MUSWELLBROOK BESS - NOISE IMPACT ASSESSMENT

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Assured Environmental

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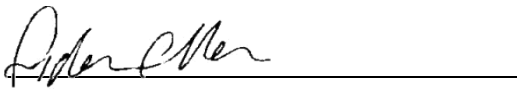
Report Prepared by:

Assured Environmental
Unit 7, 142 Tennyson Memorial Avenue
Tennyson, QLD, 4105

Report Prepared for:

Firm Power
Suite 6, Level 6, 201 Kent St,
Sydney, NSW, 2000



Author: Michelle Clifton

Reviewer: Aiden Allen

Table 1: History of Revisions

Revision	Date	Issued to	Changes
R0	15/06/2022	N. Rose	Initial Release
R1	7/07/2022	N. Rose	Comments
R2	20/07/2022	N. Rose	Comments

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GLOSSARY

A-Weighting	A response provided by an electronic circuit which modifies sound in such a way that the resulting level is similar to that perceived by the human ear.
dB (decibel)	This is the scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and the reference pressure (0.00002 N/m^2).
dB(A) or dBA	This is a measure of the overall noise level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
dB(Z)	This is a measure of the overall noise level of sound across the audible spectrum with a "Z" frequency weighting which is effectively the un-weighted signal.
Free-field	Refers to a sound pressure level determined at a point away from reflective surfaces other than the ground with no significant contribution due to sound from other reflective surfaces; generally, as measured outside and away from buildings.
Hz	Hertz. Unit of frequency of a variable parameter. Units: 1/seconds
L_{Aeq}	This is the equivalent steady sound level in dB(A) containing the same acoustic energy as the actual fluctuating sound level over the given period. Noise levels often fluctuate over a wide range with time. Therefore, when a noise varies over time, the L_{Aeq} is the equivalent continuous sound which would contain the same sound energy as the time varying sound. Many studies show that human reaction to level-varying sounds tends to relate closer to the L_{Aeq} noise level than any other descriptor.
L_{A10}, L_{A90}, L_{An}	Noise level exceeded for n% of the measurement period with A-weighted, calculated by statistical analysis - where n is between 0.01% and 99.99%. For example, L_{A10} is the noise level just exceeded for 10% of the measurement period, calculated by statistical analysis and used to determine traffic noise and L_{A90} is the noise level exceeded for 90% of the measurement period, A-weighted and calculated by statistical analysis and used to determine background noise levels.
L_{AFmax}	A-weighted, fast response, maximum, sound level.
L_{AFmin}	A-weighted, fast response, minimum, sound level.
RBL	Rating background noise level – the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
SWL	Sound Power Level in decibels is ten times the logarithm of the ratio of the sound power to the sound power reference level of 1 pico Watt.

ABBREVIATIONS

BOM	Bureau of Meteorology
CONCAWE	Conservation of Clean Air and Water in Europe
EPA	Environmental Protection Authority
NPfI	Noise Policy for Industry (NSW EPA, 2017)
BESS	Battery Energy Storage System

1 INTRODUCTION

1.1 Background

Firm Power Pty Ltd (Firm Power) propose to develop a Battery Energy Storage System (BESS) adjacent to an existing substation compound located at 20 Sandy Creek Road, Muswellbrook

The Secretary's Environmental Assessment Requirements (SEARs) for the project are:

> *Noise –*
>
> *including an assessment of the construction noise impacts of the development in accordance with the Interim Construction Noise Guideline (ICNG), operational noise impacts in accordance with the NSW Noise Policy for Industry (2017), cumulative noise impacts (considering other developments in the area), and a draft noise management plan if the assessment shows construction noise is likely to exceed applicable criteria.*

1.2 Scope of Assessment

Assured Environmental (AE) was appointed by Firm Power Pty Ltd (Firm Power) to undertake a ambient noise monitoring and noise impact assessment to determine compliance of a BESS. The assessment has been undertaken in accordance with the following guidelines:

- NSW Noise Policy for Industry (NPfI) (EPA, 2017)
- NSW Assessing Vibration: a technical guideline (DEC, 2006);
- NSW Road Noise Policy (DECCW, 2011); and
- Interim Construction Noise Guideline (ICNG) (DECC, 2009).

In accordance with the requirements of the above guidelines, computational modelling and first principal calculations have been undertaken to assess the potential for adverse amenity as a result of the project

1.3 This Report

This report summarises the methodology, results, and conclusions of the noise impact assessment.

2 DESCRIPTION OF EXISTING ENVIRONMENT

2.1 Location

The Development Site is located adjacent to an existing substation compound located at 20-24 Sandy Creek Road, Muswellbrook. The Development Site will be located on three Lots; Lots 11 and 12 on DP839233 and Lot 15 on DP905479, which is the access road. The land is zoned as SP2, with the exception of a portion of the site associated with proposed sub-transmission line which is on land zoned C3.

The Development Site is located in a primarily rural/suburban interface to the east of the New England Highway (Aberdeen Street). The Muswellbrook bypass is currently proposed and will be located east of the Development Site. At this location, the bypass will have noise barriers to minimise the impact on the existing receptors. Figure 1 illustrates the site location and sensitive receptors.

2.2 Receptors

Table 2 and Figure 1 present the nearest sensitive receptors to the Development Site and the land use as defined in the NPfI (2017). There is a master planned development which is still in the early stages of development; as the layout, land use and design of the development is unknown, the possible receptors are taken into consideration (F1 – F3).

Table 2: Sensitive Receptors

ID	Location (UTM Zone 56)		Land Use	Distance to Site Infrastructure
	X	Y		
R1	302395	6431022	Residential	725 m
R2	302380	6430918	Residential	700 m
R3	302330	6430821	Residential	720 m
R4	302543	6430512	Residential	520 m
R5	302599	6430444	Residential	470 m
R6	302655	6430404	Residential	430 m
R7	302668	6430347	Residential	425 m
R8	302605	6430334	Residential	490 m
R9	302552	6430341	Residential	545 m
R10	302545	6430278	Residential	570 m
Future development F1	302888	6430574	Future residential	145 m
Future development F2	302876	6430478	Future residential	170 m
Future development F3	302861	6430365	Future residential	210 m

The future development locations were chosen based on the separation distance of the premises from the edge of the Lot and topographical features which will restrict development (for example creeks and flood-prone areas).

