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ORANA BATTERY ENERGY STORAGE SYSTEM

Construction & Operational Noise & Vibration Assessment

31 March 2023

NGH Consulting

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40 YEARS 1982-2022 ACOUSTIC ENGINEERING EXCELLENCE

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1 Introduction

Renzo Tonin & Associates was engaged to conduct an environmental noise and vibration assessment of the proposed Orana Battery Energy Storage System (BESS) located at 6945 Goolma Road, Montefiores, approximately 2 km north-east of Wellington and within the Dubbo Local Government Area, as part of the Environmental Impact Statement (EIS) for the project. Noise and vibration impacts from the construction and operation phases of the Project will be addressed in this report in accordance with relevant Council and EPA requirements and guidelines.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Project Description

2.1 Background Information

The project site is located at 6945 Goolma Road, Montefiores NSW 2080, approximately 2 km north-east of Wellington and within the Dubbo Local Government Area (LGA), NSW. The site primarily consists of Lot 2 DP1226751; however, part of the access road includes Lot 2 DP1136578 whilst the network connection assets occupy Lot 1 DP1226751. Lot 2 DP1226751 covers an area of approximately 41 hectares; however, the BESS development footprint will only occupy an area of approximately 14.8 hectares. The site comprises privately owned farmland, and the BESS development footprint would be subdivided and purchased by the applicant. The access road and network connection infrastructure would be subject to an easement for the life of the project.

The site is immediately adjacent to the existing Transgrid 330 kV zone substation and the Wellington solar farm (constructed). The approved Wellington North solar farm is also located in the area and construction is anticipated to be completed by July 2024. The assessment for the proposed Wellington South Battery Energy Storage System, 300m east of the project site, is currently underway.

Key development and infrastructure components for the project would include:

- 400MW Lithium-ion BESS providing up to 4 hours or 1600 MWh of energy storage or 200 MW BESS providing up to 8 hours or 1600 MWh of energy storage.
- A new transmission line that would run from the development footprint to the existing Wellington Substation. There are two transmission line options:
  - Option 1: A 330 kV overhead line from the BESS to the southern portion of the Wellington Substation. This option includes two 45m tall transmission poles with a 60m wide clear easement corridor.
  - Option 2: A 330 kV underground line from the BESS to the northern portion of the Wellington substation. This option would include a 20m wide cable corridor.
- A switchyard and on-site substation
- National Energy Market compliant metering
- Internal access track from Goolma Road
- Security fencing around the perimeter of the BESS with closed circuit television (CCTV)
- An operations and maintenance building
- A water tank that would be able to supply water to an appropriate ring main and fire hydrants around the BESS
- Specific areas of vegetation screen plantings.

During the construction phase, temporary facilities would include a laydown area with a secure compound, construction site offices and amenities, and car and bus parking areas for construction staff. After decommissioning, most above ground infrastructure would be removed and the site returned to its existing land capability, for continued agricultural or alternative appropriate uses.

2.2 Regulatory Requirements

The Secretary's Environmental Assessment Requirements (SEARs) and Environment Protection Authority (EPA) Submission for the project nominate the following specific noise issues to be addressed in this assessment.

Table 2.1 – Noise Requirements Under SEARs

Secretary's Environmental Assessment Requirements (SEAR)	Section of Report Addressing SEAR Content
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.	Sections 4, 5, 6 and 7

Noise and vibration impacts are assessed in accordance with a number of policies, guidelines and standards, including:

- NSW 'Interim Construction Noise Guideline' (ICNG – DECC, 2009)
- NSW 'Noise Policy for Industry' (NPfI – EPA, 2017)
- 'Assessing Vibration: A Technical Guideline' (DECC, 2006)
- NSW 'Road Noise Policy' (RNP – DECCW, 2011).

2.3 Receiver Locations

The nearest affected receivers were identified through aerial maps and are presented in Table 2.2.

Table 2.2 – Receiver Locations

ID	Address	Description
R1	7009 Goolma Road, Montefiores	Residential property located approximately 235 m south of the development area
R2	6773 Goolma Road, Wuuluman	Residential property located approximately 870 m south-east of the development area
R3	59 Twelve Mile Road, Wuuluman	Residential property located approximately 1,030 m north-east of the development area
R4	6938 Goolma Road, Montefiores – Dwelling 2	Residential property located approximately 490 m north-west of the development area
R5	6938 Goolma Road, Montefiores – Dwelling 1	Residential property located approximately 525 m north-west of the development area

ID	Address	Description
R6	7009 Goolma Road, Montefiores	Residential property located approximately 655 m south-west of the development area
R7	79 Twelve Mile Road, Wuuluman	Residential property located approximately 1,195 m north-east of the development area
R8	60 Bela Vista Lane, Montefiores	Residential property located approximately 540 m west of the development area
R9	6945 Goolma Road, Wuuluman	Residential property located approximately 1,330 m south of the development area
R10	7 Cadonia Drive, Wuuluman	Residential property located approximately 1,365 m north-east of the development area

Figure 1 provides details of the development footprint, surrounds and receiver locations. Figure 2 provides the indicative infrastructure layout showing where key infrastructure components would likely be located and most closely represents the area of actual impact required to operate the BESS.

