Appendix H

Noise and vibration impact assessment

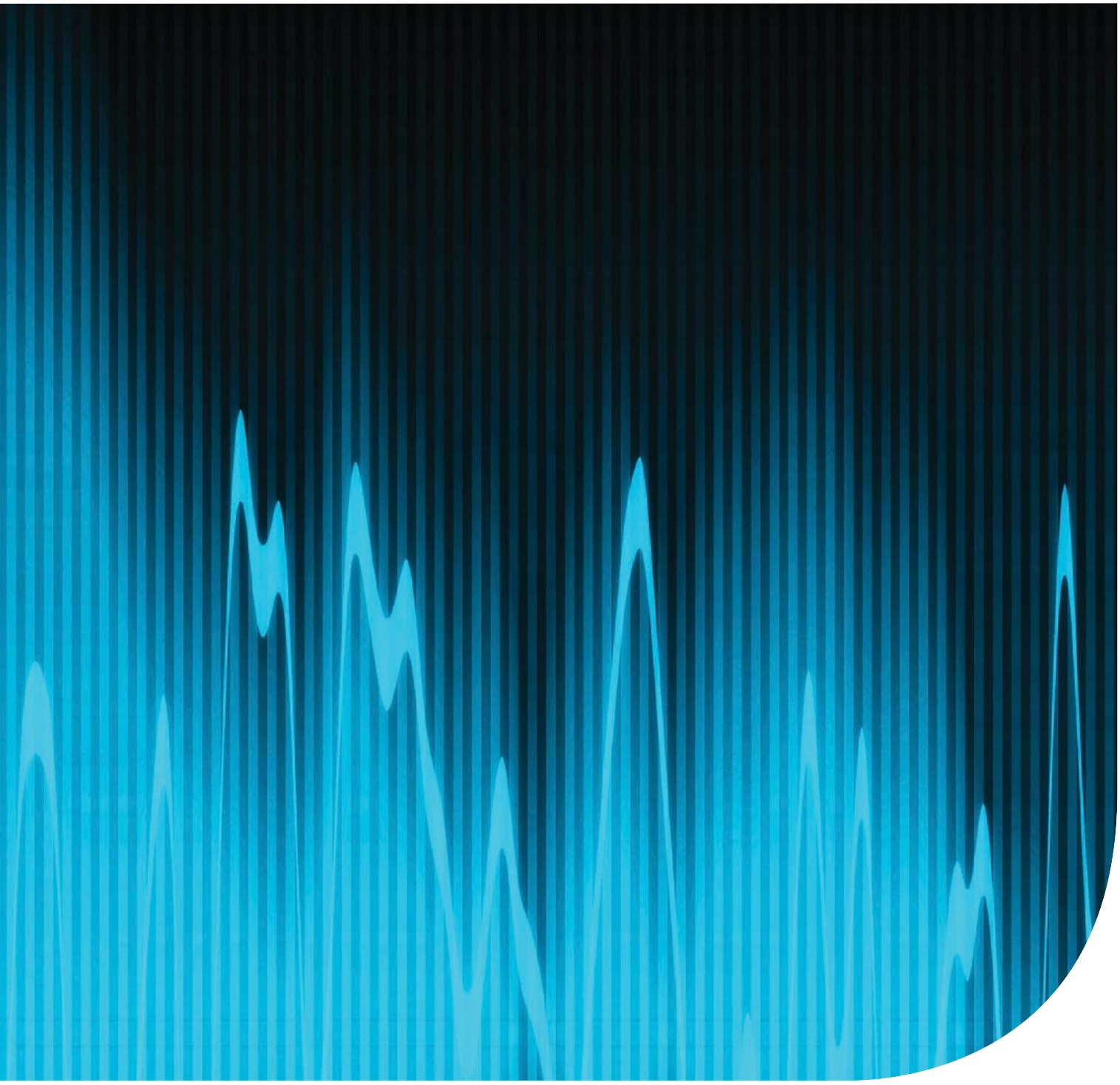
Orange Grove
Sun Farm

Overland Sun Farming

Orange Grove Sun Farm

Noise and vibration impact assessment

Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018



Orange Grove Sun Farm

Noise and vibration impact assessment

Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

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Orange Grove Sun Farm

Final

Report J17210RP1 | Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

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Date	11 May 2018	Date	11 May 2018

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1 Introduction

1.1 Overview

OVERLAND Sun Farming Pty Ltd (OVERLAND) on behalf of Orange Grove Sun Farm Pty Ltd (the proponent) proposes to develop the Orange Grove Sun Farm, a large-scale solar photovoltaic (PV) generation facility and associated building and electrical infrastructure including grid connection works near the township of Gunnedah in northern NSW (the project). The proponent proposes to develop the project on a site within the Gunnedah Shire local government area (LGA), approximately 12 kilometres (km) east of the township of Gunnedah.

The project is a State significant development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). A development application (DA) for the project is required to be submitted under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The NSW Minister for Planning, or the Minister's delegate, is the consent authority.

An environmental impact statement (EIS) is a requirement of the approval process. This noise and vibration impact assessment (NVIA) report forms part of the EIS. It documents the NVIA methods and results, the initiatives built into the project design to avoid and minimise noise and vibration associated impacts, and the additional mitigation and management measures proposed to address any residual impacts not able to be avoided.

1.2 Assessment guidelines and requirements

This NVIA has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The NVIA was prepared with reference to the methods outlined in:

- NSW Department of Environment and Climate Change (DECC) 2009, *Interim Construction Noise Guideline* (ICNG);
- NSW Environment Protection Authority (EPA) 2017, *Noise Policy for Industry* (NPfI);
- NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP);
- NSW Department of Environment and Conservation (DEC) 2006, *Assessing Vibration: a technical guideline*; and
- Australian Standard AS 2436-2010 *Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites*.

The NVIA was prepared in accordance with the requirements of the NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 20 December 2017. The SEARs identify matters which must be addressed in the EIS. A copy of the SEARs is attached to the EIS as Appendix A, while Table 1.1 lists the individual requirements relevant to this NVIA and where they are addressed in this report.

