APPENDIX 6

Noise and Vibration Assessment

MARSHALL DAY Acoustics

WATTLE CREEK
BATTERY ENERGY STORAGE SYSTEM PROJECT

SSD-63345458

NOISE AND VIBRATION ASSESSMENT

Rp 003 R01 20220318 | 18 March 2025

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EXECUTIVE SUMMARY

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Wattle Creek Battery Energy Storage System (BESS) project (Project) on land known as the 'Arthursleigh Farm', owned by the University of Sydney (the Project Area), located approximately 15 km northwest of Marulan within the Upper Lachlan Shire Council local government area (LGA).

The Project includes a standalone BESS with 350 MW capacity (AC or DC coupled), and related infrastructure.

Marshall Day Acoustics Pty Ltd (MDA) has been engaged by Umwelt (Australia) Pty Ltd (Umwelt) on behalf of Spark Renewables, to prepare this noise and vibration assessment to support the environmental impact statement (EIS) for the Project.

This report presents the results of an assessment of operational noise and construction noise and vibration for the Project, undertaken in accordance with the applicable Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-63345458) dated 22 December 2023. This document is referred to as the Project SEARs herein.

Operational noise from the Project has been assessed in accordance with the EPA *Noise Policy for Industry* (NPfI) 2017. Predicted noise levels at all non-host landowner receivers are below the most stringent project noise trigger level of 35 dB $L_{Aeq\ 15min}$, applicable during the evening and night periods, by a minimum margin of 9 dB.

Cumulative operational noise, considering the nearby existing Transgrid Marulan Substation, proposed Marulan Gas Fired Power Station, and proposed Wattle Creek Solar Farm project (to be located within the Project Area), has been conducted. The assessment indicates that the individual project amenity noise levels, the recommended amenity noise levels for the receiver categories, and therefore the overall intent of the NPfI with respect to cumulative industrial noise is satisfied.

The findings of the operational noise assessment therefore demonstrate that the Project is capable of being designed and operated to comply with Project SEARs requirements for operational noise at all non-host landowner receivers. It is recommended that the predicted noise levels for all components of the operational noise assessment be updated for the final Project design configuration and equipment selections, in order to verify compliance with the project noise trigger levels prior to the commencement of construction.

A preliminary assessment of both on-site and off-site construction noise and vibration has been conducted, accounting for typical equipment items and work practices, as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the DECC (Department of Environment and Climate Change) *Interim Construction Noise Guideline* (ICNG) 2009 and DEC (Department of Environment and Conservation) *Assessing Vibration: A Technical Guideline* (AVTG) 2006. The assessment confirmed that construction noise and vibration can be appropriately managed using standard good practice management and mitigation measures.

Measures for the management of construction noise and vibration would be implemented via the Construction Environmental Management Plan (CEMP) to be prepared during the detailed design phase of the Project, when a construction contractor has been selected and specialised construction planning for the site has been developed. This would comprise a detailed noise and vibration assessment, as well as project specific noise mitigating work practices and physical noise controls (where required).

An assessment of traffic noise associated with construction traffic movements on local and freeway/arterial/sub-arterial roads has been conducted in accordance with the DECCW (Department of Environment, Climate Change and Water) *Road Noise Policy* (RNP) 2011. The assessment established setback distances for both road types within which applicable traffic noise criteria may be exceeded.

3 receivers are located within or close to the setback zones (R108, R268, R270). These receivers have the potential to be adversely affected by general construction traffic and over-size/over-mass (OSOM) traffic movements.

These receivers should be consulted prior to and during construction activities to manage impacts and considered in more detail as part of the CEMP. Noise mitigation options are generally limited for local roads however a number of conceptual noise control measures, including speed limits, traffic limits, and OSOM scheduling have been provided. Community consultation and regular communication are typically the most effective and practical means of minimising adverse impacts. It is also understood that Spark Renewables are offering a construction disruption payment to residents living near Canyonleigh Road, to assist in mitigating construction related traffic impacts.

Overall, the assessment provided herein demonstrates that construction, operation and decommissioning of the Project can be designed and executed such that related noise is capable of complying with the relevant guidelines and criteria set out in the Project SEARs, at all non-host landowner receivers.

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1.0 INTRODUCTION

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Wattle Creek Battery Energy Storage System (BESS) project (Project)on land known as the 'Arthursleigh Farm' (the Project Area), owned by the University of Sydney, located approximately 15 km northwest of Marulan within the Upper Lachlan Shire Council local government area (LGA).

The Project includes a standalone BESS with 350 MW capacity (AC or DC coupled) and additional related infrastructure.

Marshall Day Acoustics Pty Ltd (MDA) has been engaged by Umwelt (Australia) Pty Ltd (Umwelt) on behalf of Spark Renewables, to prepare this noise and vibration assessment to support the environmental impact statement (EIS) for the Project.

This report presents the results of an assessment of operational noise and construction noise and vibration for the Project, undertaken in accordance with the applicable Planning Secretary's Environmental Assessment Requirements (SEARs) (SSD-63345458) dated 22 December 2023. This document is referred to as the Project SEARs herein.

The Project SEARs require the following assessments:

- Operational noise in accordance with the NSW EPA (Environment Protection Authority) *Noise Policy for Industry* (NPfI) 2017 (refer to Section 6.0).
- Construction noise under the DECC (Department of Environment and Climate Change) *Interim Construction Noise Guideline* (ICNG) 2009 (refer to Section 8.0).
- Traffic noise under the DECCW (Department of Environment, Climate Change and Water) *Road Noise Policy* (RNP) 2011 (refer to Section 9.0).
- Cumulative noise impacts (considering other developments in the area) (refer to Section 7.0).

The noise assessment presented in this report is based on:

- Noise limits determined in accordance with applicable regulatory documentation.
- Predicted operational noise levels, based on the proposed site layout and equipment noise emission data.
- Predicted construction noise levels, based on noise data detailed in relevant standards.
- Predicted traffic noise levels due to additional road traffic during construction and operation, based on traffic data provided by a third party.

Blasting activities are not proposed and have not been considered in this report.

A glossary of terminology is provided in Appendix A with general information regarding the description of sound provided in Appendix B.

2.0 PROJECT OVERVIEW

2.1 Description

The Project comprises a large, grid-scale energy storage facility, supported by associated infrastructure. The Project will have a capacity of up to approximately 350 MW and will have provision for up to 4 hours of storage (1400 MWh).

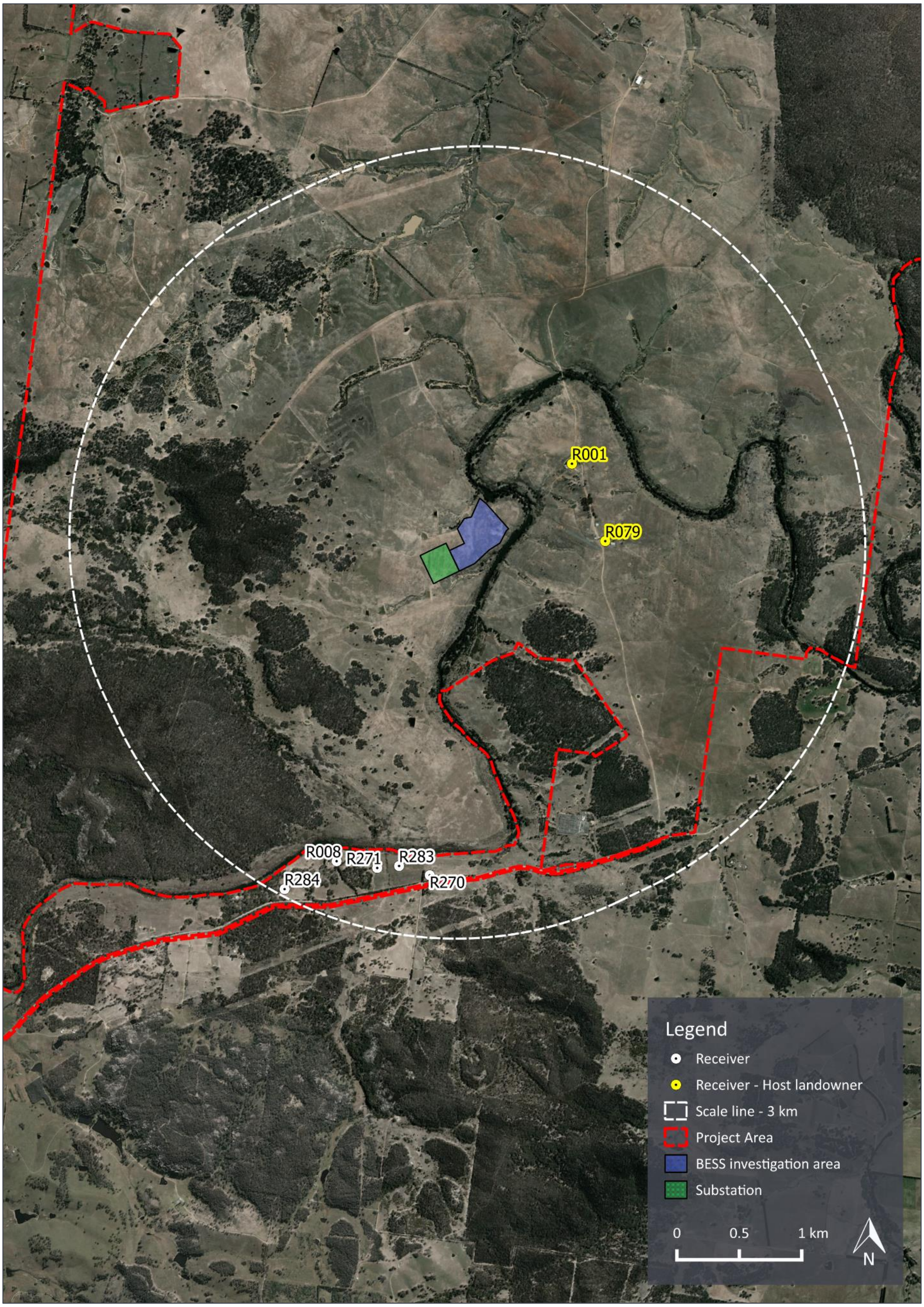
The key components of the Project include:

- A BESS with up to 350 MW/1400 MWh capacity, comprised of battery units, inverters, transformers and metering infrastructure.
- On-site collector substation to connect the Project to the electricity transmission network via the Transgrid Marulan Substation. An 80 m communication mast is also included at the collector substation location.
- Two overhead transmission line options to connect to the transmission network, to allow for optionality during the assessment process and greater flexibility in the connection design.
- Internal electrical reticulation network, i.e. electrical connections between the proposed panels and collector substation consisting of a combination of underground cables and overhead powerlines.
- Operation and maintenance (O&M) facility – including a site office, O&M buildings, amenities, equipment sheds, storage, and parking areas.
- Other associated permanent infrastructure including hardstands, new access tracks, upgrades to existing access tracks, minor upgrade to the existing access point from Canyonleigh Road, and static water tanks.
- Targeted road network resurfacing to facilitate delivery of Project components to the Project Area as required.
- Temporary and permanent meteorological monitoring masts.
- Temporary construction facilities including:
- Construction compound/s with site office building(s).
- Laydown areas used for installation and storage of BESS components.

A conceptual Project layout illustrating the general Project Area and noise generating infrastructure in relation to noise sensitive receivers is provided in Figure 1.

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

Figure 1: Conceptual Project layout



2.2 Receivers

Throughout this report, the term receiver is used to identify any noise-sensitive land use in the vicinity of the Project. Noise sensitive land uses have been determined in accordance with the requirements of the NPfI.

A total of 7 receivers have been identified by Spark Renewables within 3 km of noise generating infrastructure associated with the Project and are therefore relevant for consideration within this noise assessment. All receivers are identified as residences.

Of the 7 identified receivers, 2 receivers are located within the Project Area. These receivers are specially identified as being related to the Project host landowner. In particular R001 is a permanent residence for the on-site farm manager. R079 is used infrequently as temporary accommodation by research staff and students of the University.

Spark Renewables have advised that the relationship between noise from the Project and the host landowner properties will be managed internally by the University of Sydney. However, for completeness, these receivers are included in the noise assessment for information only.

The coordinates of the receivers identified within 3 km of the primary noise generating infrastructure associated with the Project are tabulated in Appendix D.

3.0 NEW SOUTH WALES POLICY & GUIDELINES

Based on the requirements specified in the Project SEARs, the following publications are relevant to the assessment of noise related to the Project.

- EPA (Environment Protection Authority) *Noise Policy for Industry* (NPfI) 2017
- DECC (Department of Environment and Climate Change) *Interim Construction Noise Guideline* (ICNG) 2009
- DECCW (Department of Environment, Climate Change and Water) *Road Noise Policy* (RNP) 2011.

Additionally, whilst not explicitly required by the Project SEARs, reference has also been made to the following document:

- DEC (Department of Environment and Conservation) *Assessing Vibration: A Technical Guideline* (AVTG) 2006

Details of the guidance and noise criteria provided by these publications are provided in the following sections.

3.1 Noise Policy for Industry

The NPfI is the applicable guideline for assessing operational noise associated with the Project.

The NPfI provides a method for determining project noise trigger levels that are used for assessing the potential impact of noise from industry at existing receivers. Specifically, the project noise trigger levels provide a benchmark or objective for assessing a proposal or site. The NPfI states that the project noise trigger levels are not intended for use as mandatory requirements, but represent the levels that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response; for example, further investigation of mitigation measures.

The project noise trigger levels are derived from an analysis of the background noise environment and zoning information, accounting for acoustic amenity (described as project amenity noise levels) and, in the case of residential receivers, accounting for intrusiveness (described as project intrusiveness noise levels). The project noise trigger levels are defined as the minimum of the project amenity noise level and the project intrusiveness noise level (where applicable).

Additional trigger levels are defined for the assessment of maximum noise level events. This is typically associated with sleep disturbance arising from noise sources that are characterised by transient events i.e. brief periods of increased noise levels and applies during the night-time period only.

The following subsections describe the amenity and intrusiveness noise levels used to determine the project noise trigger levels. Further details on the derivation of appropriate project noise trigger levels for the assessment of operational noise levels from the Project are provided in Section 6.1 and Appendix E.

3.1.1 Project amenity noise levels

Project amenity noise levels are designed to prevent industrial noise continually increasing above an acceptable level over time with the expansion of infrastructure and development. The NPfI provides recommended amenity noise levels based on receiver categories and typical planning zones, from which the project amenity noise levels are derived.

The recommended amenity noise levels outlined in the NPfI have been determined on the basis of studies that relate industrial noise to annoyance in communities and have been subjectively scaled to reflect the perceived differential expectations and ambient noise environments of rural, suburban, and urban communities for residential receivers. They are based on protecting the majority of the community (90 %) from being highly annoyed by industrial noise.

The recommended amenity levels defined in the NPfI relate to total industry noise levels. The project amenity noise levels for an individual industry, i.e. the Project, are set at a level 5 dB below the recommended amenity levels to provide a margin for cumulative industry noise.

A further modification is made to standardise the amenity assessment time period to align with the intrusiveness assessment.

3.1.2 Project intrusiveness noise levels

The intrusiveness noise assessment is applicable to residential receivers and is based on knowledge of the background noise level at the receiver. The background noise levels are referred to as the rating background noise level (RBL) in the NPfI.

