshold for both sections. Therefore, further detailed noise level predictions and assessments at receivers along Yanga Way are not carried out herein.

However, Balranald Road has 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 both the existing traffic volumes and those associated with the construction of the Project for Balranald Road are very low in absolute levels. The Calculation of Road Traffic Noise (CoRTN) prediction method, preferred by Transport for NSW 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 where relevant, in accordance with CoRTN.

From the traffic data in Table 22, traffic noise levels have been predicted in the vicinity of Balranald Road using the following method and assumptions:

- Traffic speed conservatively assumed to be 80 km/h;
- Road assessed as a local road as defined in the RNP;
- Predicted noise levels include an additional +2.5 dB correction for facade reflection as required by the RNP;
- $L_{Aeq, 1h}$ levels are calculated as CoRTN $L_{A10(1hr)}$ - 3 dB, per RMS practice (noting that this research was conducted by the RMS which has now been absorbed into TfNSW); 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 road surfaces in question is 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 208 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 traffic data, which is considered to be a worst-case scenario.

Table 23 shows a summary of the minimum setback distance from Balranald Road, beyond which compliance with the RNP criteria is predicted to be achieved during the day and night periods.

Table 23: Minimum setback distance for RNP compliance

Road	Minimum setback for compliance, m		Identified receivers within minimum setback zone
	Day	Night	
Balranald Road	55	100	None

It can be seen from Table 23 that there are no receivers that have been identified within the minimum setback distance from Balranald Road, within which traffic noise is predicted to be 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. It is recommended that residents on Balranald Road 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.

Based on the traffic sleep disturbance criteria established in Section 3.5, 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.

No receivers were identified within 40 m of Yanga Way or Balranald Road. However, due to the lack of information for site-related traffic volume on roads connecting to Yanga Way or Balranald Road, care needs to be executed where OSOM deliveries are required to pass through other unidentified roads where receivers may be within 40 m of the roads.

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:

- 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.

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 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted average noise level	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. 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, unless included in a direct quote of external documentation.

APPENDIX B DESCRIPTION OF SOUND

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

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

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

B1 Definition of sound

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

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

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

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

B2 Physical description of sound

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

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

- sound pressure; and
- sound frequency.

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

B2.1 Sound pressure

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

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

To provide some context, Table 24 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 24: Atmospheric pressure versus sound pressure – example values of pressure

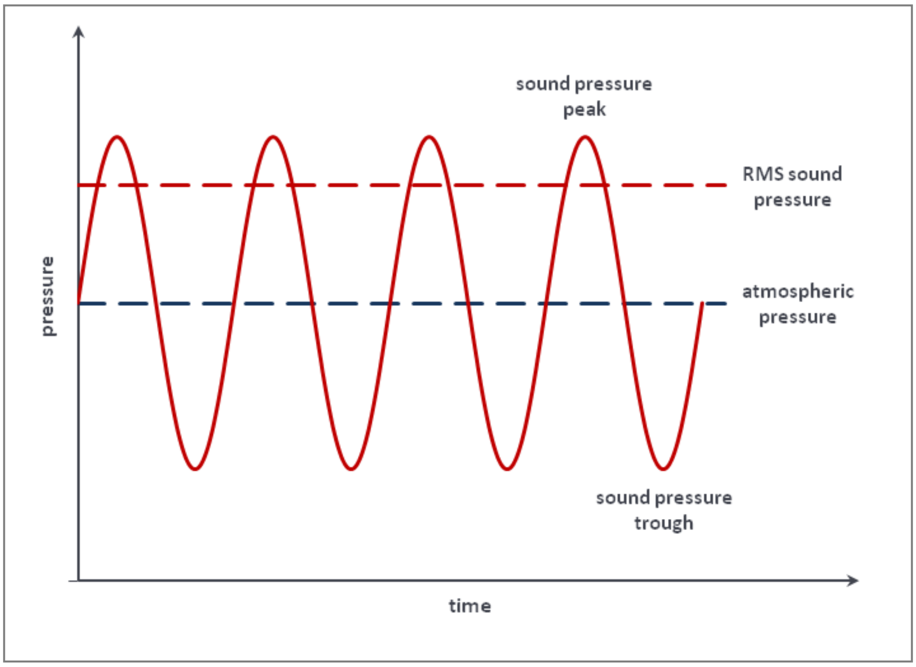
Example	Pascals	Bars	Pounds per Square Inch (PSI)
Atmospheric pressure	100,000	1	14.5
Pressure change due to weather front	10,000	0.1	1.5
Pressure change associated with sound at the threshold of pain	20	0.0002	0.003
Pressure change associated with sound at the threshold of hearing	0.00002	0.0000000002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

The pressure values in Table 24 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 5 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 5: Pressure changes relative to atmospheric pressure associated with sound



