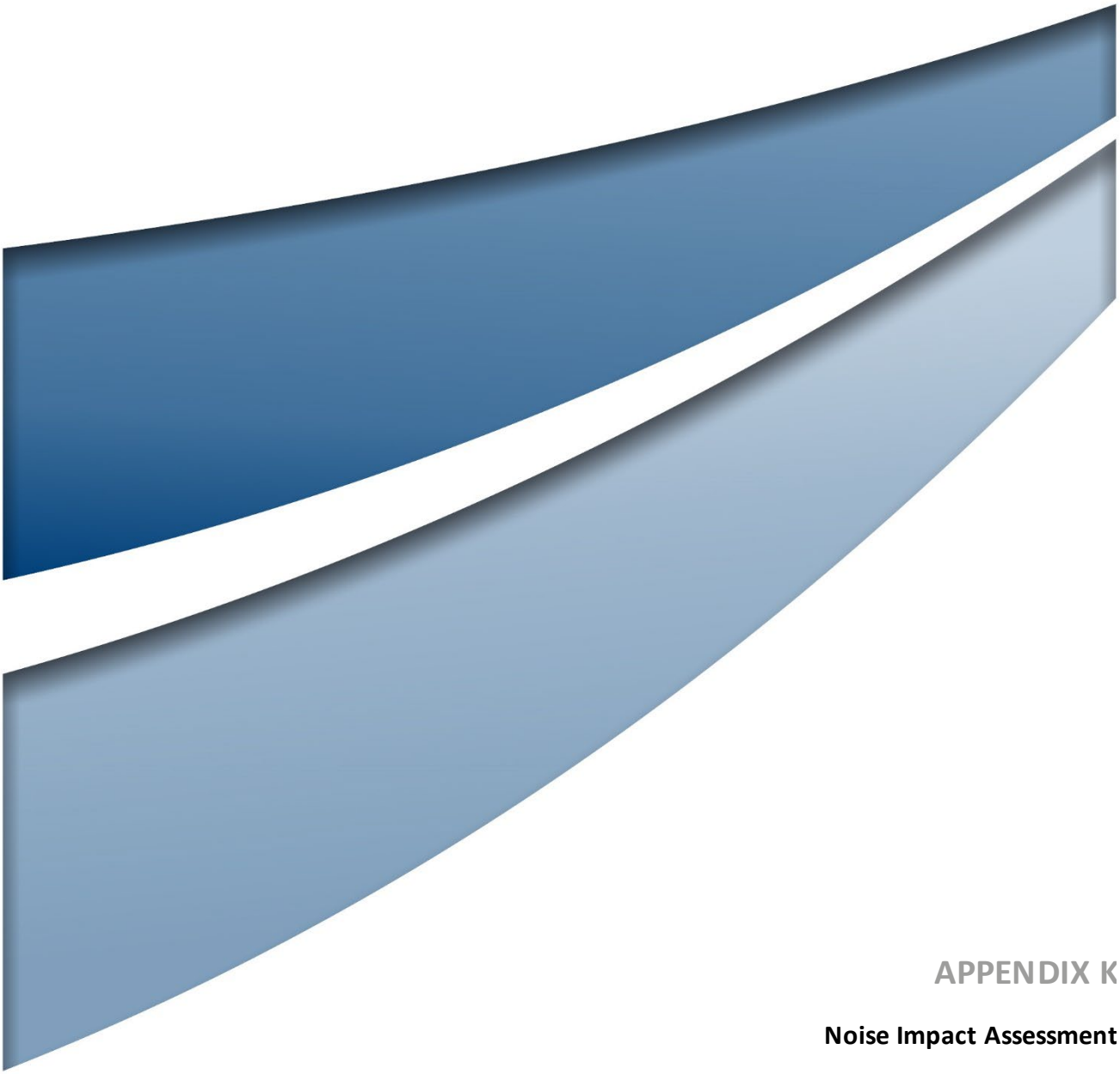


APPENDIX K

Noise Impact Assessment

Mount Hopeful Wind Farm

Noise Impact Assessment

S6515C7

March 2023

sonus.

Sonus Pty Ltd
17 Ruthven Avenue
Adelaide 5000 SA
Phone: +61 (8) 8231 2100
www.sonus.com.au

Document Title	:	Mount Hopeful Wind Farm Noise Impact Assessment
Document Reference	:	S6516C7
Date	:	March 2023
Prepared by	:	

Sonus is a member of the Association of Australian Acoustical Consultants (AAAC).