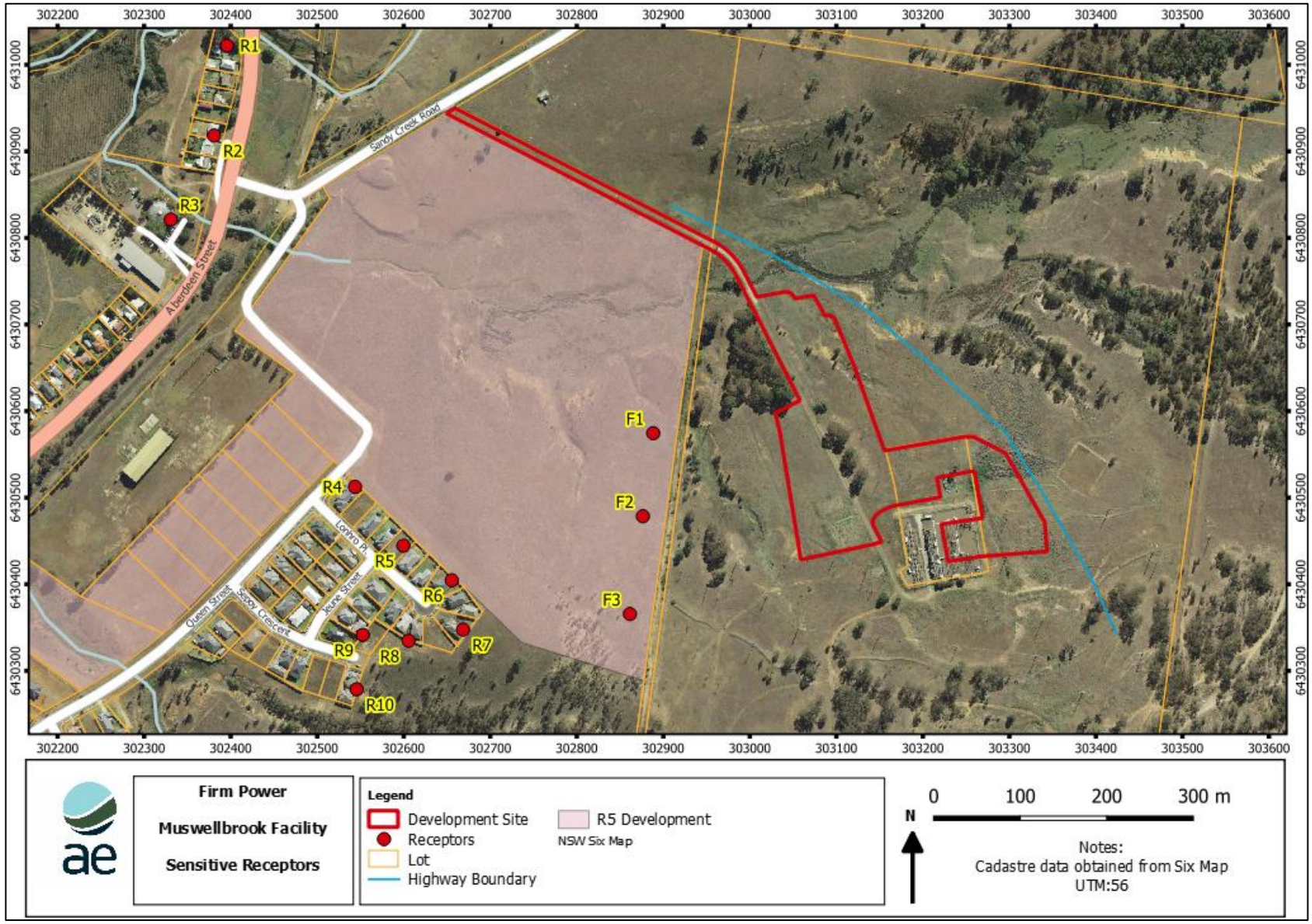


Figure 1: Site Location, Receptors and Surrounding Land Use

3 EXISTING ACOUSTIC ENVIRONMENT

3.1 Methodology

Noise measurements were undertaken in accordance with the requirements of Australian Standard AS 1055-2018 *'Acoustics – Description and measurement of environmental noise'* and the NPfI (EPA, 2017). The instrument was situated in a free-field position and a sampling time of 15-minutes was adopted for the monitoring. The microphone was positioned at a height of 1.5 metres above ground level and fitted with a windshield throughout the measurements.

3.2 Monitoring Locations

Baseline noise monitoring was conducted in February 2022 at one location at 13 Lonhro Place, Muswellbrook. Figure 2 presents the noise monitoring location.

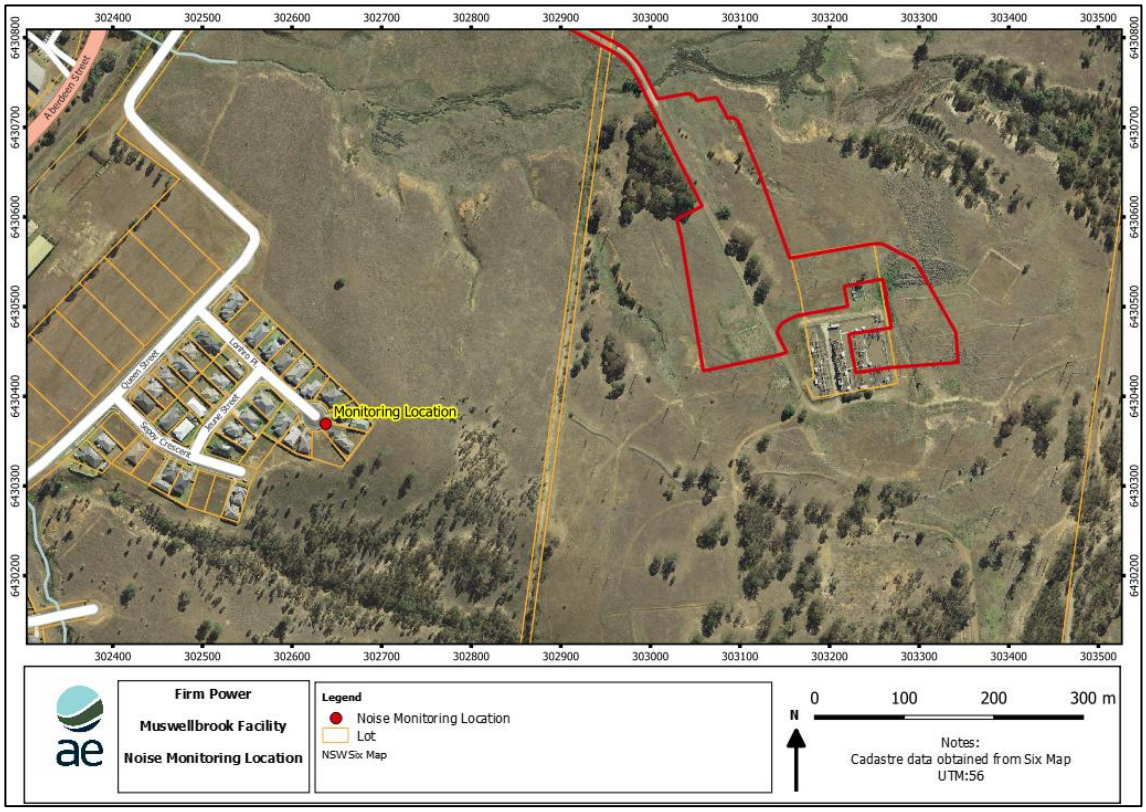


Figure 2: Noise Measurement Location

3.3 Weather Affected Bias

Wind and rainfall data from the nearest Bureau of Meteorology (BOM) Scone Station (060800) indicates approximately 31 hours of noise data were potentially affected by winds above 5 m/s or rainfall. To avoid weather-related bias, noise measurements associated with wind or rain-affected periods have not been considered.

3.4 Equipment

The serial numbers and calibration information for the sound monitoring instrument used are presented in Appendix A.

3.5 Summary of Noise Measurement Data

A summary of the noise monitoring data by period are presented in Table 3. The time history of noise measurements at the boundary is presented in Appendix A. The monitoring data shows that the Rated Background Level (RBL) is below the RBL is below the minimum level accepted by the NPfI. This is discussed further in Section 6.

Table 3: Overall Noise Measurement Data

Period	L_{max}	L_1	L_{10}	L_{90}	L_{eq}	RBL
Day	100	53	44	34	48	31
Evening	89	48	41	34	43	32
Night	86	44	39	34	42	32

4 CONSTRUCTION NOISE ASSESSMENT

4.1 Duration of Construction Works

The construction of the BESS is expected to take approximately 12 months with peak construction for five months, with a number of different activities undertaken over that time.

Construction would be restricted to what the EPA term '*recommended construction hours*' (as described in Table 4 below), which are between 7 am and 6 pm Monday to Friday and 8 am to 1 pm Saturday, with no works on Sundays or Public Holidays. It is proposed that some inaudible construction activities may be undertaken outside of standard hours in accordance with a construction noise protocol.

The assessment has therefore considered the potential for adverse amenity impacts associated with construction during recommended standard hours only.

4.2 Interim Construction Noise Guideline

Guidance on the assessment and management of construction noise in NSW is provided in the Interim Construction Noise Guideline 2009 (ICNG) published by the NSW EPA.

The main objectives of the Guideline are to:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts;
- Encourage construction to be undertaken only during the recommended standard hours, unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage;
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts; and
- Provide guidelines for assessing noise generated during the construction phase of developments.

In achieving these objectives, the guideline provides a framework for the qualitative and quantitative assessment of potential construction noise impacts noting that, for major projects, a quantitative assessment is the preferred approach.

Table 4 presents construction noise criteria outlined in the guideline. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

Table 4: NSW EPA Construction Noise Criteria – Residential Receivers

Time of Day	Management Level (Free-field)	How to Apply
Recommended standard hours: Monday to Friday, 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	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.
	Highly noise affected 75 dB(A)	The highly noise affected 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 restricting 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.
Outside recommended standard hours	Noise affected RBL + 5 dB	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.

Where nearby sensitive receptors are predicted to be noise affected, the proponent of the project is required to apply reasonable and feasible noise mitigation measures, noting that a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.

Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic, and environmental effects.

For construction in standard operating hours, the assessment criteria has been determined based on the minimum allowable RBL as provided in the NPfI (refer to Table 13). That is, for the purposes of the assessment it is assumed that the RBL is 40 dB(A) for daytime periods (standard operating hours) thereby resulting in a noise affected management level of 50 dB(A) and a highly noise affected management level of 75 dB(A).

4.3 Construction Noise Sources

In terms of noise emissions, the site preparation activities and installation of the BESS units are expected to represent those with the most significant potential for adverse impacts. It is noted that construction works are expected to progress across the site such that plant and equipment would only be in a single area for a short period of time.

Table 5 below presents a summary of the plant and equipment likely to be required to complete the on-site construction works. The sound power levels presented have been sourced from published noise emission datasets and the library of source noise levels maintained by Assured Environmental.

Table 5: Construction Phases and Expected Equipment

Timeline	Construction Activity	Source	Number Operating	Usage Factors (%)	Total Activity dB(A)
Month 1	Site establishment	Loader	1	40	107
		Vibratory Roller	2	20	103
		Water Cart	1	40	98
		Excavator	1	40	113
		Franna Crane (20t)	1	16	107
		Diesel Generator	1	50	70
Month 2 to 12	Build BESS	Loader	1	40	107
		Grader	2	40	109
		Vibratory Roller	2	20	103
		Water Cart	1	40	98
		Excavator	3	40	113
		Diesel Generator	2	50	70
Month 2 to 11	Build Substation	Grader	1	40	109
		Vibratory Roller	1	20	103
		Excavator	1	40	113
		Franna Crane (20t)	2	16	107
		Diesel Generator	1	50	70
Month 5 to 10	Build Transmission Line	Franna Crane (20t)	1	16	107
		Diesel Generator	1	50	70
Month 4 to 6	Build O&M Compound	Franna Crane (20t)	1	16	107
		Diesel Generator	1	50	70

4.4 Assessment of Impacts

For the purposes of predicting impacts associated with noise emissions from the Development Site on nearby sensitive receptors, calculations of the noise impacts from construction activities have been undertaken using first principal calculations based on the distance separation of the receptor and the Project Area boundary (Figure 1).