B2.2 Frequency

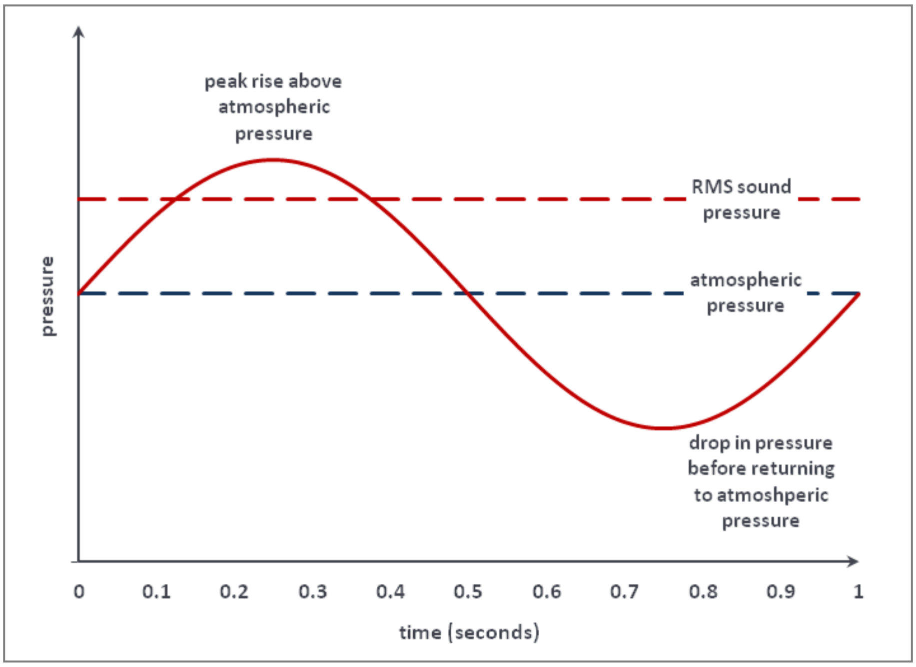
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period. The rate of change in pressure is an important feature that determines whether it can be perceived as a sound by the human ear.

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.

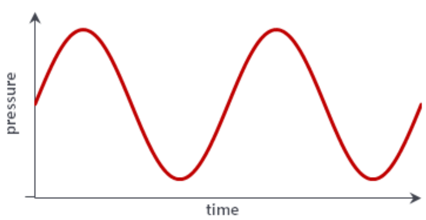
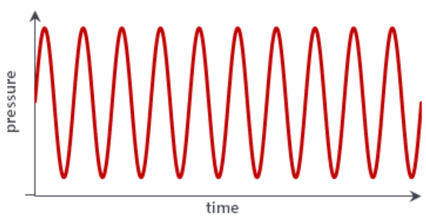
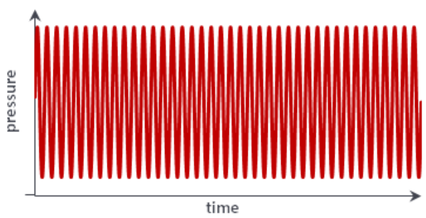
The rate of fluctuation is numerically described in terms of the number of pressure fluctuations that occur in a single second. Specifically, it is the number of cycles per second of the pressure rising above, falling below, and then returning to atmospheric pressure. The number of these cycles per second is expressed in Hertz (Hz). This concept of cycles per second is illustrated in Figure 6 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 6: 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 7 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 7: Examples of the rate of change in pressure fluctuations for low, mid, and high frequencies

Low frequency sounds: 20 to 200 Hz	
Mid-frequency sounds: 200 to 800 Hz	
High frequency sounds: greater than 800 Hz	

B2.3 Sound pressure and frequency variations

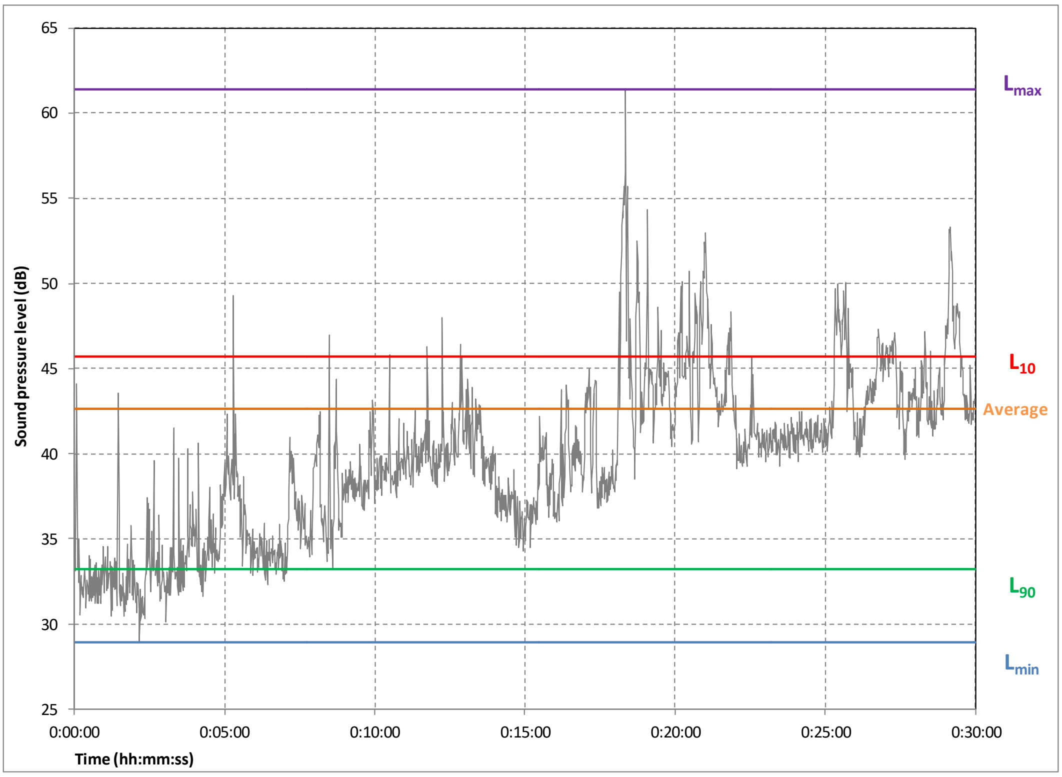
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