2.4 Hours of Operation

2.4.1 Construction

The construction phase of the Project would take about 9-18 months. The peak construction period would be a shorter period of about 6 months.

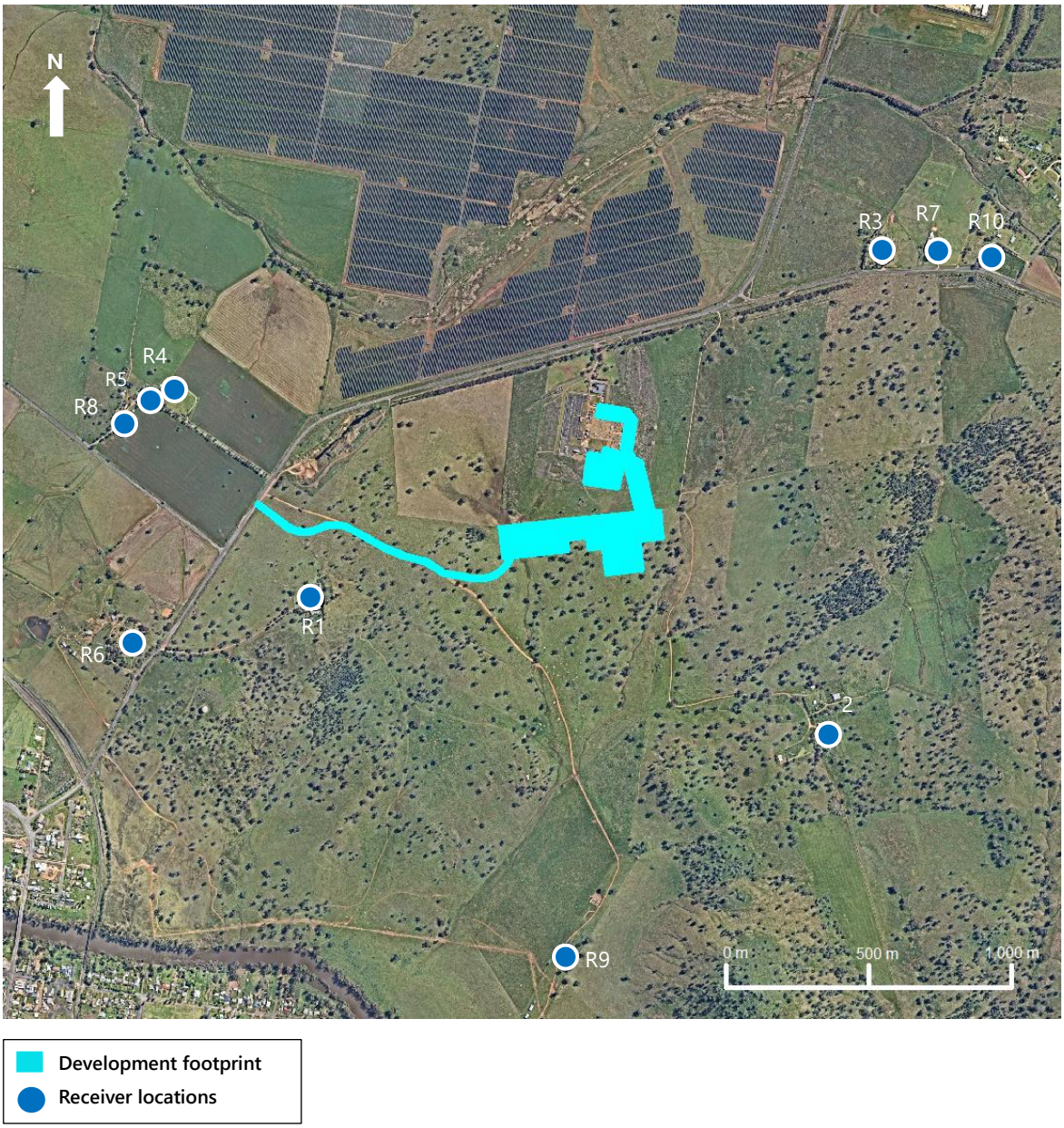
Construction will occur during the following standard hours of construction:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 8:00am to 1:00pm
- No work on Sundays or public holidays

2.4.2 Operation

The BESS will operate continuously and remotely operated for the majority of the time. There may be staff on-site at times.