Table 1.1 Relevant SEARs

Requirement	Section addressed
DPE	
Construction noise impacts in accordance with the ICNG	6.4
Construction road traffic noise impact	6.5
Cumulative construction noise impact	6.6
Cumulative traffic noise impact	6.6
Operational noise impacts in accordance with the NPfI	8
Gunnedah Shire Council	
Construction noise impacts	6.4

To inform preparation of the SEARs, DPE invited other government agencies to recommend matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPE when preparing the SEARs. Copies of the government agencies' advice to DPE were attached to the SEARs. However no additional matters were recommended in regards to noise and vibration.

Several technical terms are required for the discussion of noise and vibration. These are explained in Appendix A.

2 Project and site description

2.1 Project description

The project includes the development, construction and operation of a solar photovoltaic (PV) electricity generation facility, which comprises the installation of PV solar panels, electrical cabling, electrical switchyard / substation, electrical connection to the TransGrid network and other associated infrastructure within the development footprint. The project will connect to the TransGrid 132 kV electricity distribution network that feeds TransGrid's Narrabri to Gunnedah and Gunnedah to Tamworth network system.

The project comprises the following key components:

- a network of PV solar panel arrays including supporting structures and tracker system;
- an internal network of electrical collection and distribution systems including electrical inverters;
- an internal network of communications and control cabling and systems;
- switchyard including electrical switching, control and monitoring equipment, electrical transformation system and operational control room;
- electrical connection and communications cabling from the on-site switchyard and transformation area to the TransGrid 132 kV electrical network;
- a management hub, including material storage areas, demountable offices, amenities and equipment sheds;
- provision of land area within the development footprint for possible future energy storage and network support devices; and
- fencing, access roads from adjacent public roadways, on-site parking and internal access roads.

The proposed hours of construction activities are Monday to Friday between 7 am to 6 pm and Saturday between 8 am and 1 pm. No work will occur on Sundays or public holidays. It is important to note that these proposed construction hours are consistent with the ICNG recommended standard hours.

The expected total duration of the proposed construction activities is estimated to be approximately nine months.

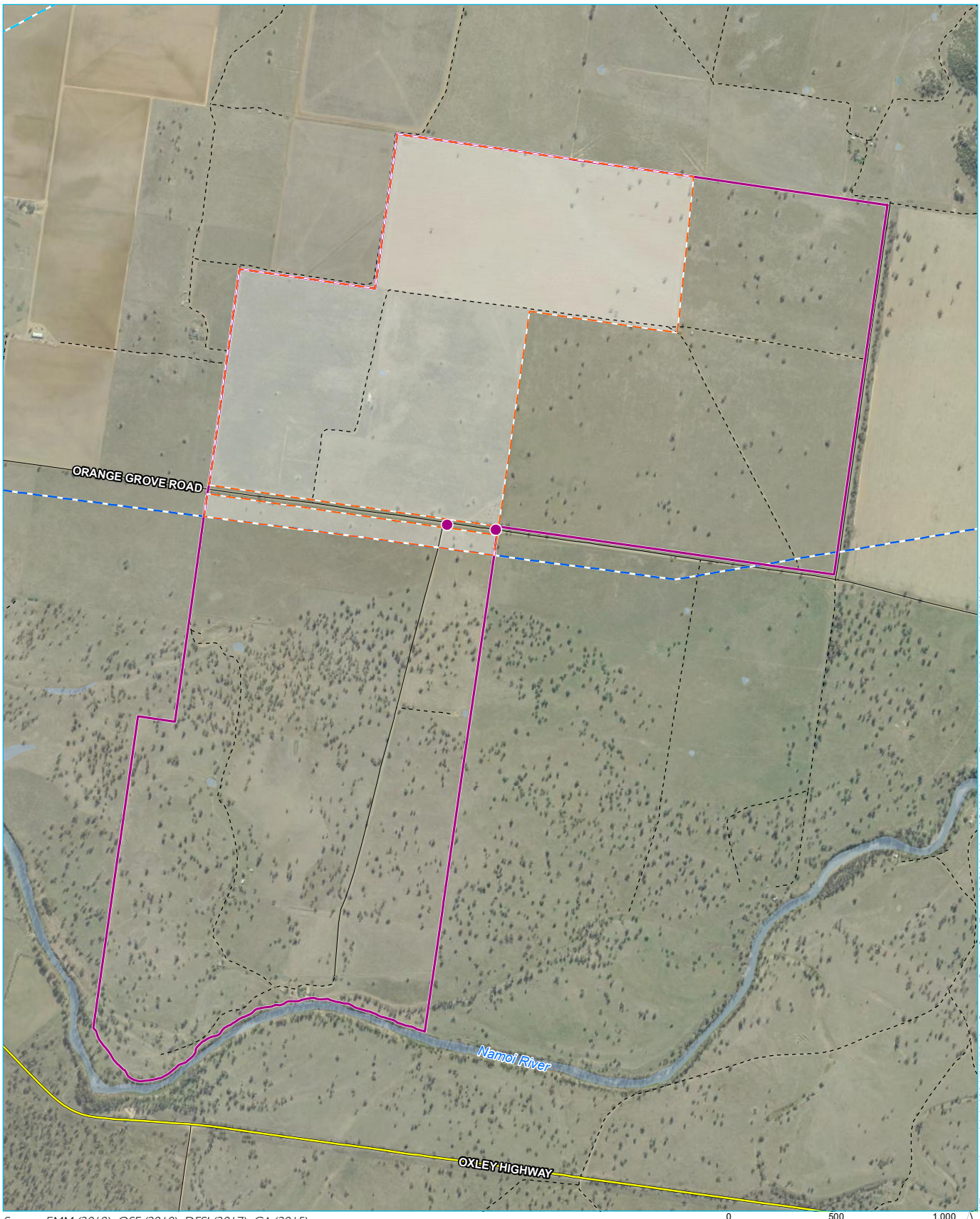
2.2 Site description

The site is approximately 12 km east of the township of Gunnedah, and within the Gunnedah Shire Local Government Area (LGA). The site is split into two separate portions by Orange Grove Road, and encompasses an area of approximately 817 hectares (ha).

The development footprint encompasses an area of 253 ha, which has been refined through the project design process to avoid identified environmental constraints. The development footprint is also split into two separate portions by Orange Grove Road (Figure 2.1).

The site is zoned RU1 Primary Production under the Gunnedah Local Environmental Plan 2011 (Gunnedah LEP). The site has been highly modified by past disturbances associated with land clearing, irrigation development, cropping, livestock grazing and weed invasion. It is currently used for livestock grazing and cropping.

