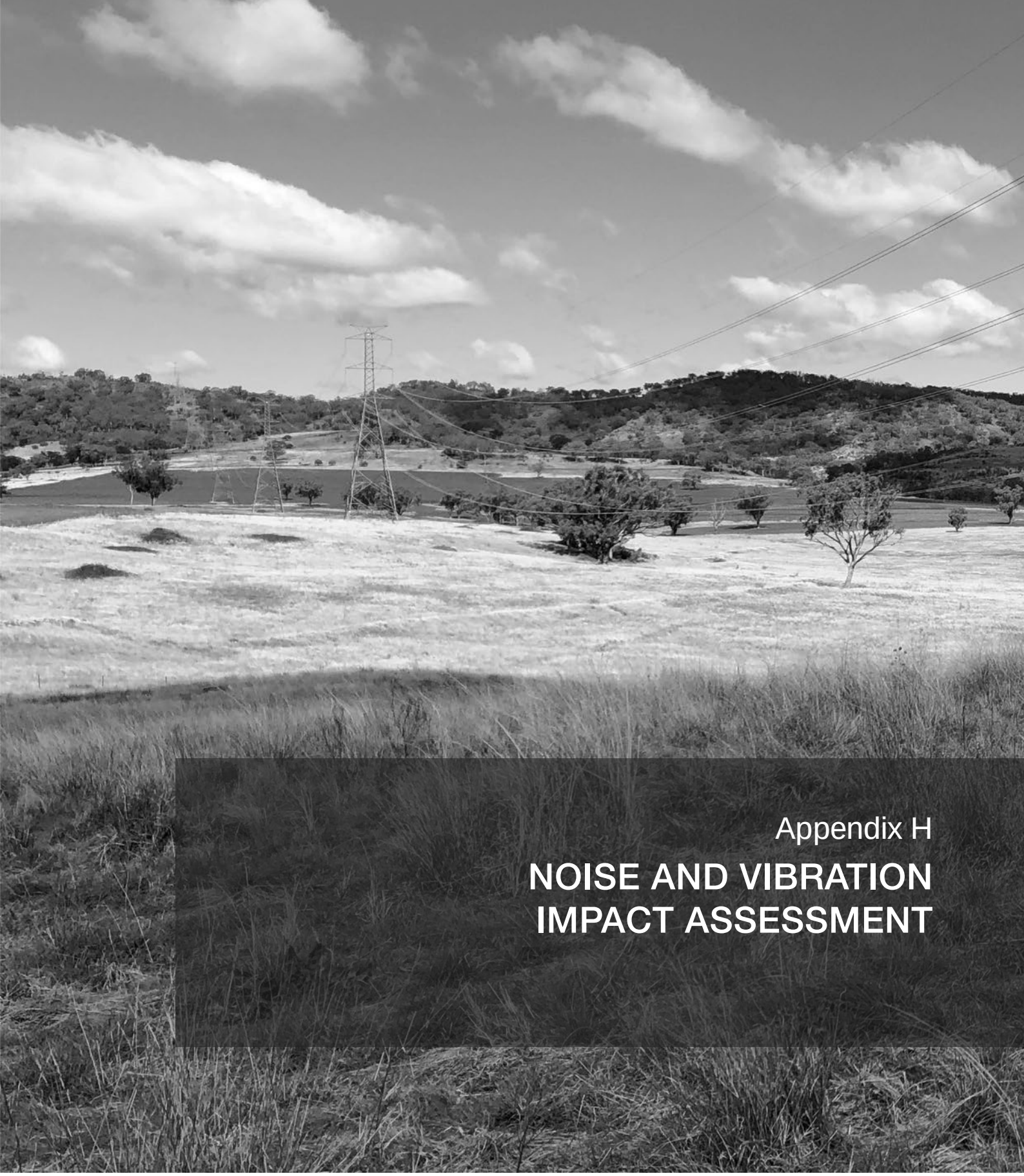

Appendix H

NOISE AND VIBRATION IMPACT ASSESSMENT

EMM

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Noise and Vibration Impact Assessment

Sundown Solar Farm

Prepared for Sundown Solar Pty Ltd

January 2023

Noise and Vibration Impact Assessment

Sundown Solar Farm

Sundown Solar Pty Ltd

J210075 RP112

January 2023

Version	Date	Prepared by	Approved by	Comments
V1 Draft	7 September 2022	Andrew Durrer	Najah Ishac	
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V3	17 January 2022	Rick Scully	Najah Ishac	Updated to include five additional assessment locations

Approved by

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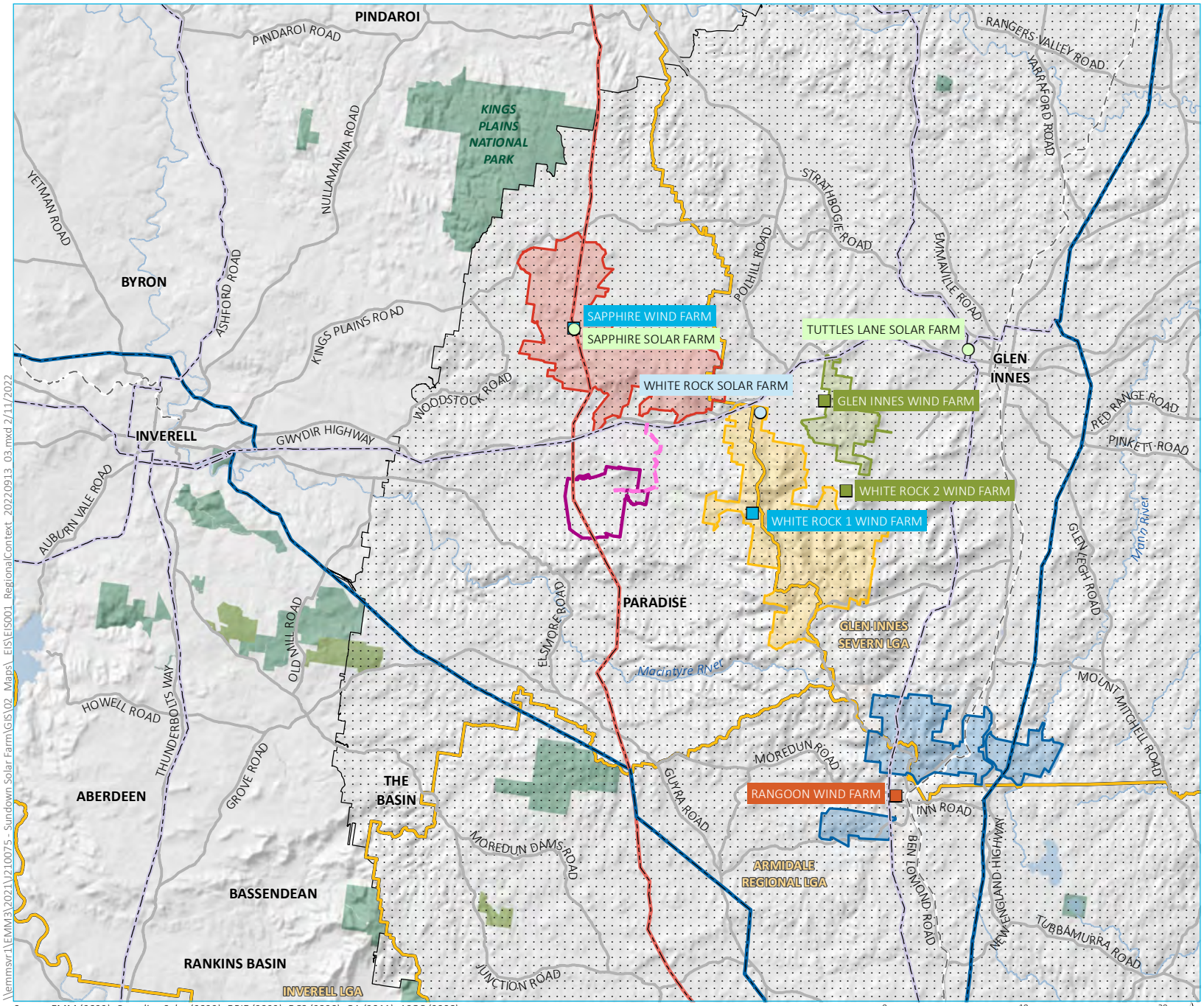
1 Introduction

1.1 Background

Sundown Solar Pty Ltd (Sundown Solar) proposes to develop a large-scale solar photovoltaic (PV) generation and battery energy storage system (BESS) facility in Spring Mountain, approximately 30 km east of Inverell in the New England Tablelands region of northern NSW (Figure 1.1).

The project will be assessed as a State Significant Development (SSD) under *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). Accordingly, an Environmental Impact Statement (EIS) for the project is required under the NSW *Environmental Planning and Assessment Act 1979 (*EP&A Act). Secretary's Environmental Assessment Requirements (SEARs) were issued in 2017, and re-issued in August 2020. Sundown Solar has engaged EMM Consulting Pty Limited (EMM) to prepare the EIS and supporting technical assessments.



KEY

- Proposed Sundown Solar Farm (Project area)
- Access road
- New England Renewable Energy Zone

Electricity transmission line

- 66 kV
- 132 kV
- 330 kV

Surrounding renewable development

Solar development

- Operational
- Approved

Wind development

- Operational
- Approved
- In planning
- Glen Innes Wind Farm
- Rangoon Wind Farm
- Sapphire Wind and Solar Farm
- White Rock Wind and Solar Farm

Existing environment

- Rail line
- Major road
- River
- Named waterbody
- NPWS reserve
- State forest
- Local government area

Source: EMM (2022); Canadian Solar (2022); DPIE (2022); DCS (2020); GA (2011); ASGC (2006)

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Regional context

Sundown Solar Farm
Noise and Vibration Impact Assessment
Figure 1.1

EMM creating opportunities

1.2 Purpose of this report

The key objectives of this report are to:

- describe the applicable noise and vibration regulatory framework;
- describe and characterise the existing noise and vibration environment relevant to the project;
- identify and assess potential noise and vibration impacts of the project construction and operation; and
- identify appropriate mitigation and management measures for the project.