Figure 1 – Development footprint, Surrounds and Receiver Locations



3 Existing Noise Environment

Background noise varies over the course of any 24 hour period, typically from a minimum at 3am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NPfI requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The NPfI defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

The identified receivers surrounding the Project site are all classified as rural under NPfI guidelines. Based on Table 2.1 on page 10 of the NPfI, for a conservative assessment the minimum assumed Rating Background Levels (RBLs) are adopted for all receiver locations. Therefore, the applicable RBLs used for this assessment are presented in Table 3.1 below.

Table 3.1 – Applicable RBLs, dB(A)

Time of Day	Minimum RBL, dB(A)[1]	Applicable RBL, dB(A)
Day	35	**35**
Evening	30	**30**
Night	30	**30**

Notes: 1. In accordance with Table 2.1 of the NSW NPfI

4 Construction Noise Assessment

4.1 Construction Noise Management Levels

The NSW 'Interim Construction Noise Guideline' (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- *Use of L_{Aeq} as the descriptor for measuring and assessing construction noise*

  NSW noise policies, including the NPfI, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- *Application of reasonable and feasible noise mitigation measures*

  As stated in the ICNG, 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.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the length of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

Table 4.1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 4.1 – Noise Management Levels (NML) at Residential Receivers, dB(A)

Time of Day	Management Level $L_{Aeq,15\ min}$	How to Apply
Recommended standard hours: Monday to Friday 7:00am to 6:00pm Saturday 8:00 am to 1:00pm No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	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)	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 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Table 4.2 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the minimum RBLs presented in Table 3.1, the proposed construction hours and the above ICNG requirements. Given that construction works are to occur during the daytime period as presented in Section 2.4.1, only the daytime period will be assessed.

Table 4.2 – Construction Noise Management Levels (NML) at Residential Receivers, dB(A)

Location Description	Day L_{A90} Background Noise Level (RBL)	Day NML $L_{Aeq,15\ min}$
All residential receivers	35[1]	**45**

Notes: 1. Construction works occur during the daytime period only; hence, only the day period is assessed

4.2 Construction Noise Sources

The following tables lists typical plant and equipment likely to be used by the contractor to carry out the necessary construction works for the project.

Table 4.3 – Typical Construction Equipment & Sound Power Levels

Plant Item	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re. 1pW (single item)
1	Crane	110
2	Drum roller	109
3	Padfoot roller	109
4	Wheeled loader	109
5	Dump truck	108
6	30t Excavator	107
7	Grader	107
8	Chain trencher	104
9	Water truck	104
10	Telehandler	98
11	Forklift	90

The sound power levels for the majority of activities presented in the above table are provided by the client, based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the ICNG, information from past projects and/or information held in our library files.

4.3 Construction Noise Assessment

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area, and possible noise control treatments using the CadnaA (version 2021 MR 1) noise modelling computer program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The noise prediction models takes into account:

- Location of noise sources and receiver locations
- Height of sources and receivers
- Separation distances between sources and receivers
- Ground type between sources and receivers (soft)
- Attenuation from barriers (natural and purpose built).

Noise levels at any receptors resulting from construction would depend on the above and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary substantially over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 4.4 presents construction noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the project. The noise level ranges represent the noise source being located at the furthest to the closest proximity to each receiver location.

Table 4.4 – Predicted $L_{Aeq,15\ min}$ Construction Noise Levels at Receiver Locations, dB(A)

Plant Item	Plant Description	Predicted $L_{eq,15\ min}$ Construction Noise Levels									
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Noise Management Level[1]		*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
1	Crane	<20-44	<20-32	<20-29	<20-38	<20-37	<20-33	<20-32	<20-26	<20-27	<20-26
2	Drum roller	<20-43	<20-31	<20-28	<20-37	<20-36	<20-32	<20-31	<20-25	<20-26	<20-25
3	Padfoot roller	<20-43	<20-31	<20-28	<20-37	<20-36	<20-32	<20-31	<20-25	<20-26	<20-25
4	Wheeled loader	<20-43	<20-31	<20-28	<20-37	<20-36	<20-32	<20-31	<20-25	<20-26	<20-25
5	Dump truck	<20-42	<20-30	<20-27	<20-36	<20-35	<20-31	<20-30	<20-24	<20-25	<20-24
6	30t Excavator	<20-41	<20-29	<20-26	<20-35	<20-34	<20-30	<20-29	<20-23	<20-24	<20-23
7	Grader	<20-41	<20-29	<20-26	<20-35	<20-34	<20-30	<20-29	<20-23	<20-24	<20-23
8	Chain trencher	<20-38	<20-26	<20-23	<20-32	<20-31	<20-27	<20-26	<20-20	<20-21	<20-20
9	Water truck	<20-38	<20-26	<20-23	<20-32	<20-31	<20-27	<20-26	<20-20	<20-21	<20-20
10	Telehandler	<20-32	<20-20	<20	<20-26	<20-25	<20-21	<20-20	<20	<20	<20
11	Forklift	<20-24	<20	<20	<20	<20	<20	<20	<20	<20	<20
Up to 3 (noisiest) plant operating concurrently		<20-**48**	<20-36	<20-33	<20-42	<20-41	<20-38	<20-32	<20-30	<20-31	<20-30

