Assured Environmental

WAGGA WAGGA SOLAR FARM SOUTH – NOISE & VIBRATION IMPACT ASSESSMENT

METKA

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R_3

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Table 1: Document Approval

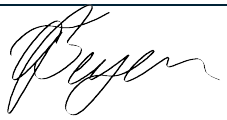
	Name	Position Title	Signature	Date
Author	Michelle Clifton	Senior Consultant		21/02/2020
Reviewer	Craig Beyers	Consulting Services Manager		21/02/2020
Approver	Craig Beyers	Consulting Services Manager		21/02/2020

Table 2: Revision Register

Revision	Date	Name	Issued to	Comment
R_0	20/11/2019	C. Beyers	J. Steele	Formal report release
R_1	21/11/2019	C. Beyers	J. Steele	Comments
R_2	21/11/2019	C. Beyers	J. Steele	Comments
R_3	21/02/2020	C. Beyers	J. Steele	RFI

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1 INTRODUCTION

1.1 Scope of Assessment

Assured Environmental (AE) was appointed on behalf of METKA to undertake a noise and vibration impact assessment for the proposed Wagga Wagga Solar Farm South (WWSFS). The project involves construction and operation of a solar farm on one (1) land parcel.

The noise and vibration study has been undertaken to assess the potential impacts of the construction and operation of the proposed solar farm on nearby sensitive receptors in accordance with the following NSW policies and guidelines:

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

In accordance with the requirements of the above guidelines, computational modelling and first principle calculations have been undertaken to support an assessment of the potential for adverse amenity impacts as a result of the development.

1.2 Information Request

City of Wagga Wagga issued an Information Request dated 17 February 2020. Item (5) relates to the noise assessment:

> *5. It is not clear if the Acoustic assessment includes a cumulative analysis of noise across both sites for during construction (machinery, vehicle movements etc.) and once all arrays are operational. If this is not included please update the report to ensure that this detail is provided.*

A cumulative assessment is presented in Section 7.

1.3 This Report

This report summarises the methodology, results and conclusions of the noise and vibration impact assessment. A glossary of terms is presented in Appendix A to assist the reader.

2 PROPOSED DEVELOPMENT SITE

2.1 Development Site

The proposed development site is located approximately 5.5 km north of Wagga Wagga in southern New South Wales. Specifically, the proposed solar farm is to be constructed within part of Lot 15 on DP1108978. Figure 1 presents the location of the site and nearby sensitive receptors.

The area surrounding the proposed development includes a range of agricultural and rural uses. To the north of the site within the same lot, there is an approved solar farm.

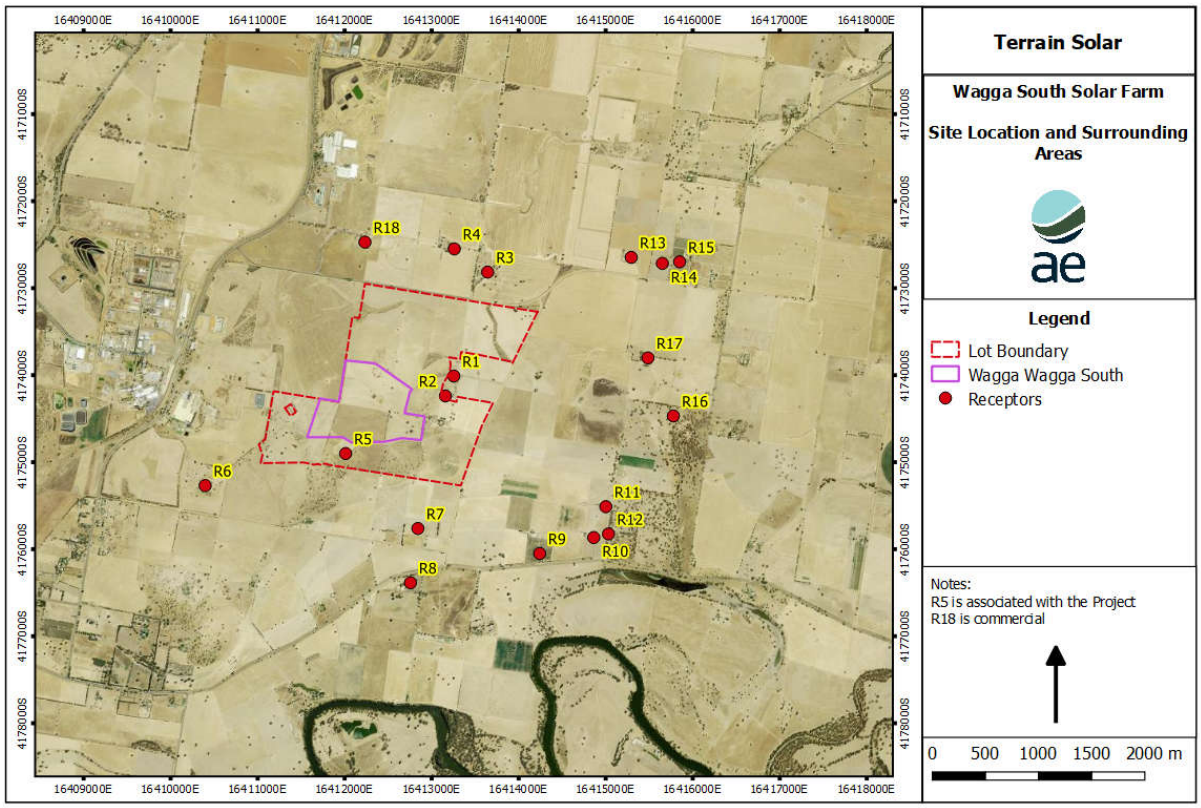

Figure 1: Site Location, Sensitive Receptors and Surrounding Land uses

2.2 Nearby Sensitive Receptors

The nearest residential receptors to the proposed solar farm include 17 single existing dwellings located within 3 km of the development. Of these, one receptor (R5) is located within the proposed development lot boundary and is associated with the Project. In addition, receptor R18 is noted to be a commercial use.

Table 3 and Figure 1 provide a summary of the nearest sensitive uses to the proposed WWSFS development.