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

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

To demonstrate this, Figure 8 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 8: 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 25 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

Table 25: 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 26 provides some examples of how changes in sound pressure levels, for a sound with the same character, can be perceived.

Table 26: 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 26 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.

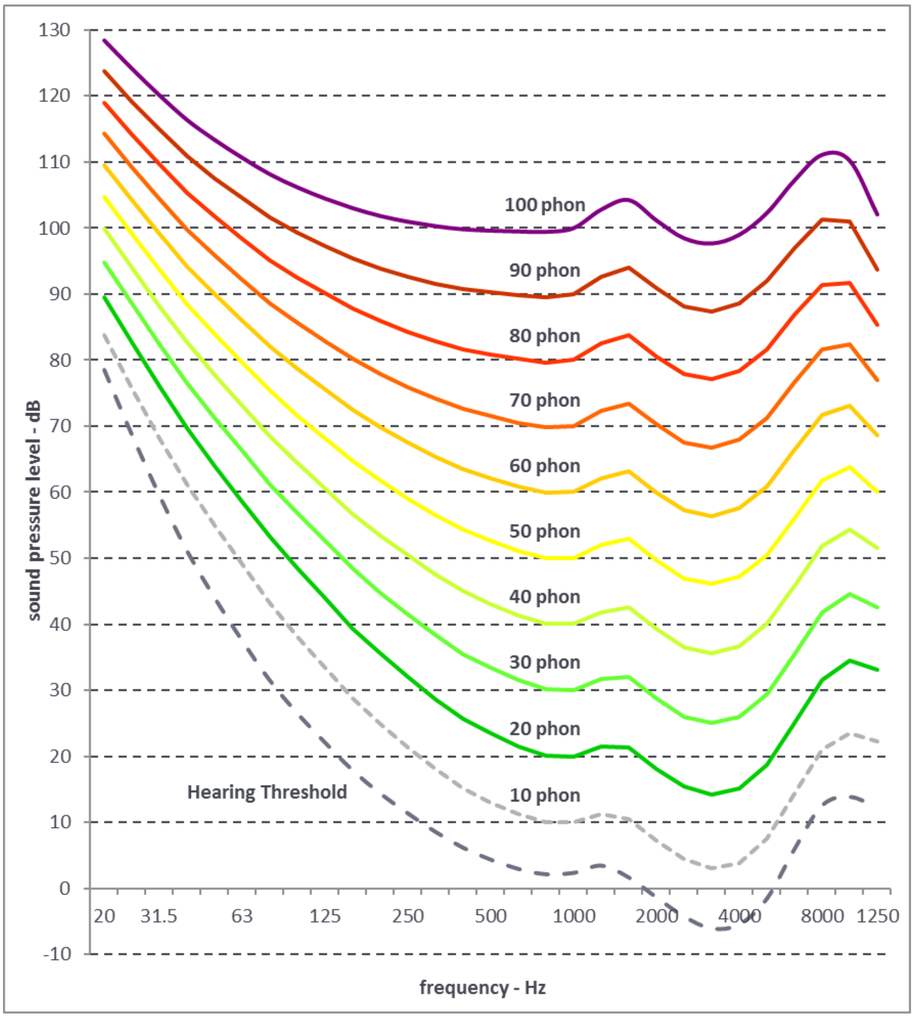
B3.2 Sound frequency and loudness

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 9. The chart presents equal loudness curves for sounds of different frequencies expressed in ‘phons’. Each point on the phon curves represents a sound of equal loudness. For example, the 40 phon curve shows that a sound level of 100 dB at 20 Hz (a very low frequency sound) would be of equal loudness to a level of 40 dB at 1,000 Hz (a whistling sound) or approximately 50 dB at just under 8,000 Hz (a very high pitch sound). The information presented is based on an international standard[10] that defines equal loudness levels for sounds comprising individual frequencies. In practice, sound is usually composed of many different frequencies, so this type of data can only be used as an indication of how different frequencies of sound may be perceived. An individual’s perceptions of sound can also vary significantly. For example, the lower dashed line in Figure 9 shows the threshold of hearing, which represents the sounds an average listener could correctly identify at least 50 % of the time. However, these thresholds represent the average of the population. In practice, an individual’s hearing threshold can vary significantly from these values, particularly at the low frequencies.