Construction activities across the site will vary in location and duration; mobile plant will move around the development site throughout the construction phase.

Table 6 below presents predicted most affected receptor noise levels taking into consideration the following assumptions:

- All equipment and plant are located in the same area – at the closest point to the Project Area boundary to the receptors. This is considered to be a hypothetical worst-case scenario and unlikely to occur; and
- The number of plant at this stage of development are estimates.

The results presented in Table 6 show the following:

- No receptors will experience noise levels >75 dB(A) for any stage during construction;
- The highest predicted noise level is 69 dB(A) at future receptor F1 during construction of the BESS. This receptor is close to the Project Area boundary and the access road; and
- The highest predicted noise level at existing receptors is 60 dB(A) at R6 and R7 during BESS construction.

It should be noted that the construction of the BESS is scheduled to occur late 2023 and there is currently no confirmed subdivision plans for the R5 land (i.e. the most affected potential receivers identified as F1, F2, F3). It is therefore anticipated that construction of the BESS may be completed before any residences are constructed or inhabited on this land.

It is recommended that reasonable and feasible mitigation measures such as those presented in Section 4.5 are implemented to reduce the noise impact at all receptors.

Table 6: Predicted Receptor Noise Levels – Daytime, dB(A)

ID	Distance from Project Area	Standard Hours Criteria		Construction Phase				
		Noise Affected	Highly Noise Affected	Site Est.	Build BESS	Build Sub-station	Build Trans Line	Build Compound
R1	725 m	50	75	51	55	51	39	39
R2	700 m	50	75	51	55	51	39	39
R3	720 m	50	75	51	55	51	39	39
R4	520 m	50	75	53	58	54	42	42
R5	470 m	50	75	54	59	55	43	43
R6	430 m	50	75	55	60	56	43	43
R7	425 m	50	75	55	60	56	43	43
R8	490 m	50	75	54	58	54	42	42
R9	545 m	50	75	53	58	53	41	41
R10	570 m	50	75	53	57	53	41	41
F1 [a)]	145 m	50	75	65	69	65	53	53
F2 [a)]	170 m	50	75	63	68	64	51	51
F3 [a)]	210 m	50	75	61	66	62	50	50

[a)] Future Development

4.5 Cumulative Impacts with Muswellbrook Bypass

Transport for New South Wales (TfNSW) is expecting to commence construction of the bypass in the Muswellbrook area at a similar time to the commencement of construction for the BESS.

The bypass is a prolonged project which will take place in stages, there could be potential for peak construction of both projects to overlap. If this occurs , Firm Power will consult with TfNSW to manage any potential impacts and implement additional noise mitigation measures in accordance with the ICNG if required.

4.6 Mitigation of Construction Noise Levels

Given the variable and mobile nature of the construction works, the use of permanent or temporary acoustic barriers at source is not considered feasible. Potential controls available to the construction contractor to minimise potential impacts for construction works could include:

- Limiting the type and scale of concurrent activities undertaken close to sensitive receptors where possible;
- Using broad band reversing alarms on all mobile plant and equipment;
- Examine different types of machines that perform the same function and compare the noise level data to select the least noisy machine;
- Operating plant in a quiet and efficient manner;
- Reduce throttle setting and turn off equipment when not being used; and
- Regularly inspect and maintain equipment to ensure it is in good working order including checking the condition of mufflers.

It is recommended that during any work generating high noise levels that have impulsive, intermittent, low frequency or tonal characteristics, consultation with sensitive receptors occurs regularly.

It should be noted that the construction assessment is conservative in nature and that the likelihood of exceeding these noise levels is low. As the highest predicted noise levels do not exceed the highly affected noise criteria of 75 dB(A) at any receptor, the implementation of additional noise controls (except those listed above) is not considered necessary.

5 ROAD TRAFFIC NOISE ASSESSMENT

5.1 Traffic Volumes

The construction traffic volumes for the project have been provided by the Applicant. It is anticipated that during peak construction the site could generate up to 60 heavy and 66 light vehicle movements per day. It is noted that a vehicle movement is classified as a vehicle travelling in one direction (i.e. a truck accessing the site would generate one movement towards the site and one movement away from the site when it departs).

Overall, the site is expected to generate approximately 51 vehicle movements during the morning and evening peak hours during the peak construction period, which will reduce to 25 vehicle movements over the typical construction periods.

Table 7: Traffic Generation During Construction

Vehicle Type	Average Vehicle Movements		Peak Vehicle Movements	
	Daily (vpd)	Peak Hour (vph)	Daily (vpd)	Peak Hour (vph)
Light vehicles	30	20	60	40
Shuttle bus	2	1	6	3
MRV/HRV	4	1	12	2
Truck and Dog	16	2	40	4
AV/B-double	4	1	8	2
Total	**56**	**25**	**126**	**51**

Following additional assumptions have been made with a summary of road traffic data presented in Table 8.

- Peak hourly light vehicles – 40 per hour arriving before shift commences at 7 am and after shift finishes;
- Peak daily heavy vehicles 66 trucks with a peak hourly of 11 heavy vehicles;
- With the exception of staff movements before shift commences, all movements are expected to occur during standard construction hours (7 am to 6 pm Monday to Friday and 8 am to 1 pm Saturday) with the exception of allowing one hour to arrive to site outside standard construction hours.

Table 8: Road Traffic Data

Road Segment	Vehicle Type	Vehicle Speed	Number of Movements	
			Day (7 am to 6 pm)	Night (Peak 1-hour)
New England Highway / Aberdeen St	Light	60 km/hr	60	40
	Heavy	60 km/hr	66	11
Sandy Creek Road	Light	100 km/hr	60	40
	Heavy	100 km/hr	60	11

5.2 Assessment Criteria

The ICNG does not provide criteria for the assessment of construction road traffic during the project. Given this, reference is made to the noise criteria provided in the NSW Road Noise Policy (RNP). Based on the type of roadway, Table 9 below presents the applicable road traffic noise criteria for existing residences affected by traffic on existing roadways generated by land use developments.

Table 9: Applicable Road Traffic Noise Criteria

Road Category	Type of Project & Land Use	Assessment Criteria
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	Day: $L_{Aeq,1\ hour}$ 55 dB(A) Night: $L_{Aeq,1\ hour}$ 50 dB(A) (external)
Freeway/arterial roads	Existing residences affected by additional traffic on existing freeways /arterial/sub-arterial roads generated by land use developments	Day: $L_{Aeq,15\text{-}hour}$ 60 dB(A) Night: $L_{Aeq,15\text{-}hour}$ 55 dB(A) (external)

5.3 Noise Modelling Methodology

For the purposes of predicting impacts associated with road traffic noise emissions was completed using the proprietary software CadnaA (2022 MR2 build 181.5221) developed by DataKustik. The model incorporates the influence of terrain, ground type and air absorption in addition to source characteristics to predict noise impacts at receptor locations. All predictions have been undertaken in accordance with Calculation of Road Traffic Noise (CRTN) methodology developed by the UK Department of Transport. In accordance with the requirements of the RNP, the predictive noise modelling incorporated the following assumptions:

- L_{Aeq} values were calculated from the L_{A10} values predicted by the CRTN methodology using the approximation $L_{Aeq,1\ hour} = L_{A10,1\ hour} - 3$.
- Noise source heights were set at 0.5 m above road level for cars, 1.5 m for heavy vehicle engines and 3.6 m for heavily vehicle exhausts.
- Noise from heavy vehicle exhausts is 8 dB lower than the steady continuous engine noise; and
- Corrections established for Australian conditions applied through a negative correction to the CRTN predations of -1.7 dB for façade-corrected levels (Samuels and Saunders, 1982).

Review of the predicted noise level presented in Table 10 below confirms that compliance with the RNP is achieved at the closet receptor.

Table 10: Predicted $L_{Aeq,15\text{-}hour}$ Noise Levels - Road Traffic Noise

Sensitive Receptor	Setback from Roadway	Period	Parameter	Criteria	Predicted Noise Level	Comply (Y/N)
R02 (Aberdeen Street)	24 m	Day	$L_{Aeq,1\ hour}$	60 dB(A)	52 dB(A)	Y
		Night	$L_{Aeq,1\ hour}$	55 dB(A)	48 dB(A)	Y
Sandy Creek Road	20 m	Day	$L_{Aeq,15\ hour}$	60 dB(A)	58 dB(A)	Y
		Night	$L_{Aeq,15\ hour}$	55 dB(A)	55 dB(A)	Y

6 ASSESSMENT CRITERIA

6.1 Operational Assessment Criteria

The acoustic assessment has been completed in accordance with the procedure identified in the NPfI. The NPfI recognises that scientific literature has identified that both the increase in noise level above background levels (that is, intrusiveness of a source), as well as the absolute level of noise are important factors in how a community will respond to noise from industrial sources.