Table 3: Nearby Sensitive Receptors

Receptor ID	Description	Distance to Nearest Solar Panel (m)	Distance to Nearest Inverter (m)
R1	Existing Dwelling	450	620
R2	Existing Dwelling	360	510
R3	Existing Dwelling	1,310	1,460
R4	Existing Dwelling	1,320	1,450
R5 [a)]	Existing Dwelling	170	290
R6	Existing Dwelling	1,080	1,300
R7	Existing Dwelling	880	1,020
R8	Existing Dwelling	1,380	1,500
R9	Existing Dwelling	1,580	1,930
R10	Existing Dwelling	1,890	2,250
R11	Existing Dwelling	1,880	2,200
R12	Existing Dwelling	2,010	2,350
R13	Existing Dwelling	2,430	2,600
R14	Existing Dwelling	2,660	2,850
R15	Existing Dwelling	2,830	2,970
R16	Existing Dwelling	2,370	2,620
R17	Existing Dwelling	2,210	2,440
R18	Commercial	1,130	1,270

a) Associated with the Project

3 CONSTRUCTION NOISE ASSESSMENT

3.1 Duration of Construction Works

The construction of the WWSFS is expected to take approximately 12 months with several different activities expected to be undertaken over that time. Table 4 below presents an overview of each of the construction tasks along with their expected duration. Review of the indicative construction schedule identifies that some activities such as civil works, trenching, piling and installation may occur concurrently.

Given the rural location and the relatively large separation distances between the development and the majority of nearby sensitive receptors, the assessment has also considered the potential for adverse amenity impacts associated with construction outside recommended standard hours (as described in Table 5 below).

Table 4: Construction Phases and Expected Duration

Construction Phase	Duration
Site clearing and preparation	2 months
Construction including piling and installation of solar PV modules & inverter assemblies	8 months
Commissioning	2-3 months

3.2 Interim Construction Noise Guideline

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

The main objectives of the Guideline are to:

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

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

Table 5 presents construction noise criteria outlined in the guideline. Noise levels apply at a height of 1.5 m above ground level at the property boundary that is most exposed to construction noise . If the property boundary is more than 30 m from the dwelling, the location for assessing noise impact is the most noise-affected point within 30 m of the dwelling.

Table 5: NSW EPA Construction Noise Criteria – Residential Receivers

Time of Day	Management Level (Free-field)	How to Apply
Recommended standard hours: Monday to Friday, 7 am to 6 pm Saturday, 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, considering: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

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

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

For construction outside standard hours, the assessment criteria have been determined based on the minimum allowable RBL described in the NPfI. That is, for the purposes of the assessment it is assumed that the RBL is 30 dB(A) for night periods thereby resulting in a noise affected limit of 35 dB(A) for construction outside standard hours.

3.3 Construction Noise Sources

In terms of noise emissions, the site preparation activities and installation of the solar PV modules (specifically driving the support posts into the ground) are expected to represent those with the most significant potential for adverse impacts. The indicative project schedule has determined these two activities may occur concurrently. Therefore, for the purposes of the assessment, the impacts associated with these two elements have been assessed cumulatively.

It is noted that construction works are expected to progress across the site such that plant and equipment would only be in a single area for a short period of time. For example, each post takes approximately 25-30 seconds to drive into the ground thereby providing the ability to install a new pile approximately every 2.5 minutes. Given this, the potential for adverse impacts at any one receptor is expected to only occur for a short period of time. Table 6 below presents a summary of the plant and equipment likely to be required to complete the on-site construction works. The sound power levels presented have been sourced from published noise emission datasets and the library of source noise levels maintained by Assured Environmental.

Table 6: Construction Phases and Expected Duration

Construction Phase	Plant Item	Number Required	Sound Power Level, dB(A)	Acoustical Usage Factor, % [e]
Site preparation and construction [a]	Truck & Dog [b]	3	110	40
	Compactor	2	103	20
	Bulldozer	3	109	40
	Mulcher	1	116	20
	Loader	6	107	40
	Grader [c]	1	108	40
	Water Cart (as required)	2	103	40
	Vibratory Roller	2	103	20
Installation of solar PV modules & inverter assemblies	Post Pounding Machine [f]	4	112 - 124	20
	Franna Crane	2	107	16
	Trencher	2	97	40
	Loader	2	107	40
	Generator	2	73	50
	Power Tools	20		

a) Construction plant used intermittently as required. Continuous use not expected.

Construction Phase	Plant Item	Number Required	Sound Power Level, dB(A)	Acoustical Usage Factor, % e)

b) Truck movements associated with deliveries assumed to move through site at 10 km per hour as a moving point source.

c) Grader required for construction of access tracks, construction offices car park, minor earthworks and grading around the solar array area as required to meet structural tolerances for the tracker equipment.

d) Deliveries to site only to occur during standard construction hours.

e) The 'Acoustical Usage Factor' represents the percentage of time that a particular item of equipment is assumed to be running at full power while working on site.

f) Includes a correction for tonality.

It should be noted that the piling sound power level used in the model is 107 dB(A) (excluding tonality correction) as presented in Table 6.

3.4 Assessment of Impacts

3.4.1 Overview

For the purposes of predicting impacts associated with noise emissions from the Subject Site on nearby sensitive receptors, noise modelling of the sources was completed using the proprietary software CadnaA (version 2020 build 175.5000) developed by DataKustik. CadnaA incorporates the influence of meteorology, terrain, ground type and air absorption in addition to source characteristics to predict noise impacts at receptor locations. All predictions have been undertaken in accordance with ISO Standard 9613 (1996) *"Acoustics - Attenuation of sound during propagation outdoors"*.

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

3.4.2 Preparatory Civil Works

For preparatory civil works activities during the construction phase of the project, the predictive noise modelling has considered the range of potential impacts likely noting that noise generating activities will progressively move across the site over the duration of construction. As such, the highest noise levels would not be expected to be experienced at a single receptor for more than one day while construction equipment is at the closest point to the receptor.

Table 7 below presents predicted receptor noise levels for preparatory civil works activities during the construction phase of WWSFS.