The development footprint is ideally located close to TransGrid's 132 kV transmission line, which runs parallel to the southern boundary of the southern portion of the development footprint. It also has suitable access to the local and regional road network including the Kamilaroi and Oxley Highways, Kelvin Road and Orange Grove Road. The site boundary and development footprint are shown on Figure 2.1.



Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

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KEY

- Orange Grove Sun Farm site boundary
- Development footprint
- Indicative site access point
- 132 kV transmission line
- 66 kV transmission line
- Main road
- Local road
- Vehicular track
- Waterbody

Site boundary and development footprint

Orange Grove Sun Farm
Noise and vibration assessment
Figure 2.1

EMM

3 Existing environment

3.1 Noise sensitive receivers

The nearest receptors are dwellings. The nearest, R1, is approximately 150 m west of the development footprint, with a further four receptors, R2, R8, R9 and R10, within 2 km (see Figure 3.1). Noise has been assessed at eleven sensitive receivers (referred to herein as assessment locations) to quantify potential noise levels from the project. No other sensitive land uses have been identified around the project. It is considered that if noise criteria can be satisfied at the assessment locations closest to the development footprint, then noise criteria will be satisfied at other noise-sensitive locations that are located further from the development footprint. The assessment locations are presented in Table 3.1 and Figure 3.1.

Table 3.1 Noise assessment locations

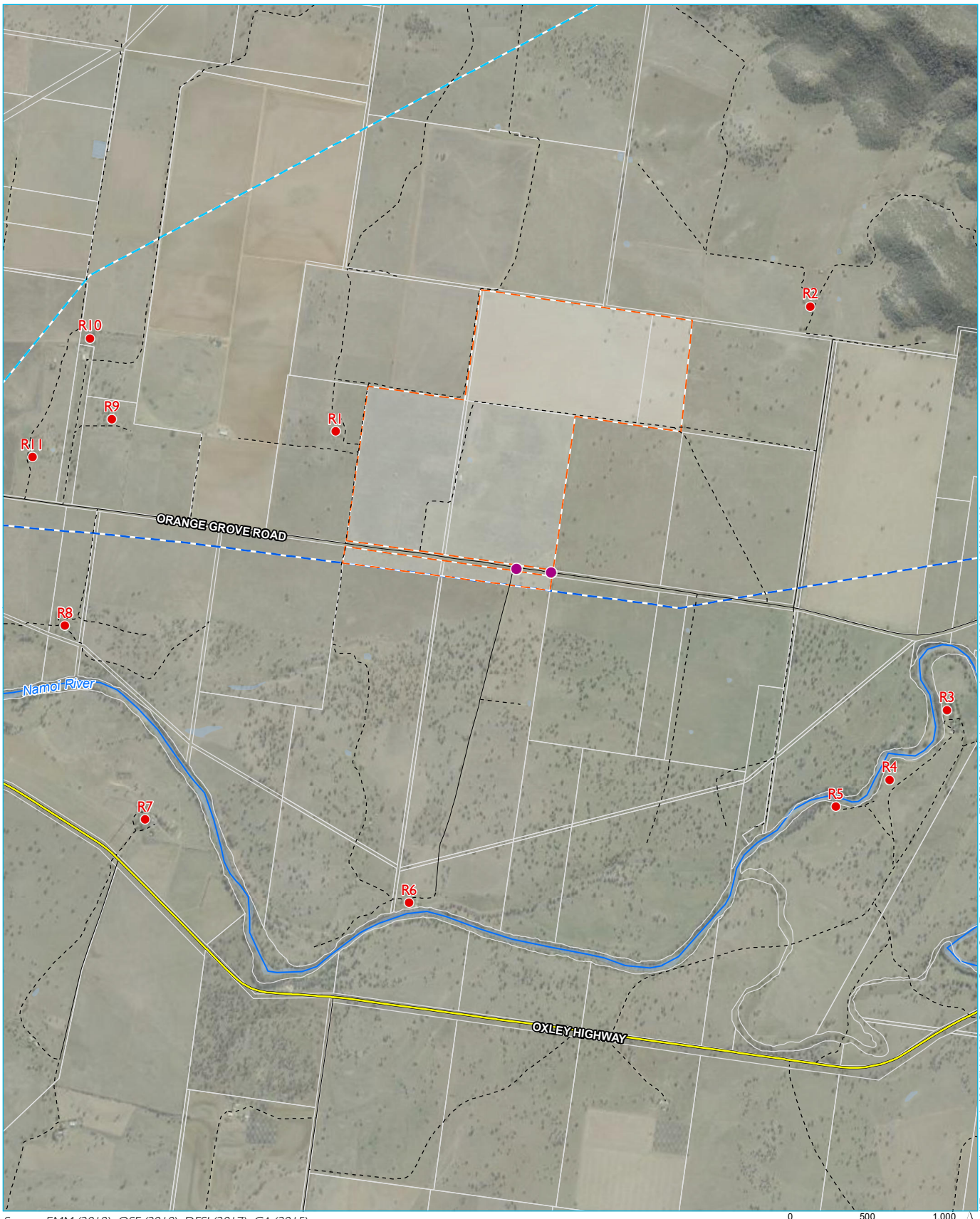
Location ID	Land use*	Approximate distance from development footprint (km)
R1	Residential	0.2
R2	Residential	0.8
R3**	Residential	2.5
R4**	Residential	2.3
R5**	Residential	2.2
R6**	Residential	2.2
R7	Residential	2.1
R8	Residential	1.9
R9	Residential	1.6
R10	Residential	1.8
R11	Residential	2.1

Notes: **As defined in the NSW NPfI and NSW ICNG.*

***The residences at these locations are owned by the project landholders.*

3.2 Acoustic environment

Given the area and surrounding agricultural land uses, existing ambient noise levels at assessment locations are likely to be dominated by rural noise sources and road traffic noise. The rating background noise levels (RBLs) are expected to be low (30 dB or below) and therefore the NPfI minimum RBLs of 35 dB and 30 dB have been adopted for this assessment for the daytime and evening/night-time periods, respectively in accordance with the NPfI (EPA 2017).



Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

0 500 1,000 m
GDA 1994 MGA Zone 56

KEY

- Development footprint
- Indicative site access point
- Assessment location
- 132 kV transmission line
- 66 kV transmission line
- Main road
- Local road
- Vehicular track
- Namoi River
- Waterbody
- Cadastral boundary

Noise assessment locations

Orange Grove Sun Farm
Noise and vibration assessment
Figure 3.1

EMM

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4 Construction noise guidelines

4.1 Objectives

Construction noise objectives aim to minimise the noise impacts from construction activities on surrounding assessment locations. This section provides a summary of applicable noise objectives for the proposed activities.

