Hampton Wind Park

DA Noise and Vibration Impact Assessment

Wakefield Planning

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Moree NSW 2400

Prepared by:

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Making Sustainability Happen

Revision Record

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v1.0	14 March 2025	Jason Rasquinha	Mark Irish, Aaron McKenzie	Draft
v1.0	10 April 2025	Jason Rasquinha	Mark Irish, Aaron McKenzie	Mark Irish

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Wakefield Planning (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Acronyms and Abbreviations

dBA	Decibel, A-weighted
DA	Development Application
EPA	Environment Protection Authority
HNA	Highly Noise Affected. Relates to construction noise levels of ≥75 dBA and is the point above which there may be strong community reaction to construction noise levels
ICNG	*Interim Construction Noise Guideline* (DECC, 2009)
L_{Aeq}	The average noise level during a measurement period, such as the daytime or night-time
L_{AFmax}	The maximum noise level measured during a monitoring period, using 'fast' weighting (also known as the L_1 level)
L_{A90}	The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
NML	Noise Management Level
NPfI	*Noise Policy for Industry* (NSW EPA, 2017)
NSW	New South Wales
NIA	Noise Impact Assessment
OOHW	Out-of-Hours Work
Project	Hampton Wind Park
RBL	Rating Background Level. This is the background noise level measured at a particular location. The method for calculating the RBL is defined in the NSW *Noise Policy for Industry*
CNVG	Construction Noise and Vibration Guideline (Transport for NSW)
SLR	SLR Consulting Australia Pty Ltd
SWL / L_W	Sound Power Level
TfNSW	Transport for New South Wales
Worst-case impacts and noise levels	The worst-case (ie highest) impacts or noise levels predicted in this report
WTG	Wind Turbine Generator

1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Wakefield Planning (Wakefield or the 'applicant') to undertake a noise and vibration impact assessment in support of an application for wind turbine (WTG) replacement at the Hampton Wind Park (the 'site').

SLR is suitably qualified to produce this noise and vibration impact assessment. SLR staff are members of the Australian Acoustical Society (AAS) and SLR is a member firm of the Association of Australasian Acoustical Consultants (AAAC).

This report assesses the potential construction noise and vibration impacts associated with the removal of the existing turbines and the installation of the new WTGs and provides a comparative assessment of the operational noise impacts associated with the new WTGs versus the existing turbines which are proposed to be replaced.

The following report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A**.

1.1 Project Description

The site is located at 43 Hampton Road, Hampton NSW 2790 and includes two Vestas V47-660 kW WTGs which were commissioned in 2001. The development application (DA) noise impact assessment (the 'DA NIA') was prepared by Parsons Brinckerhoff in February 2001 (ref: 10159-NOISE-001) which included the predicted noise levels and a noise management plan.

As these turbines have exceeded their 20-year lifespan, the applicant proposes to replace them with two new Vestas V80-2.0MW-Mk7 WTGs.

This application seeks approval for the following:

- Work associated with the removal of the existing turbines and site remediation
- Work associated with the installation of the new turbines
- Upgrades to the existing hardstands and roads
- Lead in services including stormwater, sewer, potable water, electrical and communications
- 24/7 operation of the new WTGs

The site location and nearby sensitive receivers are shown in **Figure 1**.

1.2 Construction Program

Demolition of the existing V47 VESTAS WTG

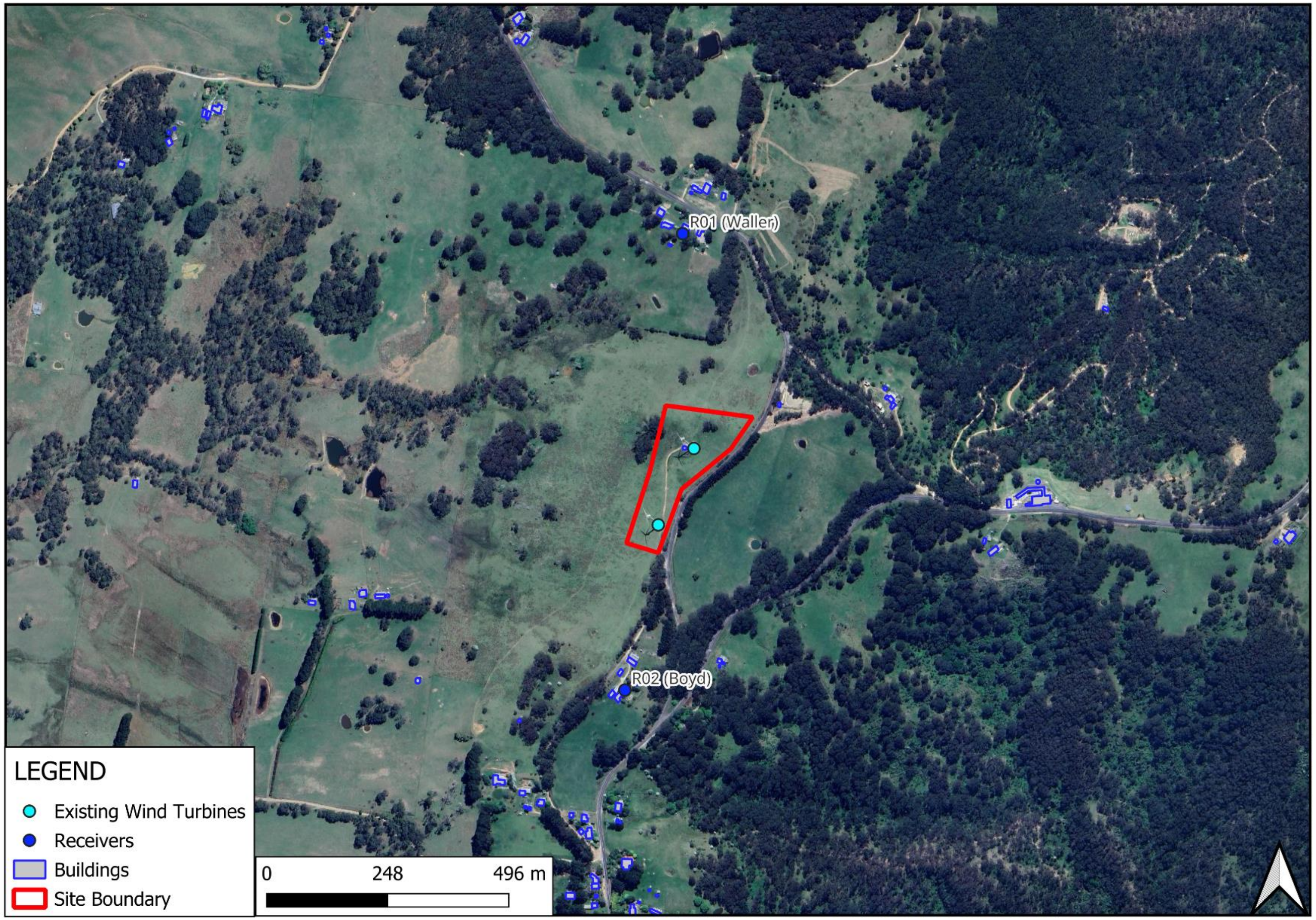
- Existing hardstands from original construction will be used (currently covered in grass)
- Existing road access and internal road to be used
- HV termination to take 1 day including outages with Endeavour Energy
- 600t Crane to be used to dismantle Blades, Nacelle, and tower sections
- 6 x 19m Trucks to remove WTG to owners Dubbo storage area
- Foundations are Rock anchors, so baseplate removed, and cables extracted