1.3 Other relevant reports

This assessment has taken into consideration the results of the traffic impact assessment.

1.4 Key terminology

The following definitions have been adopted throughout this report (Table 1.1).

Table 1.1 Key terminology

Terminology	Description
The project	The Sundown Solar Farm. This refers to all elements that comprise the project for which approval is sought.
The site	The area proposed to be developed as Sundown Solar Farm.
Project area	Comprises the three lots on which the project will be developed. The project area comprises the development footprint as well as the areas that will remain undeveloped. The project area comprises an area of approximately 2,097 hectares (ha).
Development footprint	The extent of surface area within the project area that will comprise project-related infrastructure (such as the PV panels, BESS, substation, switchroom, internal access roads, etc). The development footprint comprises an area of approximately 651 ha.
Disturbance footprint	The extent of surface area within the project area that will be disturbed to facilitate the construction of the project plus the extent of surface area associated with the access road that will be disturbed to facilitate the construction of the access road and associated intersection. The disturbance footprint comprises an area of approximately 729 ha (including approximately 7.6 ha associated with the access road).

1.5 Legislation

This assessment has been prepared in accordance with:

- *Environmental Planning and Assessment Act 1979*; and
- *Protection of the Environment Operations Act 1997* (POEO Act).

1.6 Guidelines

The following guidelines apply to project related operational and construction noise and vibration:

- *NSW Noise Policy for Industry* (NPFI) 2017, Environmental Protection Authority[1];
- *NSW Interim Construction Noise Guideline* (ICNG) 2009, Department of Environment and Climate Change;
- *NSW Road Noise Policy* (RNP), Department of Environment 2011, Climate Change and Water;
- *NSW Assessing Vibration – a technical guideline* (AVTG) 2006, Department of Environment and Conservation;
- *NSW Noise Criteria Guideline* (NCG) 2015, Roads and Maritime Services;
- *NSW Noise Mitigation Guideline* (NMG) 2015, Roads and Maritime Services;
- *Construction noise and vibration guideline* (CNVG) 2016, Roads and Maritime Services;
- Australian Standard AS/NZS 2107:2000 *'Acoustics – Recommended design sound levels and reverberation times for building interiors'*;
- Australian Standard 2834–1995 *Computer Accommodation*, Chapter 2.9 Vibration;
- Australian Standard AS 2187.2 *Explosives - Storage and use - Part 2 Use of explosives*;
- Australian Standard AS2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*;
- British Standard BS 6472–2008, *Evaluation of human exposure to vibration in buildings (1–80Hz'*;
- British Standard 7385: Part 2–1993 *Evaluation and measurement of vibration in buildings*;
- German Standard DIN4150–2016 *Structural vibration Part 3: Effects of vibration on Structures*;
- Roadway construction noise model user's guide, Federal Highway Administration 2006 (FHWA), US Department of Transportation; and
- *Environmental Noise Management Manual* (ENMM) 2001, Roads and Traffic Authority.

[1] This document has since been superseded by the NSW Noise Policy for Industry (NPfI) 2017. However, the INP remains the relevant policy in accordance with the project's Instrument of Approval and NPfI transitional requirements.

2 Project description

2.1 Project overview

The project involves the development, construction and operation of a solar PV electricity generation facility and associated BESS.

Key infrastructure is shown in Figure 2.1 and comprises:

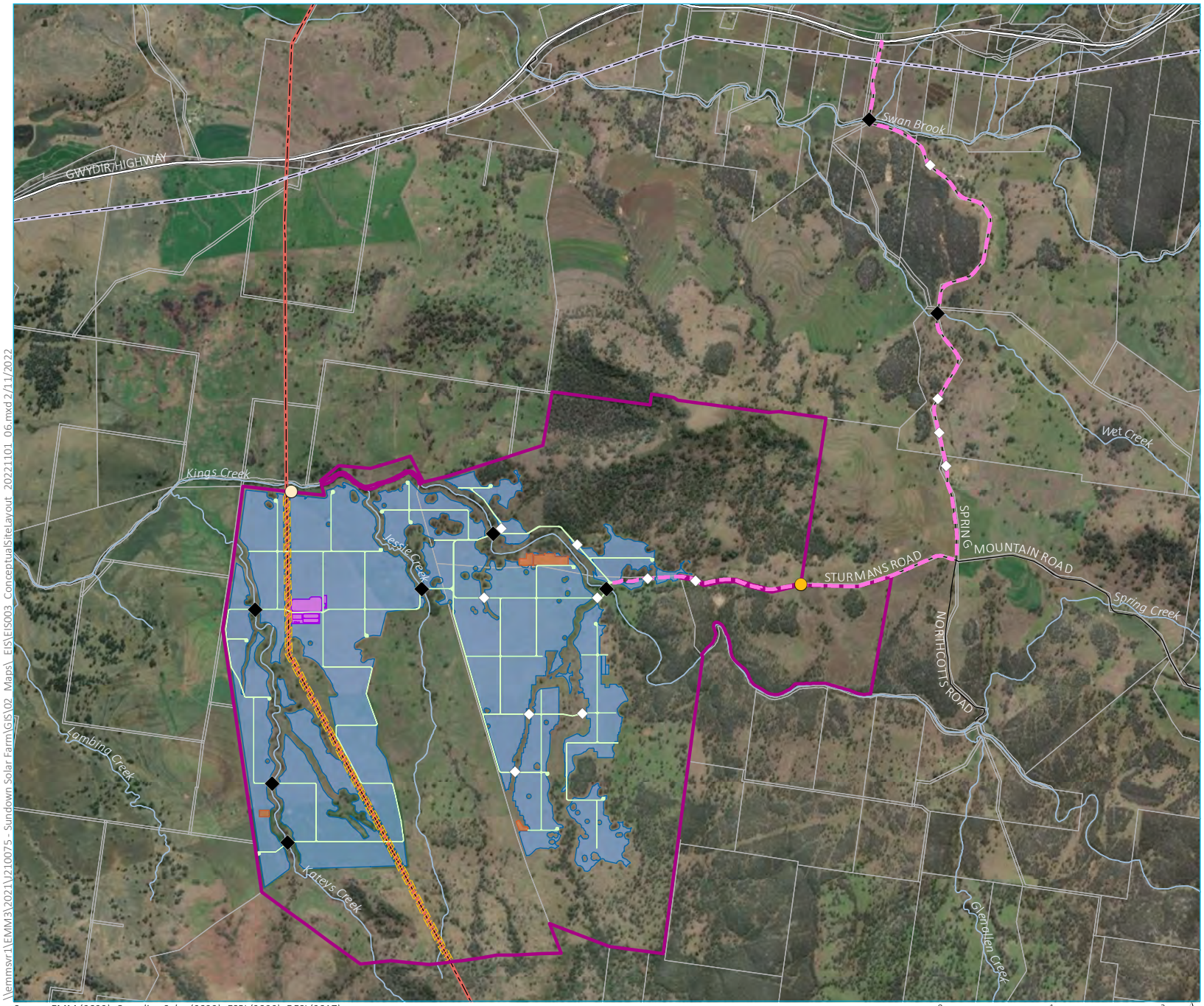
- a network of approximately 660,000 panels and associated mounting infrastructure;
- a 150 MW battery energy storage system (BESS);
- 330 kV onsite substation;
- electrical collection and conversion systems, including inverter and transformer units, switchyard and control room;
- underground and aboveground cables;
- a management hub, including demountable offices and amenities and equipment sheds;
- onsite creek crossings;
- security fencing;
- temporary laydown areas (during construction and decommissioning);
- parking and internal access roads;
- lighting; and
- firefighting infrastructure.

The project will also include the upgrade of the access road (Spring Mountain Road and Sturmans Road) and the Gwydir Highway/Spring Mountain Road intersection.

During the preparation of the EIS, the development footprint within the project boundary has been refined to consider any environmental constraints identified, outcomes of stakeholder engagement, community consultation and design of project infrastructure with the objective of developing an efficient project that avoids and minimises environmental impacts.

The project's targeted generating capacity is up to 360 MW (AC) and up to 150 MW(AC) four-hours of energy storage. The final number of PV modules will be dependent on detailed design, availability, and commercial considerations at the time of construction.

Electricity generated by the project will be injected into the grid via a new onsite substation connected to TransGrid's 330 kV transmission line that traverses the site.



KEY

- Proposed Sundown Solar Farm (Project area)
- Major road
- Minor road
- Named watercourse
- Cadastral boundary

Existing overhead transmission line

- Armidale to Dumaresq (330 kV)
- Glen Innes to Inverell (132 kV)

Development footprint

- Access road
- 330 kV OHL easment (60 m)
- Internal access road
- BESS/switchroom/substation
- Construction and laydown
- Potential PV area

Emergency access/egress point

- Primary
- Secondary

Potential water crossing

- Named watercourse
- Drainage line

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Source: EMM (2022); Canadian Solar (2022); ESRI (2022); DFSI (2017)

0 1 2 km

GDA2020 MGA Zone 56

N

Conceptual site layout

Sundown Solar Farm
Noise and Vibration Impact Assessment
Figure 2.1

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2.1.1 Construction traffic

The project would require a peak construction workforce of up to 400 people. Peak construction would be experienced during stage 2 work and more precisely during delivery and installation of solar arrays, which is expected to be 8–10 weeks in duration.

During construction, there will be a preference for employment of local and regional residents where they are able to demonstrate relevant skills and experience.

Sundown Solar will run a shuttle bus service from Inverell and Glen Innes for most of its construction workforce.

Sundown Solar has consulted with Inverell Shire Council and Glen Innes Severn Council with regards to potential pick up/muster points for shuttle bus services operating to and from Inverell and Glen Innes. The exact locations of these muster points will be determined in consultation with the relevant Councils prior to the commencement of construction.