The intrusiveness noise level is the RBL at the nearest noise sensitive location plus 5 dB. Therefore, the noise emissions from the subject industry, i.e. the Project, are considered to be intrusive if the source noise level ($L_{Aeq,\ 15\ min}$) is greater than the RBL (L_{A90}) plus 5 dB.

3.2 Interim Construction Noise Guideline

The ICNG aims to provide a clear understanding of ways to identify and minimise noise from construction works through applying all ‘feasible’ and ‘reasonable’ work practices to control noise impacts. The guideline identifies sensitive land uses and recommends construction hours, provides quantitative and qualitative assessment methods, and subsequently advises on appropriate work practices.

The ICNG recommended standard construction hours are detailed in Table 1.

Table 1: ICNG recommended standard hours of work

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

In relation to residential receivers considered in this assessment, and based on the recommended standard hours, the ICNG provides two primary management levels for consideration in the assessment of noise at residential receivers:

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

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

The ICNG also defines the following 5 categories of works that might be undertaken outside the recommended standard hours:

- the delivery of oversized plant or structures that police or other authorities determine require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- public infrastructure works that shorten the length of the project and are supported by the affected community
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

The ICNG defines additional assessment and reporting requirements that apply if out of hours work is proposed, including justification of the need to work during these periods, including additional management levels for ground borne noise from construction vibration.

General construction works associated with the Project are only expected to occur during standard working hours. On this basis a detailed assessment of out of hours construction activity is not included in this report.

While not currently planned or scheduled, unavoidable works outside of standard hours could conceptually comprise the delivery of over-size/over-mass (OSOM) components at times selected to minimise traffic disruption associated with intersection closures and unloading or installation of oversize equipment, such as power transformers.

Should these works be required, an out of hours construction noise and vibration assessment should be conducted during the detailed design stage, however, traffic noise associated with OSOM vehicle movements is considered as part of the traffic noise assessment.

3.3 Assessing Vibration: A Technical Guideline

Although not explicitly required by the Project SEARs, it is common for an assessment of vibration related to the construction and operation of a state significant development (SSD) project to be undertaken in accordance with the AVTG.

The AVTG presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. Preferred and maximum vibration values outlined in the AVTG are taken from British Standard 6472:1992 *Evaluation of human exposure to vibration in buildings (1-80 Hz)* (BS 6472).

The AVTG identifies three vibration categories:

- *Continuous vibration* – Examples: Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)
- *Impulsive vibration* – Examples: Infrequent activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading
- *Intermittent vibration* – Examples: Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Similar to other policy and guideline documentation, the AVTG allows for assessment at various receiver types.

3.3.1 Intermittent vibration

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

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

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

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

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

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

3.3.2 Continuous and impulsive vibration

Vibration criteria applicable to the residential receivers in the vicinity of the Project for continuous and impulsive vibration sources, are summarised in Table 3.

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

Vibration type	Assessment period [2]	Preferred values		Maximum values	
		Z axis	X and Y axes	Z axis	X and Y axes
Continuous vibration	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0,014	0.010
Impulsive vibration	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14

1 The preferred and maximum values are weighted RMS acceleration values. These values are only indicative, and there may be a need to assess to other sensitive areas against the relevant criteria.

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

3.4 Road Noise Policy

The SEARs indicate that additional traffic on public roads due to construction and operation of the Project must be assessed against the requirements of the RNP and relevant application notes.

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

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

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

Additionally, the RNP requires that the relative increase in noise levels at residential receivers not exceed 12 dB for land use developments with the potential to generate additional traffic on existing freeways, arterial or sub-arterial roads. The relative increase criterion does not apply for local roads.

The RNP notes that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

Where night-time construction traffic is likely to occur, such as OSOM deliveries, an assessment of sleep disturbance is appropriate. The RNP provides guidance on this matter:

- Maximum internal noise levels below 50–55 dB L_{Amax} are unlikely to awaken people from sleep
- One or two noise events per night, with maximum internal noise levels of 65–70 dB L_{Amax}, are not likely to affect health and wellbeing significantly.

Based on the assumption that an open window provides 10 dB attenuation (which would be typical of a facade with partially open windows), noise levels below 60 - 65 dB L_{Amax} outside an open bedroom window would be unlikely to cause awakening reactions.

Furthermore, one or two events with a noise level of 75 - 80 dB L_{Amax} outside an open bedroom window would be unlikely to affect health and well-being significantly.

4.0 NOISE PREDICTION METHOD

4.1 Operational noise

Operational noise levels associated with the Project is predicted using:

- noise emission data for the battery units, inverters, and transformers
- a 3D digital model of the Project and the surrounding environment, using proprietary noise modelling software SoundPLANnoise v9.0
- implementation of the environmental sound propagation method specified in International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2).

The implementation of ISO 9613-2 within proprietary noise modelling software enables multiple sound transmission paths, including reflected and screened paths, to be accounted for in the calculated noise levels. ISO 9613-2 was designed to assume conditions that favour the propagation of noise from meteorological effects, described as a slight wind (1 to 5 m/s) blowing from source to receiver, or a well-developed moderate ground-based temperature inversion.

Elevation contours with a vertical resolution of 10 m were provided by Spark Renewables and have been used to develop the topographical model referred to within the context of the noise model.

All equipment items are modelled as omnidirectional point sources of noise with associated octave and third-octave band sound power level noise emissions. Further details regarding equipment noise levels are provided in Section 6.3.

The ground factor, G, representing the ground attenuation as a result of sound reflected by the ground surface interfering with the sound propagating directly from source to receiver is variable throughout the model being:

- G = 0.1, i.e. hard ground, to the development footprint to represent an expected gravel mulch footing
- G = 0.5, i.e. mixed hard/soft ground outside the development footprint to represent surrounding existing landscape between the development footprint and noise sensitive receivers.

Additional information with respect to general noise modelling factors is provided Appendix F.

4.2 Construction noise

Predicted noise levels have been calculated in general accordance with the method detailed in Australian Standard 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* (AS 2436). This method enables the prediction of noise levels for sound propagation over hard or soft ground but does not provide the ability to calculate predicted noise levels for mixed ground cover with varied soil conditions.

The standard also notes that caution must be applied when considering predicted noise levels at distances beyond 100 m. For these reasons, predicted noise levels have been determined as the arithmetic average of the hard and soft ground prediction methods.

This approach is broadly consistent with the equivalent prediction procedure in British Standard 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites: Noise* (BS 5228), as referenced in AS 2436, and provides a margin of caution with respect to ground conditions for the typical magnitude of separating distances between construction activities and neighbouring sensitive receivers.

5.0 EXISTING NOISE ENVIRONMENT

5.1 Policy

Project noise trigger levels (per the NPfI) and noise management levels (per the ICNG) applicable to operational noise and construction noise assessment are in some cases dependent on RBLs (background noise levels) at a subject receiver, or in the vicinity of a subject site or project.

RBLs in the NPfI and ICNG are defined in terms of $L_{A90, 15\ min}$.

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

5.2 Background noise levels

The NPfI recognises that very low RBLs, particularly at night, can present challenges with the derivation of reasonable assessment criteria. Table 2.1 of the NPfI provides minimum assumed RBLs which are summarised in Table 5. In the absence of measured RBLs, these minimums have been adopted for use within the assessment and are used for derivation of the NPfI project noise trigger levels referred to in Section 6.1 and ICNG noise management levels in Section 3.2.

Table 5: Minimum assumed RBLs for NPfI and ICNG, dB L_{A90}

Time of day	Minimum assumed RBL
Day	35
Evening	30
Night	30

Time of day is defined as:

Day	0700 - 1800 hrs Monday to Saturday and 0800 - 1800 hrs Sundays and public holidays
Evening	1800 - 2200 hrs Monday to Sunday and public holidays
Night	the remaining periods

6.0 OPERATIONAL NOISE ASSESSMENT

6.1 Project noise trigger levels

Based on the definitions set out in Table 2.3 of the NPfI all receivers considered for assessment have been determined to have a 'Rural Residential' receiver category. On this basis, and considering the minimum assumed RBLs detailed in Table 5, the project noise trigger levels relevant for assessment of operational noise associated with the Project are summarised in Table 6.

Further information with respect to derivation of the project noise trigger levels is provided in Appendix E.

Table 6: Project noise trigger levels, dB $L_{Aeq,\,15\,min}$

Time of day	Project noise trigger level
Day	40
Evening	35
Night	35

The Project infrastructure has the potential to operate under worst-case operational conditions at any time of day, evening or night. This means that operation during the evening or night period, for which the most stringent project noise trigger level of 35 dB $L_{Aeq,\,15\,min}$ applies, will be the controlling factor for compliance. Generally, the assessment provided herein considers this worst-case operation only.

The noise sources associated with the Project typically give rise to steady noise levels and are not typically characterised by brief momentary increases in noise levels. Accordingly, the additional procedures defined in the NPfI for assessing maximum noise level events associated with potential sleep disturbance are not relevant. The assessment is therefore solely based on noise levels of the equipment assessed in terms of the $L_{Aeq\,15\,min}$ descriptor, which is adopted by the NPfI for the assessment of average noise energy over a 15-minute period.

6.2 Operational noise sources

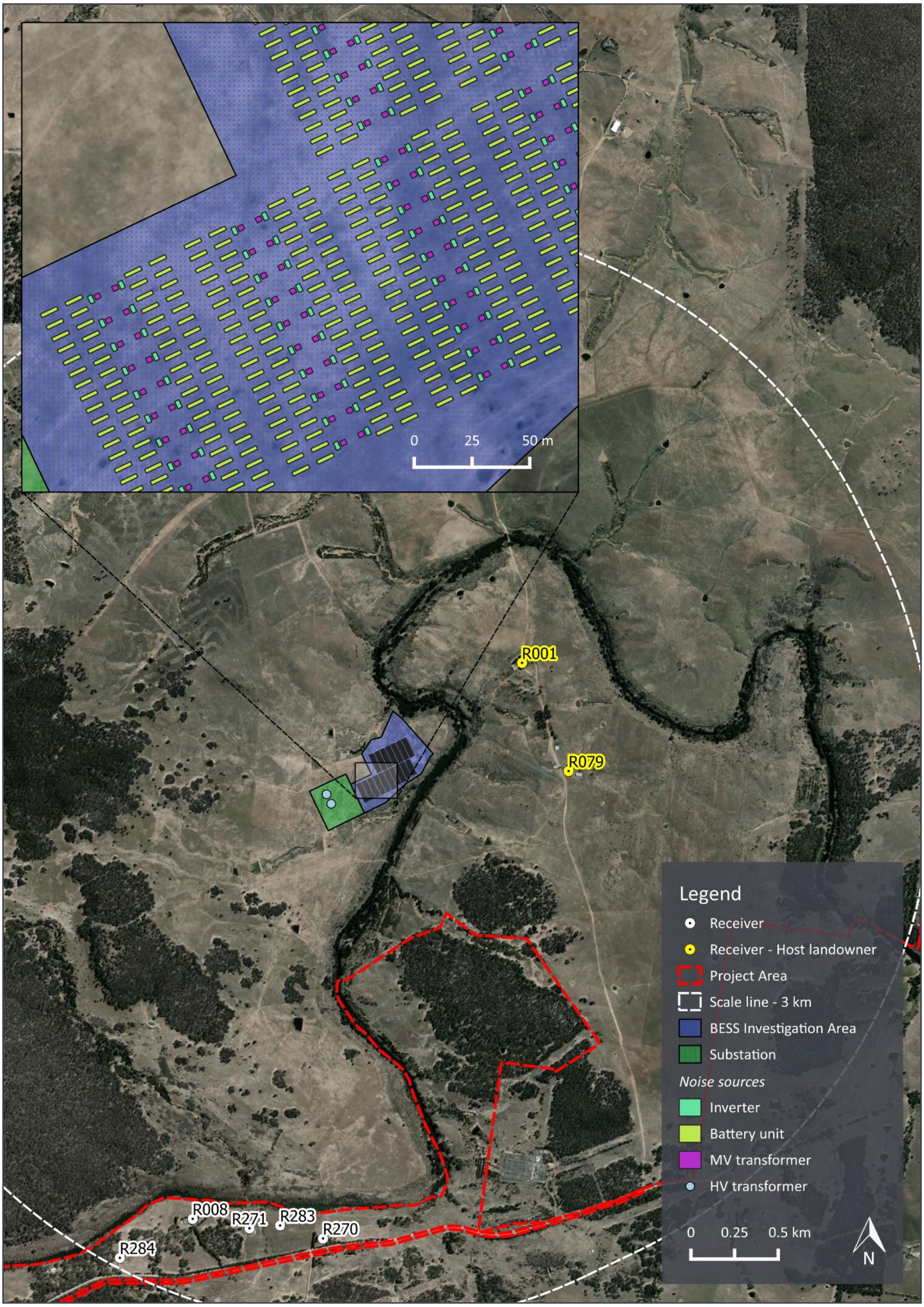
Based on information provided by Spark Renewables, permanent noise generating infrastructure that is proposed to be developed as part of the Project is limited to:

- inverters
- battery units
- transformers.

Other proposed permanent ancillary infrastructure e.g. switchyard and O&M facility, do not typically include significant sources of operational noise and are not considered further.

The location of each of the operational noise sources within the context of the broader Project is shown in Figure 2.

Figure 2: Operational noise source map



6.2.1 BESS

At this stage of the Project, a detailed project design has not been finalised, however for the purposes of the noise assessment a design concept has been developed by Spark Renewables. The concept comprises a layout of inverters, battery units and medium voltage (MV) transformers.

The discrete position of each equipment item is shown in Figure 2.

A summary of the relevant information provided by Spark Renewables is shown in Table 7.

Table 7: Operational noise source details

Equipment item	Quantity
Battery unit	656
Inverter	164
MV transformer	164

6.2.2 Substation

Operational noise sources associated with the collector substation are limited to HV transformers related to the Project.

Information provided by Spark Renewables regarding the Project HV transformers at the substation includes:

- Spatial data indicating the boundary of the substation (used to derive the positions shown in Figure 2).
- Specification details including power rating (MVA) and quantity of HV transformers.

The relevant specification of the Project HV transformers at the substation is shown in Table 8.

Table 8: Substation HV transformer specification

Location	Power rating, MVA	Quantity
Collector substation	200	2

6.3 Sound power level data

Sound power levels for the operational noise sources, as used in the noise model, are detailed in Table 9. Data is provided as un-weighted (linear) octave band sound power spectra and A-weighted overall sound power level.

Table 9: Sound power levels for operational noise sources, dB L_W

Item	Octave band centre frequency, Hz							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**L_{WA}**
BESS								
Inverter	91	92	92	87	85	83	88	93
Battery unit	85	86	88	82	82	77	73	86
MV transformer	77	79	74	74	68	63	58	75
Substation								
HV transformer	101	103	98	98	92	87	82	98

Additional information with respect to the source of the data is provided in Table 10.