In response to this, the NPfI establishes two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. These two criteria are then used to determine project trigger levels against which the proposed development will be assessed. The project noise trigger level is a level that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response.

The derivation of the two sets of criteria are presented below. For residential dwellings, the noise criteria are assessed at the most-affected point (i.e. highest noise level) on or within the property boundary. Where the property boundary is more than 30 m from the house, then the criteria applies at the most-affected point within 30 m of the house.

6.2 Intrusiveness Noise Criteria

The project intrusiveness noise level is intended to protect against significant changes in noise levels as a result of industrial development. To achieve this, the NPfI describes intrusive noise as noise that exceeds background noise levels (as defined by the Rating Background Level or RBL) by more than 5 dB.

Table 11 presents the derivation of the intrusiveness criteria based on the noise monitoring undertaken at the Development Site. The noise monitoring identified that during the daytime, the RBL is below the minimum level accepted by the NPfI, therefore this minimum level has been applied, whereas the measured noise levels for evening and night have been applied.

Table 11: Derived Intrusiveness Noise Criteria

Receptor	Intrusiveness $L_{Aeq,15\text{-minute}}$ Criteria		
	Day	Evening	Night
Measured Data [a)]	31 + 5 = 36	32 + 5 = 37	32 + 5 = 37
Minimum Level [b)]	40	35	35

a) Measured background noise level established by the NPfI 2017 + 5 dB.
b) Receptor noise criteria applied at a location 30 m from the dwelling façade.

6.3 Amenity Criteria

The project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Review of the surrounding area has identified that there are other industrial noise sources in the area, and that future industrial development in the area is likely. As such, 5 dB have been subtracted from the project amenity noise levels to the indicative noise amenity area total industrial noise levels presented in Table 12.

Table 12: NPfI Amenity Noise Levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level (dB(A))	
			Total Industrial Noise	Project Specific
Residence	Suburban	Day	55	50
		Evening	45	40
		Night	40	35

6.4 Project Noise Trigger Levels

The Project Noise Trigger Level (i.e. the noise criteria considered by the assessment) is the lower value of the project intrusiveness noise level and the project amenity level, after the conversion to $L_{Aeq,\ 15\ min}$ dB(A) equivalent level. Table 9 presents the standardised intrusiveness noise level and the project amenity level as derived by adding 3 dB(A) to each period of the day.

Table 13: Determining Project Trigger Level

Type of Receiver	Time of Day	Standardised $L_{Aeq,\ 15\ min}$ Noise Level (dB)		
		Intrusiveness Noise Level	Amenity Noise Level	Project Noise Trigger Levels
Residence	Day	40	50 + 3 = 53	40
	Evening	37	40 + 3 = 43	37
	Night	37	35 + 3 = 38	37

When applying the project specific noise levels to existing industrial uses, the NPfI acknowledges that noise mitigation measures may be limited or costly. When determining the impact from existing industry, the NPfI recommends the project noise trigger levels should not be applied as mandatory noise limits. Instead, they should be used to assess noise impact and drive the process of assessing all feasible and reasonable control measures. The NPfI also identifies that for sites with limited mitigation measures available, the achievable noise limits can be above the project noise trigger levels.

6.5 Sleep Disturbance

NSW EPA have identified a screening assessment for sleep disturbance based on the night-time noise levels at a residential location. Where noise levels at a residential location exceed the following levels during the Night time period, the potential for sleep disturbance should be investigated:

- $L_{Aeq,\ 15\ min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is greater; and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB whichever is the greater,

Based on the assessment the above sleep disturbance criteria has been applied.

7 ASSESSMENT METHODOLOGY

7.1 Software

For the purposes of predicting impacts associated with noise emissions from the Development Site on nearby sensitive receptors, noise modelling of the sources was completed using the proprietary software CadnaA (version 2022 build 185.5221) developed by DataKustik. CadnaA incorporates the influence of meteorology, terrain, ground type and air absorption in addition to source characteristics to predict noise impacts at receptor locations.

The model is utilised to assess the potential noise emissions from the Development Site under a range of operating scenarios and meteorological conditions. The noise modelling also allows investigation of possible noise management solutions, in the event that non-compliance with the assessment criterion is predicted.

7.2 Meteorology

The NPfI presents guidelines for the consideration of meteorological effects on noise propagation, specifically, temperature inversions and/or gradient winds. NPfI provides two options for assessing meteorological effects as detailed in Table 14.

Table 14: Standard and Noise Enhancing Meteorological Conditions

Meteorological Conditions	Meteorological Parameters
Standard conditions	Day/Evening/Night: stability categories A-D with wind speed up to 0.5 m/s at 10 m AGL[b].
Noise enhancing conditions	Day/Evening: stability categories A-D with light winds (up to 3 m/s at 10 m AGL).
	Night: stability categories A-D with light winds (up to 3 m/s at 10 m AGL). And/or stability category F with light winds (up to 2 m/s at 10 m AGL).

a) Pasquill-Gifford Atmospheric Stability Class
b) AGL: Above ground level

7.3 Model Configuration

Table 15 summarises the model configuration used for the modelling.

Table 15: Model Configuration

Parameter	Approach
Standards	CONCAWE
Time Periods	Day (07:00 – 18:00 hours Evening (18:00 – 22:00 hours) Night (22:00 – 07:00 hours)
Digital Terrain	LIDAR data at 1 m intervals. Triangulation calculation applied.
Ground Absorption	Default absorption for hard surface. Aerial mapping used to include soft ground.
Meteorology	Day and Evening: Stability class D at 3 m/s Night: Stability class F at 2 m/s Worst case source to receptor

7.4 Noise Sources

Table 16 provides a summary of the noise sources adopted for this assessment and the operational details of each source. Where annoying noise characteristics have been identified the adjustment has been included in the L_{Aeq} column. The sound power levels have been taken from the following sources:

- manufacturers information for:
    - Manufacturer batteries as per the communications between Firm Power and Manufacturer relating to power loading based on ambient site conditions;
        - Manufacturer confirmed fan load conditions of the battery (60% during the day and evening and 50% night). These conditions have been used to determine if tonality or impulsiveness corrections are required;
        - Analysis of the 1/3 spectra for each side of the battery provided by Manufacturer for these loading identified that there are no low frequency corrections applied to the noise sources at these identified loads;
        - Tonality corrections are applied to two of the four sides based on the analysis of the 1/3 spectra for each side of the battery provided by Manufacturer;
        - All sides are modelled as vertical area sources based on discussions with Manufacturer;
        - Operational minutes are based on the Manufacturer warranty requirements; and
        - Manufacturer have requested that specific data relating to the batteries remains confidential, however the overall sound power level will be disclosed.
- Transformer (inverter and auxiliary) SWL calculated from Australian Standard AS60076.10: 2009 '*Power transformers Determination of sound levels*'
- all other SWL taken from AE's database of typical levels taken by AE personnel or from verified sources including Australian Standards and published datasets.

It should be noted that the L_{Amax} level associated with the cooling fans is taken into consideration in the energetic average (L_{Aeq}) noise level to reflect slight changes in the fan power. Therefore, a separate maximum noise assessment will not be undertaken.

The following plans have been used to determine source heights and layout, as shown in Appendix A:

- Muswellbrook Layout – dated 13.04.2022; and
- Technical information provided by Manufacturer.

7.5 Noise Barriers

The facility includes the installation of noise barriers to the west of the BESS cells at a height of 3 m above ground. The barriers are located around the BESS cell blocks; the final location of noise barriers would be determined during detailed design to ensure that the noise criteria are met. The indicative noise barrier location is presented in Figure 3.

Table 16: Sound Power Levels

Noise Source	Qty	Height (m)	Usage Period (%)			Sound Power Level (dB(A))	Noise Characteristics (as per Appendix C of the NPfI)
			Day	Evening	Night	L_{Aeq}	
MEGAPACK (nine fan)	82	2.52 m	33	33	33	80 – 90 depending on which side	Tonal (+5 dB) for two of the four sides
Step up transformers	41	1 m	100	100	100	75	N/A
Main power transformer	1	1.5 m	100	100	100	90	N/A