These noise objectives were used to derive site specific construction noise management levels (NMLs) used to assess the potential noise levels from the proposed works and guide the requirements for mitigation or management thereof.

4.2 Interim construction noise guideline

The assessment and management of noise from construction works is completed using the ICNG (DECC 2009), which provides two methods for the assessment of construction noise emissions:

- Quantitative: suited to major construction projects with typical durations of more than three weeks; and
- Qualitative: suited to short term construction activity (less than three weeks).

The method for a quantitative assessment requires a more complex approach, involving noise emission predictions from construction activities to the nearest assessment locations, whilst the qualitative assessment methodology is a more simplified approach that relies more on noise management strategies.

Due to the anticipated duration of the proposed construction works (ie greater than three weeks), this study has adopted a quantitative assessment approach. The assessment includes quantification of potential noise impacts at assessment locations and provides construction noise criteria for activities that are proposed.

The ICNG recommends that where noise levels from construction during out of hours (OOH) periods are above the noise affected level (RBL + 5 dB) all feasible and reasonable mitigation should be adopted. The ICNG requires a strong justification for construction works outside of standard construction hours. As described in Chapter 1, the project would adopt the recommended standard construction hours as per the ICNG (DECC 2009) which are Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm with no construction work on Sundays or public holidays.

Table 4.1 is an extract from the ICNG and provides NMLs for residential assessment locations during and outside of standard construction hours.

Table 4.1 ICNG residential NMLs

Time of day	Management level, $L_{Aeq,15\ minute}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6pm Saturday 8 am to 1 pm No work on Sundays or public holidays.	Noise affected RBL + 10 dB.	The noise affected level represents the point above which there may be some community reaction to noise: • Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB.	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: i) 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 ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours.	Noise affected RBL + 5 dB.	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

The construction NMLs for this assessment have been based on the adopted NPfI minimum RBL of 35 dB in accordance with the ICNG (DECC 2009).

The NMLs are shown in Table 4.2.

Table 4.2 Project construction residential NMLs

Assessment locations	Period	Adopted RBL, dB(A)	NML, $L_{Aeq,15\ minute}$ (RBL + 10 dB)
R1-R11	**Standard hours**[1]	35	45 75 (highly affected)

Notes: 1. Standard hours as per the ICNG are Monday to Friday from 7 am to 6 pm, Saturday from 8 am to 1 pm, no work on Sundays and public holidays.

4.3 Road traffic noise

The principle guidance for assessing the impact of road traffic noise on assessment locations is in the NSW EPA's RNP (DECCW 2011).

It is anticipated that road trucks will deliver all equipment and material (eg posts, frames, cables, PV solar panels, inverters etc) to site. Both the northern and southern portions of the development footprint will be accessed directly from Orange Grove Road, however, it should be noted that no solar PV panels are proposed for the southern portion of the development footprint and subsequently, the majority of deliveries will be to the northern portion of the development footprint.

From Gunnedah, it is assumed that the majority of light vehicles would cross Cohens Bridge and travel north along O'Keefe Avenue then Kelvin Road before turning onto Orange Grove Road. However, it is noted that an alternative route for heavy vehicles is proposed due to restrictions on Cohens Bridge. This would involve turning on to Blue Vale Road off the Kamilaroi Highway approximately 5.5 km north-west of Gunnedah. The heavy vehicles would then turn right on to Old Blue Vale Road and finally rejoin Kelvin Road, thereby bypassing Cohens Bridge.

The sections of the Kamilaroi and Oxley Highways leading to the project are classified as freeway/arterial road and sub-arterial roads while Kelvin, Blue Vale, Old Blue Vale and Orange Grove roads are classified as local roads. Table 4.3 presents the road noise assessment criteria for these road categories and are reproduced from Table 3 of the RNP (DECCW 2011). It should be noted that such criteria apply to permanent situations and is therefore conservative for the temporary nature of the construction activities (ie nine months).

Table 4.3 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria, dB(A)	
		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.	$L_{Aeq,15\ hour}$ 60 (external)	$L_{Aeq,9\ hour}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 55 (external)	$L_{Aeq,1\ hour}$ 50 (external)

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 2 dB, after consideration of all feasible and reasonable noise mitigation and management measures.

5 Construction vibration criteria

5.1 Human comfort – Assessing vibration a technical guideline

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

The guideline presents preferred and maximum vibration values for 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 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 5.1.

Table 5.1 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, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	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.

5.1.1 Continuous vibration

Appendix B of the guideline outlines acceptable criteria for human exposure to continuous vibration (1 Hz to 80 Hz). The criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Table 5.2 reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 5.2 Criteria for exposure to continuous vibration

Place	Time	Peak velocity (mm/s)	
		Preferred	Preferred
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

Notes: 1. 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.

5.1.2 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 activities such as impact hammering, rolling or general excavation work (eg an excavator tracking).

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 root mean square (RMS) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula (refer *section 2.4.1* of the guideline) was used:

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

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 Vibration Dose Values (VDV) for intermittent vibration are reproduced in Table 5.3.

Table 5.3 Acceptable vibration dose values (VDV) 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	0.4	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

Notes: *1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 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 states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

5.2 Structural vibration criteria – DIN 4150

Structural vibration should be assessed at the foundation of a building structure. The German Standard *DIN 4150 - Part 3: 1999* provides 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 5.4 and shown graphically in Figure 5.1 in the case of foundation levels. 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 criteria range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings the limit range is 20 to 40 mm/s.

Table 5.4 Structural damage guideline values of vibration velocity – DIN 4150

Line	Type of Structure	Vibration velocity in mm/s			
		At foundation at a frequency of			Plane of floor of uppermost storey
		1Hz to 10Hz	10Hz to 50 Hz	50Hz to 100Hz	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	15 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 (e.g. 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 DIN 4150.

2. For frequencies above 100Hz the higher values in the 50Hz to 100Hz 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 criteria in Table 5.4, 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.