All construction traffic from both towns would use Gwydir Highway, Spring Mountain Road, and Sturmans Road to enter and exit the site.

In addition to the shuttle bus service, some of the construction workforce may instead travel via light vehicle from Glen Innes or Inverell, via Gwydir Highway. Some workers may travel from further locations and all will travel through Glen Innes or Inverell.

For the purposes of this assessment, it is assumed that 50% of the workforce would travel by shuttle buses whereas the remaining 50% would travel by private vehicles. Assumptions also include capacity of 20 passengers per shuttle bus and 1 worker traveling per private vehicle.

B-doubles will be used during the construction phase (up to 26 m in length). Over Size Over Mass (OSOM) vehicles will also be required to access the site during construction.

The predicted peak daily and hourly light and heavy vehicle movements for each type of vehicle during the peak construction stage of the project are provided in Table 2.1.

Table 2.1 Construction trips

Peak construction stage	Daily movements	Peak hour movements
Light vehicles	200	80
Shuttle buses	28	14
Heavy vehicles	200	16
Total	**428**	**110**

Note: A ‘movement’ is defined as a vehicle entering or exiting the site.

2.2 Operation

The key activities during the operation phase will comprise:

- operation of the solar arrays and BESS;
- maintenance of all electrical and mechanical equipment, including tracker system, cabling, PV modules, switchgear, BESS and communication systems;
- management of vegetation, weeds and pests;
- fence and access road management;
- landscaping;
- panel cleaning, repair and replacement; and
- site security.

2.2.1 Operational traffic

During the 35 year operational life, there will be a maximum of 2 to 3 staff which will potentially generate 6 traffic movements (3 incoming and 3 outgoing movements) per day. As the site operational traffic is expected to be significantly lower than the construction traffic, operational traffic impacts have not been assessed in any detail in this assessment.

3 Existing environment

3.1 Land use

Land use in Spring Mountain consists largely of rural farmland and with activities typically limited to daytime hours.

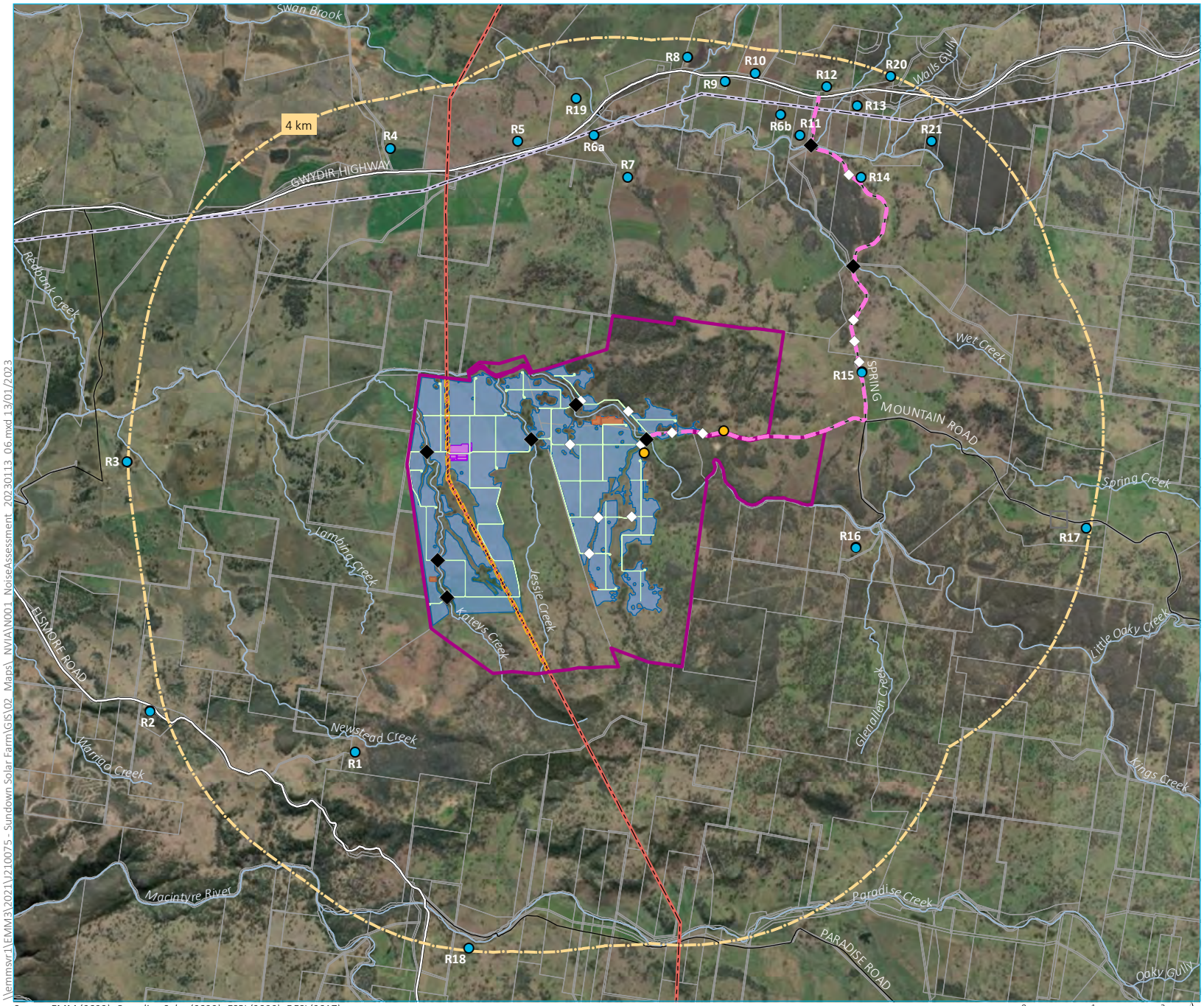
There are 21 potentially sensitive receptors (residential properties) within a 4 km radius of the project area boundary (Table 3.1 and Figure 3.1). This excludes the two associated properties located within the project area. Throughout this report, potentially sensitive receptors are referred to as noise assessment locations.

There are no schools, child-care centres, hospitals, or other potentially sensitive land uses within 2 km of the site boundary.

Table 3.1 Noise assessment locations

ID	Address	Classification	Easting	Northing
R1	Lachlana, 122 Cooks Rd, Newstead NSW 2360	Residential	345292	6696323
R2	St Lawrence, 2312 Elsmore Rd, Newstead NSW 2360	Residential	342345	6696911
R3	Newstead, 4157 Gwydir Hwy, Newstead NSW 2360	Residential	342016	6700484
R4	3692 Gwydir Hwy, Swan Vale NSW 2370	Residential	345796	6704993
R5	3598 Gwydir Hwy, Swan Vale NSW 2370	Residential	347626	6705096
R6a[1]	3382 Gwydir Hwy, Swan Vale NSW 2370	Residential	348719	6705178
R6b	3382 Gwydir Hwy, Swan Vale NSW 2370	Residential	351401	6705475
R7	77 Inverness Rd, Swan Vale NSW 2370	Residential	349204	6704581
R8	3236 Gwydir Hwy, Swan Vale NSW 2370	Residential	350061	6706299
R9	3163 Gwydir Hwy, Swan Vale NSW 2370	Residential	350603	6705951
R10	3112 Gwydir Hwy, Swan Vale NSW 2370	Residential	351037	6706073
R11	32 Spring Mountain Rd, Swan Vale NSW 2370	Residential	351677	6705176
R12	3018 Gwydir Hwy, Swan Vale NSW 2370	Residential	352063	6705874
R13	2963 Gwydir Hwy, Swan Vale NSW 2370	Residential	352499	6705604
R14	155 Spring Mountain Rd, Swan Vale NSW 2370	Residential	352552	6704570
R15	489 Spring Mountain Rd, Swan Vale NSW 2370	Residential	352567	6701774
R16	170 Northcotts Rd, Spring Mountain NSW 2360	Residential	352480	6699255
R17	Kokoda, 934 Spring Mountain Road, Spring Mountain NSW 2360	Residential	355787	6699536
R18	2929 Elsmore Road, Paradise NSW 2360	Residential	346924	6693507
R19	Yarrawa Park, 3382 Gwydir Hwy, Swan Vale NSW 2370	Residential	348460	6705714
R20	Alkoomie, 2962 Gwydir Hwy, Swan Vale NSW 2370	Residential	352981	6706030
R21	Pieta, 2861 Gwydir Hwy, Swan Vale NSW 2370	Residential	353570	6705097

1. R6a and R6b share the same postal address but the property has two separate residential properties, approximately 2–3 km apart from each other.



KEY

- Proposed Sundown Solar Farm (Project area)
- Proposed Sundown Solar Farm (Project area) - 4 km buffer
- Noise assessment location
- Associated property
- Major road
- Minor road
- Named watercourse
- Cadastral boundary

Existing overhead transmission line

- Armidale to Dumaresq (330 kV)
- Glen Innes to Inverell (132 kV)

Development footprint

- Access road
- 330 kV OHL easment (60 m)
- Internal access road
- BESS/switchroom/substation
- Construction and laydown
- Potential PV area

Potential water crossing

- Named watercourse
- Drainage line

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Source: EMM (2023); Canadian Solar (2022); ESRI (2023); DFSI (2017)

Noise assessment locations

Sundown Solar Farm
Noise and Vibration Impact Assessment
Figure 3.1

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3.2 Ambient noise levels

Given the rural nature of the locality and based on historical noise data collected in the vicinity, existing ambient noise levels are at or below the minimum levels provided in the Noise Policy for Industry (NPfI) (EPA 2017). The minimum rating background level for daytime is 35 decibels (dB) and for evening and night is 30 dB, as per the NPfI.

3.3 Meteorology

The NPfI requires assessment of noise under standard and noise enhancing weather conditions. The NPfI defines these conditions as follows:

- **Standard meteorological conditions:** defined by stability categories A through to D with wind speeds up to 0.5 metres per second (m/s) at 10 m above ground level (AGL) for day, evening and night periods.