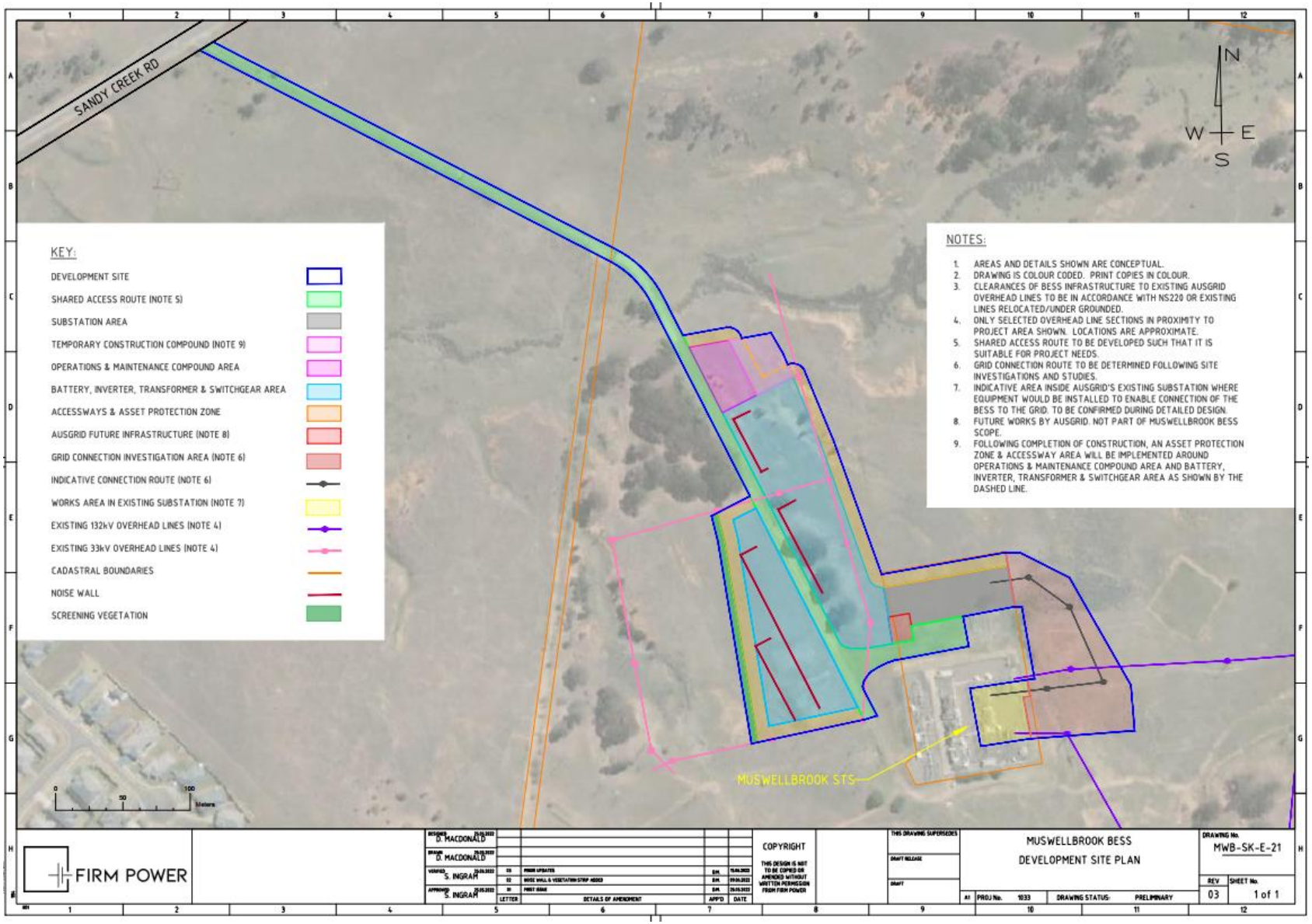


Figure 3: Development Plan

8 PREDICTED NOISE LEVELS

Table 17 below presents predicted receptor noise levels during the operational phase of the BESS based on the sound power levels listed in Table 16 and the source and barrier locations identified in Figure 3. As detailed in Table 16 the assessed load conditions of BESS megapacks are based on load conditions of 60% during the day and evening periods and 50% at night

A review of the predicted noise levels confirms that compliance with the assessment criteria established in accordance with the NPfI can be achieved for all receptors during the daytime, evening, and night-time periods under noise-enhancing meteorological conditions.

The noise contours are presented in Appendix B.

Table 17: Predicted Receptor Noise Levels

Receptor	Predicted Noise Levels (dB(A))				Criteria (D / E / N / Max)	Comply (Y/N)
	Day ($L_{Aeq, 15min}$)	Evening ($L_{Aeq, 15min}$)	Night ($L_{Aeq, 15min}$)	Night (Max)		
R1	19	19	19	27	40 / 37 / 37 / 52	Y / Y / Y / Y
R2	20	20	20	28	40 / 37 / 37 / 52	Y / Y / Y / Y
R3	19	19	19	27	40 / 37 / 37 / 52	Y / Y / Y / Y
R4	23	23	24	32	40 / 37 / 37 / 52	Y / Y / Y / Y
R5	23	23	24	33	40 / 37 / 37 / 52	Y / Y / Y / Y
R6	26	26	27	35	40 / 37 / 37 / 52	Y / Y / Y / Y
R7	27	27	28	36	40 / 37 / 37 / 52	Y / Y / Y / Y
R8	20	20	21	30	40 / 37 / 37 / 52	Y / Y / Y / Y
R9	18	18	19	28	40 / 37 / 37 / 52	Y / Y / Y / Y
R10	15	15	15	24	40 / 37 / 37 / 52	Y / Y / Y / Y
F1 [a)]	34	34	36	45	40 / 37 / 37 / 52	Y / Y / Y / Y
F2 [a)]	34	34	35	44	40 / 37 / 37 / 52	Y / Y / Y / Y
F3 [a)]	33	33	34	42	40 / 37 / 37 / 52	Y / Y / Y / Y

[a)] Future development

8.1 Cumulative Impacts with Muswellbrook Bypass

The cumulative noise level from the operations of the BESS and the road assessment are not able to be determined. The Environmental Assessment for the bypass (AECOM 2021) provide contours for the Development Site as shown in Figure 4. Due to the time average differences between road noise and industrial noise, it is difficult to assess cumulative noise levels accurately.

The highest predicted noise level from the Development is 36 dB(A) during the night time period. The predicted noise level from the bypass is around 55 dB(A). Therefore, the predicted noise level from the Development Site is 19 dB(A) lower in comparison to the bypass.

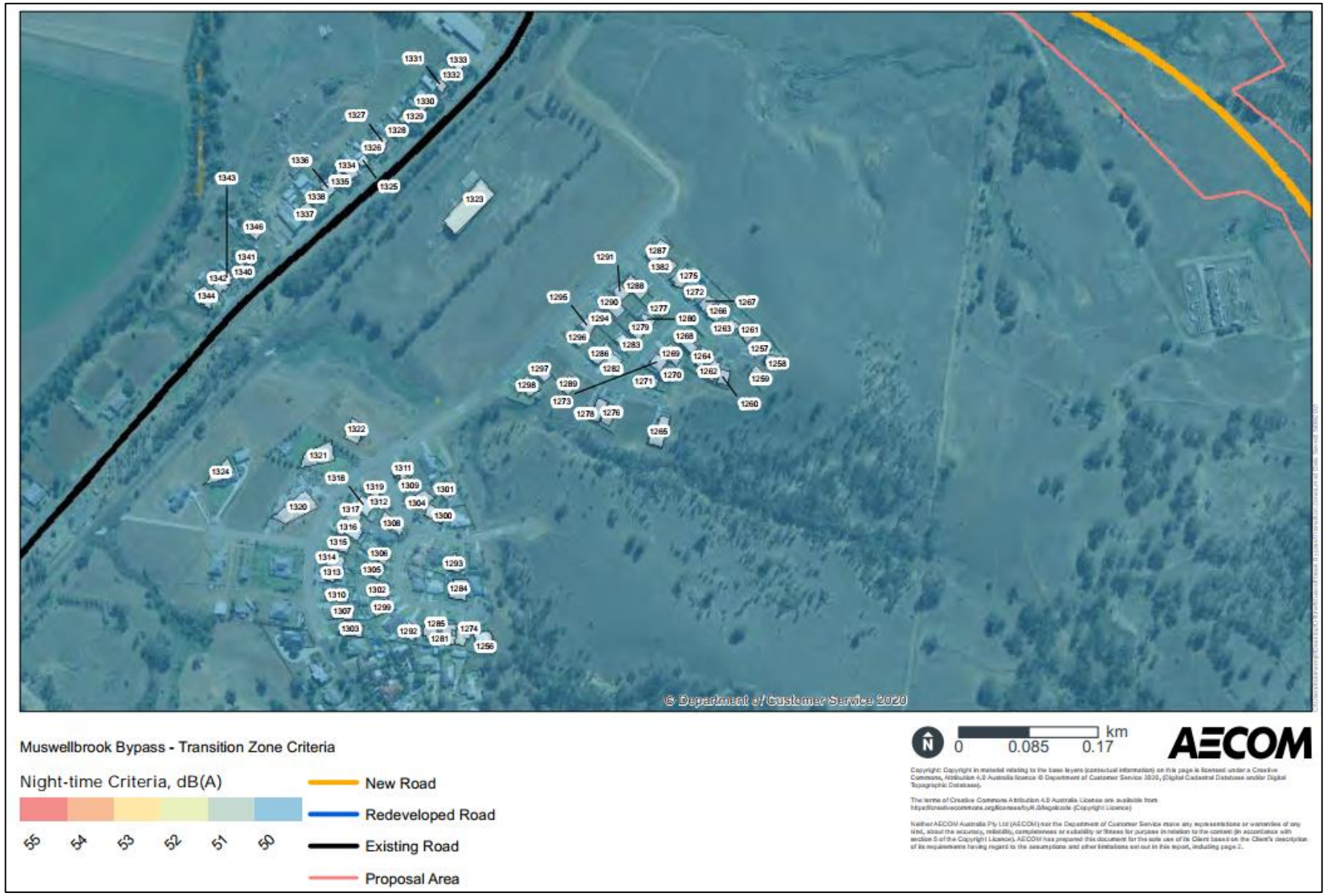


Figure 4: Predicted Noise Level from Bypass (AECOM 2021)

9 VIBRATION ASSESSMENT

9.1 Introduction

A review of the proposal indicates there is potential for impacts as a result of vibration generated by plant and equipment during the construction phase. Given this, an assessment of the potential for vibration impacts has been undertaken. In particular, the assessment has considered the potential for impacts on both human comfort and structural damage for the nearest residence to the construction works.