Table 10: Operational noise source data description

Item	Description
Inverter	Third octave band sound power levels measured in accordance with ISO 3744:2010 have been sourced from MDA library data.[1] Extensive specific operating conditions for the test were described in the supplied data sheet but included all fans running at 100 %. An OEM noise attenuation kit is available for this model of inverter however the assessment assumes that this is not applied. Due to commercial sensitivities the specific inverter manufacturer and model is not detailed in this report but has been confirmed by Spark Renewables to be representative of the specification required for the Project.
Battery unit	Manufacturer third octave band sound power levels measured in accordance with ISO 3744:2010 associated with a containerised battery system have been provided by Spark Renewables. Based on the information provided within the supplied OEM datasheet it is understood that the adopted sound power levels are associated with the fans operating at 100 %. Due to commercial sensitivities the specific battery unit manufacturer and model is not detailed in this report but has been confirmed by Spark Renewables to be representative of the specification required for the Project.
HV/MV transformers	At this stage of the Project, specific details of the transformer makes and models are yet to be finalised. Based on information provided by Spark Renewables, MDA understands that the proposed HV transformers are expected to be rated at 200 MVA, with the MV transformers proposed for the Project expected to be rated at 4.2 MVA In the absence of measured sound power level data for a specific transformer model, reference has been made to the standard maximum method for estimating overall transformer sound power levels for a given power rating described in AS 60076-10:2009. [2] Spectral data for each transformer was then estimated by applying Bies & Hansen corrections from Table 11.27, (Location 1a for outdoor transformer noise) to the determined overall sound power level. [3]

6.4 Noise modelling method

All equipment items are modelled as omnidirectional point sources of noise with associated octave band sound power level noise emissions. Additional information with respect to the noise modelling method is provided in Section 4.1 and Appendix F.

6.5 Predicted noise levels

Noise levels resulting from the operation of the Project have been predicted at all receivers referenced in Appendix D and are shown in Table 11. For conciseness, only receivers at which the predicted noise level is greater than 25 dB $L_{Aeq\ 15\ min}$ are included. Predicted noise contours have also been provided in Figure 3.

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1 ISO 3744:2010 *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

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

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

Table 11: Predicted noise levels at receivers greater than 25 dB, dB $L_{Aeq, 15 min}$

Receiver	BESS	Substation	Total [1]
R001 [2]	*38*	*20*	*38*
R008	25	12	26
R079 [2]	*37*	*20*	*37*
R270	26	12	26
R271	26	13	26
R283	26	13	26

1 Predicted noise level from all operational noise sources combined

2 Host landowner property

The following can be seen from Table 11:

- The predicted noise levels at all non-host landowner receivers are below the most stringent project noise trigger level of 35 dB $L_{Aeq 15min}$, applicable during the evening and night periods, by a minimum margin of 9 dB.
- The predicted noise levels at both host landowner receivers considered within this assessment are above the evening and night period project noise trigger levels by up to 3 dB. As discussed in Section 2.2, Spark Renewables have advised that the relationship between noise from the Project and the host landowner properties will be managed internally by the University of Sydney, with predicted noise levels provided for information only.

6.6 Tonality

Noise associated with the operation of inverters and HV transformers has the potential to be tonal in nature, as these equipment items can exhibit tonal characteristics at source.

Table C1 of Fact Sheet C of the NPfI sets out assessment procedures and modifying factor corrections for annoying noise characteristics, including tonality, that must be applied where the characteristics are evident at receiver locations.

The procedure for tonality assessment is based on analysing measured third octave band sound pressure levels from the subject noise source at receivers, using the objective method for assessing the audibility of tones in noise set out in Annex D of ISO 1996.2-2007.

It is evident that direct evaluation of tonality, via measurement at noise sensitive receivers is not feasible for a development that is yet to be constructed.

There is no documented or recognised method for the prediction of tonality, pre-construction. In order to provide the best, feasible approach, and evaluate risk associated with potential tonality, noise predictions at receivers have been repeated using third octave band sound power level data for noise sources. The resultant third octave band predictions at receivers have then been treated as effective measurements, with analysis for tonality then conducted per Fact Sheet D.

Validation of the ISO 9613-2 method is limited to octave band data, therefore when using one-third octave band noise data the modelling software assumes the same attenuation factors for the adjacent two bands. This is a limitation of the method and may result in a minor variation in the results where one-third octave band data is used.

Based on evaluation of the predicted third octave band noise levels at receivers for inverters, a modifying factor correction for tonality has not been found to be applicable.

At this stage of the Project third octave band sound power levels for the HV transformers are not available, and an objective assessment similar to the above is not feasible. However, given the magnitude of predicted HV transformer noise levels at receivers (< 20 dB $L_{Aeq\ 15\ min}$) it is unlikely that tonal character associated with HV transformer operation (if present) would be emergent from the background and ambient noise levels at receivers.

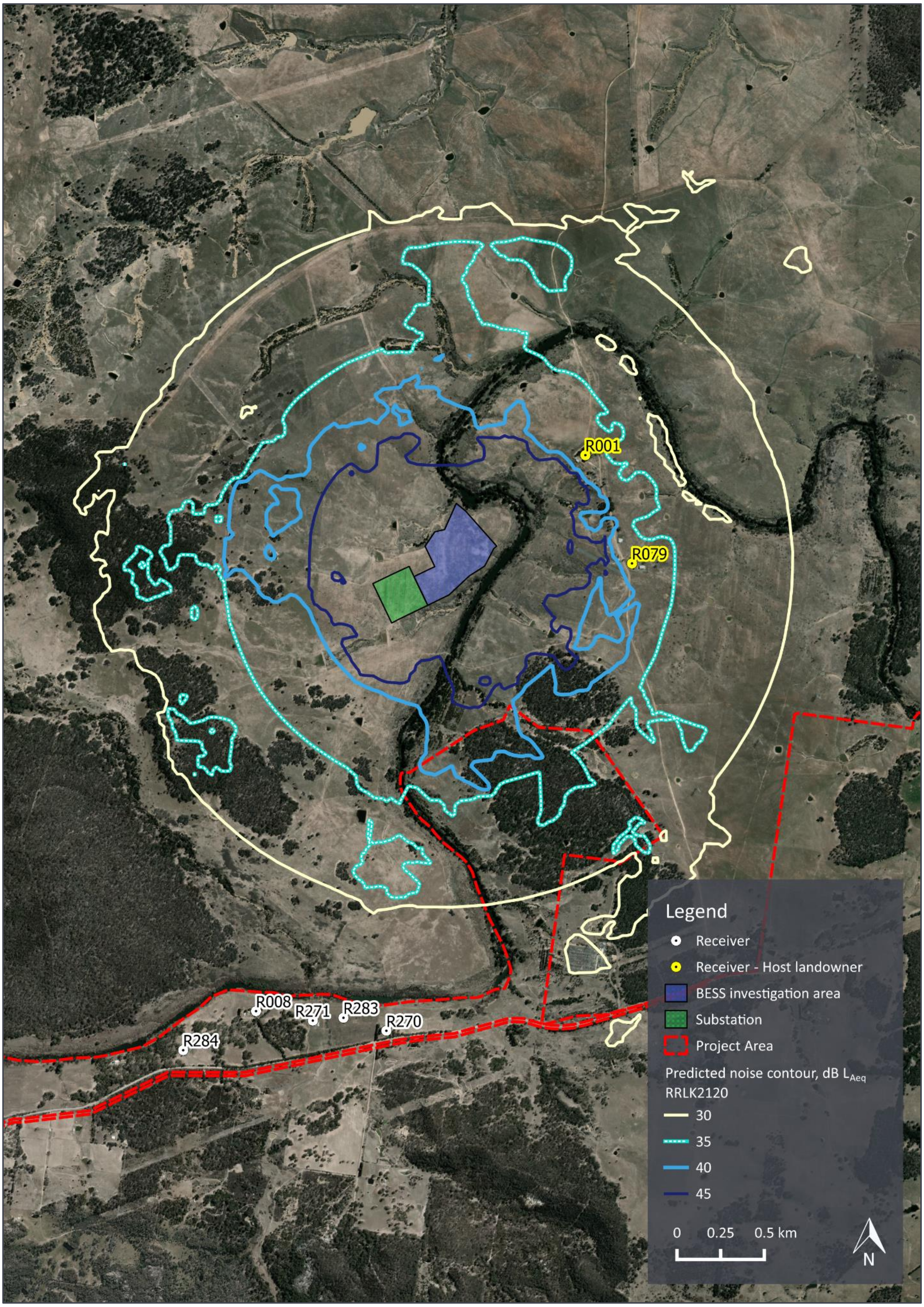
On this basis it is not expected that tonality is a material consideration for the Project, based on the current project design and equipment selections. Modifying factor corrections for tonality are therefore not applied.

6.7 Discussion

The results shown in Table 11 demonstrate that predicted noise levels are below the 35 dB $L_{Aeq,\ 15\ min}$ evening and night project noise trigger level at all non-host landowner receivers, by a minimum margin of 9 dB.

Operational noise from the Project at non-host landowner receivers is therefore predicted to be below the most stringent project noise trigger level applicable under the NPfI.

Figure 3: Predicted noise contours



7.0 CUMULATIVE OPERATIONAL NOISE ASSESSMENT

The Project SEARs requires an:

assessment of the cumulative noise impacts (considering other developments in the area).

The following developments have been considered:

- The existing Transgrid Marulan Substation (TMS) (located to the south-east of the proposed infrastructure).
- The proposed Marulan Gas Fired Power Station (MGFPS) (directly adjoining the Project Area to the south).
- The proposed Wattle Creek Solar Project, (proposed to be located within the Project Area).

7.1 Transgrid Marulan Substation

The TMS is located to the south-east of the proposed infrastructure. Current noise levels at receivers from operation of this facility have not been measured or quantified, however publicly available information and aerial imagery indicates that the currently installed power transformer is likely to have a rated capacity of 200 MVA.[4]

MDA has conducted high level prediction of noise at the nearest receiver common to the TMS and the Project (R270). Predicted noise levels are in the order of 23 dB $L_{Aeq\ 15\ min}$. Predicted noise levels at receivers further away will be lower. Further information is provided in the following sections.

7.2 Marulan Gas Fired Power Station

Based on review of publicly available information, several state significant infrastructure (SSI) applications have been submitted for various stages and iterations of the MGFPS project.[5] The latest modifications for the MGFPS project acknowledge that it is unlikely to go ahead as documented in the original submission, due to the significant time since planning approval. Additional future modifications are likely to be required to reflect contemporary preferred technology and design for the project. Given the change in noise policy since the original approval, and the Project and Wattle Creek Solar Farm project which have entered the planning process since the MGFPS approval, it is expected that further noise assessment would be necessary. This is supported by information provided in the contemporary modification applications, and associated agency advice from the EPA.

Noise level contributions from any future variation of the MGFPS project are not known at this stage but have been assumed to be no more than 35 dB $L_{Aeq\ 15\ min}$ at the nearest receiver. This is based on the legacy noise assessments for the project, which set out noise criteria applicable to the various components of the project as being 35 dB $L_{Aeq\ 15\ min}$ (applicable in day, evening and night), and the expectation that the MGFPS project will be required to comply with the equivalent contemporary NPfI project noise trigger level of 35 dB $L_{Aeq\ 15\ min}$. Expected noise levels at other receivers further from the MGFPS have been calculated considering simple distance attenuation.

4 https://www.transgrid.com.au/media/j2llfv1u/transmission-annual-planning-report-2021.pdf

5 MP07_0174, MP07_0175, MP07_0176, and subsequent modifications as shown on NSW Planning Portal https://www.planningportal.nsw.gov.au/

7.3 Wattle Creek Solar Project

Operational noise associated with the Wattle Creek Solar project has been taken from the EIS noise assessment conducted for that project.[6]

7.4 Cumulative noise

Table 12 provides predicted noise levels above 25 dB $L_{Aeq\ 15\ min}$ for both the Project and the Wattle Creek Solar project, along with cumulative total noise levels considering the TMS and MGFPS. Spark Renewables have advised that noise from the Project and the Wattle Creek Solar project at the host landowner properties will be managed internally by the University of Sydney. On this basis where the subject receiver is a host landowner property, the cumulative noise level for TMS and MGFPS only are provided in parentheses for context.

Table 12: Predicted cumulative noise levels, dB $L_{Aeq,\ 15\ min}$

Receiver	the Project	Wattle Creek Solar Project	TMS	MGFPS	Total[1]
R001[2]	*38*	*32*	*8*	*33*	*40 (33)*
R008	26	29	18	34	36
R079[2]	*37*	*30*	*12*	*35*	*40 (35)*
R270	26	31	23	35	37
R271[2]	*26*	*28*	*20*	*34*	*36 (34)*
R283	26	29	21	35	37

1 Predicted noise level from Wattle Creek Solar project and the Project noise sources combined

2 Host landowner property

7.5 Individual project amenity noise level

Section 2.4 of the NPfI sets out methods and guidelines for the development of amenity noise levels and project amenity noise levels (additional information is provided in Section 3.1 and Appendix E). The recommended amenity noise levels (set out in Table 2.2 of the NPfI) represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

Section 2.4.2 provides a method (Equation 1) for deriving individual project amenity noise levels for a greenfield site. Compliance of each subject industry with the individual project amenity noise level that is derived through the method would mean cumulative compliance with the recommended amenity noise level, satisfying the intent of the NPfI.

Equation 1

Individual project amenity noise level = 10Log($10^{(ANL/10)}$/N)

where:

ANL – recommended amenity noise level from Table 2.2 – being 40 dB

N – the number of proposed additional premises – being 3

therefore:

Individual project amenity noise level = 10Log($10^{40/10)}$/3) = 35 dB $L_{Aeq\ period}$

6 *Rp 004 r01 20220318 – Wattle Creek – Solar Farm Project – Noise and Vibration Assessment* dated 18 March 2025

Adjustment of the above $L_{Aeq\ period}$ to provide a standardised $L_{Aeq\ 15\ min}$, per Section 2.2 of the NPfI results in an individual project amenity noise level, applicable to each industry in Table 12 of 38 dB $L_{Aeq\ 15\ min}$.

As shown in Table 12 contributions from all individual industry at the receivers is 38 dB $L_{Aeq\ 15\ min}$ or less. On this basis the individual project amenity noise levels, the recommended amenity noise levels for the receiver categories, and therefore the overall intent of the NPfI with respect to cumulative industrial noise is satisfied.

Figure 4: Other developments in the vicinity of the Project Area

8.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

8.1 Overview

The construction of the Project will generate noise and vibration as a result of activities occurring both within and outside of the Project Area.

As per the Project SEARs construction noise is to be assessed in accordance with the ICNG (see Section 3.1.2). Whilst not formally required by the Project SEARs, construction vibration is also addressed considering the AVTG (see Section 3.3).

On-site works include a range of activities such as construction of access tracks, transmission infrastructure, cable trenching, battery installation, and other tasks.

Off-site noise generating activities considered within this assessment are limited to:

- Public road resurfacing – addressed within Section 8.4.
- Heavy vehicle movements to and from the Project Area - addressed separately in the traffic noise assessment in Section 9.0.

Construction works associated with the Project are only expected to occur during standard working hours. On this basis a detailed assessment of out of hours construction activity is not included in this report.

While not currently planned or scheduled, unavoidable works outside of standard hours could conceptually comprise the delivery of oversized/over mass (OSOM) components at times selected to minimise traffic disruption associated with intersection closures and unloading or installation of oversize equipment, such as HV transformers.