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

Figure 9: Equal loudness contours for pure tone sounds



The noise curves in Figure 9 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 WIND TURBINE COORDINATES

Table 27 sets out the coordinates of the proposed wind turbine layout based on the Project layout dated 18 May 2023 as supplied by Umwelt.

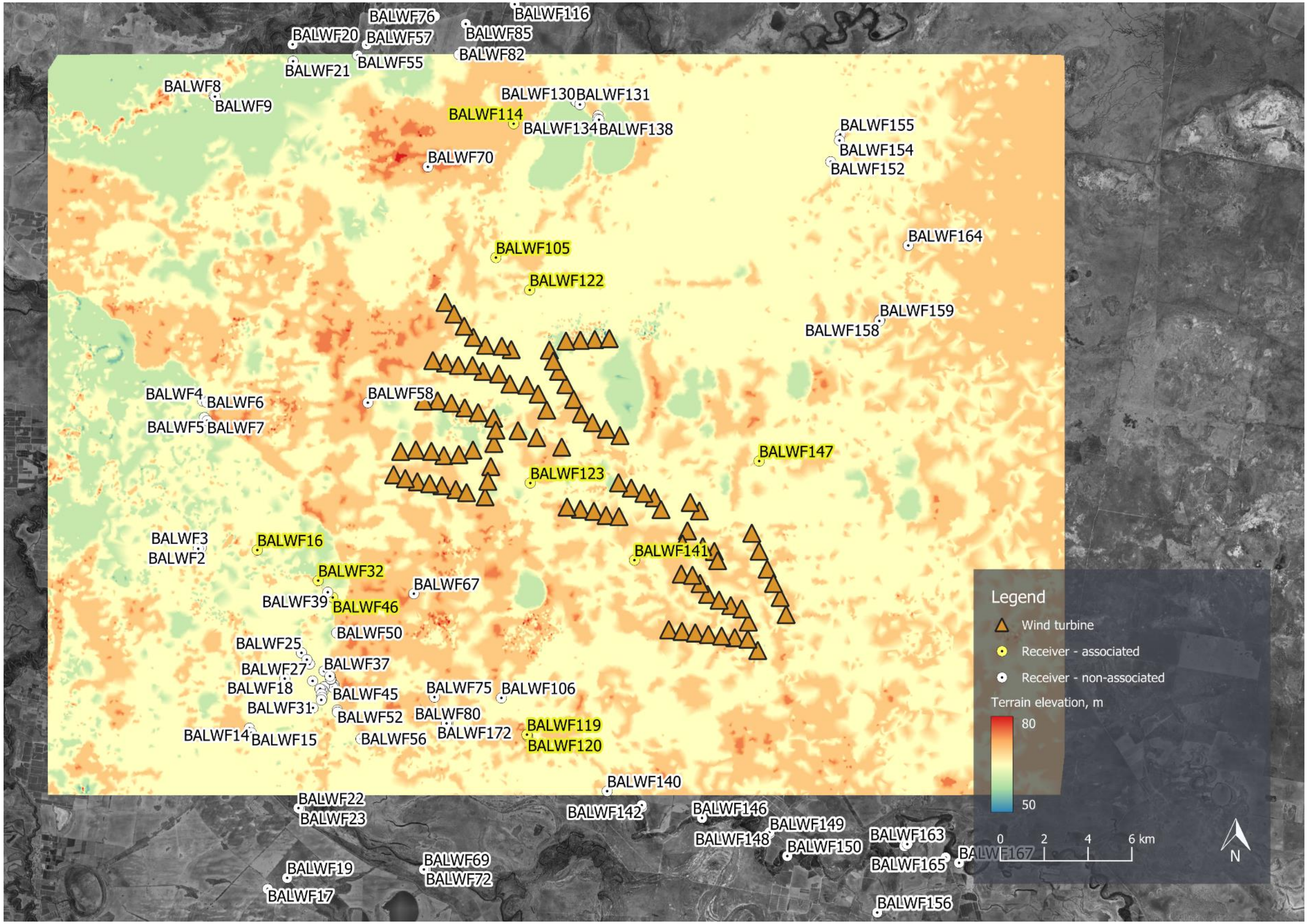
Table 27: Proposed wind turbine coordinates – GDA2020 MGA zone 54