9.2 Assessment Criteria

The vibration criteria presented in the Environmental Noise Management – *Assessing Vibration: A Technical Guideline* (2006) published by the NSW Department of Environment and Conservation (DEC) have been adopted for the assessment. The technical guide provides vibration criteria associated with amenity impacts (human annoyance) for the three categories of vibration:

- Continuous vibration (e.g. road traffic, continuous construction activity);
- Impulsive vibration includes less than 3 distinct vibration events in an assessment period (e.g. occasional dropping of heavy equipment); and
- Intermittent vibration includes interrupted periods of continuous vibration (e.g. drilling), repeated periods of impulsive vibration (e.g. pile driving) or continuous vibration that varies significantly in amplitude.

Table 18 and Table 19 present the criteria for continuous and impulsive vibration and intermittent vibration, respectively.

Table 18: Continuous & Impulsive Vibration Criteria for Residences – Peak Velocity

Location	Vibration Type	Preferred Limit (mm/s)	Maximum Limit (mm/s)
Residences	Continuous	0.28	0.56
Residences	Impulsive	8.6	17

Table 19: Intermittent Vibration Criteria for Residences

Location	Assessment Period	Preferred Value (m/s1.75)	Maximum Value (m/s1.75)
Residences	Daytime	0.20	0.40

The above criteria are suitable for assessing human annoyance in response to vibration levels. In order to assess potential damage to buildings, reference has been made to British Standard *BS 7385-2: 1993 Evaluation and measurement of vibration in buildings – Part 2: Guide to damage levels from ground borne vibration*. Table 20 presents vibration criteria for assessing the potential for building damage.

Table 20: Transient Vibration Guide Values for Cosmetic Damage

Type of Building	Peak Particle Velocity (mm/s)	
	4 Hz to 15 Hz	15 Hz and above
Unreinforced or light framed structures – residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

9.3 Potential Vibration Sources

Table 21 identifies the vibration source levels for the equipment likely to be used for the construction of the Project.

Table 21: Vibration Source levels – Peak Particle Velocity

Equipment Item	PPV at 10 metres (mm/s)	Source
Roller	5 – 6	DEC
7 tonne compactor	5 – 7	DEC
Loaded trucks (rough surface)	5	USA DT [a)]
Loaded trucks (smooth surface)	1 – 2	USA DT [a)]
Excavator	2.5 – 4	DEC

a) Transit Noise and Vibration Impact Assessment, US Department of Transportation, May 2006.

9.4 Assessment of Potential Impacts

Based on the vibration source levels at 10 metres (presented in Table 21), peak particle velocities have been predicted at various separation distances. The NSW DEC indicates that in predicting vibration levels, it can be assumed that the vibration level is inversely proportional to distance (with the relationship varying between $d^{-0.8}$ to $d^{-1.6}$ based on field data).

The US Department of Transportation's Transit Noise and Vibration Impact Assessment (May 2006) presents the following construction vibration propagation formula assuming an inverse relationship:

$$PPV@d_2 = PPV@d_1 \times (d_1/d_2)^{1.5}$$

where: d_1 = distance 1 (reference distance for source data) (m)

d_2 = distance 2 (separation distance for predicted PPV) (m)

PPV = peak particle velocity (mm/s)

The above formula has been considered for predicted PPVs at various distances from construction equipment. Based on the above information, Table 22 presents PPV predictions for the various construction equipment.

Table 22: Predicted Peak Particle Velocity at Sensitive Receptors (mm/s)

Distance from Source (m)	Predicted Peak Particle Velocity (mm/s)				
	Roller	7 tonne compactor	Excavator	Loaded trucks (rough surfaces)	Loaded trucks (smooth surfaces)
10	6.00	7.00	4.00	5.00	1.00 – 2.00
20	2.12	2.47	1.41	1.77	0.35 – 0.71
30	1.15	1.35	0.77	0.96	0.19 – 0.38
40	0.75	0.88	0.50	0.63	0.13 – 0.25
50	0.54	0.63	0.36	0.45	0.09 – 0.18
60	0.41	0.48	0.27	0.34	0.07 – 0.14
70	0.32	0.38	0.22	0.27	0.06 – 0.11
80	0.27	0.31	0.18	0.22	0.05 – 0.09
90	0.22	0.26	0.15	0.19	0.04 – 0.07
100	0.19	0.22	0.13	0.16	0.03 – 0.06
150	0.1	0.12	0.07	0.09	0.02 – 0.03
Type	Continuous			Intermittent	
Nuisance Criteria	Residential 0.28 (preferred) / 0.56 (max)			Residential 0.20 (preferred) / 0.40 (max)	
Building Criteria	Residential 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above				

The predicted vibration levels presented in Table 22 indicate compliance with the continuous maximum vibration nuisance criteria for locations at a separation distance of 50-60 metres. Compliance with the building damage criteria is predicted at 10 metres from construction for each source. Therefore, as the closest receptor (future receptor F1) is 145 m from the nearest vibration source, there will be no adverse impact.

For intermittent vibration associated with haul vehicles, it is difficult to provide an appropriate comparison with the relevant criteria (which is presented as a Vibration Dose Value (VDV) in $m/s^{1.75}$). The calculation of a VDV requires both the overall weighted RMS (root mean square) acceleration (m/s^2) typically obtained from on-site measurements and the estimated time period for vibration events.

It is noted, however, that the loaded trucks at distances of 145 m (the distance to the nearest future receptor) is predicted to be within the maximum intermittent criteria of 0.2 mm/s.

9.5 Operational Vibration

The vibration from the Development Site will be minimal due to the separation distance and design of the surface pad.

10 CONCLUSION

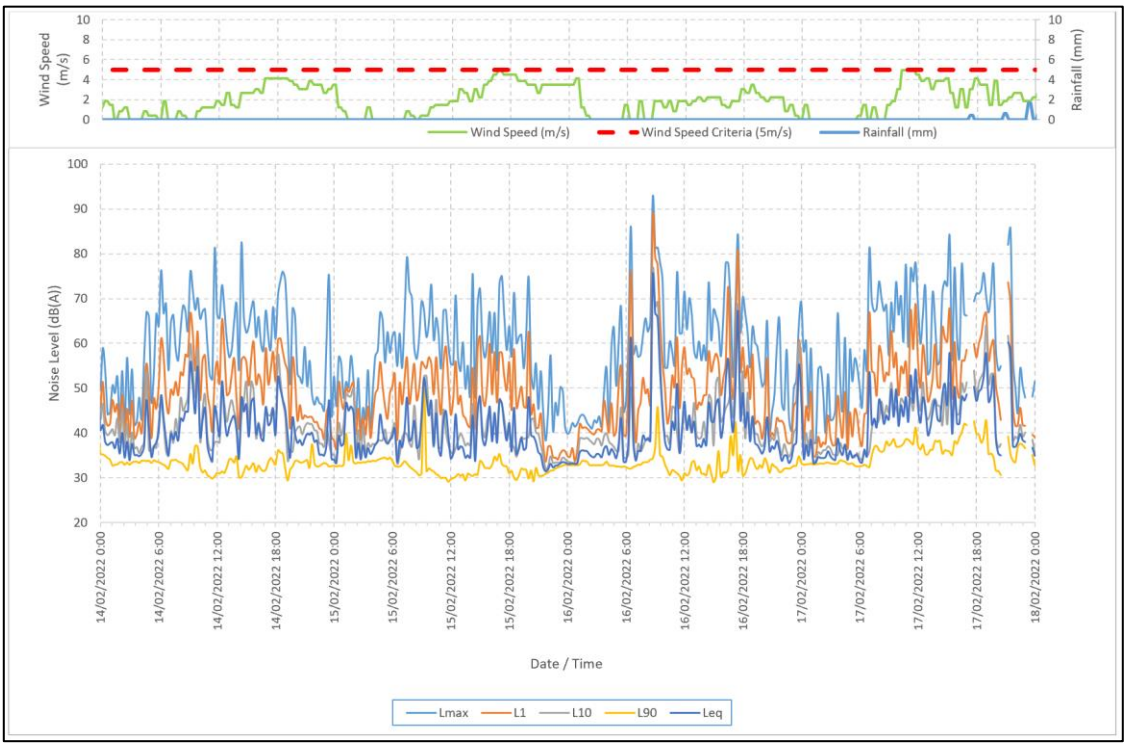
Assured Environmental (AE) was appointed by Firm Power Pty Ltd (Firm Power) to undertake a noise impact assessment. A noise model was developed to predict the noise from the BESS at surrounding land uses in in accordance with the NSW Noise Policy for Industry (EPA, 2017).