- **Noise-enhancing meteorological conditions:** defined by stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) for the day and evening periods; and stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) and/or stability category F with winds up to 2 m/s at 10 m AGL.

The NPfI specifies the following two options to consider meteorological effects:

- adopt the noise-enhancing meteorological conditions for all assessment periods for noise impact assessment purposes without an assessment of how often these conditions occur – a conservative approach that considers source-to-receiver wind vectors for all assessment locations and F class temperature inversions with wind speeds up to 2 m/s at night; or

- determine the significance of noise-enhancing conditions. This involves assessing the significance of temperature inversions (F and G class stability categories) for the night-time period and the significance of light winds up to and including 3 m/s for all assessment periods during stability categories other than E, F or G. Significance is based on a threshold of occurrence of 30% determined in accordance with the provisions in this policy. Where noise-enhancing meteorological conditions occur for less than 30% of the time, standard meteorological conditions may be adopted for the assessment.

3.3.1 Noise enhancing conditions

A conservative approach has been selected for the consideration of potentially noise-enhancing weather conditions with reference to Fact Sheet D of the NPfI. Noise emissions from the proposed solar farm have been predicted for noise-enhancing conditions, as this is expected to represent the upper range of noise emissions from the proposed solar farm.

4 Assessment criteria

4.1 Construction noise

The *Interim Construction Noise Guideline* (ICNG) (DECC 2009) promotes a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices. The ICNG recommends standard construction hours where noise from construction activities is audible at residential premises (ie assessment locations), as follows:

- Monday to Friday – 7.00 am to 6.00 pm;
- Saturday – 8.00 am to 1.00 pm; and
- Sundays or public holidays – no construction work.

The ICNG acknowledges that works outside standard hours may be necessary, with justification provided to the relevant authorities.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach that is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

4.1.1 Construction noise management levels

Table 4.1 provides ICNG noise management levels (NML) which apply to residential assessment locations.

Table 4.1 ICNG construction noise management levels for residences

Time of day	NML $L_{Aeq,15min}$	Application
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm, Saturday 8.00 am to 1.00 pm, no work on Sundays or public holidays.	Noise-affected RBL + 10 dB	The noise-affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{eq(15\text{-}min)}$ 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.

Table 4.1 ICNG construction noise management levels for residences

Time of day	NML $L_{Aeq,15min}$	Application
	Highly noise affected 75 dBA	The highly noise-affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences); and • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours.	Noise-affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise-affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Source: ICNG (EPA, 2009).

Table 4.2 summarises the ICNG recommendations and provides NML for other land uses.

Table 4.2 ICNG noise levels at other land use

Land use	Management level, $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)
Active recreation areas	External noise level 65 dB (when in use)
Passive recreation areas	External noise level 60 dB (when in use)

Source: ICNG (DECC, 2009).

The project construction NMLs for recommended standard and out of hour periods are presented in Table 4.3 for all assessment locations. However, it is acknowledged that construction of the project would be during daytime hours only.

Table 4.3 Construction noise management levels – all assessment locations

Assessment location	Period	Adopted RBL[1]	NML $L_{Aeq,15min}$, dB
Residential assessment locations	Day (standard ICNG hours)	35	45
	Evening (out of hours)	30	35
	Night (out of hours)	30	35

1. The RBLs adopted from minimum background as described in Section 3.2.

4.2 Construction vibration

4.2.1 Human perception of vibration

Humans can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not in itself be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150-2. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.4.

Table 4.4 suggests that people will just be able to feel floor vibration at levels of approximately 0.15 millimetres per second (mm/s) and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

Table 4.4 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hertz (Hz) to 80 Hz.

i Assessing vibration - a technical guideline

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC 2006) (the guideline) is based on BS 6472 – 2008, *Evaluation of human exposure to vibration in buildings* (1–80Hz).

The guideline presents preferred and maximum vibration values for the use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended that the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.5.

Table 4.5 Examples of types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZEC (1990).	Trains, intermittent nearby 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 these would be assessed against impulsive vibration criteria.

The most relevant to the proposed construction activities are continuous and intermittent vibration and these are discussed further in the following sections.

4.2.2 Continuous vibration

Appendix B of the guideline outlines acceptable criteria for human exposure to continuous vibration (1 Hz80 Hz). The criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Table 4.6 reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 4.6 Criteria for exposure to continuous vibration

Place	Time	Peak velocity[2] (mm/s)	
		Preferred	Maximum
Critical working areas (eg hospital operating theatres, precision laboratories)	Day or night-time	0.14	0.28
Residences	Day	0.28	0.56
	Night-time	0.20	0.40
Offices	Day or night-time	0.56	1.1

1. Root Mean Square (RMS) velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s).
2. Values given for most critical frequency >8 Hz assuming sinusoidal motion.

4.2.3 Intermittent vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Intermittent vibration is representative of heavy vehicle pass-bys and construction activities such as impact hammering, rolling or general excavation work.

Section 2.4 of the guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz.

To calculate VDV the following formula is used (refer to Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in Table 4.7.

Table 4.7 Acceptable vibration values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline recommends that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.2.4 Cosmetic vibration

i Australian Standard AS 2187.2 – 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 – 2006 *Explosives - Storage and Use – Use of Explosives* recommends that the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to manage minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.8 and graphically in Figure 4.1.

Table 4.8 Transient vibration guide values - minimal risk of cosmetic damage

Line[1]	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Notes: Refers to the "Line" in Figure 4.1

The standard notes that the guide values in Table 4.8 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4.8 may need to be reduced by up to 50%.

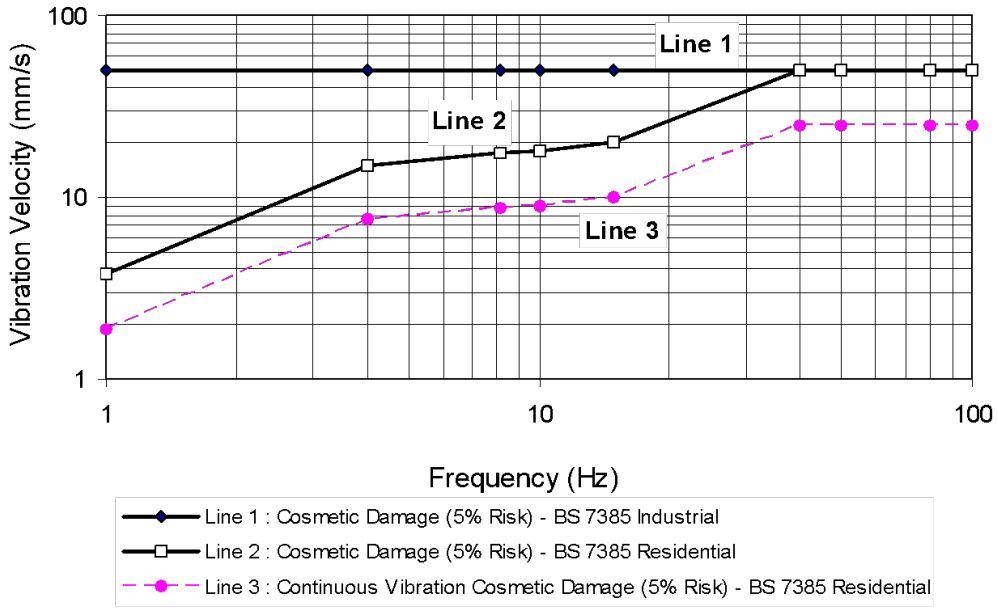


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz (as shown in Figure 4.1).

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.8 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.8.

It is noteworthy that in addition to the guide values nominated in Table 4.8 the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

ii German Standard DIN 4150-3:1999

The German Standard DIN 4150 – Part 3: 1999, provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 4.9 and shown graphically in Figure 4.1.

For residential and commercial type structures, the standard recommends safe limits as low as 5 mm/s and 20 mm/s respectively. These limits increase with frequency values above 10 Hz. The operational frequency of construction plant typically ranges between 10 Hz to 30 Hz, and hence according to DIN 4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20 mm/s, while for heritage or sensitive structures the lower limit is 3 mm/s.

Table 4.9 Structural (cosmetic) damage guideline values of vibration velocity – DIN4150

Line*	Type of structure	Vibration Velocity in mm/s			
		At foundation at a frequency of			Plane of floor of uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	5 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Notes: 1. "Line*" refers to curves in Figure 1 of DIN4150.

2. For frequencies above 100 Hz the higher values in the 50 Hz to 100 Hz column should be used.

These levels are "safe limits", for which damage due to vibration effects is unlikely to occur. "Damage" is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the “safe limits” then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the “safe limits” are present, it does not necessarily follow that damage will occur.