Table 7: Predicted Receptor Noise Levels - Construction Phase – Preparatory Works, dB(A)

Receptor	Description	Predicted Construction Noise Levels, $L_{Aeq, 15min}$	Noise Management Level		Comply (Y/N)
			Standard Hours	Outside Standard Hours	
R1	Existing receptor	40	45	35	Standard hours only
R2	Existing receptor	39	45	35	Standard hours only
R3	Existing receptor	26	45	35	Yes
R4	Existing receptor	25	45	35	Yes
R5 a)	Existing receptor	45	45	35	Standard hours only
R6	Existing receptor	28	45	35	Yes
R7	Existing receptor	36	45	35	Standard hours only
R8	Existing receptor	32	45	35	Yes
R9	Existing receptor	26	45	35	Yes
R10	Existing receptor	16	45	35	Yes
R11	Existing receptor	25	45	35	Yes
R12	Existing receptor	<10	45	35	Yes
R13	Existing receptor	10	45	35	Yes
R14	Existing receptor	<10	45	35	Yes
R15	Existing receptor	<10	45	35	Yes
R16	Existing receptor	15	45	35	Yes
R17	Existing receptor	17	45	35	Yes
R18	Commercial	24	-	-	Not applicable

a) Associated with the Project

Review of the predicted noise levels confirms that compliance with the noise management level provided in the ICNG for all receptors for standard construction hours. For construction outside standard hours, the results of the modelling indicate exceedences of the noise limits could occur at Receptors R1, R2 and R7.

It should be noted that ICNG does not provide criteria for commercial receptors, however the predicted noise levels at R18 show compliance with the residential criteria.

3.4.3 Installation Activities

For the installation activities (including piling) during the construction phase of the proposed project, predictive noise modelling has considered the range of potential impacts likely noting that noise generating activities will progressively move across the site over the duration of construction. As such, the highest noise levels from piling activities would not be expected to be experienced at a single receptor for more than one day while construction equipment is at the closest point to the receptor.

Table 8 below presents predicted receptor noise levels for installation activities during the construction phase.

Table 8: Predicted Receptor Noise Levels - Construction Phase – Installation, dB(A)

Receptor	Description	Predicted Construction Noise Levels, $L_{Aeq, 15min}$	Noise Management Level		Comply (Y/N)
			Standard Hours	Outside Standard Hours	
R1	Existing receptor	23	45	35	Yes
R2	Existing receptor	26	45	35	Yes
R3	Existing receptor	14	45	35	Yes
R4	Existing receptor	15	45	35	Yes
R5 a)	Existing receptor	43	45	35	Standard hours only
R6	Existing receptor	25	45	35	Yes
R7	Existing receptor	30	45	35	Yes
R8	Existing receptor	26	45	35	Yes
R9	Existing receptor	23	45	35	Yes
R10	Existing receptor	<10	45	35	Yes
R11	Existing receptor	<10	45	35	Yes
R12	Existing receptor	<10	45	35	Yes
R13	Existing receptor	<10	45	35	Yes
R14	Existing receptor	<10	45	35	Yes
R15	Existing receptor	<10	45	35	Yes
R16	Existing receptor	<10	45	35	Yes
R17	Existing receptor	<10	45	35	Yes
R18	Commercial	16	-	-	Not applicable

a) Associated with the Project

Review of the predicted noise levels confirms that compliance with the noise management level provided in the ICNG is predicted to be achieved for all receptors for construction during standard hours. For construction outside standard hours, the results of the modelling indicate exceedences of the noise limits could occur at Receptor R5, which is associated with the Project.

3.5 Mitigation of Construction Noise Levels

For the majority of the receptors, the highest noise levels will be experienced during site clearing activities. These high noise level are being driven by the mulching machine and on-site vehicle movements. To manage noise levels from the mulching machine, it is recommended that it is located as far away from receptors and shielded by a temporary noise barrier if practical.

High noise levels at R5 predicted to occur during the installation phase are driven by the piling activities. It should be noted that the sound power level used for the piling activities is 107 dB(A) excluding a tonality correction. Receptor R5 is located approximately 170 m from the development boundary. As noted previously, this receptor is associated with the Project,

despite this it is recommended that prior to piling activities consultation with the residents should be undertaken.

If possible, procure piling rigs with a maximum SWL of 107 dB(A), however if this is not possible and consultation with receptor R5 confirms unacceptable noise levels, piling activities should be managed such that when piling within 500 m of the boundary, only one rig is operational at any one time and piling must not occur for more than three (3) hours at any one time, with a minimum of one (1) hour break during standard construction hours.

Given the variable and mobile nature of the construction works, the use of permanent or temporary acoustic barriers is not considered feasible. Potential controls available to the construction contractor to minimise potential impacts on Receptor R1, R2 and R7 for construction works could include:

- Limiting noise generating construction activities to standard construction hours except where an acceptable acoustic solution can be identified to minimise adverse amenity impacts on Receptors R1, R2, R5 and R7;
- Consultation with landholders throughout the construction process to inform them of the duration and timing of potentially noisy activities;
- Using broad-band reversing alarms on all mobile plant and equipment;
- Examine different types of machines that perform the same function and compare the noise level data to select the least noisy machine;
- Select quieter items of plant and equipment where feasible and reasonable;
- Operating plant in a quiet and efficient manner;
- Reduce throttle setting and turn off equipment when not being used; and
- Regularly inspect and maintain equipment to ensure it is in good working order. Also check the condition of mufflers.

Overall, given the size of the Subject Site, there is potential for limited quiet construction works to be undertaken outside standard hours subject to the effective implementation of the above reasonable and feasible mitigation measures. Further, given the tendency for agricultural activities to be undertaken during evening and night periods (e.g. during harvest season etc.), construction during these periods, when undertaken concurrently with these agricultural activities is unlikely to represent a significant amenity impact for residences in the area.

4 OPERATIONAL PHASE NOISE ASSESSMENT

4.1 Operational Noise Criteria

4.1.1 Overview

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

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

4.1.2 Intrusiveness Noise Criteria

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

Given the remote location of the development site and the lack of any significant activity in the area, the impact assessment has assumed baseline noise levels equivalent to the minimum background noise levels provided in the NPfI. Therefore, Table 9 presents the derivation of the intrusiveness criteria based on the minimum background noise level established by the NPfI.

Table 9: Derived Intrusiveness Noise Criteria

Receptor	Intrusiveness $L_{Aeq,15\text{-minute}}$ Criteria		
	Day	Evening	Night
All nearby residential receptors [a)]	40 [b)]	35 [b)]	35 [b)]

a) Receptor noise limit applied at a location 30 m from the dwelling façade.

b) Minimum background noise level established by the NPfI 2017 + 5 dB.