EXECUTIVE SUMMARY

A previous assessment was made of the noise from the Mount Hopeful Wind Farm. The 97 turbine wind farm and associated ancillary infrastructure was approved on 17 June 2022, subject to a number of conditions. The conditions include the requirement to prepare an *updated Noise Impact Assessment* to *reflect the final wind turbine model and ancillary equipment selection and siting.*

As a result of further design, the project now consists of wind turbines with a maximum hub height of 170m and two substations with a single 240 MVA transformer at each. This updated Noise Impact Assessment considers the noise from operation of the proposed layout with Goldwind 165 6.0MW turbines and compares predictions against the relevant noise criteria established under the Queensland Government Department of Infrastructure, Government and Planning *State code 23: Wind farm development*, Planning Guideline (February 2022) (**State Code 23**) and the conditions of the existing development approval.

The predicted noise levels from the wind turbines have been compared with noise assessment criteria established in accordance with the conditions of approval and the background noise monitoring. Due to the separation distances to sensitive land uses, the predicted noise levels will satisfy the assessment criteria established under PO11 and PO12 of State Code 23.

The noise from the substations has also been predicted. The predicted noise levels are significantly less than the relevant wind farm criteria and therefore the ancillary wind farm infrastructure will not adversely impact on the existing acoustic amenity at the sensitive land uses.

GLOSSARY AND ABBREVIATIONS

Term	Definition
A weighting	Frequency adjustment representing the response of the human ear.
Ambient noise level	Noise level in the absence of the noise from the wind farm.
Background noise level	The ambient noise level represented by the L_{A90} in the absence of intermittent noise such as vehicles and short term wind gusts.
dB	Linear (unweighted) sound pressure or power level in decibels.
dB(A)	A weighted noise or sound pressure or power level in decibels.
Host Lot	A parcel of land (lot(s)) that accommodates any part of a wind farm development.
L_{A90}	The A weighted sound pressure level exceeded for 90% of the measurement period.
$L_{A90,10min}$	The L_{A90} sound pressure level measured over a 10 minute period.
L_{Aeq}	The A weighted equivalent continuous noise level – the energy-average of noise levels occurring over a measurement period.
May 2013 UK IOA Good Practice Guide	*UK Institute of Acoustics IOA - A Good Practice Guide To The Application Of Etsu-R-97 For The Assessment And Rating Of Wind Turbine Noise*
Non - Host Lot	Premises in proximity to the wind farm that are not Host Lots.
Sensitive land uses	A range of different uses as defined by the Planning Regulations 2017, typically dwellings. Both Non-Host Lots and Host Lots are considered sensitive land uses, albeit subject to different assessment criteria under State Code 23.
State Code 23	Queensland Government Department of Infrastructure, Government and Planning *State code 23: Wind farm development*, Planning Guideline (February 2022).
The Wind Farm	The Mount Hopeful Wind Farm project, including wind turbine generators and ancillary infrastructure
WTG	Wind Turbine Generator

TABLE OF CONTENTS

1 INTRODUCTION

An updated noise impact assessment has been undertaken for the proposed Mount Hopeful Wind Farm (the **wind farm**), in accordance with the Queensland Government Department of Infrastructure, Government and Planning *State code 23: Wind farm development*, Planning Guideline (February 2022) (**State Code 23**) and the Conditions of Approval (SARA reference: 2109-24892 SDA).

A noise impact assessment of the proposed wind farm has previously been conducted (Sonus report S6516C4) and the 97 turbine wind farm and associated ancillary infrastructure was approved on 17 June 2022, subject to Conditions of Approval. This assessment has been prepared to facilitate an application for a change to the existing development approval for the wind farm to reflect these design changes.

As a result of further design, the project now consists of up to 63 wind turbines with a maximum hub height of 170m, and two substations with a single 240 MVA transformer at each. It is noted using the highest hub height of 170m is a conservative assessment because lower hub heights would result in marginally less onerous criteria. Several turbine models have been considered and the Goldwind 165 6.0MW has been used for this assessment as a conservative approach. That is, the turbine provides the highest predicted noise level of the turbines considered. The updated Noise Impact Assessment considers the noise from operation of the proposed equipment selections and layout and compares predictions against the relevant noise criteria of the approval. The proposed wind farm layout, ancillary infrastructure and sensitive land uses in the vicinity are provided in Figure 1.

Noise levels at sensitive land uses in the vicinity of the proposed wind farm have been predicted using the noise propagation model and the inputs recommended by the *May 2013 UK IOA Good Practice Guide* and State Code 23.

The co-ordinates of the WTGs and the relevant sensitive land uses are provided in Appendices A and B, respectively.