- Site remediation and topsoil spread to be completed by owner (tractor/backhoe)
- Workforce of 8 for 4 days with 4 LV's and 1 HV
- Total construction window 14 days Mon – Sat, 8am to 5pm

Construction of the V80 VESTAS WTG

- Existing Hardstands and roads to be upgraded with additional road base
- Excavation of new rock anchor footings
- Installation of rock anchor base plate and drilling
- Mobilisation of towers
- 600t Crane established to erect new sections
- Base plate and tower sections installed
- Hi torque rock anchor
- Mobilisation of Nacelle, hub and blades
- Install tower sections
- Install Nacelle
- Install hub and blades
- HV terminations and commissioning
- Site remediation and topsoil spread to be completed by owner (tractor/backhoe)
- Workforce of 14 for 4 days with 6 LV's and 2HV
- Total construction window 30 days Mon – Sat, 8am to 5pm

Figure 1 Site Location and Sensitive Receivers



1.3 Nearest Sensitive Receivers

Nearest noise sensitive receivers in the area surrounding the site are presented in **Table 1** and shown in **Figure 1**. These receivers were also included in the DA NIA.

Table 1 Sensitive Receivers

Receiver ID	Address	Type
R01	119 Hampton Road, Hampton (Waller Residence)	Residential
R02	Hampton Post Office Road (Boyd Residence)	Residential

2.0 Assessment Criteria

2.1 Construction Noise Criteria

2.1.1 Interim Construction Noise Guideline

The NSW *Interim Construction Noise Guideline* (ICNG) is used to assess and manage impacts from construction noise on residences and other sensitive land uses in NSW.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers based on the existing background noise in the area. The 'worst-case' noise levels from construction of a proposal are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impact of the proposal.

The NMLs are not mandatory limits, however, where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

2.1.1.1 Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 2**.

Table 2 ICNG NMLs for Residential Receivers

<table>
<tr><th>Time of Day</th><th>NML $L_{Aeq(15minute)}$</th><th>How to Apply</th></tr>
<tr><td rowspan="2">Standard Construction Hours
Monday to Friday 7:00 am to 6:00 pm
Saturday 8:00 am to 1:00 pm
No work on Sundays or public holidays</td><td>Noise affected RBL[1] + 10 dB</td><td>The noise affected level represents the point above which there may be some community reaction to noise
Where the predicted or measured $L_{Aeq(15minute)}$ 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.</td></tr>
<tr><td>Highly Noise Affected 75 dBA</td><td>The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise
Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences
If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</td></tr>
<tr><td>Outside Standard Construction Hours</td><td>Noise affected RBL[1] + 5 dB</td><td>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 practises have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.</td></tr>
</table>

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the NSW Industrial Noise Policy (INP). The INP has been superseded by the NSW EPA *Noise Policy for Industry* (NPfI).

2.1.1.2 NML Summary

The construction NMLs are summarised in **Table 3**. Out of hours NMLs would be applicable to works undertaken outside the ICNG standard construction hours.

Table 3 Construction Noise Management Levels

Receiver Type	Assumed RBL[1,2] (dBA)			NML $L_{Aeq(15minute)}$ (dBA)				Sleep Disturbance Screening Level[2] L_{Amax} (dBA)
				Standard Construction Hours (RBL+10dB)	Out of Hours (RBL+5dB)			
	Day[4]	Eve.[4]	Night[4]	Day	Day	Eve.	Night	Night
Residential	35	30	30	45	40	35	35	52

Note 1: RBL = Rating Background Level.

Note 2: The minimum RBLs from the NPfI have been assumed for all residential receivers

Note 3: Sleep disturbance screening level is RBL+15 dB or 52 dBA, whichever is higher.

Note 4: The assessment periods are the daytime which is 7 am to 6 pm Monday to Saturday and 8 am to 6 pm on Sundays and public holidays, the evening which is 6 pm to 10 pm, and the night-time which is 10 pm to 7 am on Monday to Saturday and 10 pm to 8 am on Sunday and public holidays. See the NSW EPA Noise Policy for Industry.

2.2 Construction Vibration Guidelines

The nearest vibration sensitive receivers are approximately 190 m away from the proposed work areas. Due to the large separation from the work areas, vibration impacts on the surrounding receivers are unlikely and have not been considered further in this assessment.

2.3 Operational Noise Criteria

As the site already has approval to operate two WTGs and only the replacement of the existing turbines is proposed, this noise assessment is based on a comparison of the predicted noise levels from the proposed WTGs and those from the existing turbines.

2.4 Operational Vibration Guidelines

There are no operational vibration sources associated with the development that could potentially result in any perceptible vibration impact at the nearest sensitive receivers. Operational vibration impacts on the surrounding receivers are therefore not required to be considered in this assessment.

3.0 Assessment Methodology

3.1 Construction Noise Assessment Methodology

A noise model of the study area has been used to predict noise levels from the proposed construction work to all surrounding receivers. The construction noise model uses the ISO 9613 algorithm in SoundPLAN software.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding areas.