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
1	731,919	6,147,218	65
2	732,326	6,146,691	65
3	732,793	6,146,134	67
4	733,209	6,145,626	65
5	733,768	6,145,264	65
6	734,511	6,145,218	65
7	734,940	6,145,062	65
8	731,358	6,144,560	70
9	731,939	6,144,450	70
10	732,526	6,144,341	68
11	733,171	6,144,337	65
12	733,648	6,144,070	65
13	734,364	6,143,951	65
14	734,878	6,143,490	65
15	735,652	6,143,435	65
16	736,167	6,143,034	65
17	736,559	6,142,302	65
18	739,416	6,145,567	66
19	738,756	6,145,527	61
20	738,098	6,145,489	65
21	737,441	6,145,453	61
22	736,681	6,145,039	65
23	736,861	6,144,537	65
24	737,099	6,144,074	65
25	737,431	6,143,459	65
26	737,788	6,142,789	70
27	738,141	6,142,128	69
28	738,650	6,141,727	67
29	739,285	6,141,428	65
30	739,904	6,141,135	65

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
31	730,932	6,142,712	70
32	731,579	6,142,724	68
33	732,209	6,142,621	65
34	732,817	6,142,404	66
35	733,431	6,142,185	65
36	734,139	6,141,931	69
37	734,240	6,141,388	63
38	735,249	6,141,358	63
39	736,100	6,141,040	65
40	737,245	6,140,607	70
41	729,888	6,140,409	65
42	730,585	6,140,480	67
43	731,293	6,140,416	65
44	731,861	6,140,222	66
45	732,548	6,140,264	65
46	733,192	6,140,477	62
47	734,148	6,140,777	69
48	729,568	6,139,346	67
49	730,103	6,139,166	68
50	730,653	6,139,024	65
51	731,214	6,138,936	62
52	731,775	6,138,845	66
53	732,412	6,138,664	67
54	732,899	6,138,527	65
55	733,744	6,138,337	65
56	733,870	6,139,049	67
57	734,004	6,139,718	66
58	737,487	6,137,866	65
59	738,100	6,137,772	67
60	738,714	6,137,674	65
61	739,272	6,137,486	69
62	739,860	6,137,432	69
63	739,838	6,138,977	64

Wind turbine ID	Easting, m	Northing, m	Terrain elevation, m
64	740,419	6,138,736	65
65	740,998	6,138,496	65
66	741,469	6,138,293	65
67	741,780	6,137,752	65
68	743,112	6,138,075	65
69	743,533	6,137,692	65
70	742,987	6,136,782	66
71	742,759	6,136,188	70
72	743,687	6,136,057	69
73	744,213	6,135,840	65
74	744,364	6,135,416	65
75	742,704	6,134,807	70
76	743,214	6,134,749	69
77	743,562	6,134,373	70
78	743,906	6,133,878	68
79	744,432	6,133,611	65
80	744,962	6,133,364	68
81	745,468	6,133,213	69
82	745,765	6,132,611	65
83	742,132	6,132,257	70
84	742,736	6,132,185	70
85	743,344	6,132,114	70
86	743,945	6,132,043	65
87	744,546	6,131,970	70
88	745,148	6,131,899	70
89	745,748	6,131,829	69
90	746,196	6,131,312	65
91	745,925	6,136,674	69
92	746,261	6,135,852	65
93	746,627	6,135,032	65
94	746,917	6,134,377	69
95	747,221	6,133,734	65
96	747,493	6,132,956	67

APPENDIX D SITE TOPOGRAPHY



APPENDIX E RECEIVER COORDINATES

Table 28 sets out the fourteen (14) receivers identified by the Proponent within 8 km of the Project, together with the respective distance to the nearest wind turbine.

This includes eight (8) associated receivers where a noise agreement has been formalised between the landowners and the Proponent. Data has been supplied by Umwelt via email dated 10 May 2024.

Table 28: Receivers within 8 km of the proposed wind turbines – GDA2020 MGA zone 54

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Distance to the nearest wind turbine, m	Nearest wind turbine
Associated receiver					
BALWF16	723,342	6,135,899	65	7,119	48
BALWF32	726,124	6,134,504	65	5,945	48
BALWF46	726,789	6,133,729	63	6,270	48
BALWF105	734,239	6,149,263	65	3,099	1
BALWF122	735,784	6,147,784	65	2,857	7
BALWF123	735,810	6,138,962	70	1,952	56
BALWF141	740,567	6,135,437	70	2,125	62
BALWF147	746,261	6,139,965	65	3,315	91
Non-associated receiver					
BALWF39	726,561	6,133,970	60	6,163	48
BALWF50	726,967	6,132,114	69	7,688	48
BALWF58	728,390	6,142,631	75	2,552	31
BALWF67	730,492	6,133,904	75	5,087	51
BALWF70	731,132	6,153,413	75	6,248	1
BALWF140	739,319	6,124,880	65	7,898	83

APPENDIX F NOISE PREDICTION MODEL

In Australia, wind turbine noise predictions are typically calculated using ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2:1996) with a set of conservative assumptions tailored to wind farm assessment, as detailed in 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).