Notes: **Bold** font denotes exceedance of Noise Management Level

Based on the predicted construction noise levels presented in the table above, the construction noise management level will be exceeded when works are conducted at the closest proximity and when the three noisiest plant items are operating concurrently, for Receiver R1, by up to 3 dB(A). Predicted construction noise levels at all other receivers will comply with the construction noise management levels.

Furthermore, construction noise levels at all receivers are predicted to be below the highly noise affected level of 75 dB(A).

It should be noted that the exceedance predicted is based on the three loudest plant and equipment operating concurrently and at a location closest to the corresponding receiver location. This scenario would not typically occur on site.

For Receiver R1, it is expected that the exceedance of the noise management level would likely occur when the construction works are conducted within approximately 700m of the dwelling / building. Construction works conducted within approximately 700m of the dwelling / building would typically be completed over two to three days. Construction works conducted beyond 700m of the dwelling / building of Receiver R1 would comply with the noise management level. In light of the short duration of predicted noise exceedances, it is recommended that a feasible and reasonable approach towards noise management measures be applied, in consultation with the potentially affected residents.

Further details on construction noise management measures are provided in Section 4.4 below.

4.4 Construction Noise Management Measures

The following recommendations provide in-principle feasible and reasonable noise management measures to reduce noise impacts to sensitive receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

For construction works conducted within approximately 700m of the dwelling / building of Receiver R1, potential noise impacts to this location will be managed by implementing time restrictions and/or providing periods of repose for residents, where feasible and reasonable. For example, between 10am and 3pm (with one-hour break for lunch between 12pm and 1pm), noisy activities could occur with no noise level restrictions over a limited time period. Allowing the construction activities to proceed, despite the noise exceedance may be the preferred method in order to complete the works expeditiously, with noise exceedances occurring over only 2-3 days. Residents would be consulted to determine appropriate respite periods and will be notified of the potential noise impact during this time period so that they can organise their day around the noisy period.

In addition, the following noise management measures should be considered.

- Plant and equipment should be properly maintained.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

A draft construction noise management plan is presented in Appendix B which includes additional noise mitigation and management measures to be considered.

5 Operational Noise Assessment

5.1 Operational Noise Criteria

Noise impact from the general operation of the project is assessed against the NSW 'Noise Policy for Industry' (NPfI). The assessment procedure in terms of the NPfI has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the project noise trigger level which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

5.1.1 Intrusive Noise Impacts

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq,15\ min}$ descriptor) does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

$L_{Aeq,15\ min}$ Intrusiveness noise level = Rating Background Level (RBL) plus 5 dB(A)

Based on the minimum RBLs presented in Table 3.1, the intrusiveness noise levels for the residential receivers are determined in Table 5.1.

Table 5.1 – NPfI Intrusive Noise Levels at Residential Receivers, dB(A)

Period	RBL, dB(A)	Intrusiveness Noise Level, $L_{Aeq,15\ min}$, dB(A)
Daytime	35	35+5 = **40**
Evening	30	30+5 = **35**
Night-time	30	30+5 = **35**

5.1.2 Protecting Noise Amenity

The project amenity noise levels for different time periods of a day are determined in accordance with Section 2.4 of the NSW NPfI. The NPfI recommends amenity noise levels ($L_{Aeq,\ period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for **total** industrial noise experienced at a receiver location. However, when assessing a **single** industrial development and its impact on an area, "project amenity noise levels" apply.

To ensure that the total industrial noise level (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level that applies for each new industrial noise source is determined as follows:

$L_{Aeq,period}$ Project amenity noise level = $L_{Aeq,period}$ Recommended amenity noise level – 5 dB(A)

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$$L_{Aeq,15\ min} = L_{Aeq,period} + 3\ dB(A)$$

The policy, in accordance with the NPfI, applies an adjustment of (+3 dB) to the recommended noise levels ($L_{Aeq,period}$) in order to standardise the time periods for the intrusiveness and amenity noise levels. The project amenity noise levels ($L_{Aeq,15\ min}$) applied for this project are reproduced in Table 5.2.

It is noted that the residential receivers in the vicinity of the site have been categorised as being in a 'rural' area in accordance with Table 2.3 of the NPfI.