3.1.1 Construction Activities

Representative scenarios have been developed to assess the likely impacts from the various construction phases detailed in the project construction program (**section 1.2**). These have been simplified into four construction scenarios which are shown in **Table 4** along with the assessment periods (see **Table 3**) during which they are expected to occur.

The assessment uses 'realistic worst-case' scenarios to determine the impacts from the noisiest 15-minute period that are likely to occur for each work scenario, as required by the ICNG.

The sound power levels for the construction equipment used in each scenario are presented in **Appendix B**.

Table 4 Construction Scenarios and Equipment

Scenario	Works Activity	Equipment	Assumed Periods for Works
W.01	Site Establishment and Construction of Access Routes, Site Decommissioning/remediation	Tracked excavator (20 t), crane - franna (20 t), heavy truck (30 t), light vehicle (4WD), generator, hand tools (electric), vibratory roller, back hoe, front-end loader (23 t), grader	Standard construction hours[1], OOH: Saturday afternoon (1pm to 5pm)
W.02	Demolition/Installation of WTGs	Mobile telescopic crane (600 t), medium rigid truck (20 t), rattle gun (hand held), forklift, circular saw	Standard construction hours[1], OOH: Saturday afternoon (1pm to 5pm), evening and night-time
W.03	Laying of Tower Foundation	Tracked excavator (20 t), medium rigid truck (20 t), tracked hydraulic drilling rig, concrete truck, concrete pencil vibrator, concrete pump	Standard construction hours[1], OOH: Saturday afternoon (1pm to 5pm)
W.04	Removal/installation of HV connections	Tracked excavator (20 t), medium rigid truck (20 t), hand tools (electric), plate compactor	Standard construction hours[1], OOH: Saturday afternoon (1pm to 5pm)

Note 1: Standard construction hours (see **Table 2** for definition) fall under the 'daytime' assessment period (see Note 4 of **Table 3** for definition).

Note 2: The 'evening' and 'night-time' assessment period is defined in Note 4 of **Table 3.**

W.02 - Demolition and Installation of WTGs will require the use of a 600 t telescopic crane to lift the tower sections, nacelle, and rotor blades. Given the significant height of the lift required for these components, it is unlikely that this work will be conducted during windy conditions, which are typically more prevalent during the daytime. Therefore, the assessment has also considered potential for this work to occur both in the day time and out of hours evening and night time period if required.

3.2 Operational Noise Assessment Methodology

The operational noise emissions from the WTGs have been predicted to the surrounding receivers using the ISO 9613 algorithms, including factors from the Institute of Acoustics (IoA) *Good Practice Guide on Wind Turbine Noise*, as implemented in the SoundPLAN noise modelling software package. The noise model includes the following key features to ensure a conservative prediction of noise levels:

- A 3D ground model with a conservative assumption of 100% acoustically hard ground (G=0 ground attenuation factor).
- Receiver prediction points at a height of 4 m above ground.
- Atmospheric conditions at 10°C temperature and 70% relative humidity.
- Topographic screening attenuation of no greater than 2 dB
    - + 3 dBA correction where a concave ground profile “across a valley” between a WTG and a receptor, defined as: hm ≥ 1.5 x (abs (hs - hr) /2)

This noise modelling methodology using the ISO9613 calculation method algorithm includes a source to receiver noise enhancing gradient wind condition.

Two operational noise emission scenarios were assessed:

- Noise emissions from the two existing Vestas V47-660 kW WTGs with hub height of 40 m and a rotor diameter of 47 m.
- Noise emissions from the two proposed Vestas V80-2.0MW-Mk7 with a hub height of 80 m and a rotor diameter of 60 m.

As stated in **Section 3.2**, the noise emissions from the existing Vestas V47 WTGs have been validated against those in the DA NIA.

Sound power level (SWL) data for the existing Vestas V47 WTGs and four noise modes (Mode 0 to Mode 3) of the proposed Vestas V80 WTGs have been taken from the manufacturer’s documentation and reproduced in **Table 5** and **Table 6** respectively.

The locations of the existing and proposed WTGs are shown in **Figure 2**.

Table 5 Single Otave Sound Power Level Spectrum - Vestas V47-660 kW

Total Sound Power Level (dBA)	A-weighted 1/1 – Octave Spectra (dBA)[1]							
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
101	78	86	90	95	97	93	88	69

Note 1: Sound power levels presented in this table for a wind speed of 8 m/s.

Table 6 Single Otave Sound Power Level Spectrum - Vestas V80-2.0MW-Mk7

Total Sound Power Level (dBA)	A-weighted 1/1 – Octave Spectra (dBA)							
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Mode 0								
105	86	90	97	100	100	97	90	79

Total Sound Power Level (dBA)	A-weighted 1/1 – Octave Spectra (dBA)							
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Mode 1								
104	83	88	95	99	99	96	89	77
Mode 2								
102	81	87	94	97	98	94	87	76
Mode 3								
102	81	86	93	97	97	94	86	75

Note 1: Sound power levels presented in this table for a wind speed of 8 m/s.

Figure 2 Wind Turbine Location

4.0 Noise Assessment

4.1 Construction Noise

The predicted average and maximum (sleep disturbance) noise levels for the assessed construction scenarios are shown in **Section 4.1.1** and **Section 4.1.2** respectively.

The predictions are representative of the highest noise levels that could potentially be experienced at the surrounding receivers when the works are at the closest point. For most construction activities, it is expected that the construction noise levels would frequently be lower than those predicted, as the noise levels presented are based on all items of equipment in each scenario being used concurrently in the various work areas.

The assessment shows the predicted impacts based on the exceedance of the NMLs, as per the categories in **Table 7**.

The assessment uses 'realistic worst-case' scenarios to determine the impacts from the noisiest 15-minute period that are likely to occur for each work scenario, as required by the ICNG.

Table 7 Exceedance Bands and Impact Colouring

Exceedance of NML	Subjective Classification[2]	Impact Colouring
No exceedance	Negligible	
1 to 10 dB	Low impact	
11 dB to 20 dB	Moderate impact	
21 dB to 30 dB	High impact	
Highly Noise Affected[1]	Highly Noise Affected	

Note 1: Greater than 75 dBA at residential receivers

Note 2: The subjective response would vary and depends on the period in which the impacts occur (ie people are generally more sensitive to impacts during the evening and night-time).