A revised version of the standard, ISO 9613-2:2024[11], was published earlier in 2024 based on broadly equivalent procedures to ISO 9613-2:1996, subject to refinements, clarifications, and supplementary advice for different types of sources. Notably, ISO 9613-2:2024 introduces an informative annex on wind turbine noise modelling to reflect the recommendations of the UK Institute of Acoustics guidance.

At the date of preparing this report, the revised standard has not yet been implemented in commonly used proprietary noise modelling software options. However, the core elements of the two versions (particularly with respect to wind farm noise modelling), are similar, and proprietary software options already implement the UK Institute of Acoustics guidance with respect to ISO 9613-2:1996.

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

The use of this standard is supported by international research publications, measurement studies conducted by MDA and direct reference to the standard in the South Australia EPA W*ind 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 wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to ISO 9613-2:1996, the noise emissions of each wind turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence;
- Air absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; 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.

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[11] ISO 9613-2:2024 *Acoustics — Attenuation of sound during propagation outdoors Part 2: Engineering method for the prediction of sound pressure levels outdoors*

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

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2:1996 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all wind turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 ^{o}C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613-2:1996 and the choice of G = 0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- NZS 6808:2010 refers to ISO 9613-2:1996 as an appropriate prediction method for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of G = 0.5
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613-2:1996 model provided a robust representation of upper noise levels which may occur in practice and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613-2:1996 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2:1996 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics guidance. It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methods.

A range of measurement and prediction studies[12, 13, 14] for wind farms in which MDA staff have been associated in have provided further support for the use of ISO 9613-2:1996 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

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12 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.

13 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.

14 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.

The findings of these studies demonstrate the suitability of ISO 9613-2:1996 method to predict the propagation of wind turbine noise for:

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

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

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

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLANnoise 9.0 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the Project and surrounds to evaluate the path between each wind turbine and receiver pairing, and then subsequently applies the adjustments to each wind turbine's predicted noise contribution where appropriate.

APPENDIX G TABULATED BACKGROUND NOISE LEVELS

Table 29: Background noise levels, dB L_{A90}, All-time (0000 – 2400 hrs)

Receiver	Hub height wind speed [1], m/s									
	3	4	5	6	7	8	9	10	11	12
BALWF58	24.5	25.7	26.7	27.4	28.0	28.5	28.8	28.9	29.0	- [3]
BALWF123 [2]	22.3	23.7	24.9	25.9	26.6	27.2	27.6	27.8	27.9	- [3]
BALWF141 [2]	26.9	27.5	28.1	28.7	29.2	29.5	29.6	- [3]	- [3]	- [3]
BALWF147 [2]	21.1	22.5	23.7	24.6	25.2	25.6	25.8	25.8	- [3]	- [3]

1 LiDAR at 744,415 E / 6,135,097 N (GDA2020 MGA zone 54)

2 Indicates an associated receiver

3 Outside valid wind speed range of regression analysis

APPENDIX H TABULATED NOISE LIMITS

In accordance with the NSW Noise Assessment Bulletin and the SA Guideline, noise limits only apply at non-associated receivers. On this basis, Table 31 provides derived noise limits for BALWF58, being the only non-associated receiver at which background noise monitoring was conducted.

Noise levels at associated receivers will need to be managed in accordance with the commercial agreements established between the Proponent and the landowners.

Table 30: Operational wind turbine noise limits, dB L_{A90}, All-time (0000 – 2400 hrs)

Receiver	Hub height wind speed, m/s								
	3	4	5	6	7	8	9	10	≥11
BALWF58	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0

1 LiDAR at 744,415 E / 6,135,097 N (GDA2020 MGA zone 54)

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

The following excerpt concerning C-weighted wind turbine noise have been reproduced from NSW Noise Assessment Bulletin.

> ***Low Frequency Noise***
>
> *The presence of excessive low frequency noise (a special noise characteristic) [ie noise from the wind farm that is repeatedly greater than 65 dBC during day time or 60 dBC during the night-time at any relevant receiver] will incur a 5 dB(A) penalty, to be added to the measured noise level for the wind farm, unless a detailed internal low frequency noise assessment 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 noise source.*

I3 Prediction method

As stated in Section 6.3.3, there is no commonly used, practical method to accurately predict wind turbine low frequency noise levels at receiver locations.

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

C-weighted noise levels have been predicted for the worst-case wind speed as specified in Section 6.3.1.

I4 Results

Table 31 presents the results of the preliminary C-weighted noise predictions for each of the non-associated receivers located within 8 km of any wind turbine.