Table 5.2 – NPfI Project Amenity Noise Levels, dB(A)

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended Noise Level	
			$L_{Aeq,\ Period}$	$L_{Aeq,15\ min}$
Residence	Rural	Day	50 – 5 = 45	45 + 3 = **48**
		Evening	45 – 5 = 40	40 + 3 = **43**
		Night	40 – 5 = 35	35 + 3 = **38**

Notes:
1. Monday-Saturday, Day 7.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night 10.00pm to 7.00am
2. On Sundays and Public Holidays, Day 8.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night 10.00pm to 8.00am
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

5.1.3 Summary of Project Noise Trigger Levels

In accordance with the NPfI the project noise trigger level, which is the lower (ie. more stringent) value of the project intrusiveness noise level and project amenity noise level, has been determined and reproduced in Table 5.3 below.

Table 5.3 – Project Noise Trigger Levels, dB(A)

Receiver ID	Address	$L_{Aeq, 15min}$ Project Noise Trigger Levels		
		Day	Evening	Night
R1	7009 Goolma Road, Montefiores	40	35	35
R2	6773 Goolma Road, Wuuluman	40	35	35
R3	59 Twelve Mile Road, Wuuluman	40	35	35
R4	6938 Goolma Road, Montefiores – Dwelling 2	40	35	35
R5	6938 Goolma Road, Montefiores – Dwelling 1	40	35	35
R6	7009 Goolma Road, Montefiores	40	35	35
R7	79 Twelve Mile Road, Wuuluman	40	35	35
R8	60 Bela Vista Lane, Montefiores	40	35	35
R9	6945 Goolma Road, Wuuluman	40	35	35
R10	7 Cadonia Drive, Wuuluman	40	35	35

Notes:
1. Monday-Saturday, Day 7.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night 10.00pm to 7.00am
2. On Sundays and Public Holidays, Day 8.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night 10.00pm to 8.00am
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period

5.2 Operational Noise Sources

The following table lists associated plant and equipment likely to be used for the operation of the proposed BESS and their corresponding sound power levels.

Table 5.4 – Typical Operational Plant and Equipment & Sound Power Levels

Plant Item	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re. 1pW
1	Battery stacks (Powin S750) – 2660 in total	86 (each)
2	Inverters (WD3s) – 140 in total	98 (each)
3	MV transformer (Generic) – 70 in total	70 (each)

The sound power levels for the plant and equipment presented in the above table have been provided by the manufacturer, information from past projects and/or information held in our library files. The plant and equipment included are all packaged units and all sound power levels include the noise component from associated fans / cooling systems.

5.3 'Modifying Factor' Adjustments

Further to the above and in accordance with the NPfI, where the character of the noise in question is assessed as particularly annoying (i.e. if it has an inherently tonal, low frequency, impulsive or intermittent characteristic), then an adjustment of 5 dB(A) for each annoyance aspect, up to a total of 10 dB(A), is to be added to the predicted value to penalise the noise for its potential increase in annoyance. Table C1 in Fact Sheet C of the NSW NPfI provides definitive procedures for determining whether a penalty or adjustment should be applied from increased annoyance.

For the assessment of the BESS, the noise from the inverters and transformers are considered to be tonal in nature. Therefore, a 5 dB(A) penalty has been applied to the predicted noise contributions from the inverters and transformers.

5.4 Operational Noise Assessment

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area, and possible noise control treatments using the CadnaA (version 2022 MR 2) noise modelling computer program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The noise prediction models takes into account:

- Location of noise sources and receiver locations
- Height of sources and receivers
- Separation distances between sources and receivers
- Ground type between sources and receivers (soft)
- Attenuation from barriers (natural and purpose built).

Furthermore, in accordance with Fact Sheet D, Table D.1 of the NPfI noise predictions were prepared for the following standard and noise-enhancing meteorological conditions:

1. **Standard meteorological conditions** – 0.5 m/s wind velocity at 10 m from ground level between each noise source and each noise receiver. Wind direction was based on wind travelling from the source to the receiver
2. **Slight to gentle breeze** – 3 m/s wind velocity at 10 m from ground level between each noise source and each noise receiver (as per NPfI default wind conditions). Wind direction was based on wind travelling from the source to the receiver
3. **Moderate temperature inversion** – applicable for noise predictions during night time periods only. F-class temperature inversion with 2 m/s wind velocity at 10m from ground level between each noise source and each noise receiver.

Table 5.5 below present the predicted noise levels for the worst-case scenario based on concurrent operation of all the plant and equipment shown in Table 5.4.