4.1.1 Average Construction Noise Levels

The predicted average noise levels and NML exceedances for the construction scenarios listed in **Table 4** during the assumed assessment periods are shown in **Table 8** and **Table 9**, respectively.

Table 8 Predicted Average Construction Noise Levels

Rec. Type	Predicted Construction Noise Levels $L_{Aeq(15minute)}$ (dBA)			
	W.01 Site Establishment and Construction of Access Routes	W.02 Demolition/ Installation of WTGs	W.03 Laying of Tower Foundation	W.04 Removal/Laying of Power Lines
Residential	49	46	50	40

Table 9 Predicted Exceedances

Rec. Type	Period	NML	Exceedances (dB)			
			W.01 Site Establishment and Construction of Access Routes	W.02 Demolition/ Installation of WTGs	W.03 Laying of Tower Foundation	W.04 Removal/ Installation of Power Lines
Standard Hours						
Residential	Daytime	45	4	1	5	-
Out-of-hours						
Residential	Saturday (1pm to 5pm)	40	9	6	10	-
Residential	Evening / Night-time	35	n/a[1]	11	n/a[1]	n/a[1]

Note 1: These work scenarios are expected to occur during the daytime only.

The predicted construction noise levels above show the following:

- The noise levels at the most affected residential receiver are predicted comply with the standard and out-of-hours (Saturday afternoon) daytime NML during work scenario W.04.
- Low impacts (i.e. NML exceedances of up to 10dB) are predicted during the standard and out-of-hours (Saturday afternoon) daytime periods for work scenarios W.01 through to W.03.
- Moderate night-time impacts (i.e. an NML exceedance of 11 dB) are predicted at the most-affected residential receiver during work scenario W.02.
- No high impacts (i.e. exceedances greater than 20 dB) are predicted at any receiver and no residential receivers are predicted to be highly noise affected (ie >75 dBA) during any of the work scenarios.

The presented impacts would only be expected to occur when noisy work is being completed close to the most affected receivers. When work is in other areas of the site, or when less noise-intensive equipment is being used, the noise levels and impacts are expected to reduce accordingly.

Feasible and reasonable construction noise mitigation measures should be applied where exceedances of the NMLs are predicted. Construction noise mitigation and management measures are discussed in **Section 5.0**.

4.1.2 Sleep Disturbance (L_{Amax}) Construction Noise Levels

The worst-case sleep disturbance (L_{Amax}) noise levels at the most-affected residential receiver during *W.02 – Demolition /Installation of WTGs* is predicted to be 51 dBA which is below the 52 dBA sleep disturbance screening level. Hence, no further assessment of sleep disturbance impacts is required.

4.2 Operational Noise

The predicted noise levels from both the existing WTGs and all four noise modes of the proposed WTGs at residential receivers included in the DA NIA are summarised in **Table 10**. The resultant change in noise levels from the various modes of the proposed turbines are shown in parenthesis. It is noted that the applicant proposes to operate the WTGs using Mode 3.

The predicted WTG noise contours with hub height wind speeds at 8 m/s are shown in **Appendix C**.

Table 10 Predicted Wind Turbine Noise Levels

Rec. ID	Predicted Noise Level (dBA)					
	Existing WTGs (Vestas V47)		Proposed WTGs (Vestas V80)			
	DA NIA	This Assessment	Mode 0	Mode 1	Mode 2	Mode 3
R01	39	40[1]	45 (+5)	44 (+4)	43 (+3)	42 (+2)
R02	42	42[1]	46 (+4)	45 (+3)	43 (+1)	43 (+1)

Note 1: Since the predicted noise levels from the existing WTGs at R01 are similar to those in the DA NIA, and those at R02 match the DA NIA levels, the noise levels from the existing turbines modelled for this assessment are satisfactorily validated.

The above assessment indicates the following:

- Noise level increases of up to 5 dB are predicted when the proposed WTGs are used in Mode 0.
- The predicted maximum noise level increases from the operation of the proposed WTGs in Mode 3 (intended operation) is limited to 2 dB.
- According to the NSW EPA *Noise Policy for Industry,* changes in noise levels of up to 2 dB are generally not perceptible to the average listener. As such, it is considered that no additional operational noise mitigation measures would be required compared to the existing approved development.

Due to the age if the current WTGs, noise levels from the existing WTGs are expected to be higher than the predicted levels at the time of commissioning (see **Table 10**). Hence, the actual change in noise levels from the proposed Vestas V80 WTGs, operated in noise Mode 3, are likely to be lower than predicted (i.e below 2 dB) and may result in a reduction in noise levels at nearest receivers.

5.0 Mitigation and Management Measures

5.1 Construction

The impacts during the construction of the project are predicted to be typical of construction works near sensitive receivers.

It is recommended that a Construction Noise Management Plan (CNMP) would be prepared by the construction contractor before any work begins. This may include

- Site Management roles and responsibilities with regard to managing noise emissions.
- A process for engaging with potentially impacted receivers.
- Consider the potential noise impacts (including any night-time impacts) from construction activities to inform feasible and reasonable mitigation measures.
- procedures for handling complaints, should they occur, and detail a follow up and amelioration process.

5.2 Operations

Where the existing V47 WTGs are replaced with V80 noise mode 3 WTGs, it is expected that noise impacts at surrounding sensitive receivers would be maintained within 2dB of the existing approved wind farm. To ensure potential increase in noise impacts are minimised the following mitigation measures are recommended.

- Pre-replacement noise monitoring of the existing wind farm operations is undertake to confirm existing noise levels.
- A performance guarantee is established for the supply of the replacement WTGs to meet the noise emission levels presented in this assessment.
- Post commissioning performance test program is undertaken to ensure that noise emission from the replacement WTG are within the levels presented in this assessment with consideration to the special noise characteristics described in Section 3.3 of the NSW Wind Energy Guideline Technical Supplement for Noise Assessment (Nov 2024) which covers aspects such as tonal, low frequency and penalties for special characteristics.