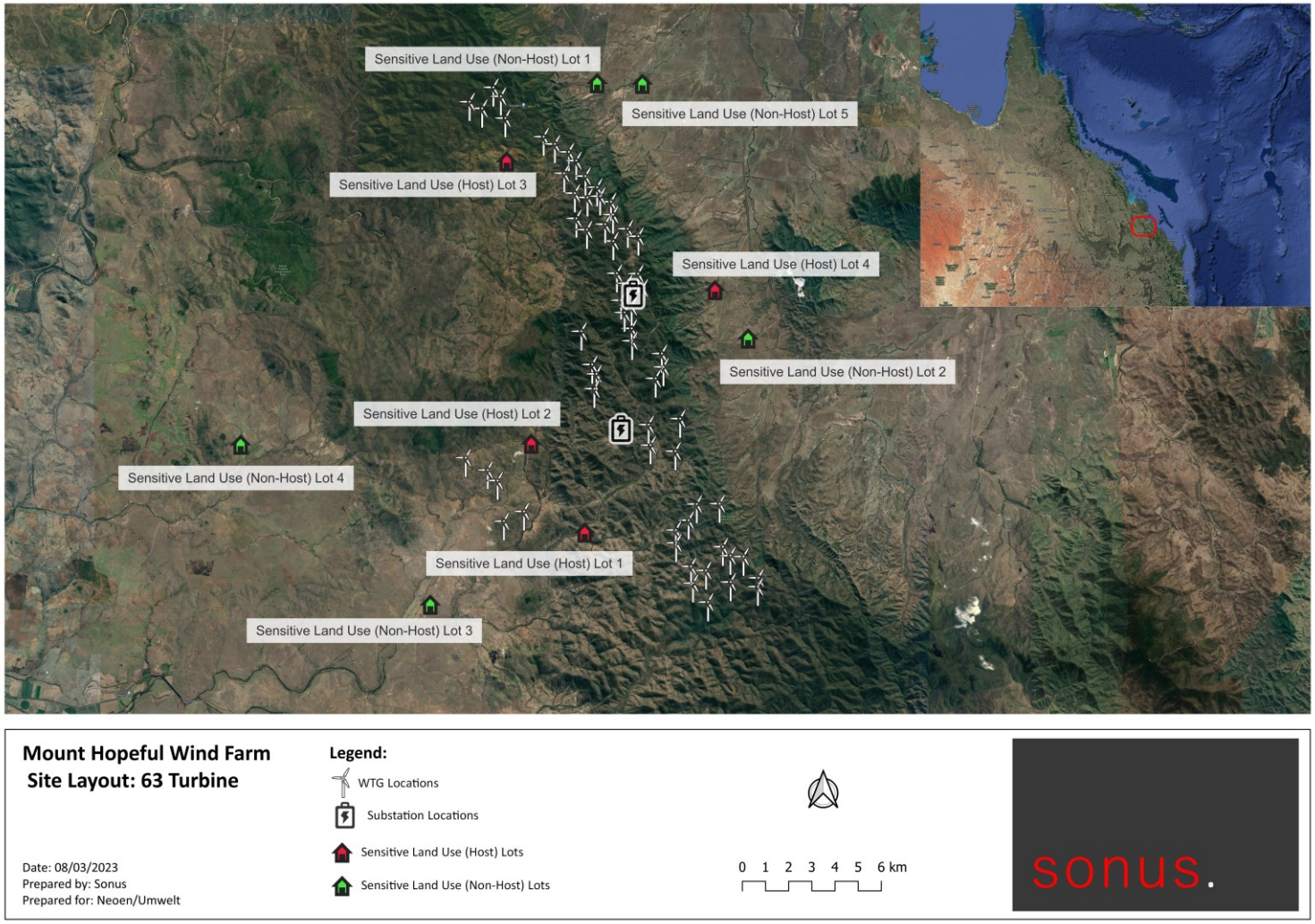


Figure 1: Wind Farm layout and sensitive land uses

2 CONDITIONS OF APPROVAL

Condition 22 of the existing project approval provides noise criteria for existing or approved sensitive land uses on host lots and non-host lots to ensure the health and safety of individuals and the community. The full Condition is provided below:

(a) Prepare an updated Noise Impact Assessment (NIA).