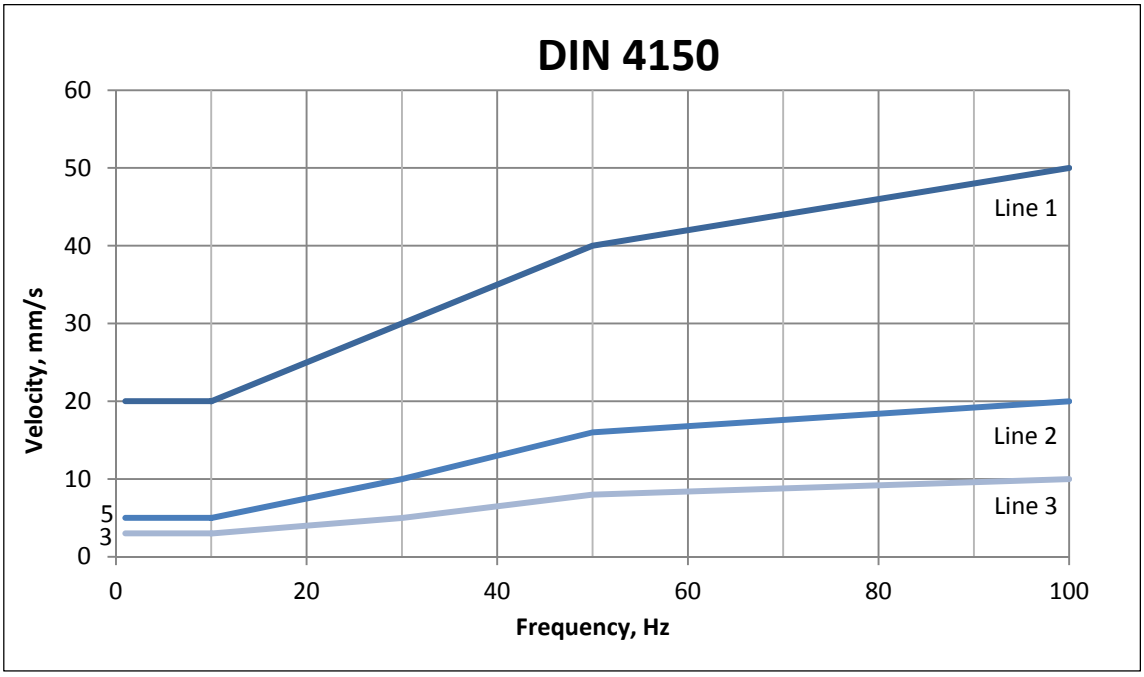


Figure 5.1 DIN 4150 Structural vibration safe limits for buildings

5.3 Ground-borne noise

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. The ICNG provides guidance on the assessment of ground-borne noise and relevant internal noise levels for the evening and night-time periods above which management actions should be implemented.

The proposed construction works are not expected to occur during the evening or night periods, and as such, ground-borne noise impacts are not expected at the nearest assessment locations.

6 Construction noise assessment

6.1 Noise modelling methodology

Construction noise levels were modelled using Brüel and Kjær 'Predictor' software. 'Predictor' calculates total noise levels at assessment locations from the concurrent operation of multiple noise sources. The model has considered factors such as:

- the lateral and vertical location of noise sources;
- source to assessment location distances;
- ground effects;
- atmospheric absorption;
- topography of the site and surrounding area; and
- applicable meteorological conditions.

Predicted noise levels over a typical worst case 15-minute scenario were modelled and assessed for comparison against the relevant NMLs.

6.2 Construction plant and equipment

The construction noise impact assessment has adopted sound power levels from the EMM 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 6.1.

The construction of the solar PV electricity generation facility would comprise the installation of PV solar panels and associated infrastructure. Site preparation would be the starting phase of the construction works, although minimum earthworks are expected to occur due to the relatively flat terrain and predominantly cleared landscape. During site preparation works, above and below ground level irrigation structures may be removed from within the development footprint. The site preparation stage would be followed by the installation of the PV solar panels. This would include the driving or screwing of piles or posts into the ground depending on the ground conditions, as well as the preparation of foundations for the inverter blocks. The PV solar panels would be arranged in a series of rows and are expected to be supported by ground-mounted framing. Underground cabling would be installed between the PV solar panels and the collection circuit and transmission infrastructure between the project switchyard and TransGrid's 132 kV transmission line would be constructed. Other activities would include the construction of an electrical switchyard, a management hub and decommissioning of temporary infrastructure once construction works are completed.

Each stage of the construction works on-site will occur separately and hence some of the plant and equipment have been duplicated for some of the activities (eg crane).

Table 6.1 Typical construction plant and equipment

Stage	Plant and equipment items	Quantity (worst case per 15-min period)[1]	A-weighted sound power level, dB
Site preparation works	Excavator	1	104
	Dozer	1	110
	Light vehicle	4	76
	Front End Loader (FEL)	1	105
	Road truck (deliveries)	1	103
	Dump truck	2	108
	Grader	1	108
	Roller	1	116
	Compactor	1	112
	Crane	1	106
	Forklift	1	106
	Water truck	1	96
	Generator	2	98
Pile driving and foundations	Piling drill rig	1	115
	Road truck (deliveries)	1	103
	Crane	1	106
	Excavator	1	104
	Concrete truck	1	113
	Light vehicle	2	76
Underground cabling	Road truck (deliveries)	1	103
	Cable trenching and laying equipment	1	100
	Light vehicle	2	76
Solar panels full installation	Powered hand tools	1	97
	Compressor	1	108
	Pneumatic wrench	1	117
	Generator	1	98
	Crane	1	106
	Road truck (deliveries)	1	103
	Light vehicle	2	76
Management hub	Crane	1	106
	Forklift	1	106
	Light vehicle	2	76
	Road truck	1	103
	Generator	1	98
Removal of temporary site compound	Crane	1	106
	Forklift	1	106
	Light vehicle	2	76
	Road truck (deliveries)	1	103

Notes: 1. Standard hours only: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm and no construction work on Sundays or public holidays.

2. Plant and equipment items have been assumed to operate continuously in any 15-minute period.

6.3 Modelled meteorological conditions

Noise propagation over distance can be significantly affected by the prevailing weather conditions. During the daytime period (coinciding with standard construction hours), of most interest are source to receiver winds as these conditions can enhance received noise levels. For permanent activities (ie industrial operations), the NPfI recommends consideration of wind effects if they are "significant". The NPfI defines "significant" as the presence of source-to-receiver wind speed (measured at 10 m above ground level) of 3 m/s or less, occurring for 30% of the time in any assessment period and season.