6.0 Conclusion

SLR has been engaged to assess the potential construction and operational noise emissions from the proposed WTG replacement at the Hampton Wind Park. The potential impacts from the proposal have been assessed against the relevant NSW policy/guidelines.

Exceedances of the construction noise management levels are predicted at the nearest receivers during a majority of the work scenarios however, this would only be expected to occur when noisy work is being completed close to the site boundary nearest to these receivers. A Construction Noise Management Plan (CNMP) should be prepared by the construction contractor before any work begins.

Operational noise levels from the proposed WTGs at the nearest receivers are predicted to be up to 2 dB greater than those from the existing WTGs when operated in noise Mode 3 (intended operation) which would not be perceptible to the average listener. Operation mitigation measures have been recommended to ensure noise emissions from the replacement turbines meet the levels predicted in this assessment.

Appendix A Acoustic Terminology

Hampton Wind Park

DA Noise and Vibration Impact Assessment

Wakefield Planning

SLR Project No.: 610.032445.00001

10 April 2025

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3. Sound Power Level

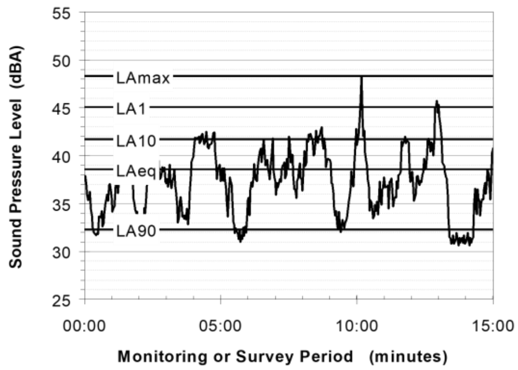
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

5. Frequency Analysis

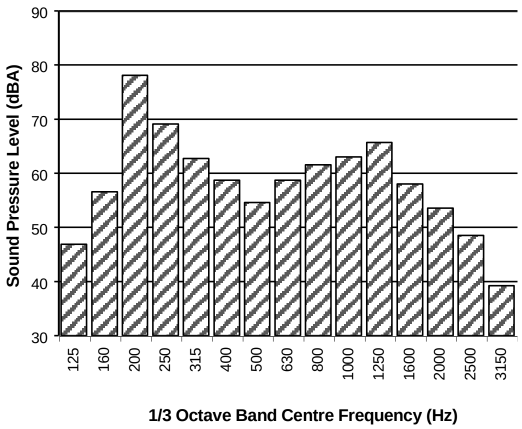
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (three bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula $20 \log (V/V_o)$, where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

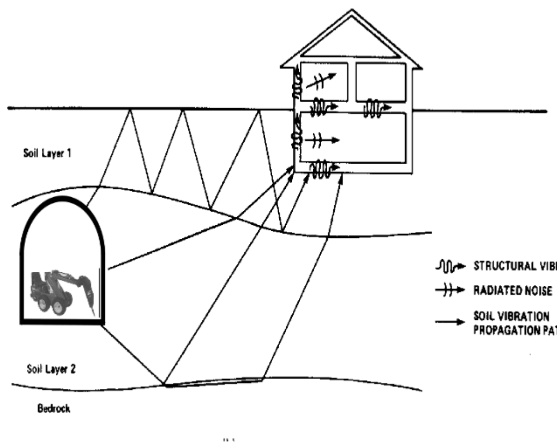
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

Appendix B Construction Noise Sources

Hampton Wind Park

DA Noise and Vibration Impact Assessment

Wakefield Planning

SLR Project No.: 610.032445.00001

10 April 2025

Equipment	Total SWL LAeq(15 minute)	Back hoe	Crane Franna (20 tonne)	Crane (Mobile Telescopic) (600 t)	Circular Saw[1]	Concrete pencil vibrator	Plate Compactor	Excavator - Tracked (20 tonne)	Grader	Hand tools (electric)	Generator - attenuated	Light Vehicle - 4WD	Loader - Front-end (wheeled) (23 t)	Pump - Concrete	Rattle Gun (hand held)	Roller – Vibratory[1]	Truck - Concrete	Truck - Medium Rigid (20 tonne)	Truck - road truck/ truck & dog (30 t)	Tracked Hydraulic Drilling Rig
Sound Power Level[2]		111	98	106	106	103	104	105	113	102	92	103	112	109	104	109	109	103	108	114
Estimated utilisation in assessment period (%)		50%	50%	100%	50%	50%	50%	50%	50%	50%	100%	50%	50%	50%	50%	50%	50%	50%	50%	100%
Scenario																				
W.01 - Site Establishment and Construction of Access Routes		1	1	-	-	-	-	1	1	1	1	2	1	-	-	1	-	-	1	-
W.02 - Demolition/Installation of WTGs		-	-	1	1	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-
W.03 - Laying of Tower Foundation		-	-	-	-	1	-	1	-	-	-	-	-	1	-	-	1	1	-	1
W.04 Removal/Laying of Power Lines		-	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	1	-	-

Note 1: Equipment classed as ‘annoying’ in the ICNG and considers a 5 dB correction.

Note 2: Sound power level data is taken from SLR measurement database, DEFRA noise database and TfNSW Construction and Vibration Guideline.

