Appendix C

NOISE AND VIBRATION ASSESSMENT

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Assured Monitoring Group

WAGGA WAGGA SOLAR FARM – NOISE & VIBRATION IMPACT ASSESSMENT

GEOLYSE PTY LTD

Project ID. 10934

R_3

DATE OF RELEASE: 6/11/2017

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Table 1: Document Approval

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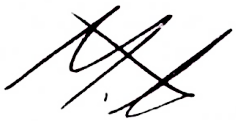
Author	Michelle Clifton	Senior Consultant		06.11.2017
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Table 2: Revision Register

Revision	Date	Name	Issued to	Comment
R_0	10.10.2017	C. Beyers	A. Brownlow	Formal report release
R_1	26.10.2017	C. Beyers	A. Brownlow	Background noise monitoring
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R_3	06.11.2017	C. Beyers	A. Brownlow	Minor text revisions

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Scope of Assessment

Assured Monitoring Group Pty Ltd was appointed by Geolyse Pty Ltd to undertake a noise and vibration impact assessment for the proposed Wagga Wagga Solar Farm (WWSF) project. The project involves construction and operation of a 26 MW solar farm on one land parcel (Lot 15 on DP1108978).

The noise 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 Environmental Protection Authority Industrial Noise Policy (EPA, 2000)
- 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 the assessment of the potential for adverse amenity impacts as a result of the development.

1.2 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 the boundary of Lot 15 on DP1108978. Figure 1 presents the location of the site.

The area surrounding the proposed development includes a range of agricultural and rural uses.

2.2 Nearby Sensitive Receptors

The nearest residential receptors to the proposed solar farm include 17 single existing dwellings located within 1.7 km of the development. Of these, one receptor is located within the proposed development lot boundary. Receptor R18 is a commercial receptor.

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

Table 3: Nearby Sensitive Receptors

Receptor ID	Description	Distance to Proposed Development Boundary
R1	Existing Dwelling	40 m
R2	Existing Dwelling	40 m
R3	Existing Dwelling	300 m
R4	Existing Dwelling	440 m
R5	Existing Dwelling	Within boundary (Landowner)
R6	Existing Dwelling	560 m
R7	Existing Dwelling	450 m
R8	Existing Dwelling	970 m
R9	Existing Dwelling	960 m
R10	Existing Dwelling	1,320 m
R11	Existing Dwelling	1,370 m
R12	Existing Dwelling	1,450 m
R13	Existing Dwelling	1,000 m
R14	Existing Dwelling	1,250 m
R15	Existing Dwelling	1,410 m
R16	Existing Dwelling	1,690 m
R17	Existing Dwelling	1,160 m
R18	Commercial	390 m