This is further clarified by defining source-to-receiver wind direction as being the directional component of wind. The NPfI states that where wind is identified to be a significant feature of the area then assessment of noise impacts should consider the highest wind speed below 3 m/s, which is considered to prevail for at least 30% of the time.

Meteorological data from the nearest Bureau of Meteorology's (BoM) Automatic Weather Station (AWS) was analysed. Data recorded between January 2013 and January 2018 (5 years) from the BoM's Gunnedah Airport AWS (ID 055202) was used for this assessment. The analysis identified that no winds were found to be a feature of the area during the day, evening or night periods and therefore only calm meteorological conditions were adopted for the construction noise modelling. Meteorological conditions adopted for the construction noise modelling are presented in Table 6.2.

Table 6.2 Meteorological conditions considered in noise modelling

Assessment period	Meteorological condition	Air temperature	Relative humidity	Wind speed	Wind direction	Stability category
Day[1, 2]	Calm	20°C	70%	0.5 m/s	All	D class
Evening[2]	Calm	10°C	90%	0.5 m/s	All	D class
Night[2]	Calm	10°C	90%	0.5 m/s	All	D class
	Inversion	10°C	90%	0.5 m/s	All	F class

Notes: *1. Corresponds to standard construction hours as per the ICNG.*

2. Corresponds to the operational hours of the project

6.4 Construction noise modelling results

Based on the noise modelling results, the site preparation works have the most potential for noise impacts given the number of plant to be used, their emission levels, duration and locations of other construction activities, and therefore are the focus for the assessment. Noise from other construction activities would result in off-site noise levels that are below those from site preparation works.

Predicted construction noise levels for the site preparation works during standard construction hours are presented in Table 6.3. Construction noise levels are predicted to satisfy the recommended NMLs at all locations. Therefore, noise levels during all construction activities are expected to satisfy the NMLs at all locations.

Table 6.3 Construction (site preparation) noise predictions

Assessment locations	Land use	Predicted construction noise level $L_{Aeq,15\ minute}$, dB	Construction NML[1] $L_{Aeq,15\ minute}$, dB
R1	Residential	45	45
R2	Residential	36	45
R3**	Residential	<30	45
R4**	Residential	<30	45
R5**	Residential	<30	45
R6**	Residential	<30	45
R7	Residential	<30	45
R8	Residential	<30	45
R9	Residential	31	45
R10	Residential	30	45
R11	Residential	<30	45

Notes: 1. Standard hours only: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm and no construction work on Sundays or public holidays.

***The residences at these locations are owned by the project landholders.*

6.5 Road traffic noise during construction

The proposed construction works will include the delivery of all construction plant and equipment, infrastructure and project parts (eg solar panels, mounting frames etc) to site by road trucks. Other traffic movements generated by the project will include movements from the construction workforce.

Daily average (and peak) traffic movements generated by construction deliveries and the construction workforce are summarised in Table 6.4. Site generated traffic movements would be travelling via Orange Grove Road and Kelvin Road.

Table 6.4 Daily average traffic movements during construction

Construction scenario	Daily heavy vehicles movements	Daily workforce movements (light vehicles)	Total daily movements	Hourly heavy vehicle movements	Hourly workforce movements (light vehicles)	Total hourly movements
Average	32	48	80	8	16	24
Peak	56	60	116	12	24	36

It is expected that the majority (approximately 60%) of the construction deliveries will arrive from the south on the Kamilaroi Highway, originating from Sydney, with the remainder of the deliveries from the east on the Oxley Highway (approximately 20%) or from the north on the Kamilaroi Highway (approximately 20%).

Approximately 40% of the construction workforce is assumed, for the purposes of assessment, to reside locally in and around the township of Gunnedah. The remaining construction workforce (60%) will be based in either the township of Tamworth (40%), or in the townships of Narrabri or Boggabri (20%).

On Orange Grove Road, the nearest residential facade (roadside) that could potentially be affected by an increase in road traffic noise is set back approximately 45 m from the road in a 100 km/h speed zone. This residence is approximately 5.5 km west of the site boundary.

On Kelvin Road, the nearest residential facade (roadside) that could potentially be affected by an increase in road traffic noise is set back approximately 50 m from the road in a 100 km/h speed zone. This residence is approximately 11 km west of the development footprint.

On Old Blue Vale Road, the nearest residential facade (roadside) that could potentially be affected by an increase in road traffic noise is set back approximately 70 m from the road in a 100 km/h speed zone. This residence is approximately 12 km west of the development footprint, just outside the township of Gunnedah.

On other parts of the route and further away from the project (towards Carroll, approximately 5 km east of the project, or Quirindi, approximately 65 km south-east of the project), nearest residential facades are set back approximately 10 and 20 m (or greater) from the road in 70 km/h and 100 km/h speed zones, respectively. These distances have been adopted for the road traffic noise assessment. Road traffic noise results are based on the peak hourly workforce movements and construction delivery movements during the peak construction scenario and hence this assessment of road traffic noise is therefore considered to be conservative.

Existing traffic data for the Kamilaroi and Oxley Highways was obtained from the publically available NSW Roads and Maritime Services' online database. In addition, Gunnedah Shire Council provided their most recent available traffic count data for the local road network, more specifically Kelvin Road and Orange Grove Road. This data was used to calculate the existing traffic volumes for 2018 assuming a 1% annual traffic growth (linear) for all roads. In the absence of traffic count data for Old Blue Vale Road, the existing traffic volume has been estimated using the RMS *Guide to Traffic Generating Developments Updated Traffic Surveys* (RMS 2013).

The estimated existing (2018) average daily traffic volumes on the transport routes can be seen in Table 6.5 below.

Table 6.5 Projected daily traffic volumes

Road	2018 projected daily traffic volume	Average proportion of heavy vehicles
Kamilaroi Highway south-west of the development footprint (near Curlewis)	1,810	17%
Oxley Highway east of development footprint (near Carroll)	1,610	13%
Orange Grove Road (sealed portion)	171	3.3%
Orange Grove Road (unsealed portion)	89	3.4%
Kelvin Road (north of Orange Grove Road)	383	5.2%
Kelvin Road (south of Orange Grove Road)	581	4.0%
Old Blue Vale Road (east of Blue Vale Road)	67	10%[1]

Notes: 1. This proportion of heavy vehicles has been assumed in the absence of vehicle classification data and on the basis that the existing traffic on Old Blue Vale Road is primarily localised traffic only.