As indicated by the guide levels from DIN 4150 in Table 4.9, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the “point source” nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

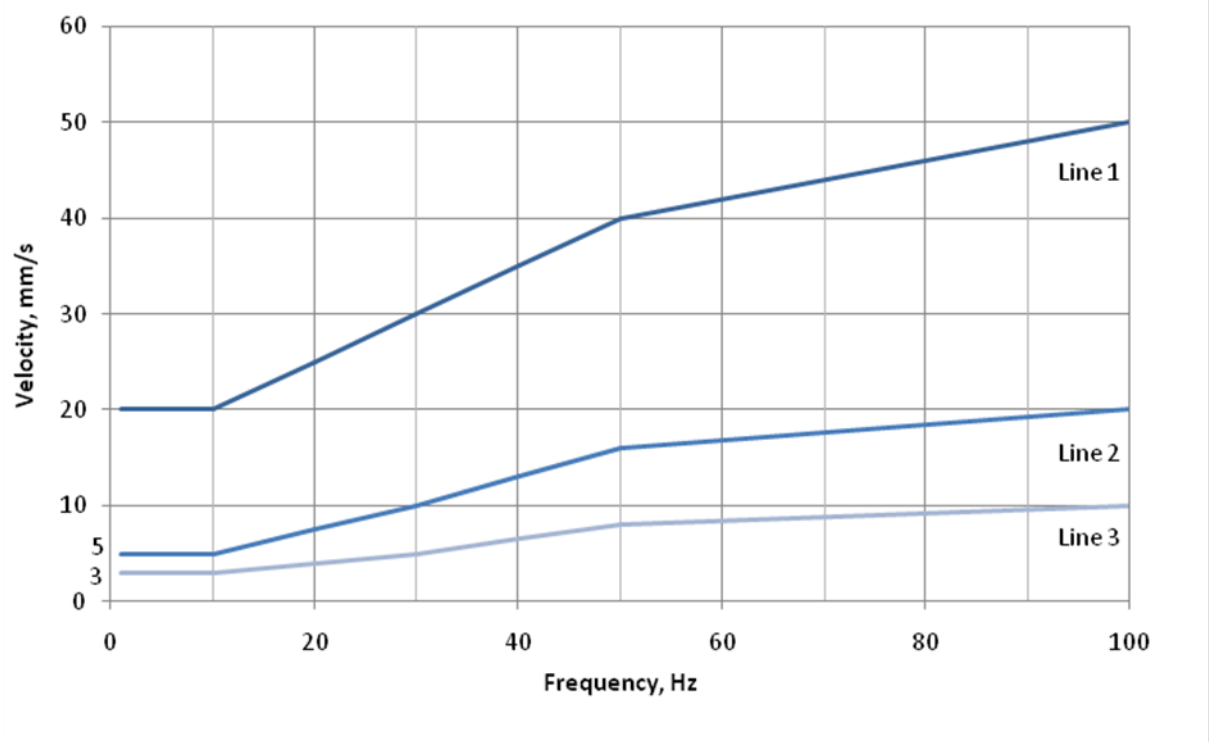


Figure 4.2 DIN4150 structural (cosmetic) damage guideline values of vibration velocity

The potential effect of vibration on particular structures can vary depending on many factors including their existing structural/cosmetic integrity and use.

4.3 Operational noise

Operational noise will largely comprise noise from tracker motors, inverter, transformers and the BESS.

Noise from industrial operations or processes (eg onsite truck movements or material processing, fabrication, manufacture, etc) in NSW is regulated by the local council, DPE and/or the EPA, and generally have a licence and/or development consent conditions stipulating noise limits. These limits are typically derived from project noise trigger or operational noise levels predicted at assessment locations. They are based on EPA guidelines (ie NPfI) or noise levels that can be achieved by a specific site following the application of all feasible and reasonable noise mitigation.

The objectives of noise trigger levels for industry established in accordance with the NPfI are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location.

To ensure these objectives are met, the EPA provides project specific noise trigger levels, namely intrusiveness and amenity.

4.3.1 Intrusiveness noise levels

The intrusiveness noise levels require that $L_{Aeq,15min}$ noise levels from the site during the relevant operational periods do not exceed the RBL by more than 5 dB. It is noted that intrusiveness noise levels are only applicable at residential assessment locations.

The NPfI (Table 2.2 notes) states:

> For isolated residences within an industrial zone as defined in a local environment plan (LEP) the industrial amenity level is usually applied.

Table 4.10 presents the intrusiveness noise levels determined for the site based on the adopted RBLs. Where assessment locations have been grouped together in the following tables, it has been assumed that the ambient noise environment at these assessment locations is similar.

Table 4.10 Project intrusiveness noise levels

Residential assessment location[1]	Assessment period[2]	Adopted RBL, dBA	Project intrusiveness noise level (RBL + 5 dB), $L_{Aeq,15min}$, dB
R1–R21	Day	35	40
	Evening	30	35
	Night	30	35

1. Residential assessment locations only.

2. Day: 7.00 am to 6.00 pm Monday to Saturday; 8.00 am to 6.00 pm Sundays and public holidays; evening: 6.00 pm to 10.00 pm; 6.00 am to 7.00 am Monday to Saturday, 6.00 am to 8.00 am Sundays and public holidays; night: remaining periods.

4.3.2 Amenity noise levels

The assessment of amenity is based on noise levels specific to the land use. The noise levels relate only to industrial noise and exclude road or rail traffic noise.

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level for a new industrial development is the recommended amenity noise level (outlined in Table 2.2 of the NPfI) minus 5 dB. It is noted that this approach is based on a receiver being impacted by multiple industrial sites (or noise sources) and in this instance is unlikely but has conservatively been adopted.

Noise assessment locations are shown in Figure 3.1. The project amenity noise levels for these locations are presented in Table 4.11.

Table 4.11 Project amenity noise levels

Residential assessment location	Time period[1]	Indicative area	Project amenity noise level[2] dB, $L_{Aeq,period}$
R1–R21	Day	Rural	45
	Evening		40
	Night		35

Source: NPfI (EPA 2017)

1. Day: 7.00 am to 6.00 pm Monday to Saturday; 8.00 am to 6.00 pm Sundays and public holidays; evening: 6.00 pm to 10.00 pm; night: 10.00 pm to 7.00 am Monday to Saturday; 10.00 pm to 8.00 am Sundays and public holidays.

2. Project amenity noise level is Amenity noise level (Table 2.2 of NPfI) -5dB in accordance with NPfI Section 2.4.2.

4.3.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusiveness or amenity noise levels. Taking account of the measured background noise levels, project intrusive noise levels and project amenity levels for residential assessment locations, a summary of the project noise trigger levels (PNTL) for the assessment of operational noise from the project is presented in Table 4.12.

Table 4.12 Project noise trigger levels

Residential assessment location	Assessment period[1]	Intrusiveness noise level, $L_{Aeq,15min}$, dB	Amenity noise level[2], $L_{Aeq,15min}$, dB	PNTL[3], $L_{Aeq,15min}$, dB
R1–R21	Day	40	48	40
	Evening	35	43	35
	Night	35	38	35

1. Day: 7.00 am to 6.00 pm Monday to Saturday; 8.00 am to 6.00 pm Sundays and public holidays; evening: 6.00 pm to 10.00 pm; night: remaining periods.

2. Project amenity LAeq,15min noise level is the recommended amenity noise level LAeq,period +3 dB as per the NPfI.

3. PNTL is the lower of the calculated intrusiveness or amenity noise levels.

4.4 Road traffic noise

Construction and operational traffic require assessment for potential noise impacts. The principle guidance to assess the impact of the road traffic noise on assessment locations is in the Road Noise Policy (2011) (RNP). Table 4.13 presents the road noise assessment criteria for residential land uses (ie assessment locations), reproduced from Table 3 of the RNP for road categories relevant to the project.

Table 4.13 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria – dBA	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Freeway/arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{eq,15hr}$ 60 (external)	$L_{eq,9hr}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{eq,1hr}$ 55 (external)	$L_{eq,1hr}$ 50 (external)

Notes: 1. Assessment criteria façade corrected.

Additionally, the RNP states that where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to an increase of up to 2 dB.

In addition to meeting the assessment criteria in Table 4.13 any significant increase in total traffic noise at the relevant residential assessment locations must be considered. Residential assessment locations experiencing increases in total traffic noise levels above those presented in Table 4.14 should be considered for mitigation.

Table 4.14 Road traffic relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase – dBA	
		Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Freeway/arterial/ sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{eq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{eq(9\text{-}hr)}$+ 12 dB (external)

Appendix B of the RNP, states that noise levels shall be rounded to the nearest integer, whilst difference between two noise levels are to be rounded to a single decimal place.

5 Assessment methodology

5.1 Noise modelling

This section presents the methods and base parameters used to model operational and construction noise and vibration emissions from the proposed solar farm.

Operational and construction noise levels were predicted using a computer-generated model using DGMR Software proprietary modelling software, iNoise. The model utilised international standard ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors*. As per Section 1 of the Standard:

> The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.
>
> These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area and applicable meteorological conditions.

The model was populated with 3-D topography of the project and surrounding area, extending out past nearest assessment locations. Plant and equipment representing the range of proposed construction and operation scenarios was placed at locations which would represent worst case noise levels throughout the construction and operational scenarios.

5.1.1 Single point predictions

In order to assess a potential worst-case scenario, the assessment has considered the identified plant and equipment operating continuously over a 15 minute period or greater. Noise levels during both operational and construction phases were predicted to the assessment locations listed in Table 3.1 and Figure 3.1.

5.1.2 Noise enhancing meteorology

A conservative approach has been selected for the consideration of potentially noise-enhancing weather conditions with reference to Fact Sheet D of the NPfI. Noise emissions have been predicted for source to receiver noise-enhancing conditions. This provides a conservative approach since the noise emissions predicted under noise-enhancing conditions are expected to represent the upper range of noise emissions from the solar farm construction and operation.

5.2 Construction noise

5.2.1 Times

Construction of the solar farm would be during daytime hours only and has an envisaged duration of up to 21 months.

5.2.2 Construction activities

Construction of the project would be undertaken in three distinct stages over a period of approximately 21 months. The timeframes are indicative only and reflect a conservative upper limit of potential impacts from the project.