Appendix C Noise Contours

Hampton Wind Park

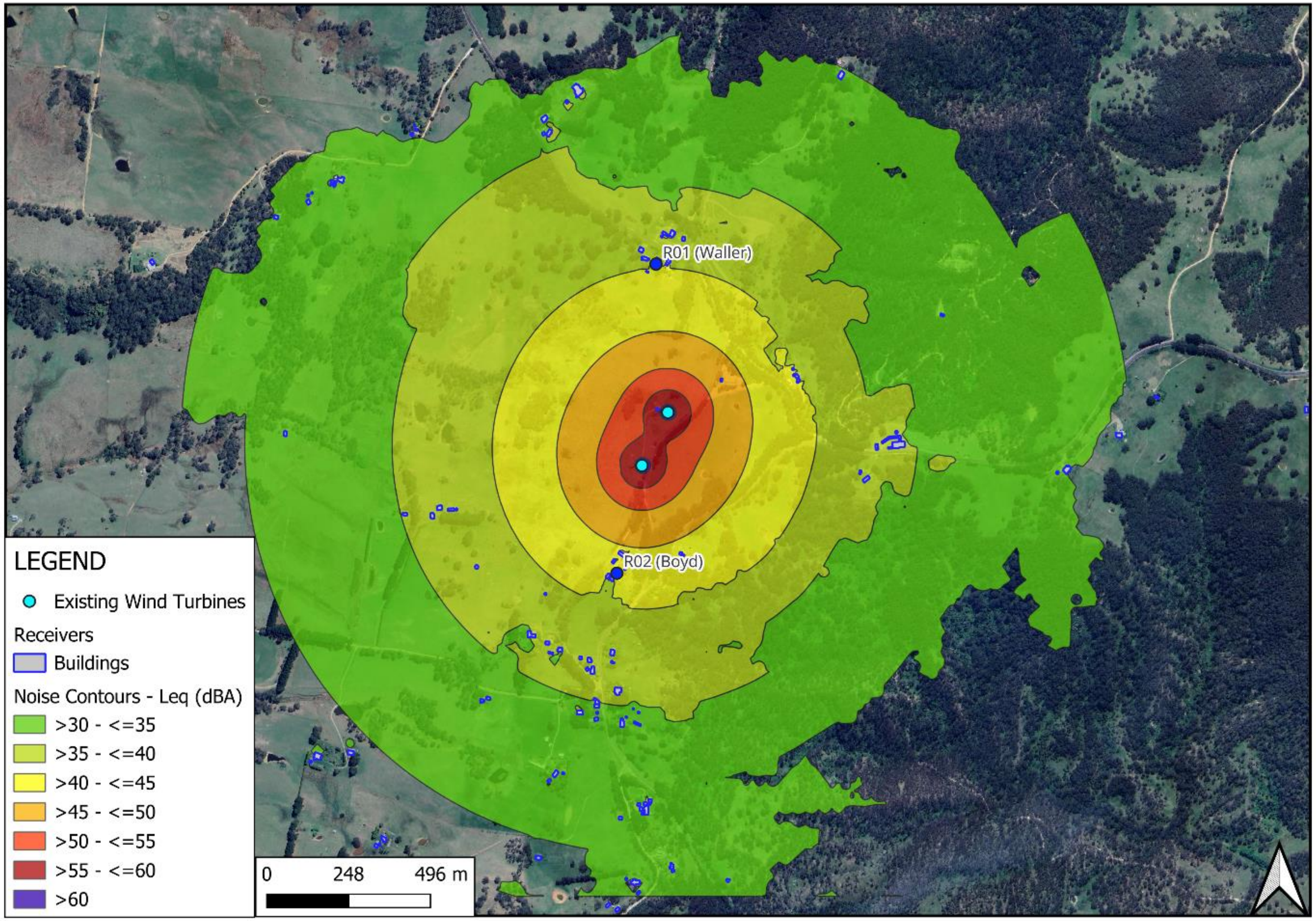
DA Noise and Vibration Impact Assessment