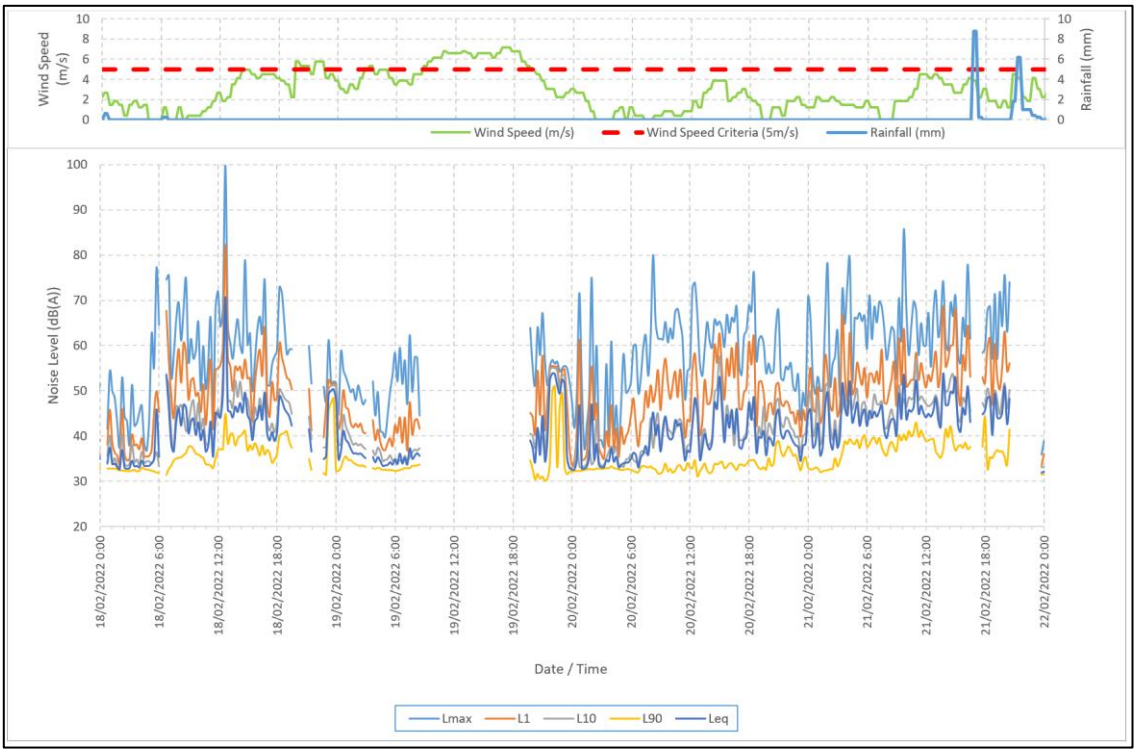
The results of the predictive noise modelling have determined compliance with the derived noise criteria is expected to be achieved at all existing and future sensitive receptors if 3 m barriers are installed as outlined in Figure 3.

APPENDIX A: NOISE MONITORING DETAILS

Table 23: Site Details

Site Details: NML 1	
Coordinates:	-32.24602 "S, 150.90511"E
Start / End Date	9 February 2022 at 13:45 hours to 23 February 2022 at 11:00 hours
Logger Details	Rion NL42 (serial number –00877035) Next Laboratory Calibration Due: 13 August 2023
Calibration Details	Pulsar 106 (serial number 79636) Start / End Calibration Level: 94.0 dB(A) / 94.1 dB(A) Next Laboratory Calibration Due: 10 February 2023
Measurement Details:	Fast/ A-weighting / 15-min duration / 1.2 m microphone height / Free field position
Weather Details	Onsite weather station indicated during the monitoring period 31 hours of data was affected by rainfall.
On-site Observations:	Located on front lawn of 13 Lonhro Place, Muswellbrook. Dominant noise sources were traffic, wind through trees, and birdsong.
Site Photo	 




Wind Speed (m/s)
Rainfall (mm)
Wind Speed (m/s)
Wind Speed Criteria (5m/s)
Rainfall (mm)
Noise Level (dB(A))
18/02/2022 0:00
18/02/2022 6:00
18/02/2022 12:00
18/02/2022 18:00
19/02/2022 0:00
19/02/2022 6:00
19/02/2022 12:00
19/02/2022 18:00
20/02/2022 0:00
20/02/2022 6:00
20/02/2022 12:00
20/02/2022 18:00
21/02/2022 0:00
21/02/2022 6:00
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21/02/2022 18:00
22/02/2022 0:00
Date / Time
Lmax
L1
L10
L90
Leq

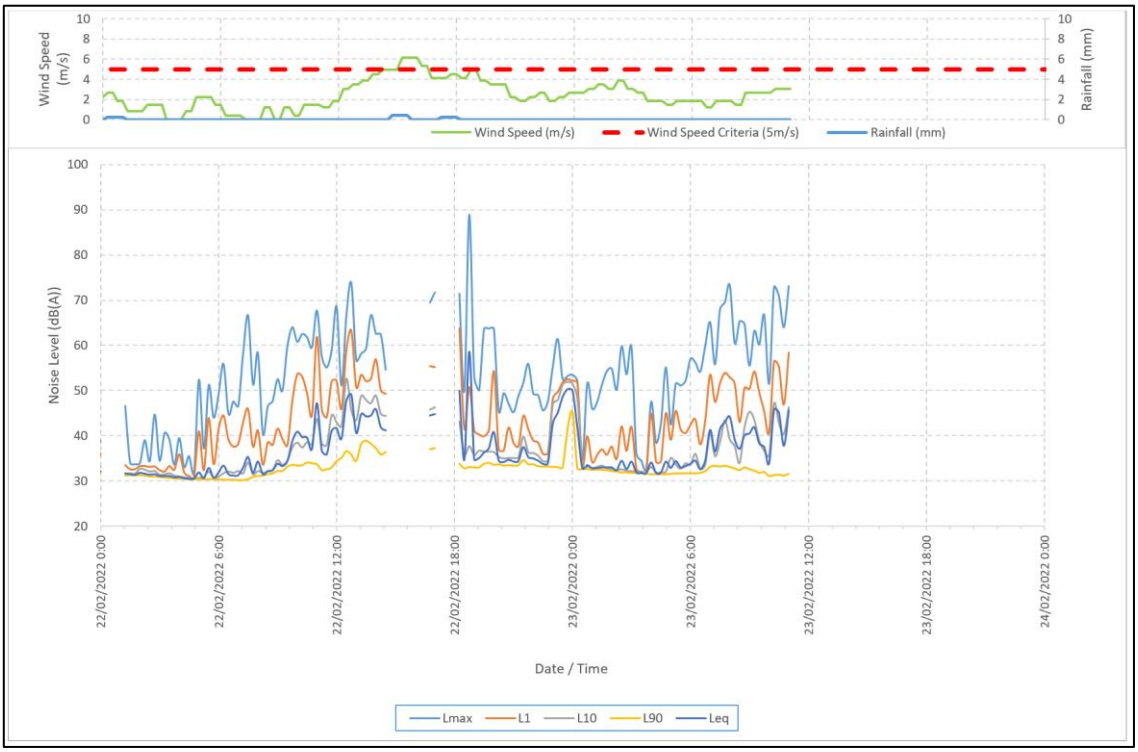
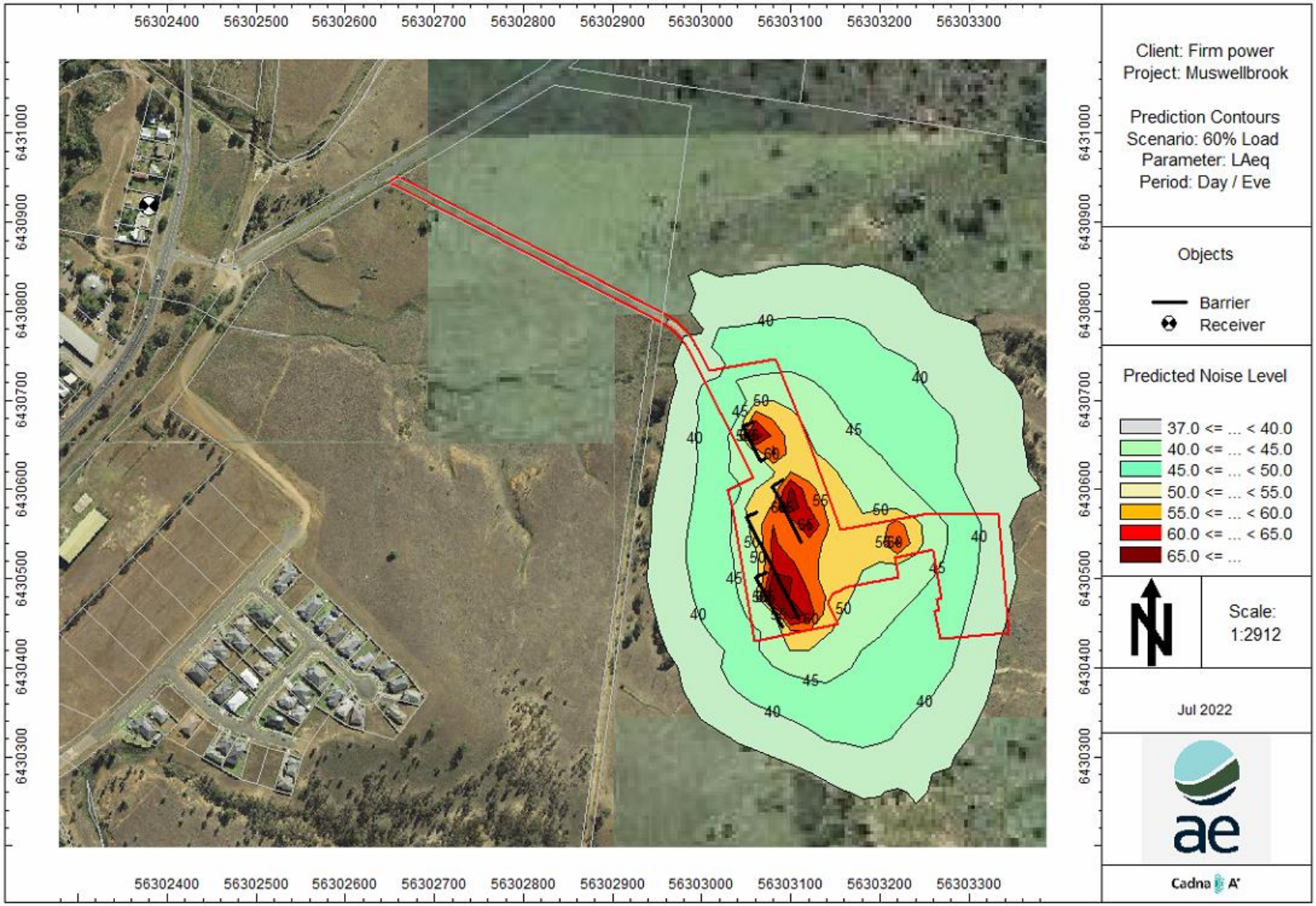