Table 5.5 – Predicted $L_{Aeq,15\ min}$ Operational Noise Levels at Residential Receiver Locations, dB(A)

Receiver Location	Project Noise Trigger Levels			Predicted Operational Noise Levels			Comply? (Yes/No)
	Day	Evening	Night	Calm & Isothermal Conditions	Slight to Gentle Breeze	Moderate Temperature Inversion[1]	
R1	*40*	*35*	*35*	32	33	33	Yes
R2	*40*	*35*	*35*	30	31	31	Yes
R3	*40*	*35*	*35*	29	29	29	Yes
R4	*40*	*35*	*35*	27	27	27	Yes
R5	*40*	*35*	*35*	27	27	27	Yes
R6	*40*	*35*	*35*	<20	<20	<20	Yes
R7	*40*	*35*	*35*	27	28	28	Yes
R8	*40*	*35*	*35*	23	24	24	Yes
R9	*40*	*35*	*35*	31	32	32	Yes
R10	*40*	*35*	*35*	26	26	26	Yes

Notes: 1. Applicable for the night time period only

Based on the predicted operational noise levels presented in the table above, predicted noise levels at the nearest receivers comply with the nominated criteria under all scenarios

Therefore, no further reasonable and feasible noise mitigation measures are required to reduce operational noise impacts.

5.5 Cumulative Operation Noise Assessment

It is likely that the Wellington Solar Farm would be operating concurrently with the Orana BESS. Therefore, cumulative noise impacts at the nearest affected receivers due to both sites operating have been considered. Not all receivers identified in Section 2.3 have been included in the Wellington Solar Farm noise and vibration assessment [ref: TJ643-01F01 Report (r5), dated 24 November 2017], as they were not identified as one of the nearest affected receivers and therefore were predicted to comply with the project trigger levels established within the report.

An assessment of the cumulative operational noise from the Orana BESS and the Wellington Solar Farm has been quantified for the receivers that have been identified as being the nearest affected receiver for both sites (i.e. Receivers R3 and R4). The cumulative noise levels are presented in Table 5.6 for the applicable meteorological conditions.

Table 5.6 – Predicted $L_{Aeq,15min}$ Cumulative Operational Noise Levels at Receiver Locations, dB(A)

Receiver Location	Project Noise Trigger Levels			Predicted Operational Noise Levels, $L_{Aeq,\ 15min}$									Comply? (Yes/No)
				Calm & Isothermal Conditions			Slight to Gentle Breeze			Moderate Temperature Inversion[1]			
	Day	Evening	Night	Wellington Solar Farm	Orana Bess	Cumulative[2]	Wellington Solar Farm	Orana Bess	Cumulative[2]	Wellington Solar Farm	Orana Bess	Cumulative[2]	
Receiver R3	*40*	*35*	*35*	31	29	33	35	29	**36**	35	29	**36**	**No**
Receiver R4	*40*	*35*	*35*	25	27	29	31	27	32	31	27	31	Yes

Notes: 1. Applicable for the night time period only

2. Overall noise contribution from Orana BESS and Wellington Solar Farm

3. **Bold** font indicates exceedance

However, under noise enhancing weather conditions, the predicted cumulative noise levels at Receiver R3 exceed the criterion by 1 dB(A) during adverse weather conditions. The exceedance at R3 is mainly attributed to the noise emissions from the Wellington Solar Farm, which predicts noise levels equal to the evening and night time Project Noise Trigger Levels of 35 dB(A).

In accordance with Table 4.1 and Table 4.2 of the NPfI, a 1 dB(A) exceedance is considered to be negligible as a 1 dB(A) change in noise level is not discernible or noticeable to the average person. Therefore, the predicted noise levels at Receiver R3 are determined to be acceptable in accordance with the NPfI and no further reasonable and feasible noise mitigation measures are required.

5.6 Sleep Disturbance Assessment

To assess the likelihood of sleep disturbance, the potential of maximum noise level events from the subject site during the night-time period has been considered in this assessment. In accordance with the NPfI, a detailed maximum noise level event assessment should be undertaken where the subject development night-time noise levels at a residential location exceed:

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

Where there are noise events found to exceed the initial screening level, further analysis is undertaken to identify:

- The likely number of events that might occur during the night assessment period,
- The extent to which the maximum noise level exceeds the rating background noise level.

During the night time period, only mechanical plant will be operating, including battery stacks, inverters and transformers. Noise emissions from these plant items are considered to be continuous with no potential for high peak noise level events. Therefore, the L_{Amax} noise levels experienced at the identified receivers will be similar to the predicted $L_{Aeq,15\ min}$ noise levels shown in Table 5.5. Hence, it is expected that both the $L_{Aeq,15\ min}$ and L_{AFmax} will be well below the nominated sleep disturbance criteria of 40 dB(A) and 52 dB(A), respectively.

6 Vibration Assessment

Vibration generating activities would occur only during the construction phase of the project. There are no vibration generating activities expected during the operational phase. As the nearest identified receivers are in excess of 235m from the subject site, structural damage due to vibration is not expected. Assessment for construction vibration impact on human comfort is assessed in accordance with EPA requirements.