(b) The NIA required under part (a) of this condition must:

i) be prepared by a suitably qualified acoustic consultant

ii) reflect the final wind turbine model and ancillary equipment selection and siting (as a result of detailed design) and address the following criteria for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height, demonstrate compliance with the following criteria (whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height)

- *for all existing noise affected sensitive land uses on host lots (as at the date of this approval):*
  - *an outdoor (free-field) night-time (10pm to 6am) A-weighted acoustic level of:*
    - *45dB(A), or*
    - *the background noise (LA90) by more than 5dB(A)*
- *at all existing noise affected sensitive land uses on non-host lots (as at the date of this approval):*
  - *an outdoor (free-field) night-time (10pm to 6am) A-weighted acoustic level of:*
    - *35dB(A), or*
    - *the background noise (LA90) by more than 5dB(A)*
  - *An outdoor (free-field) day-time (6am to 10pm) A-weighted acoustic level of:*
    - *37dB(A), or*
    - *the background noise (LA90) by more than 5dB(A).*
  - *Alternatively, the acoustic level agreed between the applicant/operator and the non-host lot owner/s via a formal deed of release and not exceeding an outdoor (free-field) night-time (10pm to 6am) A-weighted acoustic level of:*
    - *45dB(A), or*
    - *the background noise (LA90) by more than 5dB(A)*

(c) Submit the NIA required by parts (a) and (b) of this condition to the Department of State Development, Infrastructure, Local Government and Planning (windfarms@dsdilgp.qld.gov.au).

Note: A suitably qualified acoustic consultant with suitable acoustic experience is a person who is: 1) eligible for membership of the Australian Acoustical Society, or 2) whose firm is a member of the Association of Australasian Acoustical Consultants, or 3) is an RPEQ with suitable acoustic experience.

3 ENVIRONMENTAL NOISE CRITERIA

In summary, Condition 22 requires that:

- For host lots, noise from the wind farm must not exceed 45 dB(A) or the background noise level plus 5 dB(A), whichever is greater, during the night period (10:00pm to 6:00am).
- For non-host lots, noise from the wind farm must not exceed 35 dB(A) or the background noise level plus 5 dB(A), whichever is greater, during the night period; and 37 dB(A) or the background noise level plus 5 dB(A), whichever is greater, during the day period (6:00am to 10:00pm). Alternatively, a higher level, as setout in a formal deed of release, provided it does not exceed the host lot levels.

The requirements are consistent with the State Code 23, which governs wind farm developments in Queensland.

As described in detail in the previous noise impact assessment, background noise monitoring was conducted at Host Lot 5 (shown in Figure **1**) between 4 February and 17 March 2021. Photographs of the noise monitoring equipment are provided in Appendix C.

The background noise and wind speed data (referenced to the proposed hub height of 170m) have been analysed in accordance with the methodology provided in the State Code 23. The correlations for the data analysis are provided in Appendix D.

Table 1 summarises the background noise levels measured during the daytime and night-time periods for each integer hub height wind speed between 3m/s and 12m/s at Host Lot 5. The resultant criteria that apply to all host and non-host lots is also shown.

Table 1: Background Noise Levels ($L_{90,10min}$).

Based on Measurements at Host Lot 5		**Background Noise Level (dB(A)) at 170m Hub Height Wind Speed (m/s)**									
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Day (6am to 10pm)	Background	32	32	33	34	35	36	37	37	37	35
	Non-Host Lot Criteria	37	37	38	39	40	41	42	42	42	40
	Host Lot Criteria	45	45	45	45	45	45	45	45	45	45
Night (10pm to 6am)	Background	38	37	36	36	36	36	37	37	38	38
	Non-Host Lot Criteria	43	42	41	41	41	41	42	42	43	43
	Host Lot Criteria	45	45	45	45	45	45	45	45	45	45

4 NOISE ASSESSMENT

4.1 Noise Propagation Model

Noise levels from the wind farm have been predicted using the noise propagation model, *ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors* (**ISO 9613-2**). ISO 9613-2 provides a methodology for predicting noise levels at sensitive land uses under meteorological conditions favourable to noise propagation. It is known as a downwind model, based on the conservative assumption of being downwind (resulting in the highest noise level) of all WTGs operating simultaneously. The noise prediction model inputs are in accordance with the *May 2013 UK IOA Good Practice Guide* and State Code 23, including:

- 10°C temperature;
- 70% relative humidity;
- 50% acoustically hard ground and 50% acoustically soft ground;
- barrier attenuation of no greater than 2 dB(A);
- 4m receiver height; and,
- application of a 3 dB(A) correction where a "concave" ground profile exists as defined by the *May 2013 UK IOA Good Practice Guide*.

The noise model uses topographical ground contours but limits the barrier attenuation as noted above.

4.2 Noise Sources

4.2.1 WTGs

The WTG used for this modelling is the Goldwind 165 6.0MW with a hub height of 170m. This WTG model has the highest noise emission among the options being considered for the project.