Should these works be required, an out of hours construction noise and vibration assessment should be conducted during the detailed design stage, however, traffic noise associated with OSOM vehicle movements is considered at a high-level as part of the traffic noise assessment in Section 9.3.

As per the ICNG, noise associated with the construction of the Project may require the adoption of reasonable and feasible general management measures and considerate working practices. These measures will be documented and agreed in a CEMP for inclusion in a broader environmental management plan (EMP). These documents are typically prepared for review and approval by the responsible authority prior to commencing any construction works.

At this stage a detailed construction strategy is not known but would be developed during the detailed design phase of the Project, once a main contractor is appointed. Therefore, the following sections provide general information regarding the types of activities that are expected to be associated with the construction of the Project, and reference data that should be considered as part of the preparation of a future CEMP for the Project.

8.2 On-site construction activities

Based on information provided by Spark Renewables, construction of the Project is likely to involve the following key stages:

- Battery installation
- Civil earthworks
- Component delivery
- Site establishment, clearing and fencing)
- Substation construction.

Specific details of the construction program and the number, type, and duty of the construction plant to be used would be determined during the detailed design phase of the Project when a construction contractor has been selected.

The types of equipment associated with different stages of construction typically include excavation plant, pneumatic equipment, different piling processes and lifting equipment.

Appendix G provides a construction site layout denoting key work areas.

Appendix H details typical major equipment items associated with the above construction stages, alongside noise levels developed on the basis of reference data from AS 2436 and previous project experience. These are conceptual assumptions provided by Spark Renewables and provide an approximation of potential construction equipment and processes. Project specific equipment and processes will be determined once a main contractor is appointed.

As shown in Appendix H, typical construction plant sound power levels range from approximately 102 to 117 dB L_{WA} per equipment item.

Based on the groupings of major plant items during key construction tasks, the total aggregated noise emissions for the proposed works stages typically ranges from 105 to 120 dB L_{WA}. These predictions are based on the assumption that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period thus providing a conservative approach that is unlikely to occur in practice.

8.3 On-site construction noise assessment

Noise levels associated with each of the main construction tasks have been predicted at the nearest noise sensitive receivers to provide an indication of the upper range of noise levels that may occur during construction.

Given that the precise equipment selections and methods of working would be determined once a main contractor is appointed, and that the noise associated with construction plant and activity varies significantly, the predicted noise levels are provided in the following sections as an indicative range of levels which may occur in practice.

To provide a worst-case assessment, construction works have been assumed to be occurring at the nearest point in the subject construction area to the receiver, all equipment and plant items are assumed to operating for 100 % of the subject 15-minute period, and all equipment and plant items are assumed to be operating at the same location. In practice this is unlikely to happen as plant and equipment items are likely to be distributed throughout the Development Footprint, and not all plant and equipment items identified for each construction task are likely to be operating concurrently.

The predicted noise level ranges for each of the main construction tasks are provided in Table 13 and Table 14. For additional context, the results have been provided separately for host and non-host receivers.

Table 13: Indicative range of construction noise predictions at receivers (not including host landowner receivers), dB $L_{Aeq, 15 min}$

Construction phase	Nearest receiver (distance, m)	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
Battery installation	R283 (2,400)	25-30	45	-	75	-
Civil earthworks	R003 (550) [1]	50-55	45	5-10	75	-
Component delivery	R283 (2,400)	30-35	45	-	75	-
Site establishment, clearing and fencing	R283 (2,400)	35-40	45	-	75	-
Substation construction	R283 (2,300)	20-25	45	-	75	-

1 R003 is outside the 3 km scale line from primary noise generating infrastructure associated with the Project, but close to overhead transmission line infrastructure common to both the Wattle Creek Solar project and the Project. Further details are provided in Section 8.3.2

Table 14: Indicative range of construction noise predictions at host landowner receivers, dB $L_{Aeq, 15 min}$

Construction phase	Nearest receiver (distance, m)	Predicted level range	Noise affected management level	Exceedance	Highly noise affected management level	Exceedance
Battery installation	R001 (750)	40-45	45	-	75	-
Civil earthworks	R079 (350)	55-60	45	10-15	75	-
Component delivery	R001 (750)	45-50	45	0-5	75	-
Site establishment, clearing and fencing	R001 (750)	50-55	45	5-10	75	-
Substation construction	R001 (1,200)	30-35	45	-	75	-

The following can be seen from the construction noise predictions shown in Table 13 and Table 14:

- Construction noise levels are predicted to be above the noise affected management levels at some receivers during several of the assessed construction tasks.
- Construction noise levels are predicted to be below the highly noise affected management levels at all receivers during all assessed construction tasks.

8.3.1 Discussion

The ICNG provides the following context for proponents when assessing construction noise:

> *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.*

As the noise affected management levels are predicted to be exceeded during some stages of construction, work practices and mitigation measured should be considered and included in the future CEMP. Further discussion, including conceptual mitigation strategies, is provided in Section 8.7.

It is noted, however, that exceedances above the noise affected management levels are not unique to this project and are characteristic of many construction noise assessments due to the high 'at source' noise levels of construction equipment. Based on previous project experience, the predicted noise levels are typical of the range expected for a medium size infrastructure project in a rural setting.

8.3.2 Overhead transmission line

As set out in Section 2.1 the Project includes two overhead transmission line options to connect to the transmission network. This allows for optionality during the assessment process and greater flexibility in the connection design.

It is intended that one transmission option will be constructed for the Project.

Based on the construction information provided by Spark Renewables both transmission line options are included in the dataset. This means that where construction works associated with the overhead transmission lines options is conducted, primarily the '*civil and earthworks'* stages, noise levels at receivers may be conservative, as both transmission options may ultimately be combined to a single option. This has the potential to result in lower construction noise levels at receivers for these stages, depending on the relative position of the single option overhead transmission line reticulation, and position of the subject receiver.

8.4 Off-site construction noise assessment

As discussed in Section 8.1, off-site construction works addressed within this section of the assessment are limited to public road resurfacing. Specifically, road resurfacing works that are proposed to occur on Canyonleigh Road, between the Brayton Road Canyonleigh Road intersection and the site access point. The extent of this road section can be seen in Figure 5.

At this stage of the Project, definitive construction processes and associated plant and equipment items related to these works are not known. The construction assumptions set out in Table 15 have been adopted for public road resurfacing works. The table sets out plant/equipment likely to be used, the number of each plant/equipment likely to be operating concurrently in a worst case 15-minute period, and the percentage of time the plant/equipment is likely to operate within a worst case 15-minute period.

Table 15: Public road resurfacing construction assumptions

Plant/equipment	Count	'On' time in 15-minute period
Bulldozer	1	50%
Dump truck	1	10%
Excavator	1	50%
Grader	1	50%

Based on the source noise data set out in Appendix H, a combined sound power level in the order of 110 dB L_{WA} has been developed for the scenario set out in Table 15.

The prediction method set out in Section 4.2 has been adopted from which a setback distance of approximately 400 m has been established.

Receivers located within 400 m of the relevant section of Canyonleigh Road would therefore be at risk of construction noise levels being above the noise affected management level. These receivers are identified in Table 16 and presented graphically in Figure 5.

Table 16: Receivers within construction noise setback distance for public roads works

Receiver ID	Approximate distance to road, m
R108	40
R268	40
R270	75
R267	105
R269	120
R031	135
R284	135
R142	150
R441	155
R107	165
R114	165
R010	190

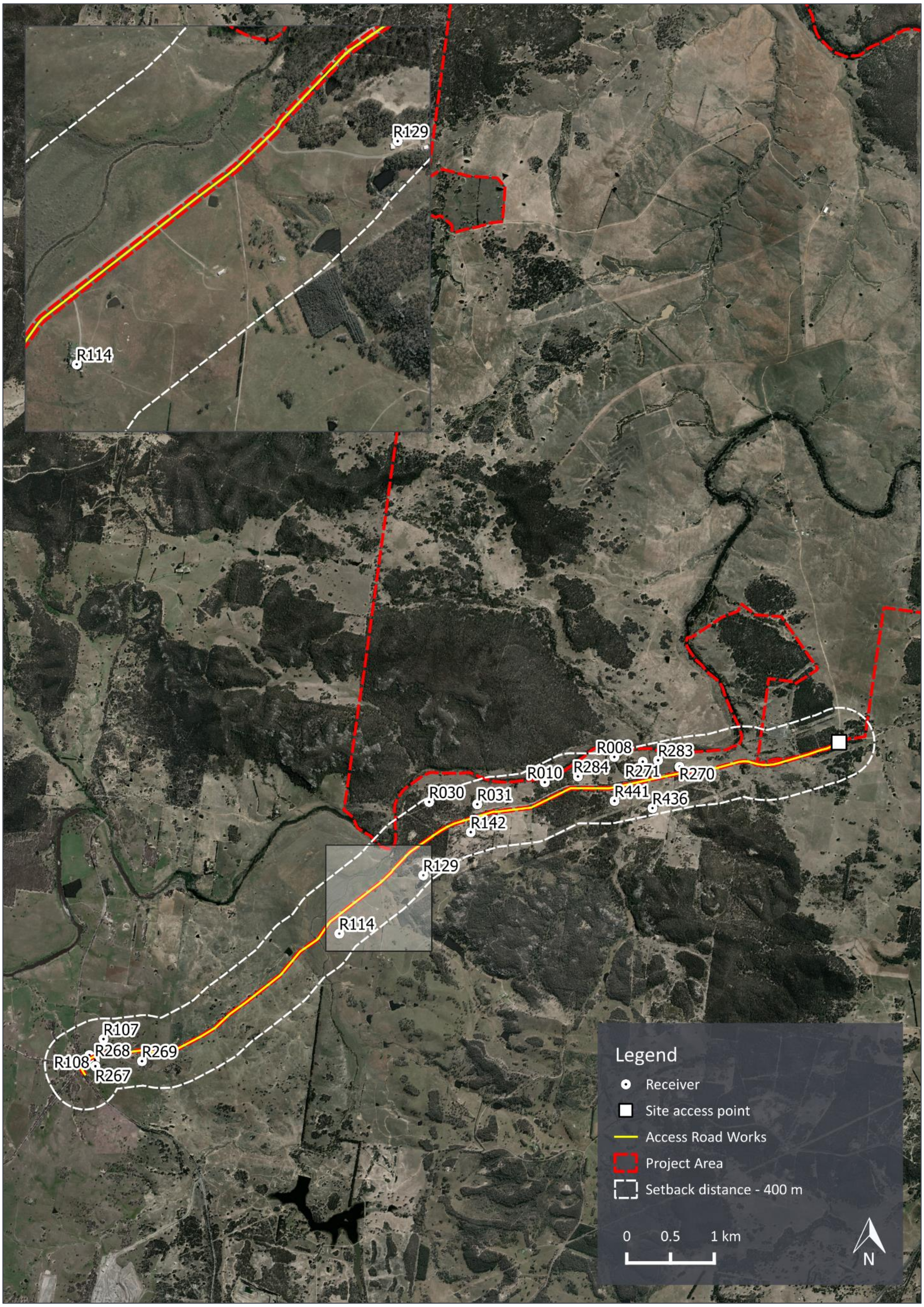
Receiver ID	Approximate distance to road, m
R283	200
R271	220
R129	295
R436	325
R008	340
R030	350

Noise levels above the noise affected management levels are not unique to this Project and are characteristic of most assessments of noise associated with works on public roads. This is due to both the typically high source noise associated with construction plant and equipment and the location of dwellings immediately adjacent transport routes.

It is recommended that these receivers be included in any community consultation and communications regarding the scheduling of public road resurfacing, given the potential for noise impacts.

It is also understood that Spark Renewables are offering construction disruption payments to residents living along Canyonleigh Road during the construction period to compensate for disruption caused by traffic and associated noise impacts.

Figure 5: Receivers within construction noise setback distance for public road works



8.5 Construction vibration assessment

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

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

8.5.1 Intermittent vibration

The AVTG indicates that intermittent vibration should be assessed in terms of the vibration dose value (VDV). Representative VDV values for construction works are calculated considering the magnitude and duration of vibration events and are highly specific to site conditions, equipment selections and operational durations. As such, calculation of VDV levels is not typical or practical at the planning stage but will need to be considered as part of a later detailed vibration assessment.

The AVTG recommends that best management practices in all cases should be to reduce values as far as practicable, and a comprehensive community consultation program should be developed.

8.5.2 Continuous vibration

Vibration due to some construction operations can be considered continuous depending on the duration and nature of the works. Since the guide values for continuous vibration are independent of exposure duration, indicative safe working distances can be developed. Section 7.1 of the NSW RMS *Construction Noise & Vibration Guideline* (CNVG) sets out minimum working distances from sensitive receivers for typical items of vibration intensive plant. The minimum distances, reproduced in Table 17 are quoted for effects relating to human comfort.

Table 17: Recommended minimum working distances for human response limits for vibration intensive plant

Plant item	Rating/description	Minimum working distance, m
Vibratory roller	< 50 kN (typically 1-2 tonnes)	15 to 20
	< 100 kN (typically 2-4 tonnes)	20
	< 200 kN (typically 4-6 tonnes)	40
	< 300 kN (typically 7-13 tonnes)	100
	> 300 kN (typically 13-18 tonnes)	100
	> 300 kN (> 18 tonnes)	100
Small hydraulic hammer	300 kg – 5 to 12 t excavator	7
Medium hydraulic hammer	900 kg – 12 to 18 t excavator	23
Large hydraulic hammer	1600 kg – 18 to 34 t excavator	73
Vibratory pile driver	Sheet piles	20
Pile boring	≤ 800 mm	4
Jackhammer	Handheld	2

Note: Reproduced from Table 2 of Section 7.1 of the CNVG

The CNVG notes that the minimum working distances for human comfort relate to continuous vibration and are indicative. In practice, appropriate minimum working distances will vary depending on the particular item of plant and local geotechnical conditions. The CNVG further notes that for most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, likely equating to greater minimum working distances.

For on-site construction works, it can be seen that the minimum working distances, are significantly less than the minimum distances between proposed on-site construction work areas and receivers, as noted in Table 13 and Table 14.

For off-site construction works, there are 3 receivers identified within the minimum working distances for the most vibration intensive plant items set out in Table 17. It is noted that these plant/equipment items are not proposed as part of the preliminary nominations shown in Table 15, however, this should be reviewed once a main contractor is appointed.

On this basis, there is a moderate risk of adverse vibration impact at these receivers. This should be addressed in the CEMP once the detailed work practices and plant items are known. The type of public road resurfacing proposed is common for typical roadworks, allowing for standard noise and vibration management practices to be adopted at that time.

8.6 Decommissioning

Similar construction activities to those detailed in Section 8.2 are expected to be required during the decommissioning of the Project. Decommissioning activities are likely to be less intensive than during construction and occur over a shorter duration. On this basis no further assessment has been conducted.

8.7 Construction noise and vibration recommendations

At this stage of the Project, only a preliminary, conceptual assessment of construction noise and vibration impact risk is feasible. Once a more detailed schedule of equipment and plant items, construction method and work areas are known, a detailed construction noise assessment and CEMP will be prepared.

The CEMP should include site and process specific noise management work practices designed to mitigate the impact of construction noise activities, including traffic noise.