6.1 Vibration Criteria

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's *'Assessing Vibration; a technical guideline'* (DECC, 2006). The guideline provides criteria which are based on British Standard BS 6472-1992 *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 6.1 provides definitions and examples of each type of vibration.

Table 6.1 – Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

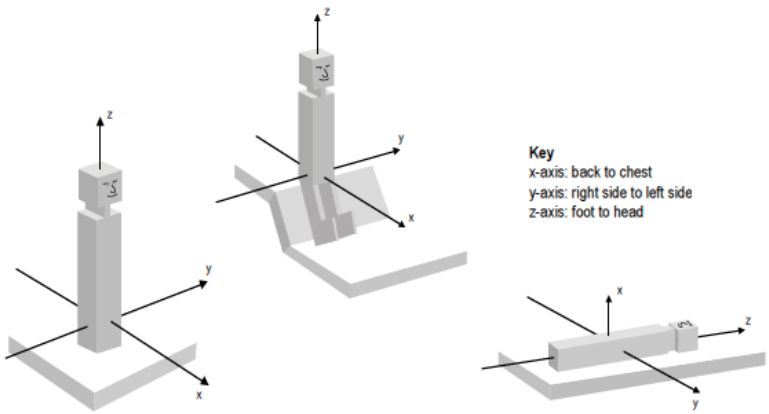
The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *"Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472)."*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore,

application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2 – Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced in Table 6.2 for the applicable receivers.

Table 6.2 – Preferred and Maximum Levels for Human Comfort

Location	Assessment Period[1]	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14

Notes: 1. Daytime is 7:00am to 10:00pm and Night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 6.3 for the applicable receiver type.

Table 6.3 – Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26

Notes: 1. Daytime is 7:00am to 10:00pm and Night-time is 10:00pm to 7:00am

6.2 Potential Vibration Impacts

Based on the proposed construction plant items presented in Table 4.3, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 6.4 below. The assessment is relevant to the identified receiver locations.

Table 6.4 – Potential Vibration Impacts for Identified Receivers

Receiver ID	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts	Vibration Monitoring
R1	234 m	Residential	Very low risk of adverse comments	Not required
R2	870 m	Residential	Very low risk of adverse comments	Not required
R3	1,030 m	Residential	Very low risk of adverse comments	Not required
R4	490 m	Residential	Very low risk of adverse comments	Not required
R5	525 m	Residential	Very low risk of adverse comments	Not required
R6	655 m	Residential	Very low risk of adverse comments	Not required
R7	1,195 m	Residential	Very low risk of adverse comments	Not required
R8	540 m	Residential	Very low risk of adverse comments	Not required
R9	1,330 m	Residential	Very low risk of adverse comments	Not required
R10	1,365 m	Residential	Very low risk of adverse comments	Not required

The potential for adverse comments to vibration impacts during the construction works was determined to be very low due to the large distances between the receiver locations and the construction activities. Therefore, additional vibration mitigation measures and vibration monitoring are not required at the identified receiver locations during construction works associated with the project.

7 Road Traffic Noise Assessment

Noise impact from the potential increase in traffic on the surrounding road network due to construction and operational activities is assessed against the NSW 'Road Noise Policy' (RNP). The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for sensitive receivers that are potentially affected by road traffic noise associated with the construction and operation of the subject site, with the aim of preserving the amenity appropriate to the land use.

Based on information provided by the client, the peak vehicle movements during the construction stage of the project are presented in the following table. Furthermore, vehicle movements will only occur during the day time period when construction works occur. Access to the subject site is directly off Goolma Road.

Table 7.1 – Summary of the Estimated Construction Traffic Volumes During Peak Construction

Vehicle Type	Daily Peak Vehicle Movements (two-way)
Light Vehicles	40
Shuttle Bus	20
Heavy Vehicles	60
Total	**120**

During the operational stage, vehicle access to the site will be maintenance vans or delivery trucks which would occur on an irregular basis. Traffic noise impacts during the operational stage of the project would be minimal and insignificant and will not be assessed further.

7.1 Road Traffic Noise Criteria

Based on functionality, Goolma Road is categorised as an arterial road. For existing residences affected by additional traffic on existing arterial roads generated by land use developments, the following RNP road traffic noise criteria apply.

Table 7.2 – RNP Road Traffic Noise Criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment Criteria, dB(A)	
		Day 7:00am – 10:00pm	Night 10:00pm – 7:00am
Freeway/arterial/sub-arterial roads	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,15\ hr}$ 60 (external)	$L_{Aeq,9\ hr}$ 55 (external)

Further to the above, the RNP states the following for land use developments generating additional traffic:

*"For existing residences and other sensitive land uses affected by **additional traffic on existing roads generated by land use development**, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'."*

7.2 Predicted Road Traffic Noise

Results of the construction traffic noise predictions are presented in the table below. It is noted that the predicted noise levels represent the traffic noise contribution from the vehicle movements associated with the construction works and does not take into account existing traffic noise levels due to existing general traffic flows as existing traffic volumes along Goolma Road are unknown.