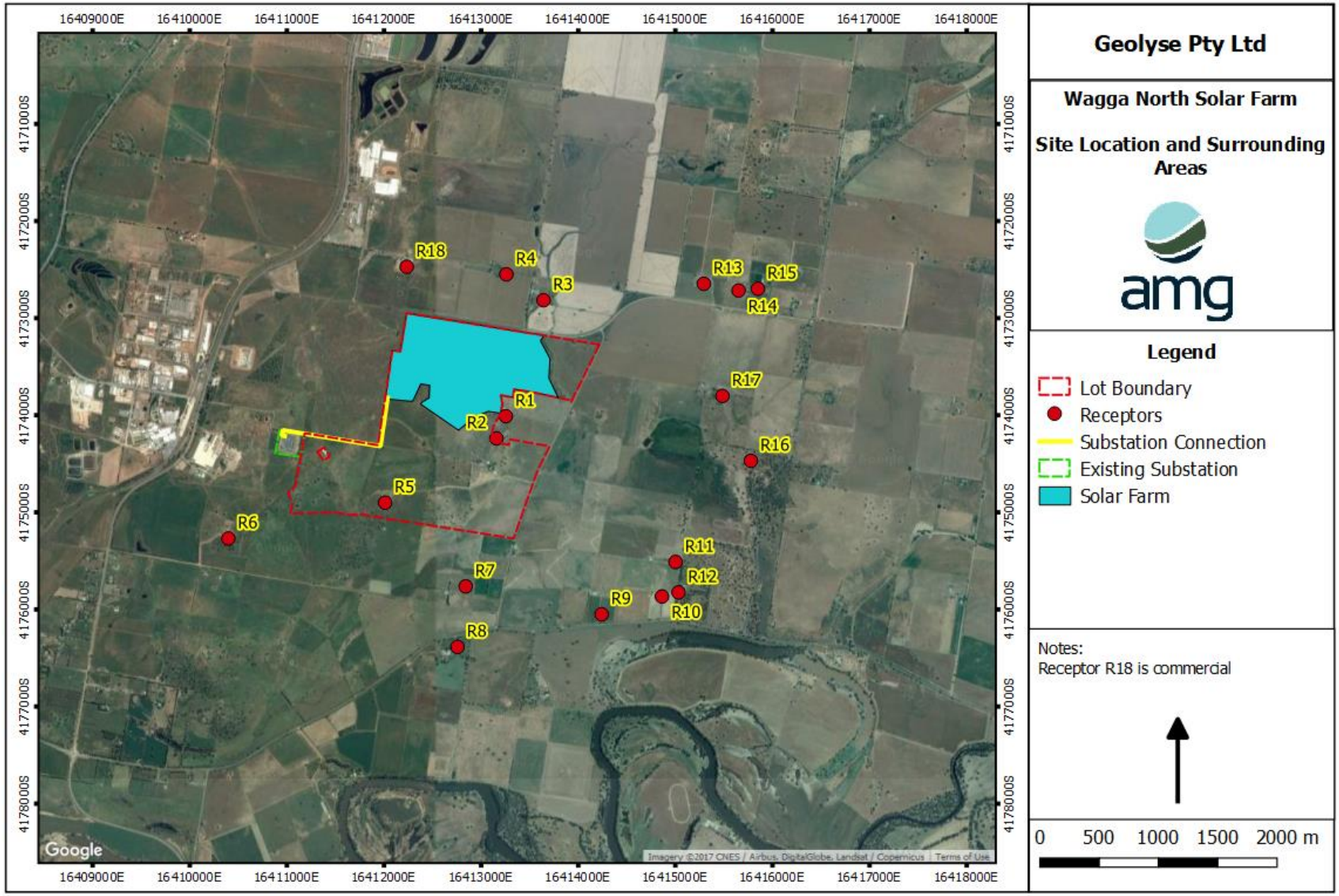

Figure 1: Site Location, Sensitive Receptors and Surrounding Landuses

3 CONSTRUCTION NOISE ASSESSMENT

3.1 Duration of Construction Works

The construction of the WWSF is expected to take approximately 12 months with a number of different activities 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	3 months
Piling – installation of module mounting structures	3 months
Installation of solar PV modules & inverter assemblies	5 months
Commissioning	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 the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

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, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	A 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 noise, the assessment criteria have been determined based on the RBL determined through background noise monitoring as detailed in Appendix B. For standard construction hours, the RBL at the representative monitoring location was 35 dB(A), resulting in a noise affected limit of 45 dB(A) for construction during standard hours.

For construction outside standard hours, the background noise monitoring data indicates a representative RBL of 29 dB(A) during night periods. It is noted that the minimum allowable RBL according to the INP 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 Monitoring Group.

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 of site substation [a]	Truck & Dog [b]	2	110	40
	Compactor	2	103	20
	Bulldozer	3	109	40
	Mulcher	1	116	20
	Grader [c]	2	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]	3	112 - 124	20
	Franna Crane	2	107	16
	Trencher	3	97	40

Construction Phase	Plant Item	Number Required	Sound Power Level, dB(A)	Acoustical Usage Factor, % e)
	Loader	2	107	40
	Generator	1	73	50

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

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, substation, maintenance building, 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

For the purposes of predicting impacts associated with noise emissions from the development site on nearby sensitive receptors, noise modelling of the sources was completed using the proprietary software Cadna/A (version 2017 build 157.4702) developed by DataKustik. Cadna/A 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 site under a range of operating scenarios and meteorological conditions. In the event that non-compliance with the assessment criterion is predicted, the noise modelling also allows investigation of possible noise management solutions.

3.4.1 Preparatory Civil Works

For preparatory civil works activities 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 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 the proposed solar farm.

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	38	45	35	Standard hours only
R3	Existing receptor	36	45	35	Standard hours only
R4	Existing receptor	34	45	35	Yes
R5	Existing receptor	33	45	35	Yes
R6	Existing receptor	19	45	35	Yes
R7	Existing receptor	24	45	35	Yes
R8	Existing receptor	<10	45	35	Yes
R9	Existing receptor	<10	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	24	45	35	Yes
R14	Existing receptor	17	45	35	Yes
R15	Existing receptor	13	45	35	Yes
R16	Existing receptor	<10	45	35	Yes
R17	Existing receptor	27	45	35	Yes
R18	Commercial	31	-	-	Not applicable

Review of the predicted noise levels confirms that compliance with the noise management level provided in the ICNG for all receptors for normal 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 R3.