The ICNG provides extensive details and guidance with respect to noise mitigation including:

- universal work practices
- consultation and notification
- plant and equipment, e.g utilising bored piling in lieu or impact or vibratory piling
- on-site controls
- work scheduling
- transmission path and at-receiver considerations.

All of the above items should be considered as part of the future CEMP.

Generally, it is likely to be feasible for a majority of works to be restricted to normal working hours, i.e. the ICNG recommended standard construction hours detailed in Section 3.1.2. This will assist in limiting noisy activities to times of the day when intrusive impacts or adverse reactions may be less likely.

In some cases, construction works may be required to occur outside of these hours. Such activities are typically related to public infrastructure i.e. timing oversized deliveries to avoid hazardous traffic conditions or weather windows.

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

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

With reasonable and feasible work practices implemented it is expected that noise associated with the construction and decommissioning of the Project can be acceptably managed.

9.0 TRAFFIC NOISE ASSESSMENT

Noise criteria for the assessment of traffic associated with the construction and operation of the Project are detailed in Section 3.4.

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

Based on information provided by Spark Renewables, noise impacts related to construction traffic along the Hume Highway, from the Hume Highway/Brayton Road and Hume Highway/Ambrose Road intersections to the Brayton Road/Canyonleigh Road intersection, and then to the proposed site access point on Canyonleigh Road have been assessed. Based on the information provided by the traffic consultant the section of Red Hills Road connecting Ambrose Road to the Hume Highway has been included as being part of Ambrose Road.

It is understood that the Project will target the use of existing major roads and designated heavy vehicle routes, with existing traffic flows expected to be greater than any increase arising from construction of the Project. On this basis traffic noise along roads outside of those identified above has not been considered further in this report - increases in traffic noise levels experienced by receivers near these major roads are likely to be negligible.

The base traffic flows and estimated construction traffic flows along the roads considered within this assessment have been provided by Access Traffic Consulting in correspondence dated 16 September 2024. It is noted that for the purposes of the traffic assessment, traffic volumes associated with Brayton Road have been provided as 4 subdivided sections, to provide additional context to the flow of construction traffic associated with the development of the Project. The traffic data is reproduced in Table 18.

Based on the definitions in the RNP and information provided by Access Traffic Consulting, the Hume Highway, Ambrose Road and Brayton Road (north and south of Ambrose Road) are considered to be *freeway/arterial/sub-arterial roads*, and Canyonleigh Road and Brayton Road (north and south of Canyonleigh Road) are considered to be *'local roads'*. The assessment is based on the relevant RNP criteria for each road category.

Table 18: Construction traffic and base traffic flows on public roads – vehicles (% heavy vehicles)

Road category	Existing traffic		Future: existing + construction traffic	
	Day[1]	Night[1]	Day[1]	Night[1]
Local roads [2]				
Canyonleigh Road	5 (0%)	5 (0%)	112 (4%)	108 (0%)
Brayton Road (Nth Canyonleigh Road)	12 (17%)	19 (0%)	12 (17%)	19 (0%)
Brayton Road (Sth Canyonleigh Road)	22 (9%)	26 (0%)	129 (5%)	129 (0%)
Freeways/arterial/sub-arterial roads [3][4]				
Hume Highway	19,693 (11%)	1,700 (21%)	19,797 (11%)	1,792 (19%)
Ambrose Road	291 (73%)	125 (73%)	344 (65%)	176 (52%)
Brayton Road (Nth Ambrose Road)	567 (43%)	243 (43%)	692 (38%)	346 (30%)
Brayton Road (Sth Ambrose Road)	374 (15%)	160 (15%)	448 (15%)	212 (11%)

1 Day is 0700 - 2200 hrs; Night is 2200 - 0700 hrs
2 Day & Night: Peak 1 hr AADT (annual average daily traffic)/% heavy vehicle
3 Day: Total 15 hr AADT/% heavy vehicle
4 Night: Total 9 hr AADT/% heavy vehicle

9.1 Screening assessment

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

Where the predicted traffic noise increase is 2 dB or less, no further assessment is conducted, as impacts will be barely perceptible. However, where the road traffic noise levels are predicted to increase by more than 2 dB as a result of additional traffic, consideration is given to the actual noise levels associated with the construction traffic and whether or not these levels comply with the road traffic noise criteria detailed in Table 4 of Section 3.4.

A 2 dB increase in relative traffic noise level is approximately equal to a 60 % increase in traffic flow.

The relative traffic flow increases that are estimated to occur on the roads included within this assessment during the construction of the Project are shown in Table 19.

Table 19: Relative increase to traffic flow on public roads

Road category	Relative increase	
	Day	Night
Local roads [2]		
Canyonleigh Road	2,140%	2,060%
Brayton Road (Nth Canyonleigh Road)	0%	0%
Brayton Road (Sth Canyonleigh Road)	486%	396%
Freeways/arterial/sub-arterial roads [3][4]		
Hume Highway	1%	5%
Ambrose Road	18%	41%
Brayton Road (Nth Ambrose Road)	22%	42%
Brayton Road (Sth Ambrose Road)	20%	33%

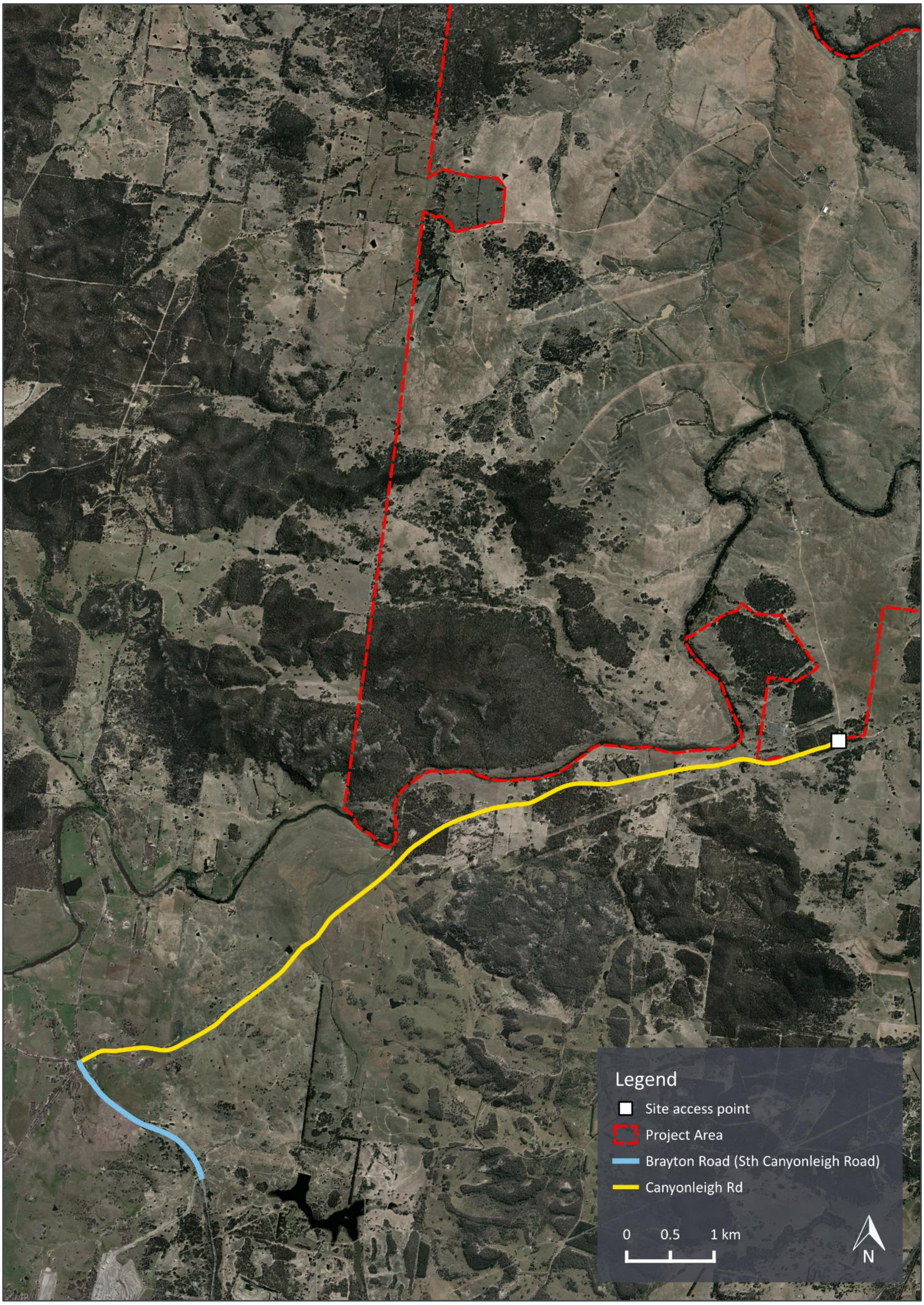
Based on the data in Table 19, the relative traffic noise level increase due to the proposed construction activities is predicted to be:

- Below the 2 dB threshold on all freeway/arterial/sub-arterial roads, as well as one local road section - Brayton Road (Nth Canyonleigh Road).
- Above the 2 dB threshold on 2 local road sections - Canyonleigh Road and Brayton Road (Sth Canyonleigh Road).

On this basis, the detailed assessment documented herein has only considered construction traffic noise along Canyonleigh Road and Brayton Road (Sth Canyonleigh Road).

The location of each of the assessed sections of road in relation to the Project Area is shown in Figure 6.

Figure 6: Assessed roads in relation to the Project Area



9.2 Construction traffic predictions

Based on the information provided in Table 18, it is noted that both the existing traffic volumes and those associated with the construction of the Project are very low in absolute levels. The Calculation of Road Traffic Noise (CoRTN) prediction method, preferred by Transport for NSW and the EPA, is not typically applied where traffic flows are less than 50 vehicles per hour. A correction factor for low traffic volumes, applicable when considering traffic flows lower than 200 vehicles per hour, has been applied where relevant, in accordance with CoRTN.

From the traffic data in Table 18, traffic noise levels have been predicted in the vicinity of the assessed roads using the following method and assumptions:

- Traffic speed set to 100 km/h (this will be conservative for receivers close to intersections)
- Roads assessed as local roads as defined in the RNP.
- Predicted noise levels include an additional +2.5 dB correction for facade reflection as required by the RNP.
- $L_{Aeq, 1h}$ levels are calculated as CoRTN $L_{A10(1hr)}$ - 3 dB, per RMS practice (noting that this research was conducted by the RMS which has now been absorbed into TfNSW).
- Grass or cultivated fields assumed between the road and receivers.

Modifying corrections for Australian conditions (e.g. per Australian Road Research Board report ARR 121 dated 1983) or for road surface conditions have not been applied as applicable data for the road surfaces in question is not available.

Table 20 shows a summary of the minimum setback distances from the assessed roads, beyond which compliance with the RNP criteria is predicted to be achieved during the day and night periods.

Table 20: Minimum setback distance for RNP compliance

	Minimum setback distance for compliance, m		
Road	**Day**	**Night**	**Receivers within setback zone**
Local roads			
Canyonleigh Road	40	85	3 (R108, R268, R270)
Brayton Road (Sth Canyonleigh Road)	45	95	-

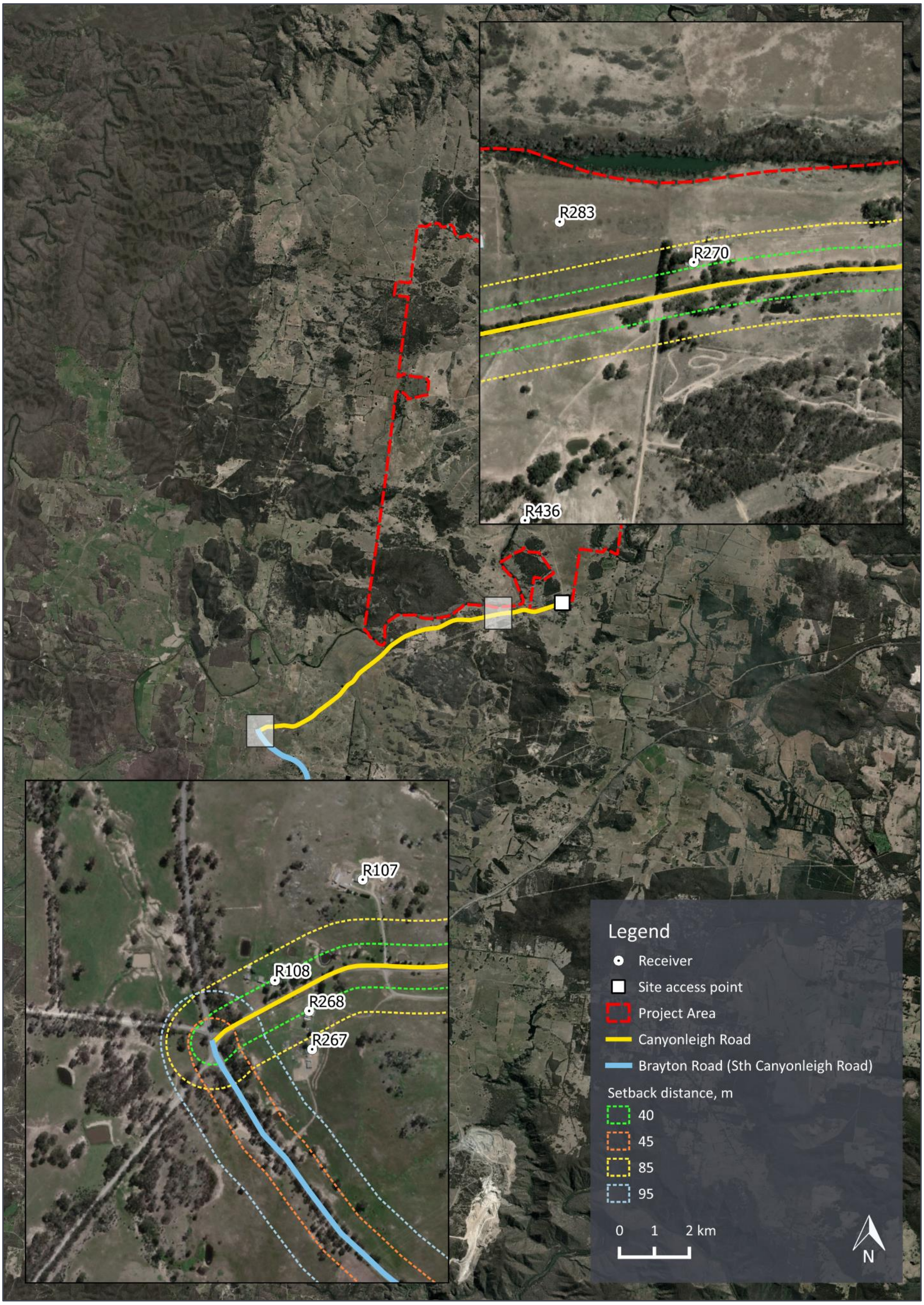
As shown in Table 20, there are 3 receivers close to Canyonleigh Road that are located within the predicted setback zones for RNP compliance. 2 of these receivers are located further than 3 km away from the Project infrastructure and are therefore not identified elsewhere within this assessment. All of these receivers are located either within or marginally within both the day and night setback zones.

These receivers are presented graphically in Figure 7, and should be included in the CEMP, where relevant.