One-third octave band sound power levels for the proposed wind turbine generator have been provided by *Goldwind* for each integer hub height wind speed from 6m/s to 15m/s. The sound power levels are based on measurement results, summarised in WIND-consult GmbH Reuterstr.9 18211 Bargeshagen Extract 147SE622-01-EX01 of test report 147SA622-01 *Determination of noise emission of a wind turbine (WT) of the type GW165-6.*0.

In accordance with the IOA Good Practice Guide, an allowance of 1.645 times the overall measurement uncertainty for each integer wind speed has been added to the prediction results. Table 2 summarises the specified sound power levels and the measurement uncertainty for each integer wind speed, which have been used for the noise prediction.

Table 2: Goldwind sound power level data

1/3 Octave Band Centre Frequency	Hub height wind speed									
	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s	13 m/s	14 m/s	15 m/s
10 Hz	39.2	43.1	45.3	48.9	47.7	46.7	47.3	46.8	47.1	47.0
12.5 Hz	45.8	49.9	52.0	53.6	53.9	53.5	53.5	52.6	52.4	52.0
16 Hz	50.9	55.0	57.1	58.8	59.4	58.7	58.2	58.3	56.7	56.0
20 Hz	56.7	60.8	63.1	65.8	65.2	65.2	64.7	64.7	63.6	61.6
25 Hz	61.8	66.2	68.8	70.9	70.5	70.1	69.3	69.1	68.0	66.9
31.5 Hz	66.2	70.9	73.5	75.8	74.5	75.1	74.0	73.7	72.8	71.8
40 Hz	69.9	73.8	76.2	78.3	78.0	78.2	77.1	77.2	76.1	75.4
50 Hz	73.2	77.0	79.1	81.3	81.2	81.1	79.8	79.8	78.7	77.7
63 Hz	77.1	80.3	82.7	84.9	84.7	84.4	82.9	83.1	81.8	81.3
80 Hz	81.5	83.7	85.7	88.0	87.2	87.2	85.8	86.1	85.3	84.3
100 Hz	84.0	86.6	88.4	90.2	89.9	90.0	89.0	89.1	88.6	88.2
125 Hz	86.3	89.1	91.0	91.8	92.6	92.6	91.4	91.4	90.8	90.5
160 Hz	88.2	90.7	92.8	94.6	94.9	94.6	93.8	93.7	93.7	93.4
200 Hz	89.9	92.9	95.3	96.8	97.6	97.6	96.5	96.2	96.1	95.9
250 Hz	91.1	94.5	97.1	98.8	99.5	99.4	98.2	97.8	97.5	97.2
315 Hz	90.9	95.4	98.7	100.6	101.2	101.3	100	99.7	99.3	99.2
400 Hz	90.0	95.0	98.6	100.8	101.1	101.3	100.3	100.1	99.9	99.8
500 Hz	87.6	93.1	97.1	99.3	100.9	101.1	100.9	100.9	100.8	100.7
630 Hz	85.1	90.7	95.0	97.5	100.3	100.5	100.7	100.9	100.9	100.9
800 Hz	82.7	88.1	92.4	94.8	98.7	99.0	99.6	100.1	100.2	100.1
1 kHz	80.2	85.5	89.7	92.2	96.8	97.2	98.1	98.7	98.8	98.9
1.25 kHz	78.5	83.4	87.5	90.0	94.2	94.7	95.8	96.5	96.6	96.6
1.6 kHz	74.7	79.2	83.2	86.5	91.6	92.0	93.3	94.2	94.3	94.3
2 kHz	74.5	77.8	81.7	85.1	87.8	88.3	89.7	90.9	90.8	90.7
2.5 kHz	74.1	76.6	80.0	83.6	83.8	84.0	85.9	87.7	86.8	86.9
3.15 kHz	73.6	75.7	78.2	81.7	81.0	81.4	82.4	84.2	83.7	84.1
4 kHz	72.0	73.6	75.6	78.4	78.0	78.4	79.3	81.0	80.5	80.9
5 kHz	70.9	72.1	73.7	75.9	75.7	76.1	76.9	78.6	78.1	78.5
6.3 kHz	71.7	72.6	73.9	75.7	75.5	75.9	76.6	78.1	77.6	78.0
8 kHz	73.2	73.9	74.9	76.3	76.3	76.6	77.2	78.6	78.1	78.5
10 kHz	72.7	73.2	73.9	75.1	75	75.2	75.8	77.0	76.6	76.9
Total	98.7	102.8	106.0	108.0	109.5	109.6	109.3	109.4	109.3	109.2
Measurement Uncertainty	0.75	0.72	0.71	0.68	0.71	0.73	0.74	0.75	0.68	0.76

4.2.2 Ancillary Infrastructure

The proposed wind farm also includes two substation locations, with approximate coordinates detailed in Table 3.