Table 5.1 Construction activities by stage

Stage	Construction activities	Duration
Stage 1: Site establishment	Due to the development footprint's relatively flat terrain and predominantly cleared landscape, it is expected that limited site preparation and civil works will be required. Site establishment works and preparation for construction are expected to include: • upgrade of the Gwydir Highway/Spring Mountain Road to include a right turn traffic lane (type (CHR(S))) at the eastbound approach; • upgrade the site access road (Spring Mountain Road and Sturmans Road) to accommodate 26 m B-double trucks; • widen access road to 8.7 m; • compact and gravel road; • upgrade/replace existing box culvert over Swan Brook Creek; • upgrade/replace bridge over Kings Creek; • remove internal fencing; • relocation of one project-related house and one shearing shed to a location agreed with the landowners; • scrub, grade and minor cut/fill as required to prepare the site surface; • establish secured temporary construction laydown areas comprising a site office, containers for storage and parking areas; • survey to confirm infrastructure positioning; • geotechnical investigations to confirm foundation requirements for infrastructure, as applicable; • install project perimeter fencing; and • first deliveries of construction materials and equipment.	3 months

Table 5.1 Construction activities by stage

Stage	Construction activities	Duration
Stage 2: Civil, mechanical and electrical works and deliveries	Delivery of construction materials and infrastructure will occur throughout the construction period. Materials, including the BESS, will likely be shipped to the nearest port and then transported to the site via road. Consistent with the vehicle length allowances of the designated B-Double route for Gwydir Highway, heavy vehicles up to 26 m in length will require access to the site. The following construction material and infrastructure will be delivered to site: • solar panels, piles, tracker mounting structures and frames; • electrical equipment and infrastructure including cabling, inverters, transformers, switchgear and the onsite substation; • construction and permanent buildings and associated infrastructure; and • earthworks and lifting machinery and equipment. Key activities during the civil/mechanical/electrical works stage are outlined below: • drive piles into the ground to support the solar panel mounting structure; • assemble tracker frames and solar panels on top of the piles; • install underground cabling between the solar panels and the inverters, and to the onsite substation; • prepare foundations for the inverter blocks, switchyard and management hub structures; • install combiner boxes, inverters, onsite substation, switchgear and BESS; • construct the management hub; • construct internal access tracks; • construct transmission infrastructure between the project electrical switchyard and the existing overhead transmission line; and • install external and internal security fencing and CCTV.	14 months
Stage 3: Commissioning and testing	The commissioning and testing stage includes cold commissioning, hot commissioning and testing of the power plant. This includes testing of all equipment and circuits, including inverters, cabling, tracker systems, earthing, SCADA and grid-compliance testing according to the transmission network operator and the Australian Energy Market Operator requirements.	4 months

5.2.3 Construction equipment sound power levels

The construction noise impact assessment has adopted sound power levels from Department of Environment, Food and Rural Affairs (DEFRA) and EMM's noise database for plant and equipment items used on similar projects. Plant and equipment items, sound power levels and quantities adopted in the noise modelling are summarised in Table 5.2.

Note, as no noise intensive equipment is expected to be used during the commissioning and testing stage (stage 3), there are no anticipated construction noise impacts during this stage.

Table 5.2 Construction noise source sound power levels

	Equipment	Quantity	Item $L_{Aeq,15min}$, (dB)	Overall $L_{Aeq,15min}$, (dB)
Stage 1: Site establishment	Vibratory roller (>18 tonnes)	5	112	124
	Dozer	5	117	
	Grader	5	97	
	Scraper	4	110	
	Flat bed floats	5	99	
	Excavator	5	110	
	Bobcat	5	103	
	Concrete truck	5	105	
	Crane	3	108	
	Trenching equipment	1	108	
	Water trucks[1]	1	111	
Stage 2: Civil, mechanical and electrical works and deliveries	Vibratory roller (>18 tonnes)	5	112	126
	Hydraulic hammer	2	117	
	Pile driver	15	97	
	Dozer	5	110	
	Grader	5	99	
	Scraper	4	110	
	Flat bed floats	5	103	
	Excavator	5	105	
	Bobcat	5	108	
	Concrete truck	5	108	
	Drilling rig	10	111	
	Crane	3	94	
	Forklift	30	80	
	Water trucks[1]	1	111	

1. Plant and equipment items have been assumed to operate continuously in any 15-minute period unless otherwise specified.

5.3 Operational noise

The acoustic assessment has been based on concept design drawings and details listed below.

5.3.1 Plant and equipment

Noise impact from the general operation of the project was considered at assessment locations outlined in Table 3.1 and Figure 3.1.

As part of the detailed design process, the final locations for potential noise-generating infrastructure, in particular the quantity of tracker motors, inverters and power conversion unit (PCU) would be reviewed to minimise operational noise impacts, where practicable.

Noise sources considered during the operational phase of the project include tracker motors (PV modules), inverters with integrated transformers and PCU. It is noted that noise from the inverters with integrated transformers can be tonal in nature and therefore a 5 dB penalty has been applied to the predicted noise contributions from this source in accordance with Table C.1 of the NPfI (EPA 2017). Operational noise sources are shown in Table 5.3.

Table 5.3 Operational noise source sound power levels

Noise source	$L_{Aeq,15min}$ sound power level per unit, dB
Tracker motor (NEXtracker or similar) x 1940	78
Inverters x 72	99[1]
Power Conversion Unit (PCU) x 72	87
BESS	101
Light vehicle	76
LV-MV transformer	68
MV-HV transformer (200 MVA)	98
Grid transformer (450 MVA)	103

1. This includes a 5 dB adjustment for tonal characteristics as per the NSW NPfI (ie 94 dB + 5 dB = 99 dB).

5.4 Construction vibration

5.4.1 Mobile plant and equipment

Safe working distances for typical items of vibration intensive plant are listed in Table 5.4. The safe working distances are quoted for both “Cosmetic Damage” (refer British Standard BS 7385) and “Human Comfort” (refer British Standard BS 6472-1).

Table 5.4 Recommended safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (comfort)(BS 6472)
Large hydraulic hammer	(1,600 kg – 18 to 34 t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Vibratory rollers	>300 kilonewtons (kN) (>18 tonnes)	25 m	100 m

Source: From Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects), November 2007 – based on residential building.

Safe work distances relate to continuous vibration. For most construction activity, vibration emissions are intermittent in nature. The safe working distances are therefore conservative.

The safe working distances presented in Table 5.2 are indicative and will vary depending on the item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

The safe working distances have been used to assess the potential for vibration impacts based on proposed construction activities.

5.5 Road traffic noise

Traffic volumes in the region were found to be relatively low (<200 vehicles per hour). As the United States EPA Federal Highways (FHWA) procedures are more sensitive to low traffic volumes, the FHWA algorithm was used in the modelling of traffic noise impacts for this assessment. The NSW EPA refers to the US FHWA method in its RNP as an acceptable calculation tool. A summary of the road sections and assessment methodology is provided in Table 5.5 and Figure 4.1.

Table 5.5 Road segments considered in noise assessment

Road	Description of road	Approximate daily existing traffic volume
Gwydir Highway	State road between Grafton (east) and Castlereagh Highway (west) near Walgett	1,450
Spring Mountain Road	Local road between Gwydir Highway (north) and site (south)	<50
Sturmans Road	Local road between site (west) and Spring Mountain Road (east)	<50

Road traffic movements associated with construction of the solar farm have been referenced from the Traffic Impact Assessment (EMM 2022) and adapted to suit RNP assessment requirements (Section 4.4).

Road traffic noise levels from the project have been assessed by calculating existing and existing plus project traffic at representative residential assessment locations using the FHWA method. The following assumptions have been adopted:

- speed limit for Gwydir Highway signposted as 100 km/h;
- speed limit for Spring Mountain Road as 100 km/h;
- speed limit for Sturmans Road as 100 km/h;
- there are no buildings or other intervening objects that will act as a noise barrier between the road and the noise assessment point; and
- a facade reflection has been added to predicted noise levels as appropriate for each calculation method.

6 Impact assessment

6.1 Construction noise

6.1.1 Single point predictions

In accordance with procedures outlined in Section 5.2, predictions of construction noise levels are provided in Table 6.1 for standard day periods under ISO9613-2 conditions. The predictions for each assessment location represent the energy-average noise level over a 15-minute period and assumes all plant operating concurrently. The predicted exceedance of the ICNG noise affected NML at each assessment location is also provided.

Construction noise levels are predicted to exceed NMLs at up to 11 assessment locations, namely R6b, R9–R16 (inclusive), R20 and R21, during standard day construction hours. These assessment locations are in close proximity to the intersection and the access road. The proposed mitigation measures for these assessment locations are outlined in Table 7.1.

All remaining assessment locations are predicted to satisfy the NMLs.

All assessment locations are predicted to comply with the EPA's highly noise affected level of 75 dB.

Where work outside of standard hours is unavoidable, noise should be managed in accordance with the noise limits of the ICNG. Works outside of standard hours would typically require approval from the relevant regulatory authority and be justified with specialist acoustic assessment of the proposed works to be undertaken.

Table 6.1 Predicted construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$ Stage 1/Stage 2	Compliance with NML Stage 1/Stage 2
R1	Residential	Standard	45	75	39/41	Yes/yes
R2	Residential	Standard	45	75	36/38	Yes/yes
R3	Residential	Standard	45	75	38/39	Yes/yes
R4	Residential	Standard	45	75	39/40	Yes/yes
R5	Residential	Standard	45	75	40/42	Yes/yes
R6a	Residential	Standard	45	75	41/43	Yes/yes
R6b	Residential	Standard	45	75	51/53	No/no (+6/+8)
R7	Residential	Standard	45	75	42/44	Yes/yes
R8	Residential	Standard	45	75	41/43	Yes/yes
R9	Residential	Standard	45	75	45/47	Yes/no (+2)
R10	Residential	Standard	45	75	44/46	Yes/no (/+1)
R11	Residential	Standard	45	75	57/59	No/no (+12/+14)
R12	Residential	Standard	45	75	53/55	No/no (+8/+10)
R13	Residential	Standard	45	75	52/53	No/no (+7/+8)
R14	Residential	Standard	45	75	61/63	No/no (+16/+18)

Table 6.1 Predicted construction noise levels

Assessment location	Classification	Period	Noise affected NML, dB	Highly noise affected NML, dB	Predicted construction noise level, dB $L_{Aeq,15min}$ Stage 1/Stage 2	Compliance with NML Stage 1/Stage 2
R15	Residential	Standard	45	75	66/67	No/no (+21/+22)
R16	Residential	Standard	45	75	45/46	Yes/no (/+1)
R17	Residential	Standard	45	75	39/40	Yes/yes
R18	Residential	Standard	45	75	34/35	Yes/yes
R19	Residential	Standard	45	75	40/42	Yes/yes
R20	Residential	Standard	45	75	45/46	Yes/no (/+1)
R21	Residential	Standard	45	75	47/49	No/no (+2/+4)

6.2 Construction vibration

The assessment shows that construction vibration levels associated with work within the project area are highly unlikely to impact any of the potentially sensitive receptors. The nearest residence (R16) to the project area is approximately 1 km from the site boundary. R16 is beyond the safe working distances for human comfort and cosmetic damage for all listed plant.