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.

3.4.2 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 of the proposed solar farm.

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	40	45	35	Standard hours only
R2	Existing receptor	37	45	35	Standard hours only
R3	Existing receptor	35	45	35	Yes
R4	Existing receptor	31	45	35	Yes
R5	Existing receptor	31	45	35	Yes
R6	Existing receptor	<10	45	35	Yes
R7	Existing receptor	25	45	35	Yes
R8	Existing receptor	<10	45	35	Yes
R9	Existing receptor	<10	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	20	45	35	Yes
R14	Existing receptor	17	45	35	Yes
R15	Existing receptor	16	45	35	Yes
R16	Existing receptor	<10	45	35	Yes
R17	Existing receptor	27	45	35	Yes
R18	Commercial	26	-	-	Not applicable

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 Receptors R1 and R2.

Receptor R3 has a higher predicted noise level during preparatory civil works due to the proximity to the site access road.

3.5 Mitigation of Construction Noise Levels

Receptor R1 is located approximately 40 m from the development boundary. As noted previously, the piling activities during the installation phase of the construction works are expected to generate the highest noise levels. For the purposes of this assessment, the sound power level used for the piling activities is 107 dB(A) excluding a tonality correction.

Due to the proximity of receptors R1 and R2, prior to piling activities being undertaken, it is recommended that the following approach is considered:

- Stage 1: Undertake consultation with the residents;

- Stage 2: If possible procure piling rigs with a maximum SWL of 107 dB(A);
- Stage 3: Where quieter piling rigs are unable to be sourced and consultation with Receptors 1 and 2 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 and R2 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 and R3;
- Consultation with R1 and R2 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.

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 INP. The INP 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.

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 metres from the house, then the criteria applies at the most-affected point within 30 m of the house.

4.1.2 Intrusiveness Noise Criteria

In accordance with the INP, intrusive noise refers to noise that exceeds background noise levels (as defined by the Rating Background Level) 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 used background noise monitoring data reported by Atkins Acoustic (2008) as detailed in Appendix B. This data was collected near to the subject site at a location considered representative of the acoustic environment expected to be experienced by the nearest sensitive receptors to the proposed solar farm.

Therefore, based on the available monitoring data, Table 9 presents the derivation of the intrusiveness criteria.

Table 9: Derived Intrusiveness Noise Criteria

Receptor	Intrusiveness $L_{Aeq,15\text{-minute}}$ Criteria		
	Day	Evening	Night
All nearby residential receptors [a)]	40 [b)]	37 [b)]	35 [b)]

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

b) Based on background monitoring (refer Appendix B). Night period background noise level established by the INP minimum allowable level (30 dB(A)) + 5 dB.

4.1.3 Amenity Criteria

To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels (ANL) specified in Section 2.2 of the INP. The ANL is dependent on the type of area being considered. Table 10 presents ANL values for residential receivers in rural areas.

Table 10: INP Acceptable Noise Levels for Residential Receivers

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dBA	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
Commercial	All	When in use	65	70

When the existing industrial noise levels approach the ANL, then the noise level from a new source must be controlled to preserve the amenity of the area. In the absence of the proposed solar farm, no other industrial noise sources have been identified in the area. Equally, it is also noted that noise emissions from the proposed solar farm would not be expected to limit the future potential for development of the adjacent Bowman Urban Release Area.

In view of this, the assessment has considered the compliance of noise emissions during the operational phase of the project against the (limiting) intrusiveness criteria presented in Section 4.1.2 above.

4.1.4 Sleep Disturbance

NSW EPA have identified the potential for noise emissions from developments to impact on the sleep of residents living in the area. To assist in reducing the potential for these impacts, the EPA released a policy statement in relation to the assessment of the potential for sleep disturbance effects. The following presents an excerpt from this policy statement:

> *"Peak noise level events, such as reversing beepers, noise from heavy items being dropped or other high noise level events, have the potential to cause sleep disturbance. The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development."*

For the operational phase of the project, loud impact noises associated with sleep disturbance are considered unlikely with all plant and equipment continuous or semi-continuous in its operations. Furthermore, the operation of plant and equipment on-site is expected to only occur during daylight hours where solar energy is available with peak operations.

Given the lack of short-term impact noise sources on site consideration of sleep disturbance impacts for the operational phase of this project is considered unnecessary. Rather, where compliance can be demonstrated with the intrusive noise criteria established for the development, compliance with the sleep disturbance provisions would also be expected.