Table 3: Substation coordinates

Substations	Approximate Coordinates (GDA 94 MGA Zone 56)	
	Easting	Easting
Substation 1	254054	7363875
Substation 2	253625	7358075

The main noise generating equipment associated with the substations are the transformers.

Each substation is proposed to have a transformer which is rated up to 240 MVA. Noise levels from the substations have been modelled based on a 240 MVA rated transformer with a sound power level of 99 dB(A), derived for from the Australian/New Zealand Standard *AS/NZS 60076.10:2009 Power transformers – Part 10: Determination of sound levels.*

4.3 Predicted Noise Levels

The noise from the wind farm has been predicted based on the methodology described in Section 4.

4.3.1 WTGs

As shown in Table 2, the highest noise levels from the proposed WTG occurs at an operational wind speed of 11m/s (lower noise levels predicted for higher wind speeds). The highest noise levels (wind speed of 11m/s) are shown in Figure 2 along with the sensitive land uses in the vicinity of the wind farm.

The predicted wind farm noise levels at each sensitive land use for each WTG hub height integer wind speed up to 11m/s are tabulated in Table 4.

Table 4: Predicted wind farm noise levels (L_{eq}) at integer wind speeds from 6m/s to 11m/s

Location ID	170m Hub Height Wind Speed (m/s)					
	6	7	8	9	10	11
Sensitive Land Use (Host) Lots						
Host Lot 1	25	28	31	33	33	34
Host Lot 2	27	30	33	35	36	36
Host Lot 3	31	35	38	40	41	41
Host Lot 4	26	29	32	34	35	35
Sensitive Land Use (Non-Host) Lots						
Non-Host Lot 1	26	29	32	34	35	35
Non-Host Lot 2	25	28	31	33	33	33
Non-Host Lot 3	18	22	24	26	27	27
Non-Host Lot 4	2	5	8	10	10	10
Non-Host Lot 5	25	28	31	33	34	34