There are two residences (R14 and R15) within 100 m of the access road. As such vibration impacts associated with road works require consideration for these residences.

6.2.1 Human comfort

In relation to human comfort, the safe working distances in Table 5.4 relate to continuous vibration and apply to residential assessment locations. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, as discussed in BS 6472-1.

The nearest residences to the access road (R14 and R15) are located approximately 50 m and 45 m respectively to the closest proposed construction activities. These assessment locations are beyond the safe working distances for cosmetic damage however, subject to size of vibratory roller required (greater than 6 t), vibration levels may be above the levels for human comfort (Table 4.6).

6.2.2 Cosmetic damage

The safe working distances for cosmetic damage should be monitored throughout the construction process. Based on the safe working distances guide in Table 5.4, if construction is within 25 m of sensitive structures, then work practices should be reviewed so that the safe working distance in Table 5.4 are followed.

If safe working distances need to be encroached, real time vibration monitoring with audible and visual alarms should be installed at vibration sensitive structures so actual vibration levels can be monitored and managed appropriately in real-time.

The number of receptors with potential to exceed relevant vibration criteria at each site is summarised in Table 6.2.

Table 6.2 Potential vibration impacts for R14 and R15

Equipment item	Construction stage	Number of receptors with potential to exceed vibration criteria[1]	
		Human comfort (residences)	Cosmetic damage
Large vibratory roller (>6 t)	1	2 (R14, R15)	0
Small vibratory roller (<6 t)	1	0	0

6.3 Operational noise

6.3.1 Single point predictions

In accordance with procedures outlined in Section 5.1, prediction of single point operational noise levels is provided in Table 6.3 for day and evening/night periods. The levels presented for each assessment location represents the energy-average noise level over a 15-minute period and assumes all plant operating concurrently under ISO9613-2 noise enhancing conditions. As shown in Table 6.3, no exceedances have been predicted at any assessment location.

Table 6.3 Predicted operational noise levels

Assessment location	Classification	Period	PNTL, dB	Predicted noise level, dB $L_{Aeq,15min}$
R1	Residential	Day	40	<30
		Evening/night	35	
R2	Residential	Day	40	<30
		Evening/night	35	
R3	Residential	Day	40	<30
		Evening/night	35	
R4	Residential	Day	40	<30
		Evening/night	35	
R5	Residential	Day	40	<30
		Evening/night	35	
R6	Residential	Day	40	<30
		Evening/night	35	
R7	Residential	Day	40	<30
		Evening/night	35	
R8	Residential	Day	40	<30
		Evening/night	35	

Table 6.3 Predicted operational noise levels

Assessment location	Classification	Period	PNTL, dB	Predicted noise level, dB $L_{Aeq,15min}$
R9	Residential	Day	40	<30
		Evening/night	35	
R10	Residential	Day	40	<30
		Evening/night	35	
R11	Residential	Day	40	<30
		Evening/night	35	
R12	Residential	Day	40	<30
		Evening/night	35	
R13	Residential	Day	40	<30
		Evening/night	35	
R14	Residential	Day	40	<30
		Evening/night	35	
R15	Residential	Day	40	<30
		Evening/night	35	
R16	Residential	Day	40	<30
		Evening/night	35	
R17	Residential	Day	40	<30
		Evening/night	35	
R18	Residential	Day	40	<30
		Evening/night	35	
R19	Residential	Day	40	<30
		Evening/night	35	
R20	Residential	Day	40	<30
		Evening/night	35	
R21	Residential	Day	40	<30
		Evening/night	35	

6.4 Road traffic noise – construction

Road traffic noise level predictions for construction traffic during the day are provided in Table 6.4 . For residences on Gwydir Highway, the EPA's RNP criterion is 60 dB $L_{Aeq,15hour}$ applies. For all other residential locations (local roads) the EPA's RNP criterion of 55 dB $L_{Aeq,1hour}$ applies. Traffic volumes were collected by EMM between 2–4 June 2021. The survey represents the peak generation of light vehicles (LV) and heavy vehicles (HV) associated with the busiest construction stage (PV installation) of the project.

Table 6.4 Road traffic noise calculations (construction), day (7.00 am to 10.00 pm)

Road name	Approximate distance from nearest carriageway	Road segments	Existing movements[1]			Existing plus project movements			Noise level increase due to the Project, $L_{Aeq,15hour}$, dB
			Total	%HV	Calculated level, $L_{Aeq,15hour}$, dB	Total	%HV	Predicted level, $L_{Aeq,15hour}$, dB	
Gwydir Highway	30 m	State road between Inverell (west) and Spring Mountain Road	1,346	15	62	1774	12	61	0
	170 m	State road between Glen Innes (east) and Spring Mountain Road							
Spring Mountain Road	60 m	-	<50	<10	39	460	17	50	11
Sturmans Road	1,720m	-	<50	<10	20	460	17	30	10

Notes: 1. Existing movements are based on 2018/2019 long-term road traffic counts. Refer TIA (EMM 2022) for detail.

Assessment of day traffic predictions demonstrate that all road segments likely to be used by vehicles associated with construction of the project comply with the relevant absolute or relative increase criterion. As the existing traffic volumes on Gwydir Highway were found to be above the RNP's absolute criterion of 60 dBA, additional traffic volumes were assessed against the relative increase in traffic noise generated by the project. The relative traffic increase on Gwydir Highway was found to be negligible (0 dB) and as such the ≤2 dB allowance criterion is met for both road segments likely to be used by vehicles associated with construction of the project. Traffic associated with operations is relatively minor compared to construction periods and furthermore, traffic noise generation will meet the RNP requirements.

6.5 Decommissioning

Decommissioning activities are expected to be limited to removal of plant and equipment during standard day hours in accordance with the ICNG. Noise from these activities would be substantially less than levels predicted for construction activities (Section 6.1) as the proposed decommissioning would not include further roadworks (which are the main cause of noise impacts during the construction phase. As a result, decommissioning activities are not anticipated to result in any adverse noise impacts at the identified assessment locations.

Vehicle movements associated with decommissioning activities would be significantly lower than that generated by the project construction and therefore will satisfy RNP requirements.

7 Management of impacts

7.1 Mitigation and management measures

During construction (particularly during access road upgrades in Stage 1) up to 11 assessment locations are expected to experience noise above relevant NMLs and two assessment locations are predicted to experience vibration impacts relating to human comfort criteria. No assessment locations are predicted to experience vibration impacts relating to structural (cosmetic) criteria.

Operational noise levels and maximum event noise levels are predicted to be well below the relevant criteria at all assessment locations.

This section outlines the recommended noise and vibration mitigation and management measures.

The project's construction environmental management plan (CEMP) will include a suite of best practice noise and vibration management and mitigation measures, as outlined in Table 7.1.

Table 7.1 Noise and vibration mitigation measures

Reference	Mitigation measure	Responsibility	When
Universal work practices			
N1	Ensure the importance of minimising noise and vibration is reinforced at toolbox meetings.	Construction contractors	Construction
N2	Minimise unnecessary metal-on-metal contact.	Construction contractors	Construction
N3	Minimise the need for vehicle reversing for example, by arranging for one-way site traffic routes where possible.	All staff	At all times
N4	Ensure access road is maintained.	All staff	At all times
Plant and equipment			
N5	Ensure potentially noisy plant and equipment is maintained in accordance with manufacturer specifications.	All staff	At all times
N6	Where practical, use quieter plant and equipment.	All staff	At all times
N7	Minimise unnecessary movement of equipment/material/plant.	All staff	At all times
N8	Operate plant and equipment in the quietest and most efficient manner.	All staff	At all times
N9	Undertake regular inspections/maintenance of plant and equipment to ensure that all noise reduction devices are operating effectively.	All staff	At all times
Work scheduling			
N10	Construction work to be limited to standard construction hours, including delivery of plant and equipment. Exceptions to these hours may be required on limited occasions. Regulatory authorities (including the Inverell Shire Council) and surrounding landholders will be notified of any exceptions prior to any works being undertaken.	Construction contractors	Construction

Table 7.1 Noise and vibration mitigation measures

Reference	Mitigation measure	Responsibility	When
Specific assessment locations (noise)			
N11	Ensure the following mitigation measures are undertaken for R6b, R11, R12, R14 and R15: • verification; and • notification. See Section 7.2 for further details.	Construction contractor	Pre-construction Construction
Vibration			
N12	Wherever practicable, ensure that vibration intensive activities are undertaken outside of the safe working distances. Where this is not practicable: • use less vibration intensive methods of construction or equipment where practicable; • limit vibration intensive works to the least sensitive times of the day, in consultation with the relevant sensitive receivers; and/or • undertake vibration monitoring to ensure compliance with DIN-4150 criteria.	Construction contractor	Construction
N13	If ongoing works are required[1], and where monitoring has confirmed actual vibration levels are nearing the DIN-4150 criteria, consider installation of a monitoring system to warn operators when vibration levels are approaching the cosmetic damage criteria (eg flashing light, audible alarm etc).	Construction contractor	Construction
N14	Ensure the following mitigation measures are undertaken for R14 and R15: • verification; • notification; and • respite offer. See Section 7.3 for further details.	Construction contractor	Pre-construction Construction

Notes 1. Ongoing works are defined by long-term works occurring for a period greater than 3 weeks.

The relative effectiveness of various forms of noise control is outlined in Table 7.2.