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

Table 31: Predicted C-weighted noise levels

Receiver	Predicted noise level, dB L_{Ceq}		Below 60 dB L_{Ceq} for all wind turbine models?
	V162-6.2	GW165-6.0	
BALWF39	47.8	53.1	Yes
BALWF50	47.1	52.4	Yes
BALWF58	52.9	58.3	Yes
BALWF67	49.7	55.1	Yes
BALWF70	47.0	52.4	Yes
BALWF140	46.5	51.8	Yes

APPENDIX J EFFECTS OF WIND TURBINE NOISE

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

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

J1 Health and amenity

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

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

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

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

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

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

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

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

> *Noise standards are used not only for environmental noise (such as wind farms and traffic noise) but also for industry and even household appliances.*
>
> *Noise standards are set to protect the majority of people from annoyance. The wide individual variation in response to noise makes it unrealistic to set standards that will protect everyone from annoyance. A minority of people may still experience annoyance even at sound levels that meet the standard. This is the case not only for wind farms, but for all sources of noise.*

The subject of health effects related to operational wind farms in Australia has been extensively considered by the Commonwealth Government's National Health and Medical Research Council (NHMRC) and the Australian Medical Association; in particular, the NHMRC has undertaken and coordinated a systematic review of evidence related to wind farms and health. The research reviews[15] and public statements[16, 17] produced by these peak health bodies support that, as with any audible sound, wind farm noise can represent a potential source of annoyance or sleep disturbance for some individuals. Their findings did however indicate that there was no reliable evidence to support a relationship between wind farm noise and direct adverse effects on human health.

In July 2012, Health Canada undertook a large-scale epidemiology study in response to community health concerns expressed in relation to wind turbines. The following conclusions[18] 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).*

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

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

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

18 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*[19] 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 night time.*

As detailed in the MDA paper *WHO Environmental Noise Guidelines for the European Region: conditional recommendation for wind turbine noise in the context of Australian regulations*[20], 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 wind turbines, the extent of vegetation around the dwelling, and the degree to which the dwelling is sheltered from prevailing wind conditions. Irrespective of the relatively low levels which operational wind farm noise is restricted to, an individual's judgement of the audible noise from a wind farm is highly subjective and will be influenced by a range of contextual factors.

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

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

20 http://tinyurl.com/WTN2019-Delaire

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

The NSW Noise Assessment Bulletin states the following concerning infrasound:

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

These types of emissions have been the subject of considerable misrepresentation in media commentary. Notably, the work of Dr Geoff Leventhall, a prominent UK consultant in the field of acoustics and vibration, and researcher in the field of low frequency noise is often cited in some documents which continue to claim concerns about infrasound and low frequency noise from wind turbines. However, Dr Leventhall has regularly made clear statements to assert that there is no significant infrasound from current designs of wind turbines and very little low frequency sound, neither of which are anywhere near the sorts of levels which would represent a direct health risk for neighbouring residents of modern wind farms. An example of such publication, co-authored by Dr Leventhall, was published in the UK Institute of Acoustics Bulletin in March 2009[21]. 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.*

21 Institute of Acoustics Bulletin – Bowdler, Bullmore, Davis, Hayes, Jiggins, Leventhall, McKenzie - *Prediction and Assessment of Wind Turbine Noise* –March 2009

Another example of the misrepresentations made in relation to the environmental effects of wind turbines centred around work carried out by Keele University in the UK on ground vibration. Professor Peter Styles and his team at Keele University undertook a study of the effects of wind turbines on the seismic detection array at Eskdalemuir, Scotland. The results of this work were widely misinterpreted and resulted in a statement[22] 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[23, 24] have demonstrated that infrasound and low frequency sound produced by regularly encountered natural and man-made sources, such as the infrasound produced by the wind or distant traffic, is comparable to that of modern wind turbines, noting that:

> *Infrasound levels in the rural environment appear to be controlled by localised wind conditions. During low wind periods, levels as low as 40dB(G) were measured at locations both near to and away from wind turbines. At higher wind speeds, infrasound levels of 50 to 70dB(G) were common at both wind farm and non-wind farm sites.*
>
> *Organised shutdowns of the wind farms adjacent to [sic: measurement locations] indicate that there did not appear to be any noticeable contribution from the wind farm to the G-weighted infrasound level measured at either house. This suggests that wind turbines are not a significant source of infrasound at houses located approximately 1.5 kilometres away from wind farm sites*

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

23 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

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

In 2010, the UK Health Protection Agency published a report[25] on the health effects of exposure to ultrasound and infrasound. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

> *Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.*
>
> *[…]*
>
> *For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects.*

Also, a recent State Government of Victorian Department of Health document[26] concludes the following in relation to infrasound from wind farms:

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

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

In February 2015, the National Health and Medical Research Council (NHMRC) released an information paper[27] 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.*

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

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

[27] *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 wind turbines are well below perception thresholds, and low frequency levels are typically low.