Notwithstanding the prediction results, the increase in traffic noise from the already low existing volumes may result in a noticeable increase in noise during some periods of construction. Noise mitigation options are generally limited for local roads, with community consultation and regular communication being the most effective and practical means of minimising adverse impacts.

Alternative practical methods for minimising noise impact may include limiting construction traffic speed for the affected stretches of Canyonleigh Road and Brayton Road (Sth Canyonleigh Road). Reducing construction traffic speeds would reduce the minimum setback distances and potential for adverse noise impacts to these receivers.

Figure 7: Receivers within minimum setback distances adjacent to assessed roads



9.3 Sleep disturbance due to construction traffic

The majority of construction traffic movements will occur during the day period, as construction works associated with the Project are only expected to occur during standard working hours.

Out of hours work is not specifically scheduled in the current conceptual construction works information provided by the Spark Renewables.

Notwithstanding the above, a conceptual assessment is included for potentially unavoidable works requiring oversize/over mass vehicles (OSOM), e.g. for the delivery of oversized components at times selected to minimise traffic disruption associated with intersection closures and unloading or installation of oversize equipment, such as HV transformers.

Based on the RNP sleep disturbance criteria established in Section 3.4, an external noise level screening threshold of 65 dB L_{Amax} is established to assess the potential for sleep disturbance due to construction traffic during the periods of OSOM delivery. Based on typical OSOM vehicle noise data, a maximum external noise level of 65 dB L_{Amax} or higher, is feasible at receivers within 40 m of the OSOM vehicle movements.

The OSOM Transport Route would be used for OSOM deliveries where required. On this basis, the sleep disturbance assessment has considered the potential for noise impacts resulting from OSOM deliveries along all road sections identified in Table 18, with the exception of Brayton Road (Sth Ambrose Road), being the assessed road section that passes through the township of Marulan. Based on information provided by Access Traffic Consulting, it is understood that OSOM deliveries would preference the Ambrose Road exit from the Hume Highway to minimise the risk of impacts within Marulan.

Based on the receiver dataset provided by Spark Renewables, only receiver R108, close to the intersection of Canyonleigh Road/Brayton Road, is within the 40 m setback zone.

It should be noted that, as shown Table 20 and Figure 7, receivers R268 and R270 are marginally outside the 40 m setback zone and should also be proactively considered.

It is recommended that these receivers be included in any community consultation and communications regarding the scheduling of OSOM deliveries, given the potential for noise impacts associated with both OSOM vehicle movements and general construction traffic associated with the Project.

It is also understood that Spark Renewables are offering construction disruption [payments to residents living along Canyonleigh Road during the construction period to compensate for disruption caused by traffic and associated noise impacts.

Where OSOM deliveries must be carried out during night periods, reasonable and feasible noise mitigations should be considered. Potential mitigation could include:

- Reducing the maximum number of movements to once or twice each night.
- Scheduling for times when adverse impact is less likely, e.g. the very start of the night period and the very end of the night period, to reduce the potential for sleep disturbance.

10.0 CONCLUSIONS

Marshall Day Acoustics Pty Ltd (MDA) has been engaged to prepare this noise and vibration assessment to support the environmental impact statement (EIS) for the Project.

Operational noise from the Project has been assessed in accordance with the NPfI. Predicted noise levels at all non-host landowner receivers are below the most stringent project noise trigger level of 35 dB $L_{Aeq\ 15min}$, applicable during the evening and night periods, by a minimum margin of 9 dB.

Cumulative operational noise, considering the nearby existing Transgrid Marulan Substation, proposed Marulan Gas Fired Power Station, and Wattle Creek Solar Farm project (to be located within the Project Area), has been conducted. The outcomes of the assessment indicate that the individual project amenity noise levels, the recommended amenity noise levels for the receiver categories, and therefore the overall intent of the NPfI with respect to cumulative industrial noise are satisfied.

The findings of the operational noise assessment therefore demonstrates that the Project is capable of being designed and operated to comply with Project SEARs requirements for operational noise at all non-host landholder receivers. It is recommended that the predicted noise levels for all components of the operational noise assessment be updated for the final Project configuration and equipment selections, in order to verify compliance with the project noise trigger levels prior to the commencement of construction.

A preliminary construction noise and vibration assessment has been conducted, accounting for typical equipment items and work practices, as well as details of the relevant NSW guidelines and preliminary noise management recommendations. The assessment was undertaken in accordance with the ICNG and AVTG. The assessment confirmed that construction noise and vibration can be appropriately managed using standard good practice measures.

Measures for the management of construction noise and vibration would be implemented via a CEMP to be prepared during detailed design phase of the Project when a construction contractor has been selected and specialised construction planning for the site has been developed. This would comprise a detailed noise and vibration assessment, as well as project specific noise mitigating work practices and physical noise controls (where required).

An assessment of traffic noise associated with construction traffic movements on local and freeway/arterial/sub-arterial roads has been conducted in accordance with the RNP. The assessment established setback distances for both road types within which applicable traffic noise criteria may be exceeded.

3 receivers are located within or close to the setback zones (R108, R268, R270). These receivers have the potential to be adversely affected by general construction traffic and OSOM traffic movements.

These receivers should be consulted prior to and during construction activities to manage impacts and considered in more detail as part of development of a CEMP. Noise mitigation options are generally limited for local roads however a number of conceptual noise control measures, including speed limits, traffic limits, and OSOM scheduling have been provided. Community consultation and regular communication are typically the most effective and practical means of minimising adverse impacts. The proposed construction disruption payments being offered to the residents on Canyonleigh Road may help to alleviate the associated noise impacts.

Overall, the assessment provided herein demonstrates that construction, operation and decommissioning of the Project can be designed and executed such that related noise is capable of complying with the relevant guidelines and criteria set out in the Project SEARs (SSD-63345458), at all non-host landowner receivers.

APPENDIX A GLOSSARY OF TERMINOLOGY

Term	Definition	Abbreviation
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion below this table.
A-weighted 90th centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
A-weighted average noise level	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.	$L_{Aeq\ (t)}$
A-weighted maximum noise level	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.	L_{Amax}
C-weighting	The process by which noise levels are corrected to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).	See discussion below this table
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Peak Particle Velocity	The measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment	PPV
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special Audible Characterises	A term used to define a set group of Sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics comprise tonality, impulsiveness and amplitude modulation.	SAC
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

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

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

APPENDIX B DESCRIPTION OF SOUND

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

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

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

B1 Definition of sound

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

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

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

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

B2 Physical description of sound

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

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

- sound pressure; and
- sound frequency.

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

B2.1 Sound pressure

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

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

To provide some context, Table 21 lists example values of pressure associated with the atmosphere and different sounds. The key point from these example values is that even an extremely loud sound equates to a change in pressure that is thousands of times smaller than the typical pressure of the atmosphere.

Table 21: Atmospheric pressure versus sound pressure – example values of pressure

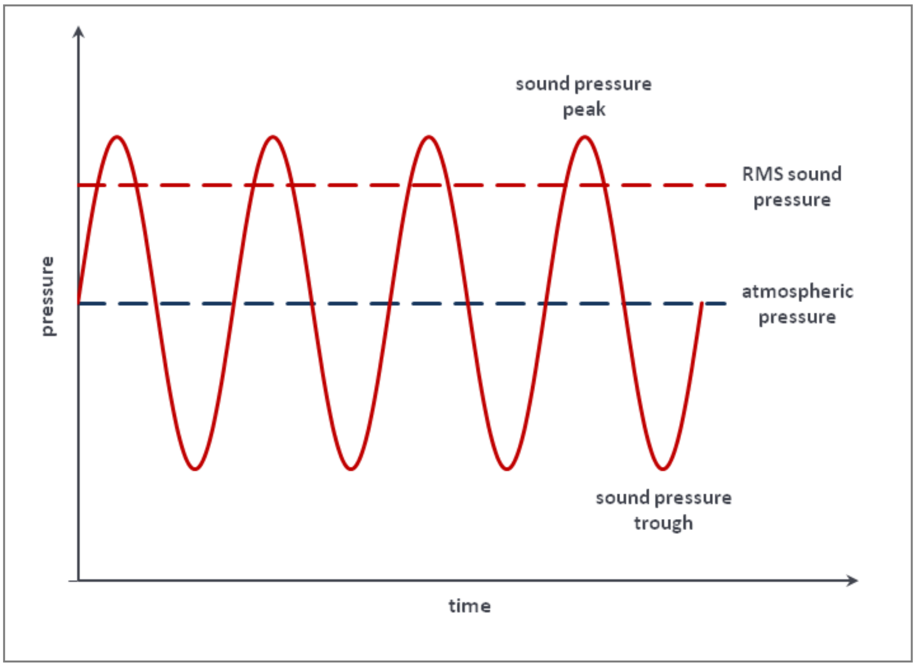
Example	Pascals	Bars	Pounds per Square Inch (PSI)
Atmospheric pressure	100,000	1	14.5
Pressure change due to weather front	10,000	0.1	1.5
Pressure change associated with sound at the threshold of pain	20	0.0002	0.003
Pressure change associated with sound at the threshold of hearing	0.00002	0.0000000002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

The pressure values in Table 21 also show that the range of pressure changes associated with quiet and loud sounds span over a very large range, albeit still very small changes compared to atmospheric pressure. To make the description of pressure changes more practical, sound pressure is expressed in decibels or dB.

To illustrate the pressure variation associated with sound, Figure 8 shows the repetitive rise and fall in pressure of a very simple and steady sound. This figure illustrates the peaks and troughs of pressure changes relative to the underlying pressure of the atmosphere in the absence of sound. The magnitude of the change in pressure caused by the sound is then described as the sound pressure level. Since the magnitude of the change is constantly varying, the sound pressure may be defined in terms of:

- Peak sound pressure levels: the maximum change in pressure relative to atmospheric pressure i.e. the amplitude as defined by the maximum depth or height of the peaks and troughs respectively; or
- Root Mean Square (RMS) sound pressure levels: the average of the amplitude of pressure changes, accounting for positive changes above atmospheric pressure, and negative pressure changes below atmospheric pressure.

Figure 8: Pressure changes relative to atmospheric pressure associated with sound



B2.2 Frequency

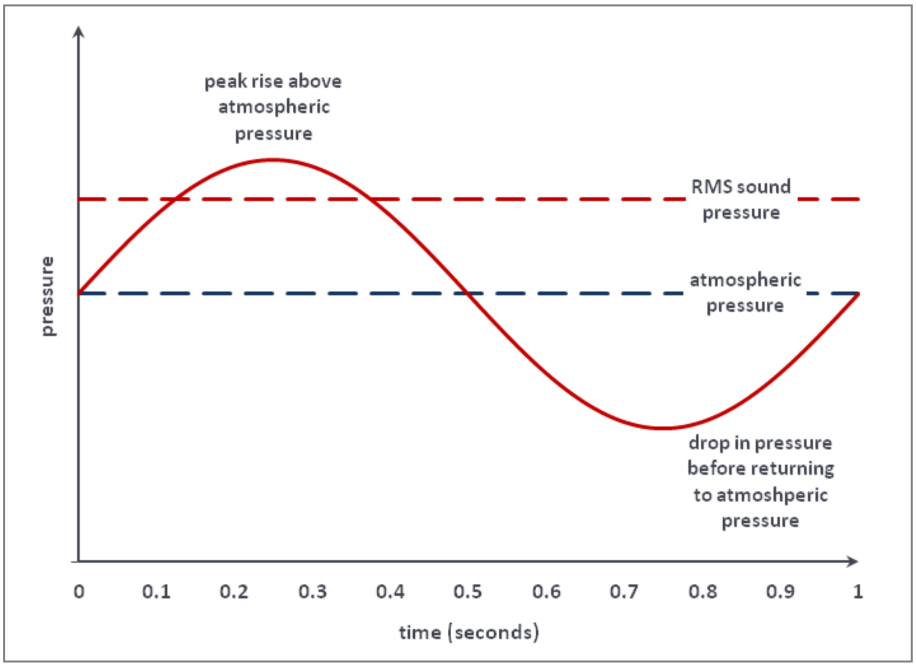
Frequency is a term used to describe the number of times a sound causes the pressure to rise and fall in a given period. The rate of change in pressure is an important feature that determines whether it can be perceived as a sound by the human ear.

Repetitive changes in pressure can occur as a result of a range of factors with widely varying rates of fluctuation. However, only a portion of these fluctuations can be perceived as sound. In many cases, the rate of fluctuation will either be too slow or too fast for the human ear to detect the pressure change as a sound. For example, local fluctuations in atmospheric pressure can be created by someone waving their hands back and forth through the air; the reason this cannot be perceived as a sound is the rate of fluctuation is too slow.

At the rates of fluctuation that can be detected as sound, the rate will influence the character of the sound that is perceived. For example, slow rates of pressure change correspond to rumbling sounds, while fast rates correspond to whistling sounds.

The rate of fluctuation is numerically described in terms of the number of pressure fluctuations that occur in a single second. Specifically, it is the number of cycles per second of the pressure rising above, falling below, and then returning to atmospheric pressure. The number of these cycles per second is expressed in Hertz (Hz). This concept of cycles per second is illustrated in Figure 9 which illustrates a 1 Hz pressure fluctuation. The figure provides a simple illustration of a single cycle of pressure rise and fall occurring in a period of a single second.

Figure 9: Illustration of a pressure fluctuation with a frequency of 1 Hz



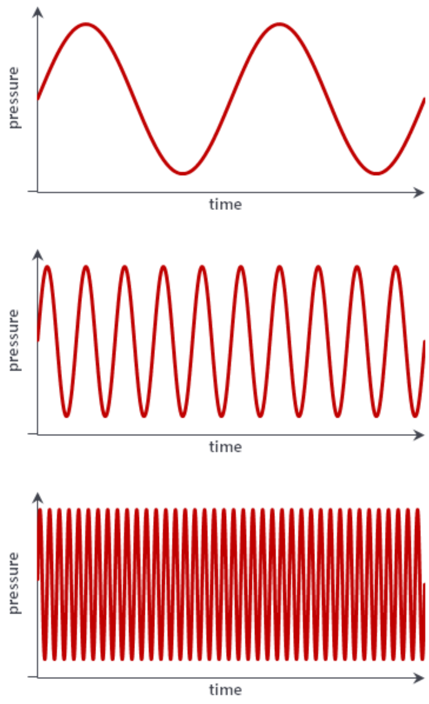
The rate that sound pressure rises and falls will vary depending on the source of the sound. For example, the surface of a tuning fork vibrates at a specific rate, in turn causing the pressure of the adjacent air to fluctuate at the same rate. Recalling the idea of pressure fluctuations from someone waving their hands, the pressure would fluctuate at the same rate as the hands move back and forth; a few times a second translating to a very low frequency below our hearing range (termed an infrasonic frequency). Examples of low and high frequency sound are easily recognisable, such as the low frequency sound of thunder, and the high frequency sound of crashing cymbals. To demonstrate the differences in the patterns of different frequencies of sound, Figure 10 illustrates the relative rates of pressure change for low, mid and high frequency sounds. Note that in each case the amplitude of the pressure changes remains the same; the only change is the number of fluctuations in pressure that occur over time.