Wind Speed (m/s)
Rainfall (mm)
Wind Speed (m/s)
Wind Speed Criteria (5m/s)
Rainfall (mm)
Noise Level (dB(A))
22/02/2022 0:00
22/02/2022 6:00
22/02/2022 12:00
22/02/2022 18:00
23/02/2022 0:00
23/02/2022 6:00
23/02/2022 12:00
23/02/2022 18:00
24/02/2022 0:00
Date / Time
Lmax
L1
L10
L90
Leq

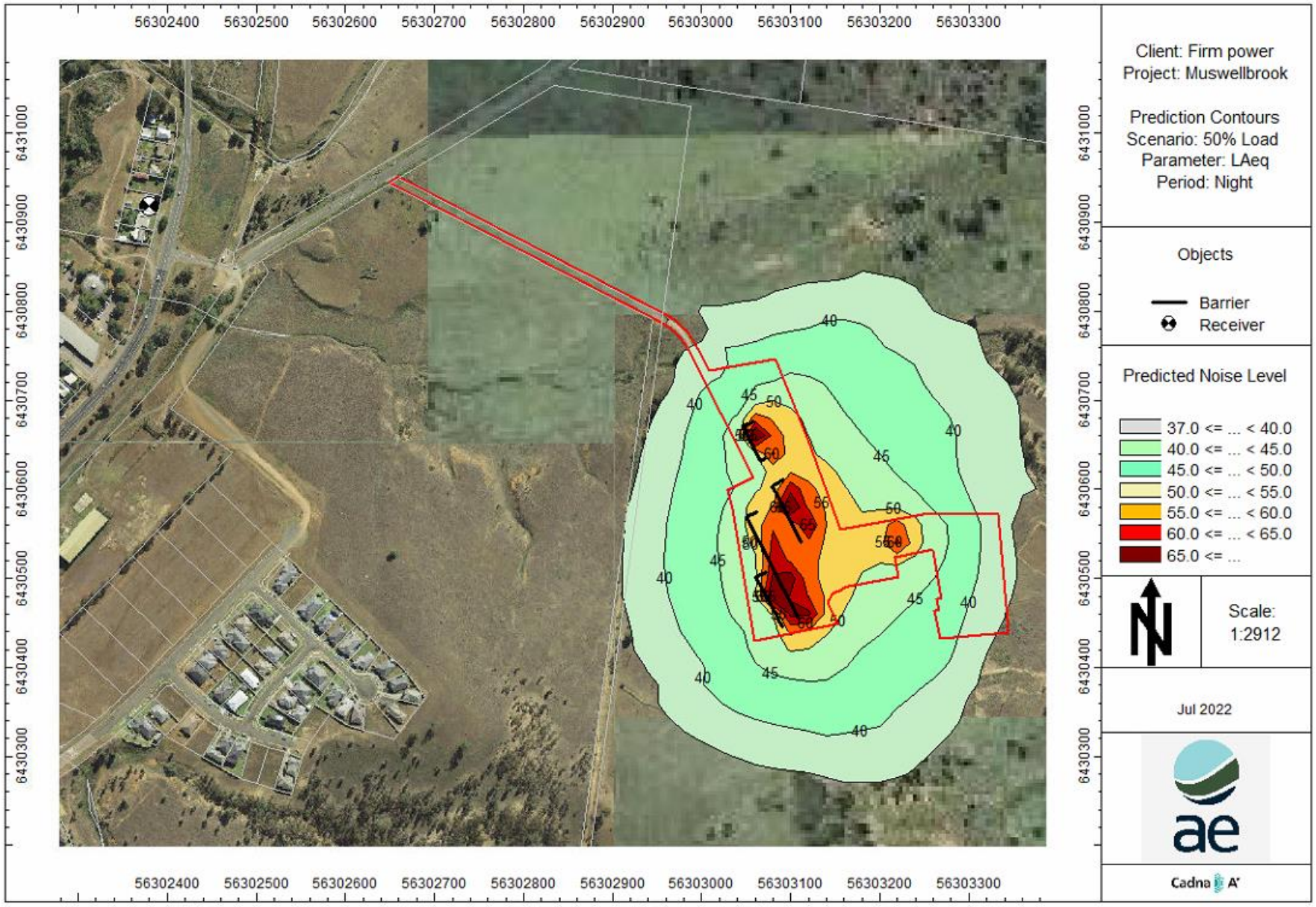
Table 24: Noise Monitoring Results

Date	Period	L_{max}	L_1	L_{10}	L_{90}	L_{eq}	ABL
09/02/2022	Day	-	-	-	-	-	-
	Evening	75	54	49	41	48	35
	Night	72	50	46	38	45	34
10/02/2022	Day	77	50	41	33	43	30
	Evening	71	50	43	35	43	32
	Night	-	-	-	-	-	-
11/02/2022	Day	-	-	-	-	-	-
	Evening	76	47	40	35	42	33
	Night	76	41	36	32	37	32
12/02/2022	Day	78	53	44	34	45	32
	Evening	73	47	40	32	40	30
	Night	74	42	38	33	38	32
13/02/2022	Day	79	53	44	33	46	30
	Evening	-	-	-	-	-	-
	Night	76	47	42	35	45	33
14/02/2022	Day	82	53	44	33	46	30
	Evening	76	50	42	34	45	32
	Night	75	45	39	34	40	33
15/02/2022	Day	79	51	41	32	43	30
	Evening	75	47	38	31	40	30
	Night	86	41	37	33	46	32
16/02/2022	Day	93	55	45	33	60	30
	Evening	70	46	41	33	41	31
	Night	69	42	37	33	41	32
17/02/2022	Day	84	56	46	37	48	35
	Evening	-	-	-	-	-	-
	Night	-	-	-	-	-	-
18/02/2022	Day	100	53	46	37	55	34
	Evening	-	-	-	-	-	-
	Night	-	-	-	-	-	-
19/02/2022	Day	-	-	-	-	-	-
	Evening	-	-	-	-	-	-
	Night	75	43	38	34	45	32
20/02/2022	Day	80	51	42	33	43	32
	Evening	76	50	43	35	43	33
	Night	79	50	44	36	45	32
21/02/2022	Day	86	55	48	39	47	37
	Evening	-	-	-	-	-	-
	Night	-	-	-	-	-	-
22/02/2022	Day	-	-	-	-	-	-

Date	Period	L_{max}	L_1	L_{10}	L_{90}	L_{eq}	ABL
	Evening	89	43	37	34	48	33
	Night	61	40	36	33	41	32

APPENDIX B: NOISE CONTOURS

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56303200
56303300
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6430900
6430800
6430700
6430600
6430500
6430400
6430300
Client: Firm power
Project: Muswellbrook
Prediction Contours
Scenario: 50% Load
Parameter: LAeq
Period: Night
Objects
Barrier
Receiver
Predicted Noise Level
37.0 <= ... < 40.0
40.0 <= ... < 45.0
45.0 <= ... < 50.0
50.0 <= ... < 55.0
55.0 <= ... < 60.0
60.0 <= ... < 65.0
65.0 <= ...
Scale:
1:2912
Jul 2022
Cadna A