Road traffic noise levels during construction works are predicted to be below the relevant criteria at the affected residential dwellings on the surrounding road network, as shown in Table 6.6.

Table 6.6 Predicted road traffic noise during peak construction

Stage	Road	Distance to road (m)	Speed (km/h)	Calculated existing traffic noise level, dB	Predicted project generated traffic noise level, dB[1]	Future traffic noise level, dB	Criteria, dB
Peak	Orange Grove Road	≥45	100	42 $L_{Aeq,1\ hour}$	51 $L_{Aeq,1\ hour}$	51 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Kelvin Road	≥50	100	42 $L_{Aeq,1\ hour}$	47 $L_{Aeq,1\ hour}$	48 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Old Blue Vale Road	≥70	100	36 $L_{Aeq,1\ hour}$	47 $L_{Aeq,1\ hour}$	48 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Oxley Highway	≥10	70	57 $L_{Aeq,15\ hour}$	46 $L_{Aeq,15\ hour}$	58 $L_{Aeq,15\ hour}$	60 $L_{Aeq,15\ hour}$
	Kamilaroi Highway	≥20	100	58 $L_{Aeq,15\ hour}$	49 $L_{Aeq,15\ hour}$	58 $L_{Aeq,15\ hour}$	60 $L_{Aeq,15\ hour}$

Notes: 1. Based on the peak hourly workforce movements and construction delivery movements.

6.6 Cumulative construction noise

Photon Energy Pty Ltd (Photon) is seeking to develop the Gunnedah Solar Farm approximately 3 km to the west of the Orange Grove Sun Farm. The construction works for the Gunnedah Solar Farm have potential to occur at the same time as that of the project. Modelling results from the proposed construction works for the project are predicted to satisfy the NMLs at all assessment locations. As noted earlier, the predictions assume plant and equipment are operating simultaneously and at the nearest locations to relevant assessment locations, hence it is likely that actual noise levels from the proposed construction works will be lower than predicted.

Based on the size of the Gunnedah Solar Farm, distances of nearest assessment locations and predicted noise levels for the project (results provided in Table 6.3), the total cumulative construction noise level from both developments is predicted to satisfy the NMLs during standard hours at the identified assessment locations. Therefore, cumulative noise from the project and the Gunnedah Solar Farm is not anticipated to cause an impact at nearby identified assessment locations.

Further, there is potential for cumulative road traffic movements from both the project and the Gunnedah Solar Farm. Road traffic noise predictions for the Gunnedah Solar Farm were unavailable at the time of this assessment; however, predicted traffic volumes were available in the Preliminary Environmental Assessment – Gunnedah Solar Farm (Pitt&Sherry 2017). Road traffic noise levels for the Gunnedah Solar Farm have been calculated using these predicted traffic volumes.

The results of the cumulative road traffic noise assessment are provided in Table 6.7 As shown in Table 6.7, total cumulative road traffic noise levels are predicted to be below the relevant RNP criteria during a concurrent construction scenario for the project and the Gunnedah Solar Farm.

Table 6.7 Predicted cumulative road traffic noise during peak construction

Stage	Road	Calculated existing traffic noise level, dB	Orange Grove predicted traffic noise level, dB[1]	Gunnedah predicted traffic noise level, dB[1]	Future traffic noise level, dB	Criteria, dB
Peak	Orange Grove Road	42 $L_{Aeq,1\ hour}$	51 $L_{Aeq,1\ hour}$	50 $L_{Aeq,1\ hour}$	54 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Kelvin Road	42 $L_{Aeq,1\ hour}$	47 $L_{Aeq,1\ hour}$	46 $L_{Aeq,1\ hour}$	50 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Old Blue Vale Road	36 $L_{Aeq,1\ hour}$	47 $L_{Aeq,1\ hour}$	46 $L_{Aeq,1\ hour}$	50 $L_{Aeq,1\ hour}$	55 $L_{Aeq,1\ hour}$
	Oxley Highway	57 $L_{Aeq,15\ hour}$	46 $L_{Aeq,15\ hour}$	45 $L_{Aeq,15\ hour}$	58 $L_{Aeq,15\ hour}$	60 $L_{Aeq,15\ hour}$
	Kamilaroi Highway	58 $L_{Aeq,15\ hour}$	49 $L_{Aeq,15\ hour}$	48 $L_{Aeq,15\ hour}$	59 $L_{Aeq,15\ hour}$	60 $L_{Aeq,15\ hour}$

There is potential for approximately nine months of concurrent construction activities, however, it is unlikely that construction activities would overlap for this entire period, if at all. Furthermore, the application of the RNP criteria to construction projects is highly conservative given the RNP is designed for permanent scenarios and not temporary impacts possible from construction activities.

7 Construction vibration assessment

The majority of vibration generating activities associated with the proposed construction work utilise a roller and a piling drill rig. As a guide, safe working distances for typical items of vibration intensive plant are listed in Table 7.1. 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 7.1 Recommended safe working distances for vibration intensive plant

Plant item[1]	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Vibratory Roller	<50 kN (typically 1–2 tonnes)	5 m	15 to 20 m
	<100 kN (typically 2–4 tonnes)	6 m	20 m
	<200 kN (typically 4–6 tonnes)	12 m	40 m
	<300 kN (typically 7–13 tonnes)	15 m	100 m
	>300 kN (typically 13–18 tonnes)	20 m	100 m
	>300 kN (>18 tonnes)	25 m	100 m
Small hydraulic hammer	(300 kg - 5 to 12 tonne excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg - 12 to 18 tonne excavator)	7 m	23 m
Large hydraulic hammer	(1,600 kg - 18 to 34 tonne excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Source: Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects), November 2007.

Notes: 1. Plant items shown are indicative to illustrate safe working distances, not all plant items will be used.

The safe working distances presented in Table 7.1 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

In relation to human comfort response, the safe working distances in Table 7.1 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, in accordance with BS 6472-1.

The nearest residence (R1) is approximately 150 m from the development footprint. Given this distance is well outside the safe working distance for cosmetic damage and human comfort, the assessment predicts no vibration impacts will occur throughout the approximate nine month duration of the construction stage of the project.