APPENDIX K TABULATED PREDICTED NOISE LEVELS

Table 32: Predicted noise levels, dB L_{Aeq} for all receivers within 8 km of the Project – Vestas V162-6.2

Receiver	Hub-height wind speed (m/s)							
	4	5	6	7	8	9	10	≥11
Associated receivers								
BALWF16	10.4	10.6	12.5	15.5	18.3	20.6	21.1	21.1
BALWF32	12.2	12.4	14.3	17.3	20.1	22.4	22.9	22.9
BALWF46	12.1	12.3	14.2	17.2	20.0	22.3	22.8	22.8
BALWF105	18.4	18.6	20.5	23.5	26.3	28.6	29.1	29.1
BALWF122	21.1	21.3	23.2	26.2	29.0	31.3	31.8	31.8
BALWF123	24.9	25.1	27.0	30.0	32.8	35.1	35.6	35.6
BALWF141	23.5	23.7	25.6	28.6	31.4	33.7	34.2	34.2
BALWF147	17.8	18.0	19.9	22.9	25.7	28.0	28.5	28.5
Non-associated receivers								
BALWF39	12.1	12.3	14.2	17.2	20.0	22.3	22.8	22.8
BALWF50	10.8	11.0	12.9	15.9	18.7	21.0	21.5	21.5
BALWF58	20.4	20.6	22.5	25.5	28.3	30.6	31.1	31.1
BALWF67	15.1	15.3	17.2	20.2	23.0	25.3	25.8	25.8
BALWF70	11.0	11.2	13.1	16.1	18.9	21.2	21.7	21.7
BALWF140	10.1	10.3	12.2	15.2	18.0	20.3	20.8	20.8

Table 33: Predicted noise levels, dB L_{Aeq} for all receivers within 8 km of the Project – Goldwind GW165-6.0

Receiver	Hub-height wind speed (m/s)								
	4	5	6	7	8	9	10	11	≥11.5
Associated receivers									
BALWF16	12.7	14.3	18.2	21.6	24.0	25.5	26.3	26.3	26.5
BALWF32	14.5	16.1	20.0	23.4	25.8	27.3	28.1	28.1	28.3
BALWF46	14.4	16.0	19.9	23.3	25.7	27.2	28.0	28.0	28.2
BALWF105	20.7	22.3	26.2	29.6	32.0	33.5	34.3	34.3	34.5
BALWF122	23.4	25.0	28.9	32.3	34.7	36.2	37.0	37.0	37.2
BALWF123	27.3	28.9	32.8	36.2	38.6	40.1	40.9	40.9	41.1
BALWF141	25.8	27.4	31.3	34.7	37.1	38.6	39.4	39.4	39.6
BALWF147	20.2	21.8	25.7	29.1	31.5	33.0	33.8	33.8	34.0
Non-associated receivers									
BALWF39	14.4	16.0	19.9	23.3	25.7	27.2	28.0	28.0	28.2
BALWF50	13.1	14.7	18.6	22.0	24.4	25.9	26.7	26.7	26.9
BALWF58	22.8	24.4	28.3	31.7	34.1	35.6	36.4	36.4	36.6
BALWF67	17.4	19.0	22.9	26.3	28.7	30.2	31.0	31.0	31.2
BALWF70	13.3	14.9	18.8	22.2	24.6	26.1	26.9	26.9	27.1
BALWF140	12.4	14.0	17.9	21.3	23.7	25.2	26.0	26.0	26.2

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

Table 34: Construction noise sources sound power data, dB L_{WA}

Noise source	Sound power level
Batching Plant	110
Bulldozer	108
Concrete pump	108
Concrete truck	108
Crane (1200 t)	115
Crane (200 t)	105
Crane (500 t)	110
Crane (mobile)	104
Delivery Trucks	107
Dump truck	117
Excavator (100 to 200 kW)	107
Excavator fitted with pneumatic breaker	118
Generator	99
Grader	110
Rock crusher	120
Screening plant	109
Tracked loader	115

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 35, and assume that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

Table 35: Overall sound power levels of key construction tasks, dB L_{WA}

Construction task	Plant/Equipment	Approximate overall sound power level
Wind turbine foundations	1 x Bulldozer, 3 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
Wind turbine assembly	1 x Crane (1200 t), 2 x Crane (200 t), 1 x Crane (500 t), 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
BESS 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
O&M/construction compounds	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, 1 x Screening plant	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
Cable trench digging	2 x Dump truck, 1 x Excavator (100 to 200 kW), 1 x Crane (mobile), 1 x Grader	120
Temporary met mast 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
Concrete batching plant	1 x Batching Plant, 1 x Concrete pump, 1 x Concrete truck	115
Temporary laydown areas	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
Power performance mast 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

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 EIS. The requirements and the location within this report where the requirement is addressed, are summarised in Table 36.

Table 36: NSW Noise Assessment Bulletin – information requirements

Information requirement	Location of relevant content
• *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
• *background noise measurement locations including time and duration of the background noise monitoring program;*	See Background Noise Assessment[28]
• *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 Assessment
• *a summary of the environmental noise criteria for the Project at each integer wind speed based on the above correlation;*	See Background Noise Assessment
• *make and model of the representative WTG(s) along with the positions of the WTGs;*	Figure 1 / Section 6.2 / Appendix C
• *predicted noise levels at the closest non-associated dwellings to the wind energy project at each integer wind speed;*	Section 6.4 / Appendix I
• *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
• *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

[28] MDA report Rp 001 20220419 *Junction Rivers Wind Project - Background Noise Assessment* (Background Noise Assessment), dated 22 May 2024