Table 7.3 – Predicted Road Traffic Noise Contribution Levels Along Public Roads, dB(A) $L_{Aeq,15\ hr}$

Receiver	Criteria	Traffic Movements	Speed (km/h)[1]	Distance to Road[2]	Predicted Noise Level	Exceed?
Residences on Goolma Road	$L_{Aeq,15\ hr}$ 60	As per Table 7.1	100	20 m	53	No

Notes: 1. Based on posted speed limit
2. Based on closest typical distance from facade of dwelling to the road

From the above table, it can be seen that road traffic noise level contributions from the vehicle movements associated with the construction works are at least 7 dB(A) below the applicable noise criterion based on dwellings being approximately 20m from the road. Given that residences are located within a rural environment, distances between the road and the dwellings would likely be significantly greater than 20m.

Furthermore, as the predicted levels are 7 dB(A) less than the traffic noise criterion, it is not expected that the traffic noise contribution from the construction vehicles would result in an exceedance of the traffic noise criterion and/or increase the existing traffic noise levels by more than 2 dB(A).

Therefore, traffic noise levels as a result of the construction works for the subject site would not adversely contribute to the existing traffic noise levels at the most affected residences along the surrounding roads.

8 Conclusion

Renzo Tonin and Associates has completed an environmental noise and vibration assessment of the proposed Orana Battery Energy Storage System.

Noise emissions from the construction phase of the project were predicted to exceed the nominated criteria at one (1) of the nearest nominated receiver locations when the three (3) loudest plant and equipment are operating concurrently and at the closest proximity to the receiver. In-principle recommendations are provided in Section 4.4 to limit the potential impact of noise generated by construction activities to acceptable levels.

Noise emissions from the operational phase of the project were predicted to comply with the nominated criteria at all existing nearest affected receivers.

Given the large separation distance between the nearest affected receivers and the subject site, vibration impacts resulting in structural damage to buildings at the nearest affected receivers are determined to be negligible and there is a very low risk of adverse comments from occupants of dwellings due to construction vibration.

Road traffic noise impacts due to additional traffic generated during the construction phase of the project on residential properties along the access routes were found to comply with the relevant RNP criteria. Road traffic noise impacts from traffic associated with the operation of the project were considered to be negligible due to the minimal traffic movements.

APPENDIX A Glossary of Terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Draft Construction Noise Management Plan

B.1 Project Description

Refer to Section 2.1.

B.2 Receiver Locations

Refer to Section 2.3.

B.3 Construction Hours

Refer to Section 2.4.1.

B.4 Construction Noise Management Levels

Refer to Section 4.1.

B.5 Construction Noise Sources

Refer to Section 4.2.

B.6 Construction Noise Assessment

Refer to Section 4.3.

B.7 Construction Noise Mitigation and Management Measures

The following recommendations provide in-principle feasible and reasonable noise management measures to reduce noise impacts to sensitive receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

B.7.1 General Engineering Noise Controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 "Guide to Noise Control on Construction, Demolition and Maintenance Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after

treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table B.1 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table B.8.1 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise control method	Practical examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table B.2 below identifies possible noise control measures, which are applicable for the construction plant likely to be used on site.

Table B.8.2 – Noise Control Measures for Likely Construction Plant

Plant description	Screening	Acoustic enclosures	Silencing	Alternative process
Dozer	✔	x	✔	x
Grader	✔	x	✔	x
Excavator	✔	x	✔	x
Roller	✔	x	✔	x
Bobcat	✔	x	✔	x
Front End Loader	✔	x	✔	x
Road truck (delivery)	✔	x	✔	x
Concrete truck	✔	x	✔	x
Drilling Rig	✔	✔	✔	x
Crane	✔	x	✔	x

B.7.2 General Noise Management Measures

The following general noise management measures should be followed:

- Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- Trucks should not be left idling when possible.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits. See Appendix B for an example of a complaint handling procedure and form.

Where noise level exceedances cannot be avoided, then consideration may be given to providing periods of repose for residents, where feasible and reasonable.

Some items of plant may exceed noise limits even after noise treatment is applied. To reduce the overall noise impact, the use of noisy plant may be restricted to within certain time periods, where feasible and reasonable and to be negotiated with the residents. For example, between 10am and 3pm (with one-hour break for lunch between 12pm and 1pm), noisy activities could occur with no noise level restrictions over a limited time period. Residents would be notified of the potential noise impact during this time period so that they can organise their day around the noisy period. Allowing the construction activities to proceed, despite the noise exceedance may be the preferred method in order to complete the works expeditiously.