Wakefield Planning

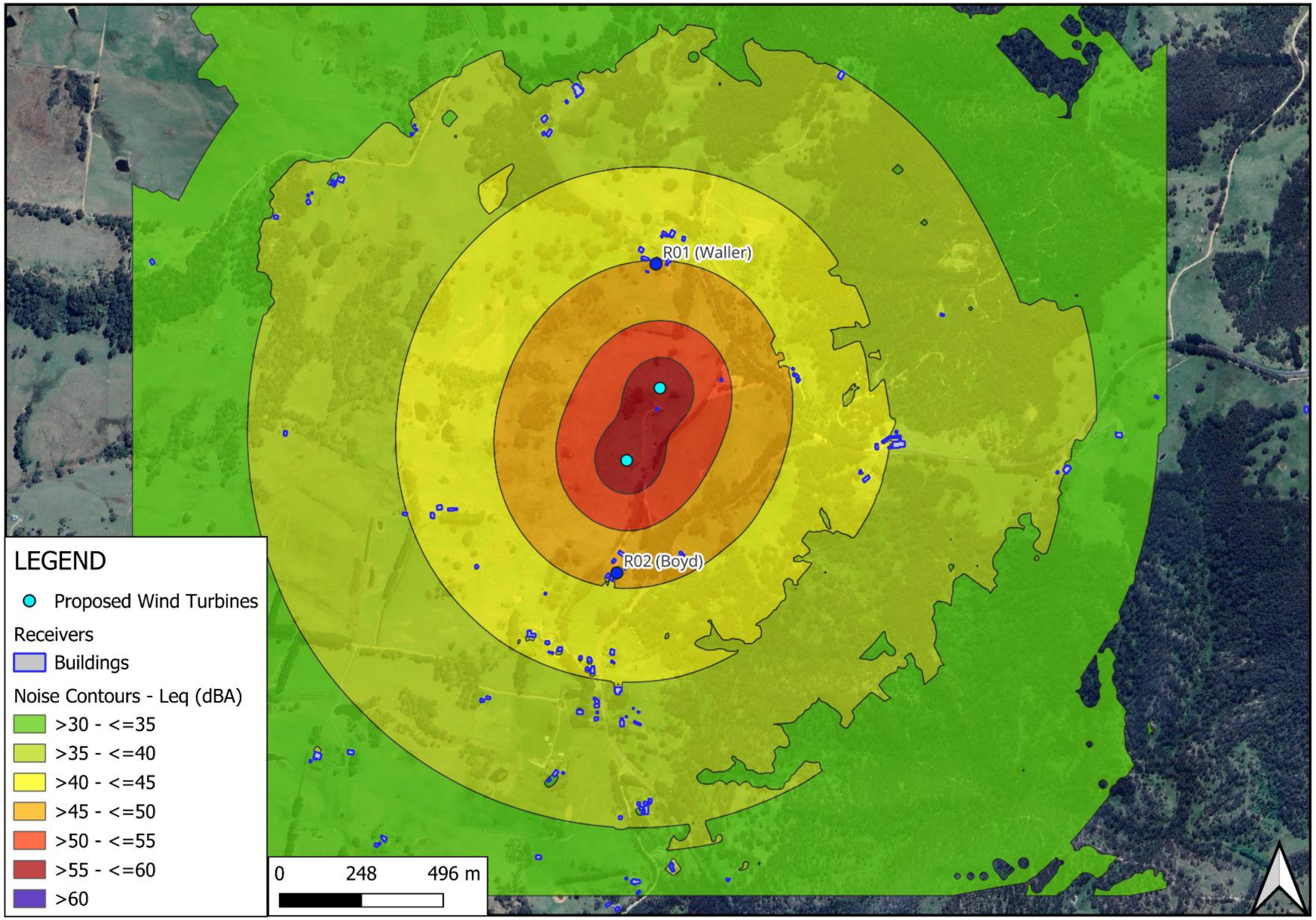
SLR Project No.: 610.032445.00001

10 April 2025

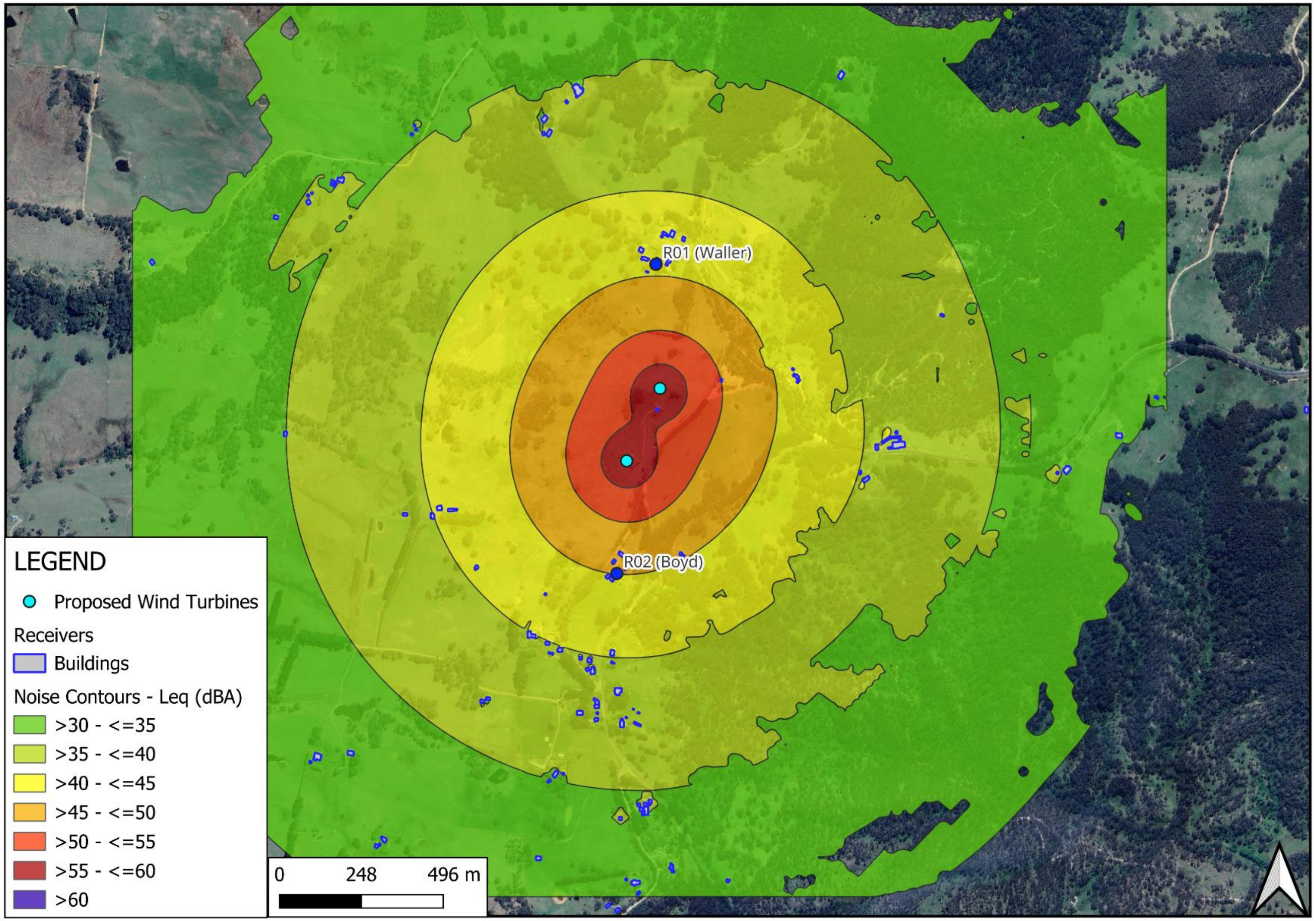
Existing Wind Turbines



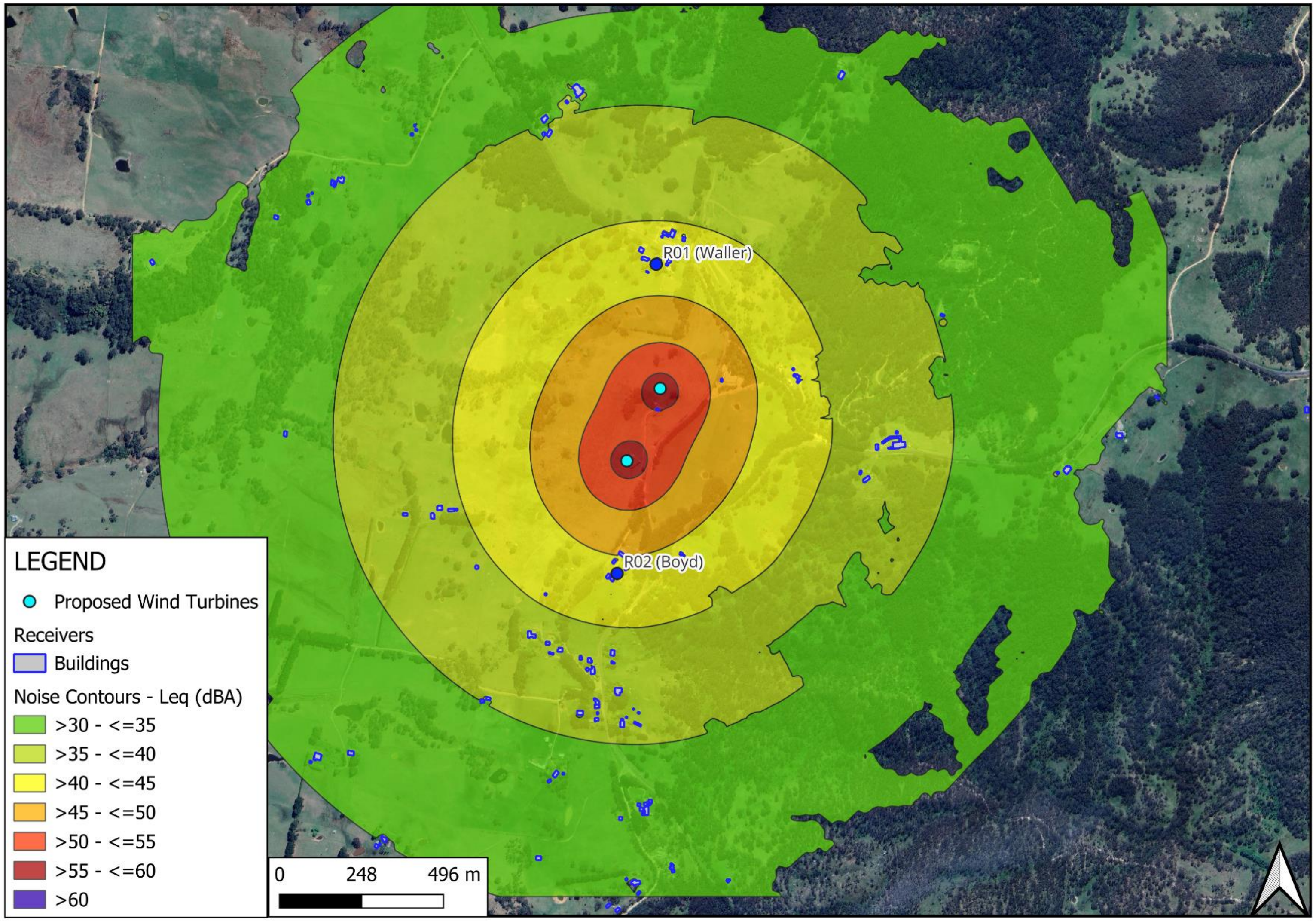