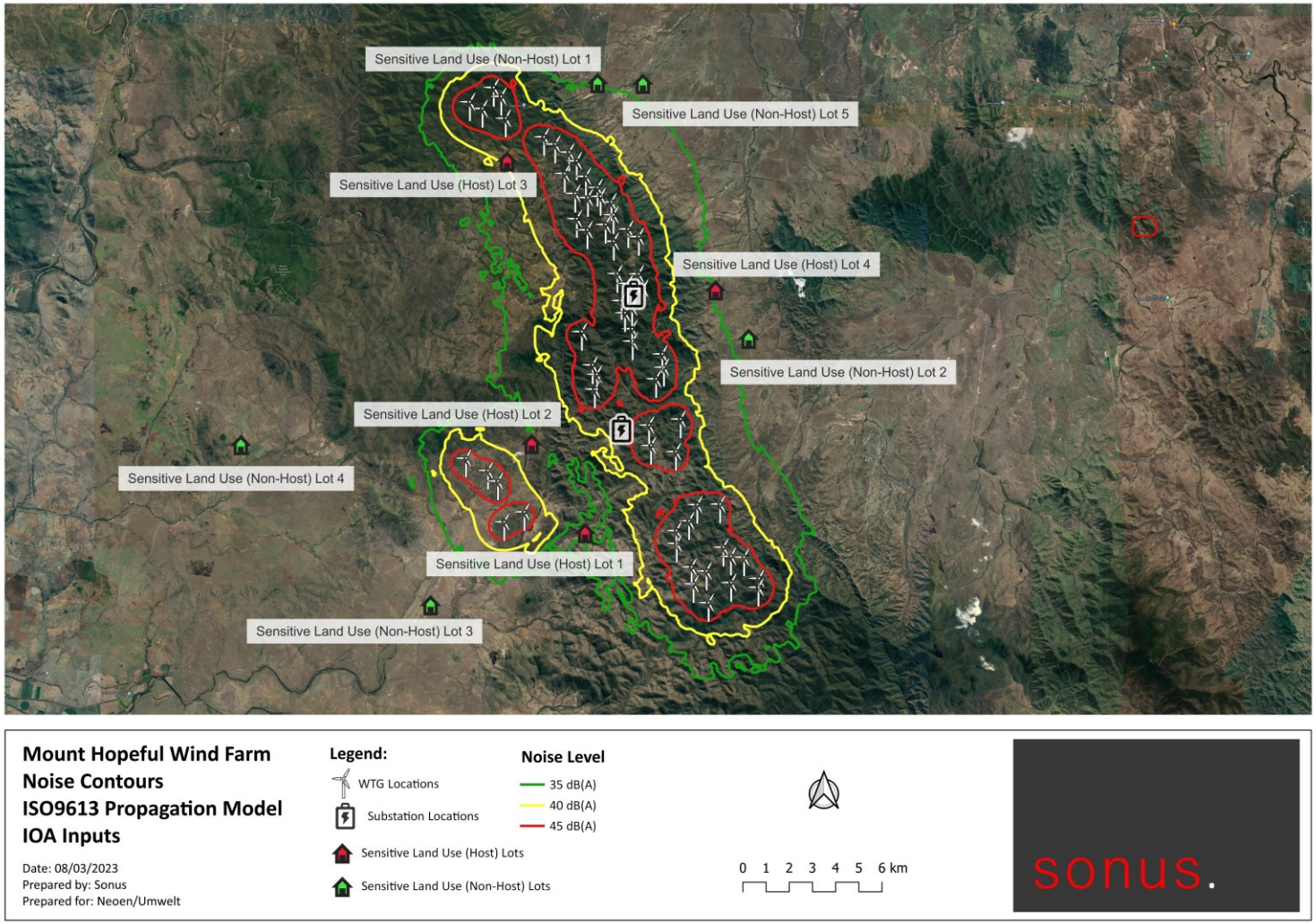


Figure 2: Highest predicted noise levels (L_{eq}) from Goldwind 165 6.0MW turbines

The above results indicate that the predicted noise levels at the lots are as follows:

- 35 dB(A), or less, at non-host lots (baseline criterion 35 dB(A)); and,
- 41 dB(A), or less, at host lots (baseline criterion 45 dB(A)).

Therefore, the wind farm is predicted to readily satisfy the noise assessment criteria established in accordance with the Conditions of Approval and the State Code 23.

4.3.2 Ancillary Infrastructure

Noise from the substations associated with the wind farm are not required to be assessed in accordance with the State Code 23, however Condition 22 requires the noise to be considered. Therefore, a prediction has been made of noise levels from the substations to the surrounding sensitive land uses.

Given the significant separation distance between the proposed infrastructure and the closest sensitive land uses, the highest noise level is predicted to be much less than 20 dB(A) at all locations.

That is, the noise from the proposed substations will be more than 15 dB(A) below the wind farm assessment criteria. Therefore, the noise from ancillary infrastructure will not adversely impact on the acoustic amenity of the sensitive land uses.

5 CONCLUSION

An updated noise impact assessment has been undertaken for the proposed Mount Hopeful Wind Farm (the wind farm), in accordance with the Queensland Government Department of Infrastructure, Government and Planning *State code 23: Wind farm development*, Planning Guideline (February 2022) and the Conditions of Approval (**State Code 23**).

Noise levels at sensitive land uses from the proposed wind farm have been predicted using the noise propagation model and the inputs recommended by the State Code 23.

The noise predictions have been made based on the wind turbine generator (WTG) selection and layout, being 63 of the Goldwind 165 6.0MW turbines. The outcomes of this assessment indicate that the proposed WTG selection complies with the relevant assessment criteria, established under the State Code 23 and the conditions of the existing development approval.

The noise from ancillary infrastructure including substations has also been predicted and will be at levels significantly less than the wind farm assessment criteria. The noise therefore will not result in adverse impacts on the acoustic amenity at the sensitive land uses.