Figure 10: Examples of the rate of change in pressure fluctuations for low, mid and high frequencies

Low frequency sounds: 20 to 200 Hz

Mid-frequency sounds: 200 to 800 Hz

High frequency sounds: greater than 800 Hz



B2.3 Sound pressure and frequency variations

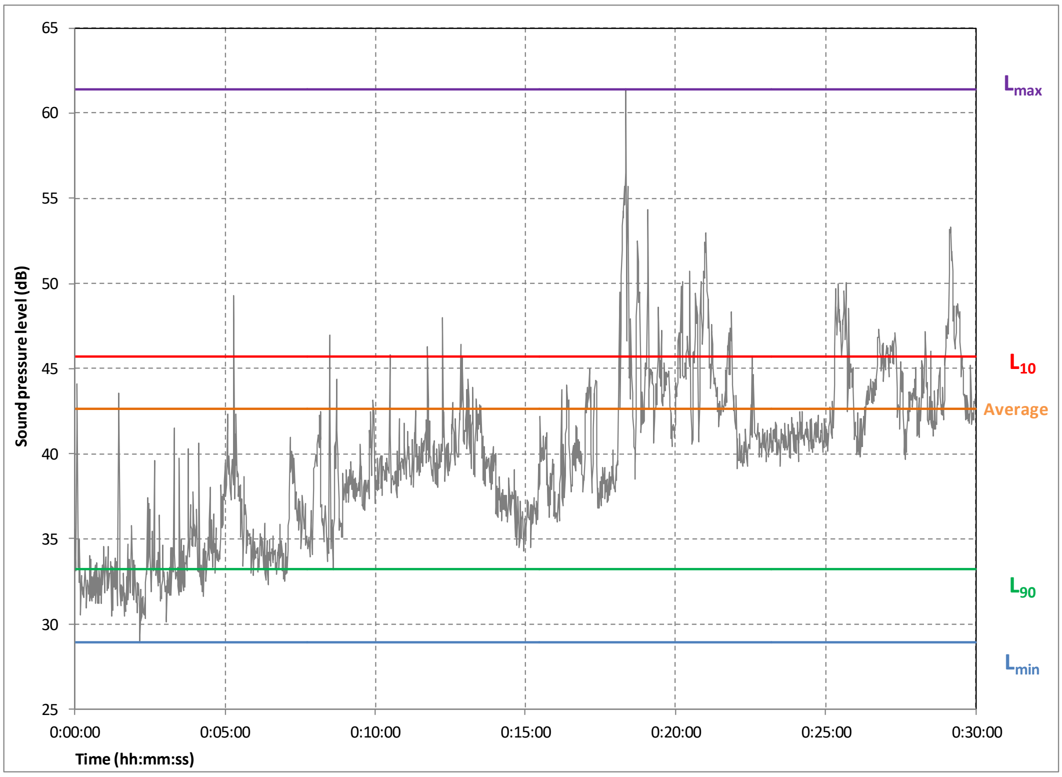
The preceding sections describe important aspects of the nature of sound, the changes in pressure and the changes in the rate of pressure fluctuations.

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

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

To demonstrate this, Figure 11 illustrates an example time-trace of total sound pressure levels which varies with time. This variation presents challenges when attempting to describe sound pressure levels. As a result, multiple metrics are generally needed to describe sound pressure, such as the average, minimum or maximum noise levels. Other ways of describing sound include statistics for describing how often a defined sound pressure level is exceeded; for example, typical upper sound levels are often described as an L_{10} which refers to the sound pressure exceeded for 10 % of the time, or typical lower levels or lulls which are often described as an L_{90} which refers to the sound exceeded for 90 % of the time.

Figure 11: Example of noise metrics that may be used to measure a time-varying sound level



This example illustrates variations in terms of just total sound pressure levels, but the variations can also relate to the frequency of the sound, and frequently the number of sources affecting the sound.

These types of variations are an inherent feature of most sound fields and are an important point of context in any attempt to describe sound.

B3 Hearing and perception of sound

This section provides a discussion of:

- The use of the decibel to practically describe sound levels in a way that corresponds to the pressure levels the human ear can detect as sounds; and
- The relationship between sound frequency and human hearing.

The section concludes with a discussion of some of the complicating non-acoustic factors that influence our perception of sound.

B3.1 Sound pressure and the decibel

Previous sections discussed the wide range of small pressure fluctuations that the ear can detect as sound. Owing to the wide range of these fluctuations, the way we hear sound is more practically described using the decibel (dB). The decibel system serves two key purposes:

- Compressing the numerical range of the quietest and loudest sounds commonly experienced.

  As an indication of this benefit, the pressure of the loudest sound that might be encountered is around a million times greater than the quietest sound that can be detected. In contrast, the decibel system reduces this to a range of approximately 0-120 dB.

- Consistently representing sound pressure level changes in a way that correlate more closely with how we perceive sound pressure level changes.

  For example, a 10 dB change from 20-30 dB will generally be subjectively like a 10 dB change from 40-50 dB. However, expressed in units of pressure as Pascals, the 40-50 dB change is ten times greater than the 20-30 dB change. For this reason, sound pressure changes cannot be meaningfully communicated in terms of units of pressure such as Pascals.

Sound pressure levels in most environments are highly variable, so it can be misleading to describe what different ranges of sound pressure levels correspond to. However, as a broad indication, Table 22 provides some example ranges of sound pressure levels, expressed in both dB and units of pressure.

Table 22: Example sound pressure levels that might be experienced in different environments

Environment	Example sound pressure level	
Outside in an urban area with traffic noise	50-70 dB	0.006-0.06 Pa
Outside in a rural area with distant sounds or moderate wind rustling leaves	30-50 dB	0.0006-0.006 Pa
Outside in a quiet rural environment in calm conditions	20-30 dB	0.0002-0.0006 Pa
Inside a quiet bedroom at night	<20 dB	0.0002 Pa

The impression of how much louder or quieter a sound is, will be influenced by the magnitude of the change in sound pressure. Other important factors will also influence this, such as the frequency of the sound which is discussed in the following section. However, to provide a broad indication, Table 23 provides some examples of how changes in sound pressure levels, for a sound with the same character, can be perceived.

Table 23: Perceived changes in sound pressure levels

Sound pressure level change	Indicative change in perceived sound
1 dB	Unlikely to be noticeable
2-3 dB	Likely to be just noticeable
4-5 dB	Clearly noticeable change
10 dB	Distinct change - often subjectively described as halving or doubling the loudness

The example sound pressure level changes in Table 23 are based on side by side comparison of a steady sample of sound heard at different levels. In practice, changes in sound pressure levels may be more difficult to perceive for a range of reasons, including the presence of other sources of sound, or gradual changes which occur over a longer period.

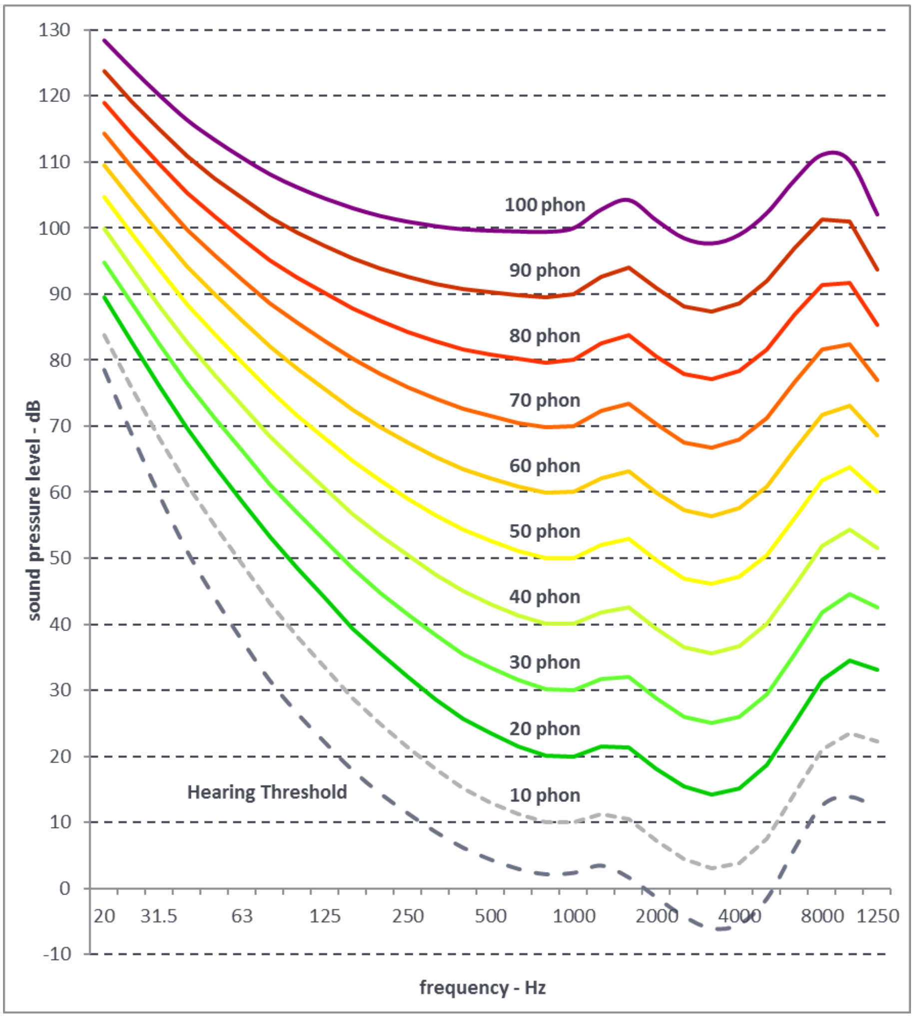
B3.2 Sound frequency and loudness

Although sound pressure level and the sensation of loudness are related, the sound pressure level is not a direct measure of how loud a sound appears to humans. Human perception of sound varies and depends on a number of physical attributes, including frequency, level and duration.

An example of the relationship between the sensation of loudness and frequency is demonstrated in Figure 12. The chart presents equal loudness curves for sounds of different frequencies expressed in 'phons'. Each point on the phon curves represents a sound of equal loudness. For example, the 40 phon curve shows that a sound level of 100 dB at 20 Hz (a very low frequency sound) would be of equal loudness to a level of 40 dB at 1,000 Hz (a whistling sound) or approximately 50 dB at just under 8,000 Hz (a very high pitch sound). The information presented is based on an international standard[7] that defines equal loudness levels for sounds comprising individual frequencies. In practice, sound is usually composed of many different frequencies, so this type of data can only be used as an indication of how different frequencies of sound may be perceived. An individual's perceptions of sound can also vary significantly. For example, the lower dashed line in Figure 12 shows the threshold of hearing, which represents the sounds an average listener could correctly identify at least 50 % of the time. However, these thresholds represent the average of the population. In practice, an individual's hearing threshold can vary significantly from these values, particularly at the low frequencies.

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

Figure 12: Equal loudness contours for pure tone sounds



The noise curves in Figure 12 demonstrate that human hearing is most sensitive at frequencies from 500 to 4,000 Hz, which usefully corresponds to the main frequencies of human speech. The contours also demonstrate that sounds at low frequencies must be at much higher sound pressure levels to be judged equally loud as sounds at mid to high frequencies.

To account for the sensitivity of the ear to different frequencies, a set of adjustments were developed to enable sound levels to be measured in a way that more closely aligns with human hearing. Sound levels adjusted in this way are referred to as A-weighted sound levels.

B3.3 Interpretation of sound and noise

Human interpretation of sound is influenced by many factors other than its physical characteristics, such as how often the sound occurs, the time of day it occurs and a person's attitude towards the source of the sound.

For example, the sound of music can cause very different reactions, from relaxation and pleasure through to annoyance and stress, depending on individual preferences, the type of music and the circumstances in which the music is heard. This example illustrates how sound can sometimes be considered noise; a term broadly used to describe unwanted sounds or sounds that have the potential to cause negative reactions.

The effects of excess environmental sound are varied and complicated and may be perceived in various ways including sensations of loudness, interference with speech communication, interference with working concentration or studying, disruption of resting/leisure periods, and disturbance of sleep. These effects can give rise to behavioural changes such as avoiding the use of exposed external spaces, keeping windows closed, or timing restful activities to avoid the most intense periods of disruption. Prolonged annoyance or interference with normal patterns can lead to possible effects on mental and physical health. In this respect, the World Health Organization (preamble to the *Constitution of the World Health Organization*, 1946) defines health in the following broad terms:

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

The World Health Organization Guidelines for Community Noise (Berglund, Lindvall, & Schwela, 1999) documents a relationship between the definition of health and the effects of community noise exposure by noting that:

> *This broad definition of health embraces the concept of well-being, and thereby, renders noise impacts such as population annoyance, interference with communication, and impaired task performance as 'health' issues.*

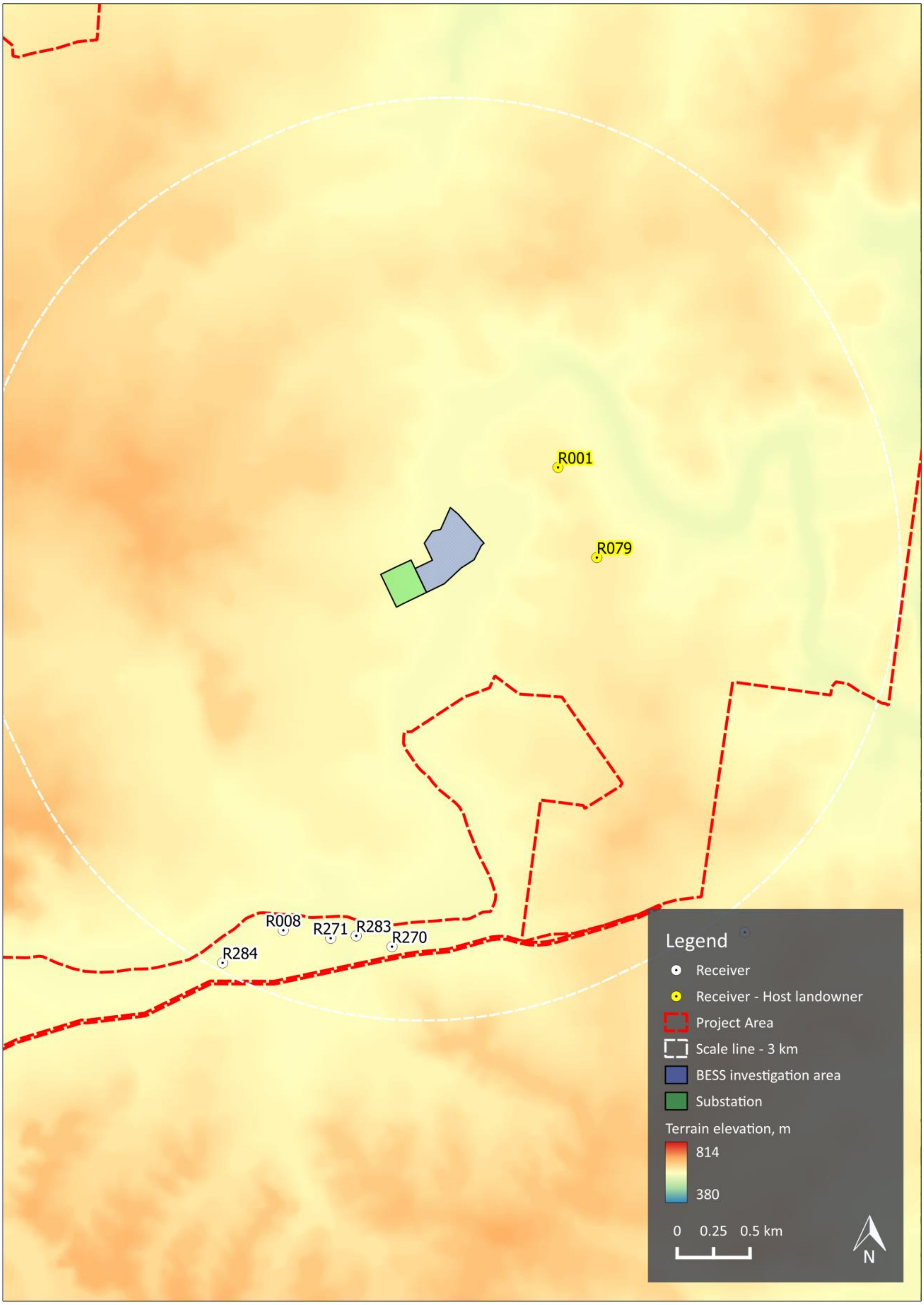
The reaction that a community has to sound is highly subjective and depends on a range of factors including:

- The hearing threshold of individuals across the audible frequency range. These thresholds vary widely across the population, particularly at the lower and upper ends of the audible frequency range. For example, at low frequencies the distribution of hearing thresholds varies above and below the mean threshold by more than 10 dB;
- The attitudes and sensitivities of individuals to sound, and their expectations of what is considered an acceptable level of sound or intrusion. This in turn depends on a range of factors such as general health and the perceived importance of sound amongst other factors relevant to overall amenity perception;
- The absolute sound pressure level of the sound in question. The threshold for the onset of community annoyance varies according to the type of sound; above such thresholds, the percentage of the population annoyed generally increases with increasing sound pressure level;
- The sound pressure level of the noise relative to background noise conditions in the area, and the extent to which general background noise may offer beneficial masking effects;
- The characteristics of the sound in question such as whether the sound is constant, continually varies, or contains distinctive audible features such as tones, low frequency components or impulsive sound which may draw attention to the noise;
- The site location and the compatibility of the source in question with other surrounding land uses. For example, whether the source is in an industrial or residential area;

- The attitudes of the community to the source of the sound. This may be influenced by factors such as the extent to which those responsible for the sound are perceived to be adopting reasonable and practicable measures to reduce their emissions, whether the activity is of local or national significance and whether the noise producer actively consults and/or liaises with the community; and
- The times when the sound is present, the duration of exposure to increased sound levels, and the extent of respite periods when the sound is reduced or absent (for example, whether the sound ceases at weekends).

The combined influence of the above considerations means that physical sound levels are only one factor influencing community reaction to sound. Importantly, this means that individual reactions and attitudes to the same type and level of sound will vary within a community.

APPENDIX C SITE TOPOGRAPHY



APPENDIX D RECEIVER COORDINATES

Table 24 sets out the 7 receivers identified by Spark Renewables that are located within 3 km of the noise generating infrastructure associated with the Project and have therefore been considered within the noise assessment.

Data has been supplied by Spark Renewables on 21 August 2024.

Table 24: Receivers within 3 km of the Project infrastructure– GDA2020 MGA zone 56

Receiver ID	Easting, m	Northing, m	Terrain elevation, m	Approximate distance to project infrastructure, m
R001 [1]	229,763	6,168,554	610	730
R008	227,877	6,165,372	600	2,520
R079 [1]	230,029	6,167,935	620	780
R271	228,202	6,165,318	592	2,470
R270	228,623	6,165,260	597	2,450
R283	228,377	6,165,334	592	2,410
R284	227,459	6,165,149	593	2,910

1 Host landowner property

APPENDIX E NOISE POLICY FOR INDUSTRY DERIVATION

In NSW, the Environmental Protection Authority's NPfI is the guideline for assessing noise emissions from industrial facilities and other developments with noise sources that may be considered industrial in nature. The NPfI sets out a procedure where an industrial facility can be assessed against a series of noise levels. Project specific noise levels are derived from an analysis of background noise levels, ambient noise environment and zoning information.

An NPfI assessment requires the derivation of two project noise trigger levels - one from an intrusiveness assessment and another from an amenity assessment. Assessment locations for residential receivers have been taken as the nearest point within 30m of the dwelling, in accordance with the NPfI.

E1 Project intrusiveness noise level

The intrusiveness noise assessment is applicable to residential receivers and is based on knowledge of the RBL (background noise level) at the receiver location. In the absence of measured RBLs, minimum assumed RBLs are provided in Table 2.1 of the NPfI. The project intrusiveness noise level is taken to be the RBL plus 5dB. Therefore, the noise emissions from the noise source are considered to be intrusive if the A-weighted source noise level ($L_{Aeq, 15min}$) is greater than the RBL (L_{A90}) plus 5 dB.

Assessment time periods are set out in Table 5 of Section 5.2.

The minimum project intrusiveness noise levels set out in Table 2.1 of the NPfI are reproduced in Table 25.

Table 25: Minimum assumed RBLs and minimum project intrusiveness noise levels, dB $L_{Aeq, 15 min}$

Time of day	Minimum assumed RBL	Minimum project intrusiveness noise level
Day	35	40
Evening	30	35
Night	30	35

E2 Project amenity noise level

Project amenity noise levels are designed to prevent industrial noise continually increasing above an acceptable level over time with the expansion of infrastructure and development.

Based on guidance provided in Table 2.3 of the NPfI all receivers relevant for assessment have been determined to be 'Rural Residential', being a residential receiver type in a rural noise amenity area.

Table 2.2 of the NPfI sets out recommended amenity noise levels for each receiver category. Modification of the recommended amenity noise level is required in accordance with Section 2.4 of the NPfI, to account for the potential existing contribution or future contribution of industrial noise on receivers. This has been applied to allow for existing noise from the TransGrid Marulan 330/132 kV substation (and the Wattle Creek Solar Farm project).

A further modification is made to standardise the amenity assessment time period to align with the intrusiveness assessment. This adjustment assumes that the $L_{Aeq, 15 min}$ will be taken to be equal to the $L_{Aeq, period}$ + 3 dB. The resultant project amenity noise levels are shown in Table 26.

Table 26: Project amenity noise level, dB

Receiver	Time of day	Recommended amenity noise level, dB $L_{Aeq, period}$	Project amenity noise level, dB $L_{Aeq, 15min}$
Residential (Rural)	Day	50	48
	Evening	45	43
	Night	40	38

E3 Project noise trigger levels

The final process in determining the operational noise limits for the Project is to derive the project noise trigger levels. The project noise trigger levels are levels that, if exceeded, would indicate a potential noise impact on the community, and so ‘trigger’ a management response; for example, further investigation of noise mitigation measures.

The project noise trigger levels are derived by selecting the more stringent of either the project intrusiveness noise level or project amenity noise level. The project noise trigger levels applicable to receivers relevant for assessment of the Project are shown in Table 27.

Table 27: Project noise trigger levels, dB $L_{Aeq,\,15min}$

Receiver	Time of day	Project noise trigger level
Residential (Rural)	Day	40
	Evening	35
	Night	35

APPENDIX F NOISE PREDICTION MODEL

A computer model was created in the environmental noise modelling program SoundPLANnoise v9.0 to predict noise levels from noise sources to relevant receivers in the vicinity of the Project. The noise model has been used to calculate noise levels at the nearest noise-affected premises in accordance with ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2).

This standard has recently been superseded by the standard ISO-9613-2:2024 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: Engineering method for the prediction of sound pressure levels outdoors*. However, at the date of preparing this report, the revised standard has not yet been implemented in commonly used noise modelling software options, including SoundPLANnoise v9.0.

The core elements of the two versions are similar and the relevant calculation formulae have not materially changed. The noise model enables the calculation of noise levels over a wide area, and accounts for key considerations including site arrangement, terrain, and atmospheric conditions.

ISO 9613-2 specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions that are favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of ±45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion.

Accordingly, predictions based on ISO 9613-2 account for the instances when local atmospheric conditions at the site favour the propagation of sound to surrounding receptor locations. Under alternative atmospheric conditions, such as when the wind is blowing from a receiver location to the development site, the noise levels would be lower than calculated.

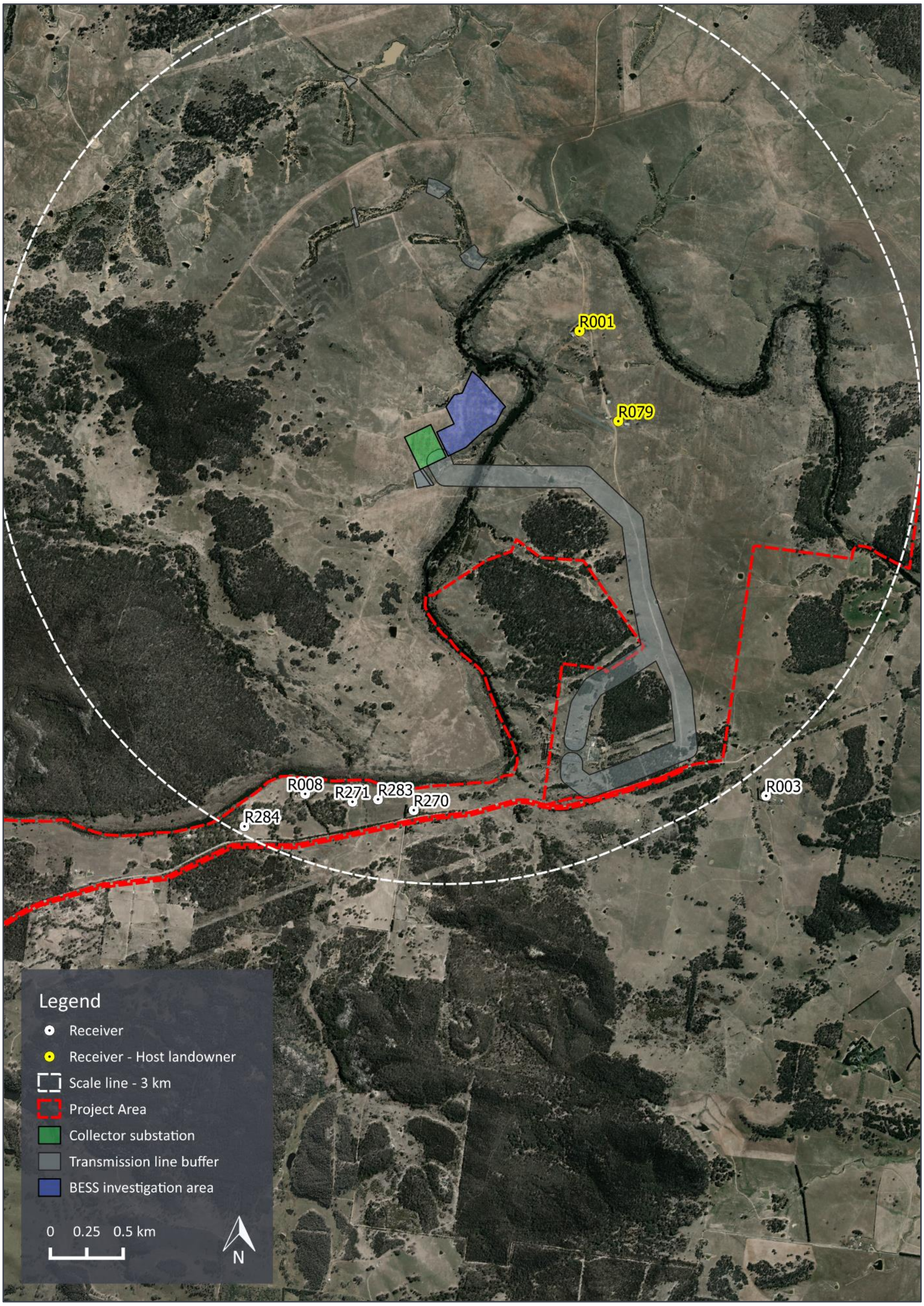
To calculate far-field noise levels according to ISO 9613-2, the noise levels of each source are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- geometric divergence
- air absorption
- reflecting obstacles
- screening
- ground reflections.

The octave band attenuation factors are then applied to the noise data to determine the corresponding octave band and total calculated noise level at relevant receivers.

Topographical data with a vertical resolution of 10 m has been provided by Spark Renewables. This has been configured to a level of detail that is appropriate for noise calculation purposes. Receivers have been modelled at 1.5 m above local ground.

APPENDIX G CONSTRUCTION WORK AREA LAYOUT



APPENDIX H CONSTRUCTION EQUIPMENT, WORK STAGES AND ACOUSTIC DATA

Sound power levels for the types of equipment used to construct the Project have been determined from guidance and data sources including AS 2436, and noise level data from previous projects of a similar nature.

Table 28 summarises the noise emissions used to represent key items of plant associated with construction.

Table 28: Construction noise sources sound power level data, dB L_{WA}

Noise source	Sound power level
Bulldozer	108
Compactor	113
Concrete truck	108
Crane (mobile)	104
Dump truck	117
Excavator	107
Forklift	106
Front end loader	113
Grader	110
Hand tools (electric)	102
Machine mounted hydraulic drill	113
Roller (vibratory)	108
Truck (> 20 t)	107
Truck (dump)	117
Truck (water cart)	107
Vehicle (light commercial e.g. 4WD)	106
Welder	105

Overall aggregated total sound power levels for key construction tasks have been determined on the basis of a typical schedule of equipment associated with each task. The actual equipment choices and equipment numbers for each task are not presently defined in detail, and therefore the schedule of equipment listed here does not represent a final or definitive list of plant. The equipment schedule is therefore presented solely as an indication of typical construction noise levels.

The overall total aggregated sound power levels for each of the key construction tasks are detailed in Table 29. These have been developed based on the assumption that each item of plant associated with a task operates simultaneously for the entire duration of an assessment period.

Table 29: Approximate aggregate sound power levels of key construction tasks, dB L_{WA}

Construction task	Plant/Equipment	Approx. aggregate level, L_{WA}
Battery installation	1 x Crane (mobile), 1 x Hand tools (electric), 1 x Vehicle (light commercial e.g. 4WD), 1 x Welder	110
Civil earthworks	1 x Bulldozer, 1 x Compactor, 1 x Dump truck, 1 x Excavator, 1 x Front end loader, 1 x Grader, 1 x Roller (vibratory), 1 x Truck (dump), 1 x Truck (water cart), 1 x Vehicle (light commercial e.g. 4WD)	120
Component delivery	1 x Concrete truck, 1 x Forklift, 1 x Machine mounted hydraulic drill, 1 x Truck (> 20 t), 1 x Truck (water cart), 1 x Vehicle (light commercial e.g. 4WD)	115
Site establishment, clearing and fencing	1 x Dump truck, 1 x Excavator, 1 x Forklift, 1 x Front end loader, 1 x Grader, 1 x Machine mounted hydraulic drill, 1 x Roller (vibratory), 1 x Truck (water cart), 1 x Vehicle (light commercial e.g. 4WD)	120
Substation construction	1 x Hand tools (electric), 1 x Welder	105