4.1.3 Amenity Criteria

The project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Review of the surrounding area has identified that there are no other industrial uses at present, however a solar farm to the north

of the Subject Site (Wagga Wagga North Solar Farm) has been given development approval. Given this, to maintain acceptable amenity for the existing sensitive uses in the area, the project amenity noise criteria are derived in Table 10 below and have included an adjustment of -5dB to provide capacity for future development without impacting on overall amenity.

Table 10: NPI Amenity Noise Levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, (dB(A))	
			Total Industrial Noise	Project Specific (Total – 5dB(A))
Residence	Rural	Day	50	45
		Evening	45	40
		Night	40	35
Industrial	Industrial Premises	When in use	70	65

4.1.4 Project Trigger Levels

The project trigger level (i.e. the noise limit considered by the assessment) is the lower value of the project intrusiveness noise level and the project amenity level, after the conversion to $L_{Aeq,\ 15\ min}$ dB(A) equivalent level. Table 11 presents the standardised intrusiveness noise level and the project amenity level as derived by adding 3 dB to each period of the day.

Table 11: Determining Project Trigger Level

Type of Receiver	Time of Day	Standardised $L_{Aeq,\ 15\ min}$ Noise Level (dB)		
		Intrusiveness Criteria	Project Specific ANL	Project Trigger Level
Residential	Day	40	45 + 3 = 48	40
	Evening	35	40 + 3 = 43	35
	Night	35	35 + 3 = 38	35
Industrial	Day	- a)	65 + 3 = 68	68
	Evening	- a)	65 + 3 = 68	68
	Night	- a)	65 + 3 = 68	68

a) Intrusive Nosie levels are only applied to residential receivers. For all other types ANL are used.

4.1.5 Sleep Disturbance

NSW EPA have identified a screening assessment for sleep disturbance based on the night-time noise levels at a residential location. Where noise levels at a residential location exceed:

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

a detailed maximum noise level event assessment should be undertaken.

As discussed in Section 4.5, the predicted noise levels at residential locations do not exceed 40 dB(A) $L_{Aeq,\ 15\ min}$, therefore a detailed sleep disturbance assessment is not required.

Further, given the noise sources associated with the operation of a solar farm are all continuous (inverters) or semi-continuous (tracking motors) during daylight hours, short-term instantaneous noise events are unlikely. As such, consideration of compliance against the L_{AFmax} sleep disturbance limits is unwarranted.

4.2 Noise Sources

The Wagga Wagga Solar Farm South is to consist of solar photovoltaic (PV) plant and associated infrastructure for storing energy and supplying it into the grid. It is expected that, at completion, infrastructure installed on site will incorporate:

- 80 DRN 90L4 tracker motors;
- 15 solar inverters; and
- 3 transformers.

The PV panels will be mounted onto fixed support structures by single axis tracking panels which track the suns movement across the day through the use of small motors which rotate the panel arc of the sun to maximise the solar effect. Noise emissions from the tracking motors are expected to occur for approximately one minute out of each 15-minute period (providing for up to five degrees' rotation per hour) during day periods.

Table 12 presents a summary of the source noise levels considered in the assessment. The sound power levels for the plant and equipment presented in the table below are as provided by the manufacturer or taken from information held in our library. The site layout and location of the inverters and transformers is presented in Figure 2.

Table 12: Source Noise Levels

Source	Quantity	Supplier	Sound Power Level (dB(A))
Tracker Motor	80	DRN 90L4	66 (each)
Inverter [a)]	15	Ingecon PowerMax B 1640TL B630	94 (each) at 100% load 83 (each) at 50% load
Transformer	3	Ingecon PowerStation MV Transformer	68 (each)
Light Vehicle [b)]	1	N/A	88

a) Based on previous experience with similar sources there is potential for tonal influences associated with this source. Therefore, in accordance with the NPfI, a +5 dB penalty has been applied to this source in the noise model.