APPENDIX A: COORDINATES OF TURBINES

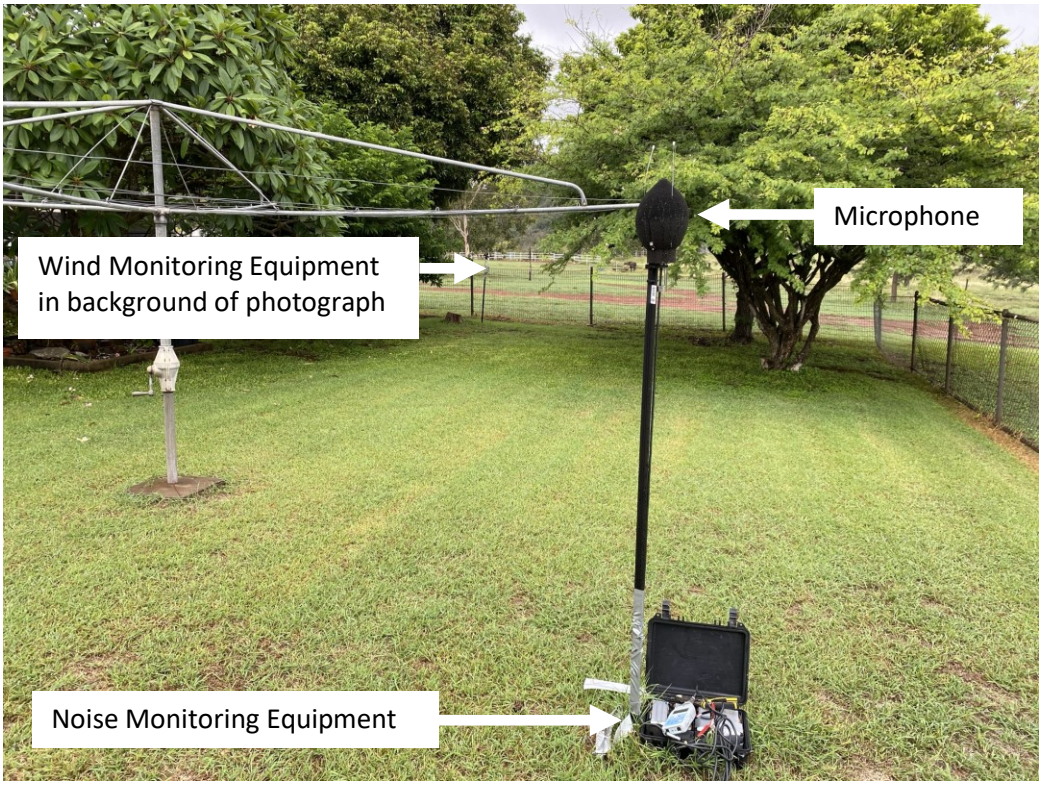
Turbine ID	Coordinates (GDA 94 MGA Zone 56)	
	Easting	Northing
WTG 01	247250	7371525
WTG 02	248260	7371125
WTG 03	249930	7370355
WTG 04	250420	7370050
WTG 05	251030	7369720
WTG 06	251360	7369350
WTG 07	250850	7368800
WTG 08	251770	7368690
WTG 09	252280	7368220
WTG 10	251870	7367780
WTG 11	252890	7367610
WTG 12	251408	7366866
WTG 13	251875	7366390
WTG 14	252990	7367060
WTG 15	253640	7366460
WTG 16	253020	7365920
WTG 17	254100	7366140
WTG 18	253200	7364540
WTG 19	253660	7364120
WTG 20	254320	7363920
WTG 21	253400	7363380
WTG 22	253880	7362180
WTG 23	253910	7361650
WTG 24	251710	7362020
WTG 25	252200	7360600
WTG 26	252390	7360200
WTG 27	252310	7359560
WTG 28	255200	7361120
WTG 29	255280	7360550
WTG 30	254950	7360050
WTG 31	254680	7358060
WTG 32	256040	7358340

Turbine ID	Coordinates (GDA 94 MGA Zone 56)	
	Easting	Northing
WTG 33	254780	7357180
WTG 34	255860	7356940
WTG 35	246800	7356500
WTG 36	247760	7355990
WTG 37	248200	7355540
WTG 38	249360	7354240
WTG 39	248500	7353800
WTG 40	256820	7354680
WTG 41	257810	7354720
WTG 42	256480	7353980
WTG 43	255940	7353550
WTG 44	255960	7353000
WTG 45	256620	7352000
WTG 46	257270	7351840
WTG 47	256720	7351280
WTG 48	257380	7350480
WTG 49	257980	7352870
WTG 50	258310	7352490
WTG 51	258880	7352460
WTG 52	259540	7351560
WTG 53	259520	7351180
WTG 54	258340	7351360
WTGA01	246700	7371800
WTGA02	247720	7372440
WTGA03	248050	7372060
WTGA04	251320	7367950
WTGA05	252420	7367840
WTGA07	252660	7366640
WTGA08	254120	7364540
WTGA09	253860	7363120
WTGA10	253560	7362860

APPENDIX B: COORDINATES OF SENSITIVE LAND USES

Location ID	Coordinates (GDA 94 MGA Zone 55)	
	Easting	Northing
Sensitive Land Use (Host) Lots		
Host Lot 1	252114	7353621
Host Lot 2	249742	7357399
Host Lot 3	248468	7369516
Host Lot 4	257572	7364134
Sensitive Land Use (Non-host) Lots		
Non-Host Lot 1	252322	7372942
Non-Host Lot 2	259038	7362076
Non-Host Lot 3	245496	7350407
Non-Host Lot 4	237177	7357133
Non-Host Lot 5	254280	7372949

APPENDIX C: PHOTOGRAPH OF THE MONITORING EQUIPMENT AT HOST LOT 5



APPENDIX D: NOISE MONITORING RESULTS AND REGRESSION CURVES