Proposed Wind Turbines (Mode 0)



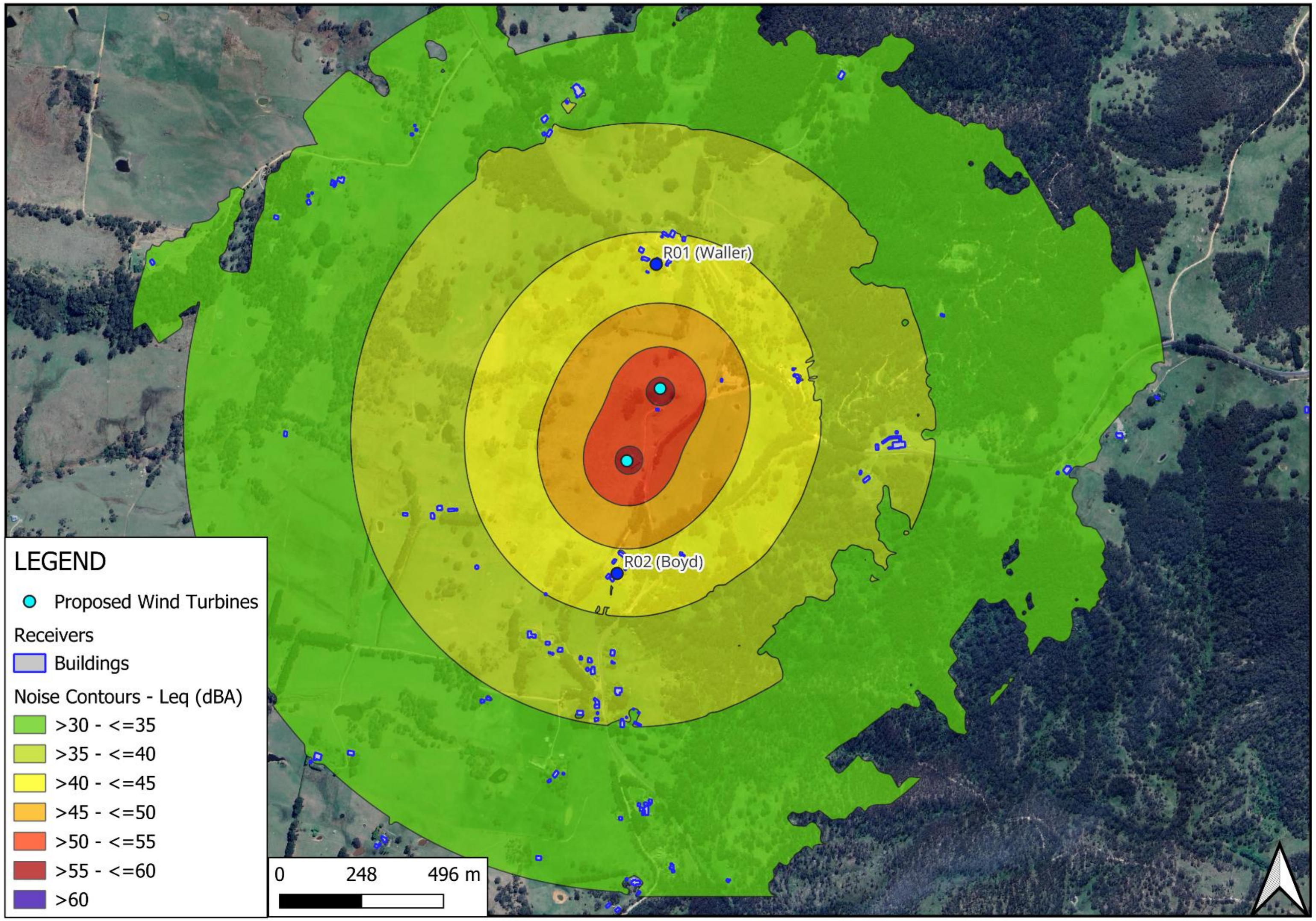
Proposed Wind Turbines (Mode 1)



Proposed Wind Turbines (Mode 2)



Proposed Wind Turbines (Mode 3)



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