b) No permanent staff onsite, however occasional visitation for maintenance

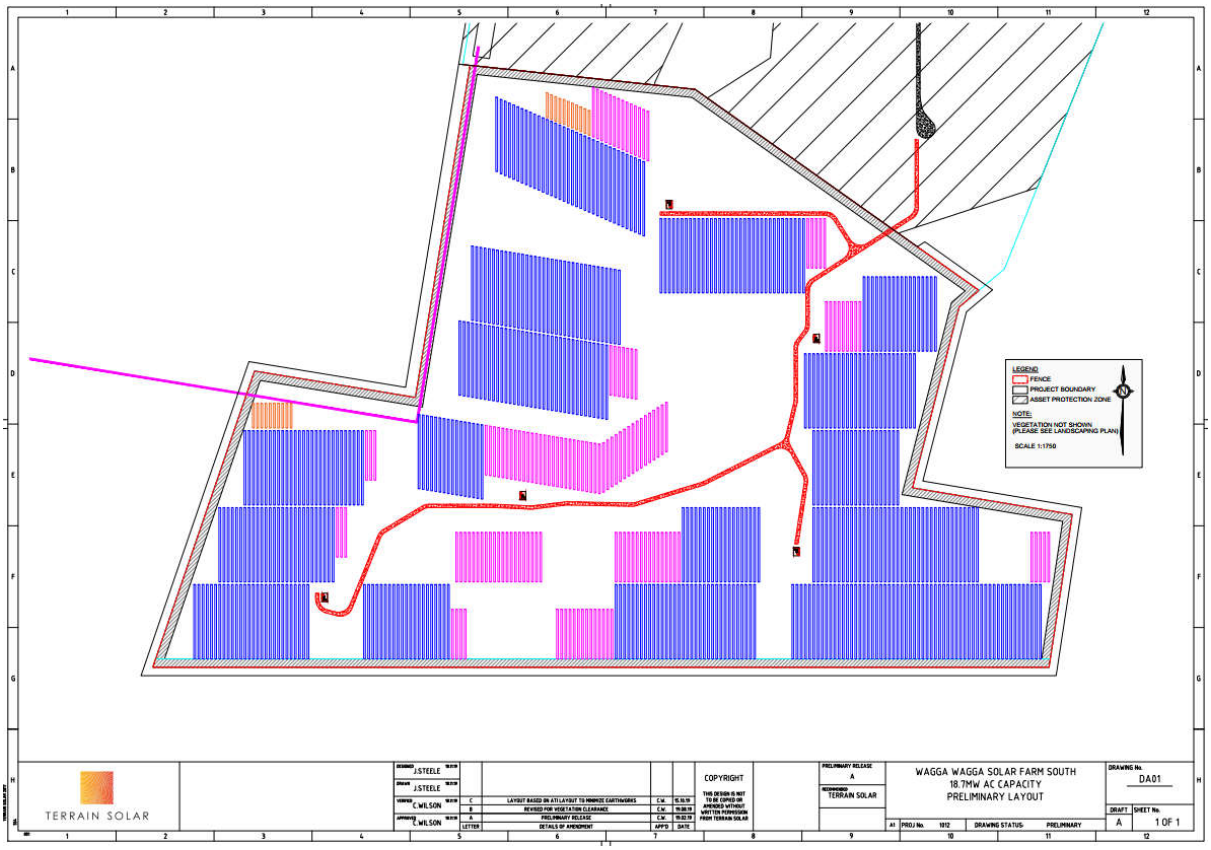

Figure 2: Site Layout and Inverter Locations

4.3 Noise Modelling Methodology

For the purposes of predicting impacts associated with noise emissions from the Subject Site on nearby sensitive receptors, noise modelling of the sources was completed using the proprietary software CadnaA (version 2020 build 175.5000) developed by DataKustik. CadnaA incorporates the influence of meteorology, terrain, ground type and air absorption in addition to source characteristics to predict noise impacts at receptor locations. All predictions have been undertaken in accordance with ISO Standard 9613 (1996) *"Acoustics - Attenuation of sound during propagation outdoors"*.

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

4.4 Meteorology

The NPfI presents guidelines for the consideration of meteorological effects on noise propagation, specifically, temperature inversions and/or gradient winds. NPfI provides two options for assessing meteorological effects as detailed in Table 13.

Table 13: Standard and Noise Enhancing Meteorological Conditions

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

The following conditions have been modelled:

- Day Periods – Stability class D at 3 m/s representing a worst-case assessment of potential impacts for day-periods; and
- Night Periods - Temperature inversion (stability class F) with light (2 m/s) winds a worst-case assessment of potential impacts for night periods.

4.5 Predicted Noise Levels

Table 14 below presents predicted receptor noise levels during the WWSFS operational phase. Review of the predicted noise levels confirms that compliance with the intrusive noise criteria established in accordance with the NPfI can be achieved for all receptors for day periods under worst-case meteorological conditions.

During evening and night periods where solar radiation is present (e.g. early mornings or late afternoons), the reduced load on the inverters results in a reduction in noise emissions. As such, solar farm noise emissions during day periods represents the limiting scenario with noise emissions during other periods significantly lower than those presented below.

Table 14: Predicted Receptor Noise Levels – Operational Phase, dB(A)

Receptor	Predicted Operational Noise Levels, $L_{Aeq, 15min}$	Intrusive Noise Criteria [a)]	Comply (Y/N)
R1	25	40	Yes
R2	28	40	Yes
R3	15	40	Yes
R4	15	40	Yes
R5 [b)]	43	40	No
R6	25	40	Yes
R7	29	40	Yes
R8	25	40	Yes
R9	17	40	Yes
R10	<10	40	Yes
R11	<10	40	Yes
R12	<10	40	Yes
R13	<10	40	Yes
R14	<10	40	Yes

Receptor	Predicted Operational Noise Levels, $L_{Aeq, 15min}$	Intrusive Noise Criteria [a)]	Comply (Y/N)
R15	<10	40	Yes
R16	<10	40	Yes
R17	<10	40	Yes
R18	16	65 [c)]	Yes

a) Intrusive noise criteria for day periods

b) This receptor is associated with the project and an agreement is in place relating to the operational noise from the Project.

c) Acceptable noise criteria for when in use

Given the predicted compliance with the noise limits derived in accordance with the NPfI, no further noise mitigation is considered necessary.

5 ROAD TRAFFIC NOISE ASSESSMENT

5.1 Introduction

Noise impacts associated with vehicle movements during the operational phase of the WWSFS project are expected to be negligible given the small number of movements expected (maximum of six per day for three permanent staff). During the construction phase of the project however, significantly higher traffic volumes are expected for the duration of the construction works.

Construction is expected to be completed over a 12-month period with an expected peak period of six months during which a range of construction tasks are concurrently undertaken. During this peak, it is anticipated that up to 100 workers would be on-site daily, dropping to 20 workers for the six-month shoulder periods.

While it is expected that the contractor would provide a shuttle bus service, for assessment purposes it is assumed that only 30% of the 90 workers would participate in some form of carpooling. Therefore, the modelling has assumed an estimated maximum of 63 private light vehicles travelling to and from the site daily for this peak period.

The infrastructure will be delivered to the site from via Byrnes Road, with a turn into East Bomen Road. Estimates of total heavy vehicle movements associated with the delivery of farm infrastructure and associated materials and resources to build the solar farm are provided in Table 15. The maximum number of heavy vehicles accessing the site during the peak of the construction period is not expected to exceed 15 (i.e. generating a total of 30 heavy vehicle movements in a day).

Table 15 : Construction Phase Traffic Generation

Plant/Equipment	Description	Heavy Vehicles
Modules	594 modules per container delivered on 84 semi-trailers	84
Mounting Frames	3.6 containers per MWdc, inclusive of piles, torque tubes and all associated hardware, delivered on 73 semi-trailers	73
Inverter Stations	5 Skid inverter stations, delivered one per semi-trailer	5
Concrete	Estimated 134 m^3 required for skid inverter bases and security fence foundations, delivered in 13 x 11m^3 concrete trucks	13
Gravel	Estimated 2,443m^3 (3,176 tonne) required for internal access roads delivered in 42.5 tonne truck & dog trailers	75
Sand	Estimated 1,267m^3 (2,027 tonne) of sand , delivered on 41 x 50 tonne truck & dog trailers	41
Fencing	Estimated 3,500m of solar farm fencing, delivered on 3 semi-trailers	3
Miscellaneous	Provision for 4 miscellaneous deliveries (water for dust suppression, etc) per week during the 6 month peak periods, dropping to 2 trucks a week for the 6 month shoulder periods	156
Total		**450**

Given this, the assessment has considered the potential impacts associated with noise emissions from the maximum expected 140 light and 40 heavy vehicle movements from the site entry along the local access road (East Bomen Road) onto the Byrnes Road as summarised in Table 16 below. All vehicle movements are expected to occur during standard construction hours however, as a worst-case, it has been assumed that vehicle movements associated with arrival of construction workers to site could occur over the one-hour period from 6 am – 7 am (i.e. during night periods).