Table 7.2 Relative effectiveness of various forms of noise control

Noise control	Nominal noise reduction possible, in total A-weighted sound pressure level, dB
Increase source to receiver distance[1]	Approximately 6 dB for each doubling of distance
Reduce equipment operating times or turn off idling machinery [2]	Approximately 3 dB per halving of operating time
Operating training on quiet operation[2]	Up to 3 to 5 dB
Screening (eg. noise barrier)[1]	Normally 5dB to 10 dB, maximum 15 dB
Enclosure (eg. shed/building)[1]	Normally 15 dB to 25 dB, maximum 50 dB
Silencing (eg exhaust mufflers) [1]	Normally 5 dB to 10 dB, maximum 20 dB

1. Sourced from AS2436-2010.

2. Based on EMM's measurement experience at construction and mining sites.

7.2 Additional noise mitigation measures

A number of assessment locations will require additional mitigation measures during the construction stage, according to the CNVG (Table 7.3).

Table 7.3 Assessment locations requiring additional noise mitigation

CNVG perception category	No. of assessment locations during Stage 1	No. of assessment locations during Stage 2	CNVG additional mitigation measures
Moderately intrusive (NML + 10)	2 (R11, R14)	3 (R11, R12, R14)	Verification Notification drop
Highly intrusive (NML + 20)	2 (R6b, R15)	2 (R6b, R15)	Verification Notification drop
Highly noise affected (75 dBA or greater[1])	0	0	Verification Notification drop Respite offer

1. This count of highly affected residences is independent of the highly and moderately intrusive counts. Ie the highly affected residences are also captured in the moderately and highly intrusive counts.

Table 7.3 defines a total of five assessment locations which are predicted to experience moderate to high intrusive noise impacts. As such, these locations should have the following mitigation measures undertaken prior to construction of the access road:

1. Notification (letterbox drop or equivalent):

    - Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works.

2. Verification:

    - Verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

7.3 Additional vibration mitigation measures

Additional mitigation measures with respect to human response (human comfort) to vibration will be applied in accordance with the CNVG as presented in Table 7.4.

Table 7.4 Additional mitigation measures matrix – construction vibration

Predicted human comfort vibration levels	Additional mitigation measures	
	Type[1]	Apply to
Standard hours: Monday – Friday (7.00 am – 6.00 pm), Saturday (8.00 am – 1.00 pm), Sunday/public holiday (Nil)		
Predicted vibration exceeds maximum human comfort levels	V, N, RO	R14, R15

Notes: 1. The following abbreviations are used: Alternative Accommodation (AA), Respite Offer (RO), Respite Period 1 (R1), Validation of predicted noise levels (V), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Duration respite (DR).

Table 7.4 defines a total of two assessment locations (R14 and R15) which exceed the maximum human comfort levels. As such, these locations should have the following mitigation measures undertaken prior to construction of the access road:

1. Notification (letterbox drop or equivalent):

    - Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works.

2. Verification:

    - Verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

3. Respite offer:

    - Respite offers should be considered due to vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers.

8 Conclusion

This NVIA outlines the predicted noise and vibration impacts associated with the proposed Sundown Solar Farm.

Construction noise levels are predicted to exceed NMLs at up to 11 assessment locations in relation to the upgrade of the site access road and the intersection. No exceedance of the 'Highly Noise Affected' level is expected.

Construction vibration levels are predicted to exceed acceptable human comfort thresholds at two assessment locations, depending on the size of vibratory rollers used during the upgrade of the site access road. These can be managed by employing the mitigation measures outlined in Chapter 7.

Operational noise is predicted to satisfy the NPfI PNTLs for all assessment locations.

During peak construction, increases in road traffic noise will occur along the Gwydir Highway, Spring Mountain Road and Sturmans Road. Assessed road traffic noise levels indicate that predicted levels will remain below the thresholds provided in the *Road Noise Policy* (RNP) (DECCW 2011).

Decommissioning phase noise and vibration are expected to satisfy all applicable criteria.

By applying the proposed mitigation measures outlined in Chapter 7, the project is not anticipated to generate significant noise or vibration impacts.

Glossary

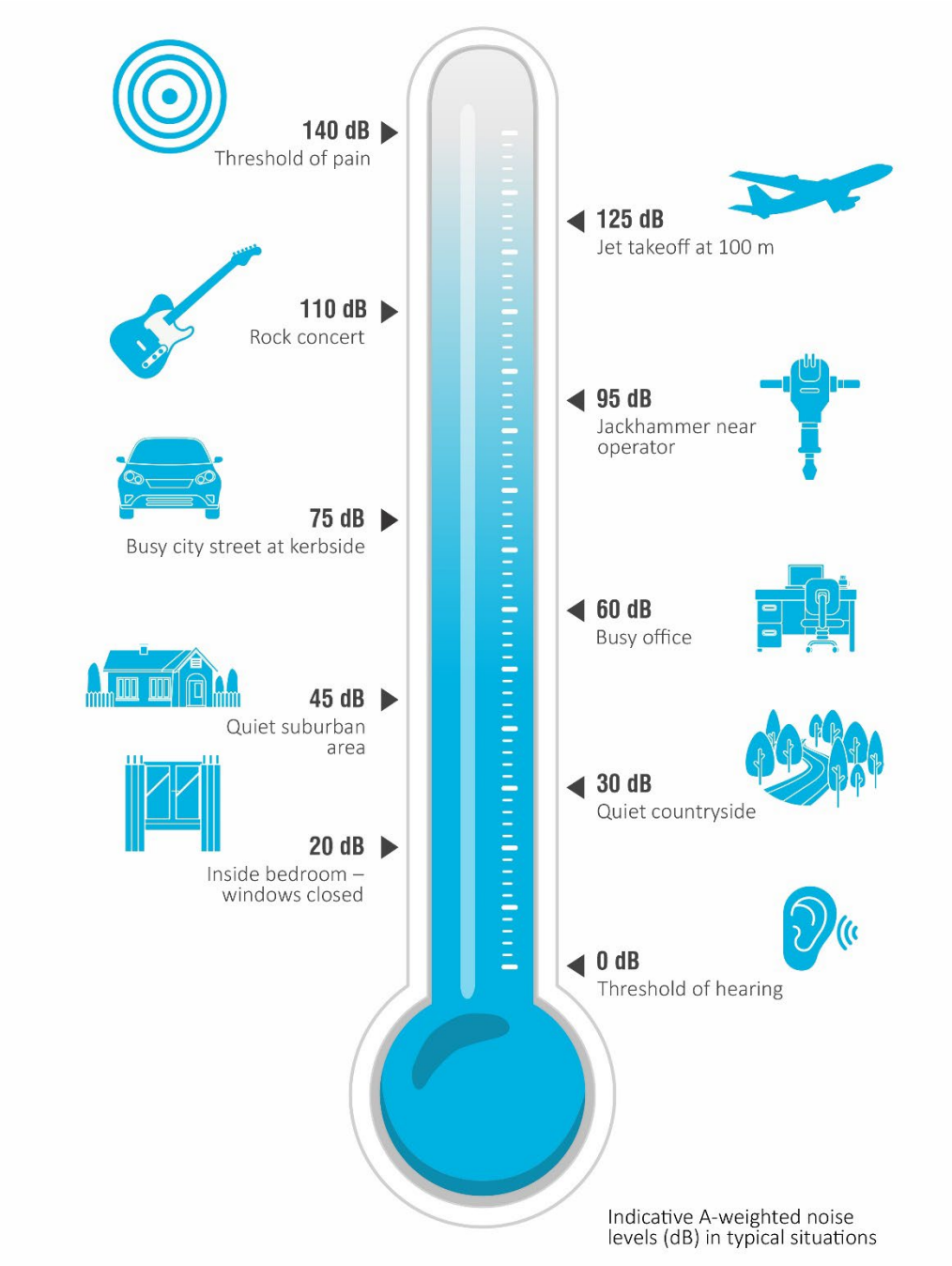
Table 8.1 Glossary of acoustic terms

Term	Description
dB	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A1}	The 'A-weighted' noise level which is exceeded 1% of the time.
L_{A10}	The 'A-weighted' noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise level.
L_{A90}	Commonly referred to as the background noise level. The 'A-weighted' noise level exceeded 90% of the time.
L_{Aeq}	The energy average noise from a source. This is the equivalent continuous 'A-weighted' sound pressure level over a given period.
$L_{Aeq,15min}$	This is the equivalent continuous 'A-weighted' sound pressure level over a 15-minute period. The $L_{Aeq,15min}$ descriptor refers to an L_{Aeq} noise level measured over a 15-minute period.
L_{Amin}	The minimum 'A-weighted' noise level received during a measuring interval.
L_{Amax}	The maximum root mean squared 'A-weighted' sound pressure level (or maximum noise level) received during a measuring interval.
L_{Ceq}	This is the equivalent continuous 'C-weighted' sound pressure level over a given period. The $L_{Ceq,15min}$ descriptor refers to an L_{Ceq} noise level measured over a 15-minute period. C-weighting can be used to measure low frequency noise.
Day period	Monday – Saturday: 7.00 am to 6.00 pm, on Sundays and public holidays: 9.00 am to 6.00 pm at a sensitive place and 7.00 am to 6.00 pm at a commercial place.
Evening period	All days: 6.00 pm to 10.00 pm.
Night period	Monday – Saturday: 10.00 pm to 7.00 am, on Sundays and public holidays: 10.00 pm to 9.00 am at a sensitive place and 10.00 pm to 7.00 am at a commercial place.

It is useful to have an appreciation of decibels (dB), the unit of noise measurement. Table 8.1 gives an indication as to what an average person perceives about changes in noise levels. Examples of common noise levels are provided in Table 8.2.

Table 8.2 Perceived change in noise

Change in sound pressure level (dB)	Perceived change in noise
3	Just perceptible
5	Noticeable difference
10	Twice (or half) as loud
15	Large change
20	Four times (or quarter) as loud



Source: Noise Measurement Manual (Department of Environment and Heritage Protection 2013).

Figure 8.1 Common noise levels

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Level 2 Suite 2.04
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8 454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Suite 9.02 Level 9 109 St Georges Terrace
Perth WA 6000

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5

VANCOUVER
60 W 6th Ave Suite 200
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