8 Operational noise

Noise impact from the general operation of the project was considered at assessment locations R1-R11, with the nearest residential assessment location approximately 150 m from the development footprint. A semi-qualitative assessment of the potential impact from operational noise was conducted.

As per Section 6.3, a prevailing winds analysis identified that no winds were found to be a feature of the area during the day, evening or night periods. An analysis of temperature inversions based on sigma-theta data obtained from the Bureau of Meteorology's Gunnedah Airport weather station found that F or G stability class (temperature inversions) occur for greater than 30% of the night-time period and, as such, have been considered in the prediction and assessment of noise emissions for the night-time period.

Noise sources considered during the operational phase of the project include inverters with integrated transformers, tracker motors (PV solar panels) and light vehicles. The tracker motors and light vehicles are assumed to operate during the daytime period only. 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).

The semi-qualitative assessment identified that the $L_{Aeq,15\ minute}$ noise levels from the proposed development would satisfy the minimum daytime and evening/night-time NPfI trigger levels of 40 dB and 35 dB, respectively at all assessment locations.

9 Conclusion

EMM has completed a construction and operational NVIA for the proposed Orange Grove Sun Farm east of the township of Gunnedah, NSW.

The nearest assessment location (R1) is approximately 150 m west of the development footprint. Modelling has demonstrated that noise levels during construction are predicted to satisfy the relevant NMLs during standard hours at all assessment locations.

The assessment predicts that vibration associated with the proposed construction works will not generate impacts at the nearest assessment locations throughout the approximate nine month duration of the construction stage of the project.

Traffic generated by the project is not expected to result in any noticeable increase in average road traffic noise levels at the nearest residential locations surrounding the project routes.

Cumulative construction noise impacts from the project and the Gunnedah Solar Farm were considered in this assessment, however, cumulative impacts during the concurrent construction of the two projects have been identified as unlikely given construction noise levels from the project are predicted to be well below the relevant NMLs.

Cumulative road traffic noise generated during the concurrent construction of the project and the Gunnedah Solar Farm is expected to satisfy relevant RNP criteria.

Operational noise levels are shown to satisfy the NPfI noise trigger levels at all assessment locations during the daytime, evening and night-time periods.

References

Australian Standard (AS) 1055-1997, Acoustics - Description and Measurement of Environmental Noise.

Australian Standard (AS) 2436-2010, Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites.

NSW Department of Environment, Climate Change and Water (DECCW) 2011, *NSW Road Noise Policy*.

NSW Department of Environment and Conservation (DEC) 2006, *Assessing Vibration: a technical guideline*.

NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry*.

NSW Environment Protection Authority (EPA) 2009, *NSW Interim Construction Noise Guideline*.

NSW Roads and Maritime Services (RMS) 2013, *Guide to Traffic Generating Developments Updated Traffic Surveys*.

Appendix A

Acoustic terms

Several technical terms discussed in this report are explained in Table A.1.

Table A.1 Glossary of acoustic terms

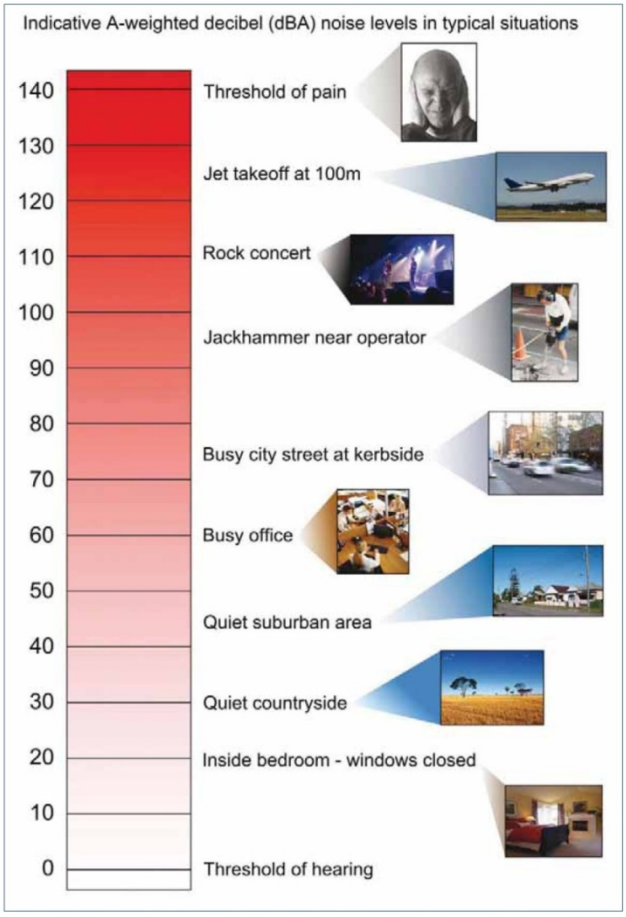
Term	Description
dB	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A90}	Commonly referred to as the background noise level. The '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. The $L_{Aeq,15\ minute}$ descriptor refers to an L_{Aeq} noise level measured over a 15 minute period.
L_{Amax}	The maximum root mean squared 'A-weighted' sound pressure level (or maximum noise level) received during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Day period	Monday – Saturday: 7 am to 6 pm, on Sundays and Public Holidays: 8 am to 6 pm.
Evening period	Monday – Saturday: 6 pm to 10 pm, on Sundays and Public Holidays: 6 pm to 10 pm.
Night period	Monday – Saturday: 10 pm to 7 am, on Sundays and Public Holidays: 10 pm to 8 am.

It is useful to have an appreciation of decibels (dB), the unit of noise measurement. Table A.2 gives an indication as to what an average person perceives about changes in noise levels.

Table A.2 Perceived change in noise

Change in sound 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

Examples of common noise levels are provided in Figure A.1.



Source: *Road Noise Policy (Department of Environment, Climate Change and Water (DECCW) 2011).*

Figure A.1 Common noise levels

SYDNEY
Ground floor, Suite 01, 20 Chandos Street
St Leonards, New South Wales, 2065
T 02 9493 9500 F 02 9493 9599

NEWCASTLE
Level 1, Suite 6, 146 Hunter Street
Newcastle, New South Wales, 2300
T 02 4907 4800 F 02 4907 4899

BRISBANE
Level 4, Suite 01, 87 Wickham Terrace
Spring Hill, Queensland, 4000
T 07 3839 1800 F 07 3839 1866