Table 16: Summary of Road Traffic Data

Road Segment	Vehicle Type	Vehicle Speed	Number of Movements	
			Day (7 am to 10 pm)	Night (10 pm to 7 am)
Byrnes Road	Light	100 km/hr	126	63 a)
	Heavy	100 km/hr	30	0 b)
East Boman Road	Light	60 km/hr	126	63 a)
	Heavy	40 km/hr	30	0 b)

a) Assumes construction workers may arrive prior to between 6 am and 7 am

b) Assumes all truck deliveries to site occur during the hours of 7 am to 10 pm.

5.2 Assessment Criteria

The ICNG does not provide criteria for the assessment of construction road traffic during the project. Given this, reference is made to the noise criteria provided in the NSW Road Noise Policy (RNP). Based on the type of roadway, Table 17 below presents the applicable road traffic noise criteria for existing residences affected by traffic on existing roadways generated by land use developments.

Table 17: Applicable Road Traffic Noise Criteria

Road Category	Type of Project & Land Use	Assessment Criteria
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	Day: $L_{Aeq,1\ hour}$ 55 dB(A) Night: $L_{Aeq,1\ hour}$ 50 dB(A) (external)
Freeway / arterial / sub-arterial road	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	Day: $L_{Aeq,15\ hour}$ 60 dB(A) Night: $L_{Aeq,9\ hour}$ 55 dB(A) (external)

5.3 Noise Modelling Methodology

For the purposes of predicting impacts associated with road traffic noise emissions was completed using the proprietary software CadnaA (version 2020 build 175.5000) developed by DataKustik. The model incorporates the influence of terrain, ground type and air absorption in addition to source characteristics to predict noise impacts at receptor locations. All predictions have been undertaken in accordance with Calculation of Road Traffic Noise (CRTN) methodology developed by the UK Department of Transport. In accordance with the requirements of the RNP, the predictive noise modelling incorporated the following assumptions:

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

Table 18 below presents predicted noise levels for the nearest potential receptor to the Byrnes Road assuming a minimum setback distance of 20 m. It should be noted that this is considered to represent a conservative assumption with the majority of dwellings along Byrnes Road noted to be setback considerably further than this.

Review of the predicted noise level presented in Table 18 confirms that non-compliance with the RNP is predicted at the nearest receptor to Brynes Road. Despite this, adverse amenity impacts due to peak traffic levels generated by the proposed construction works is considered unlikely as the construction will be managed to minimise road traffic impacts.

Table 18: Predicted $L_{Aeq,15\ hour}$ Noise Levels - Road Traffic Noise

Receptor	Setback from Roadway	Period	Parameter	Criteria	Predicted Noise Level	Comply (Y/N)
Nearest to Byrnes Road (R06)	20 m	Day	$L_{Aeq,15\ hour}$	60 dB(A)	57	Y
		Night	$L_{Aeq,9\ hour}$	55 dB(A)	55	Y
Nearest to East Bomen Road (R18)	360 m	Day	$L_{Aeq,1\ hour}$	55 dB(A)	31	Y
		Night	$L_{Aeq,1\ hour}$	50 dB(A)	29	Y

6 VIBRATION ASSESSMENT

6.1 Introduction

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

6.2 Assessment Criteria

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

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

Table 19 and Table 20 present the criteria for continuous and impulsive vibration and intermittent vibration, respectively.

Table 19: Continuous & Impulsive Vibration Criteria for Residences – Peak Velocity

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

Table 20: Intermittent Vibration Criteria for Residences

Location	Assessment Period	Preferred Value ($m/s^{1.75}$)	Maximum Value ($m/s^{1.75}$)
Residences	Day-time	0.20	0.40

The above criteria are suitable for assessing human annoyance in response to vibration levels. In order to assess potential damage to buildings, reference has been made to British Standard *BS 7385-2: 1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration*. Table 21 presents vibration criteria for assessing the potential for building damage.

Table 21: Transient Vibration Guide Values for Cosmetic Damage

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

6.3 Potential Vibration Sources

Table 22 identifies the vibration source levels for the equipment and likely to be used for the construction of the solar farm.

Table 22: Vibration Source levels – Peak Particle Velocity

Equipment Item	PPV at 10 metres (mm/s)	Source
Piling	1 – 2	Rockhill, D.J. et. al. [b]
Roller	5 – 6	DECCW
7 tonne compactor	5 – 7	DECCW
Loaded trucks (rough surface)	5	USA DT [a]
Loaded trucks (smooth surface)	1 – 2	USA DT [a]
Excavator	2.5 – 4	DECCW

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

b) Rockhill, D.J., Bolton, M.D. & White, D.J. (2003) 'Ground-borne vibrations due to press-in piling operations'

6.4 Assessment of Potential Impacts

Based on the vibration source levels at 10 metres (presented in Table 22), peak particle velocities have been predicted at various separation distances. The NSW DECCW indicates that in predicting vibration levels, it can be assumed that the vibration level is inversely proportional to distance (with the relationship varying between $d^{-0.8}$ to $d^{-1.6}$ based on field data).

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

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

- where: d_1 = distance 1 (reference distance for source data) (m)
- d_2 = distance 2 (separation distance for predicted PPV) (m)
- PPV = peak particle velocity (mm/s)

The formula has been considered for predicted PPVs at various distances from construction equipment. Based on the above information, Table 23 presents PPV predictions for the various construction equipment.

Table 23: Predicted Peak Particle Velocity at Sensitive Receptors (mm/s)

Distance from Source (m)	Predicted Peak Particle Velocity (mm/s)					
	Roller	7 tonne compactor	Excavator	Piling	Loaded trucks (rough surfaces)	Loaded trucks (smooth surfaces)
10	6.00	7.00	4.00	0.35 - 0.71	5.00	1 – 2
20	2.12	2.47	1.41	0.19 - 0.38	1.77	0.35 – 0.71
30	1.15	1.35	0.77	0.13 - 0.25	0.96	0.19 – 0.38
40	0.75	0.88	0.50	0.09 - 0.18	0.63	0.13 – 0.25
50	0.54	0.63	0.36	0.07 - 0.14	0.45	0.09 – 0.18
60	0.41	0.48	0.27	0.05 - 0.11	0.34	0.07 – 0.14
70	0.32	0.38	0.22	0.04 - 0.09	0.27	0.06 – 0.11
80	0.27	0.31	0.18	0.04 - 0.07	0.22	0.05 – 0.09
90	0.22	0.26	0.15	0.03 - 0.06	0.19	0.04 – 0.07
100	0.19	0.22	0.13	0.02 - 0.03	0.16	0.03 – 0.06
150	0.1	0.12	0.07	0.35 - 0.71	0.09	0.02 – 0.03
Type	Continuous	Continuous	Continuous	Intermittent	Intermittent	Intermittent
Nuisance Criteria	Residential 0.28 (preferred) / 0.56 (max) School 0.56 (preferred) / 1.1 (max)					
Building Criteria	Residential 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above					

The predicted vibration levels presented in Table 23 indicate compliance with the continuous preferred vibration nuisance criteria for locations at a separation distance of 50-60 metres. Compliance with the building damage criteria is predicted at 10 metres from construction for each source.

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

It is noted, however, that the piling PPV at distances of 260 m (the distance to the nearest sensitive receptor from closest potential piling location) is predicted to be within the maximum continuous criteria of 0.56 mm/s. This comparison with the continuous criteria (as a conservative approach) indicates that vibration levels associated with piling are not considered to be significant (which is expected given the significant separation distances).

7 CUMULATIVE IMPACTS

As noted in previously, the WWSFS is to be located adjacent to a solar farm which has development approval (Wagga Wagga solar Farm North (WWSFN)). Predicted impacts from the neighbouring solar farm have been taken from the Noise and Vibration Impact Assessment by Assured Environmental (reference 10934 version R_6 dated 14/11/2018).

7.1 Construction

When reviewing the cumulative impacts from both solar farms, the construction stages of both projects are unknown at present, however it is expected that the preparatory works for WWSFN would have been completed prior to construction activities commencing on WWSFS. Additionally, it is not anticipated that installation activities will be concurrent.

Table 24 to Table 26 present the worst-case cumulative impacts relation to both solar farms and are presented as the following:

- WWSFN Preparatory works and WWSFS Preparatory works;
- WWSFN Installation and WWSFS Preparatory works; and
- WWSFN installation and WWSFS installation.

Review of the predicted noise levels in Table 24 confirms that compliance with the noise criteria is predicted to be achieved for all receptors for construction during standard hours, with the exception of R5, which has a noise agreement in place. As noted, preparatory works for both solar farms is not expected to occur at the same time.

Table 24: Predicted Receptor Noise Levels – Cumulative Construction Phases

Receptor	Predicted Construction Noise Levels, $L_{Aeq, 15min}$			Noise Management Level		Comply (Y/N)
	WWSFN (Prep Works)	WWSFS (Prep Works)	Cumulative	Standard Hours	Outside Standard Hours	
R1	40	40	43	45	35	Standard hours only
R2	38	39	42	45	35	Standard hours only
R3	36	26	36	45	35	Standard hours only
R4	34	25	34	45	35	Yes
R5	33	45	46	45	35	No
R6	19	28	29	45	35	Yes
R7	24	36	36	45	35	Standard hours only
R8	10	32	32	45	35	Yes
R9	10	26	26	45	35	Yes
R10	10	16	17	45	35	Yes
R11	10	25	25	45	35	Yes
R12	10	<10	13	45	35	Yes
R13	24	10	24	45	35	Yes
R14	17	<10	20	45	35	Yes

Receptor	Predicted Construction Noise Levels, $L_{Aeq, 15min}$			Noise Management Level		Comply (Y/N)
	WWSFN (Prep Works)	WWSFS (Prep Works)	Cumulative	Standard Hours	Outside Standard Hours	
R15	13	<10	16	45	35	Yes
R16	10	15	16	45	35	Yes
R17	27	17	27	45	35	Yes
R18	31	24	32	-	-	Not applicable

Review of the predicted noise levels in Table 25 confirms that compliance with the noise criteria is predicted to be achieved for all receptors for construction during standard hours if installation of both solar farms are undertaken at the same time.

Table 25: Predicted Receptor Noise Levels – Cumulative Construction Phases

Receptor	Predicted Construction Noise Levels, $L_{Aeq, 15min}$			Noise Management Level		Comply (Y/N)
	WWSFN (Installation)	WWSFS (Installation)	Cumulative	Standard Hours	Outside Standard Hours	
R1	40	23	40	45	35	Standard hours only
R2	37	26	37	45	35	Standard hours only
R3	35	14	35	45	35	Standard hours only
R4	31	15	31	45	35	Yes
R5	31	43	44	45	35	Standard hours only
R6	10	25	25	45	35	Yes
R7	25	30	32	45	35	Yes
R8	10	26	26	45	35	Yes
R9	10	23	23	45	35	Yes
R10	10	<10	13	45	35	Yes
R11	10	<10	13	45	35	Yes
R12	10	<10	13	45	35	Yes
R13	20	<10	23	45	35	Yes
R14	17	<10	20	45	35	Yes
R15	16	<10	19	45	35	Yes
R16	10	<10	13	45	35	Yes
R17	27	<10	30	45	35	Yes
R18	26	16	26	-	-	Not applicable

Review of the predicted noise levels in Table 26 confirms that compliance with the noise criteria is predicted to be achieved for all receptors for construction during standard hours.

Table 26: Predicted Receptor Noise Levels – Cumulative Construction Phases

Receptor	Predicted Construction Noise Levels, $L_{Aeq, 15min}$			Noise Management Level		Comply (Y/N)
	WWSFN (Installation)	WWSFS (Pre Works)	Cumulative	Standard Hours	Outside Standard Hours	
R1	40	40	43	45	35	Standard hours only
R2	37	39	41	45	35	Standard hours only
R3	35	26	36	45	35	Standard hours only
R4	31	25	32	45	35	Yes
R5	31	45	45	45	35	Standard hours only
R6	10	28	28	45	35	Yes
R7	25	36	36	45	35	Standard hours only
R8	10	32	32	45	35	Yes
R9	10	26	26	45	35	Yes
R10	10	16	17	45	35	Yes
R11	10	25	25	45	35	Yes
R12	10	<10	13	45	35	Yes
R13	20	10	20	45	35	Yes
R14	17	<10	20	45	35	Yes
R15	16	<10	19	45	35	Yes
R16	10	15	16	45	35	Yes
R17	27	17	27	45	35	Yes
R18	26	24	28	-	-	Not applicable

Vibration impacts are not expected to be cumulative.

7.2 Operation

Table 27 presents predicted receptor noise levels during the operational phase of both solar farms. Review of the predicted noise levels confirms that compliance with the intrusive noise criteria established in accordance with the NPfI can be achieved for all receptors for day periods under worst-case meteorological conditions, with the exception of R5, which has an agreement in relation to noise from the Project.

Table 27: Predicted Receptor Noise Levels – Cumulative Operational Phase, dB(A)

Receptor	Predicted Cumulative Operational Noise Levels, $L_{Aeq, 15min}$			Intrusive Noise Criteria [a)]	Comply (Y/N)
	WWSFN	WWSFS	Cumulative		
R1	37	25	39	40	Yes
R2	32	28	35	40	Yes
R3	23	15	29	40	Yes
R4	22	15	28	40	Yes

Receptor	Predicted Cumulative Operational Noise Levels, $L_{Aeq, 15min}$			Intrusive Noise Criteria [a]	Comply (Y/N)
	WWSFN	WWSFS	Cumulative		
R5 [b]	25	43	44	40	No
R6	<10	25	26	40	Yes
R7	20	29	30	40	Yes
R8	<10	25	26	40	Yes
R9	<10	17	17	40	Yes
R10	<10	<10	<10	40	Yes
R11	<10	<10	<10	40	Yes
R12	<10	<10	<10	40	Yes
R13	<10	<10	13	40	Yes
R14	<10	<10	13	40	Yes
R15	<10	<10	<10	40	Yes
R16	<10	<10	<10	40	Yes
R17	17	<10	18	40	Yes
R18	21	16	27	65 [c]	Yes

a) Intrusive noise criteria for day periods

b) This receptor is associated with the project and an agreement is in place relating to the operational noise from the Project.

c) Acceptable noise criteria for when in use

8 CONCLUSIONS AND RECOMMENDATIONS

METKA propose to construct the WWSFS on one land parcel (Lot 15 in DP1108978). The impact assessment has considered the potential for adverse impacts resulting from noise (site clearing and installation construction phases, road traffic and operational) and vibration (construction) emissions on nearby residential uses.

The assessment of potential noise impacts has considered both construction during standard hours and outside standard hours. Based on the results of the assessment, acceptable noise amenity impacts can be achieved throughout the construction works where appropriate management controls are implemented including:

- Limiting noise generating construction activities to standard construction hours except where an acceptable acoustic solution can be identified to minimise adverse amenity impacts on Receptors R1, R2 and R7;
- To manage noise levels from the mulching machine, it is recommended that the mulcher is located as far away from receptors as possible and shielded by a temporary noise barrier if practical.
- High noise levels at R5 are predicted to occur during the installation phase are driven by the piling activities. It should be noted that the sound power level used for the piling activities is 107 dB(A) excluding a tonality correction. Receptor R5 is located approximately 170 m from the development boundary. As noted previously, this receptor is associated with the Project, despite this it is recommended that prior to piling activities consultation with the residents should be undertaken.
- If possible, procure piling rigs with a maximum SWL of 107 dB(A), however if this is not possible and consultation with receptor R5 (which is associated with the Project) confirms unacceptable noise levels, piling activities should be managed such that when piling within 500 m of the boundary, only one rig is operational at any one time and piling must not occur for more than three (3) hours at any one time, with a minimum of one (1) hour break during standard construction hours.
- Consultation with landholders throughout the construction process to inform them on the duration and timing of potentially noisy activities;
- Using broad-band reversing alarms on all mobile plant and equipment;
- Examine different types of machines that perform the same function and compare the noise level data to select the least noisy machine;
- Select quieter items of plant and equipment where feasible and reasonable.;
- Operating plant in a quiet and efficient manner;
- Reduce throttle setting and turn off equipment when not being used; and
- Regularly inspect and maintain equipment to ensure it is in good working order. Also check the condition of mufflers.

For the operational phase of the project, adverse amenity impacts are considered unlikely given the proposed layout and design of the facility.

At present, the construction schedule is unknown, however an assessment of cumulative impacts for various construction stages has been undertaken and the following has been identified compliance with the assessment criteria at all sensitive receptors, with the exception of R5 if preparatory works are undertaken on both solar farms at the same time. The construction phases of each solar farm will be scheduled to ensure that construction activities are managed to minimise noise emissions.

Predicted cumulative operational noise levels confirms that compliance with the intrusive noise criteria established in accordance with the NPfI can be achieved for all receptors for day periods under worst-case meteorological conditions, with the exception of R5, which has an agreement in relation to noise from the Project.

Overall, based on the results of the assessment, the risk of adverse impacts as a result of the proposed WWSFS is considered to be low and complies with all applicable criteria at all sensitive receptors not associated with the Project. Hence, from an acoustic perspective, the proposed development site is considered acceptable for the proposed use.

APPENDIX A: GLOSSARY OF TERMS

A-Weighting	A response provided by an electronic circuit which modifies sound in such a way that the resulting level is similar to that perceived by the human ear.
dB (decibel)	This is the scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and the reference pressure (0.00002 N/m^2).
dB(A) or dBA	This is a measure of the overall noise level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
Free-field	Refers to a sound pressure level determined at a point away from reflective surfaces other than the ground with no significant contribution due to sound from other reflective surfaces; generally, as measured outside and away from buildings.
L_{Aeq}	This is the equivalent steady sound level in dB(A) containing the same acoustic energy as the actual fluctuating sound level over the given period. Noise levels often fluctuate over a wide range with time. Therefore, when a noise varies over time, the L_{Aeq} is the equivalent continuous sound which would contain the same sound energy as the time varying sound. Many studies show that human reaction to level-varying sounds tends to relate closer to the L_{Aeq} noise level than any other descriptor.