4.2 Noise Sources

The WWSF is to consist of solar photovoltaic (PV) plant and associated infrastructure producing up to 26 Megawatts of electricity for supply into the grid. It is expected that, at completion, infrastructure installed on site will incorporate:

- a total of 101,562 solar panels;
- 12 solar inverters with integrated transformers; and
- a high-voltage step-up transformer.

The PV panels are expected to be 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. Up to 1,295 NexTracker tracking motors will be installed. For the purposes of the assessment it is assumed that these tracking motors would be evenly distributed across the development area as identified on the layout plan below.

The inverters required for the development will be placed to optimise cabling and maintenance requirements in accordance with the layout shown in Figure 2.

A single transformer is required for the proposed solar farm to allow connection of the solar farm to the power grid and will be located in the south-west corner of the subject site with connection to the nearby Transgrid substation provided by overhead transmission line.

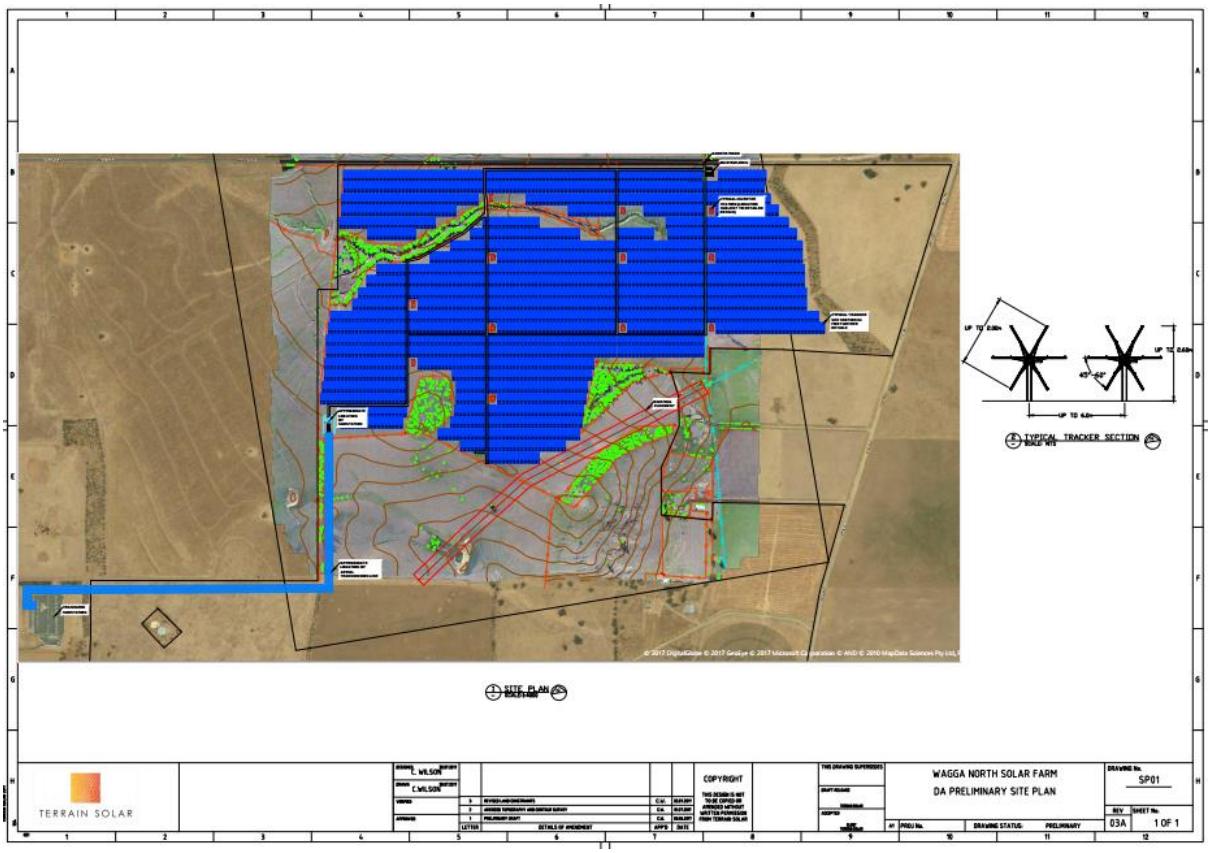

Figure 2: Layout of the Inverters

Table 11 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.

Table 11: Source Noise Levels

Source	Sound Power Level (dB(A))
NexTracker	60 (each)
Inverter [a)]	92 (each)
Transformer	75
Light Vehicle (maintenance activities)	88

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

4.3 Noise Modelling Methodology

For the purposes of predicting impacts associated with noise emissions from the development site on nearby sensitive receptors, noise modelling of the sources was completed using the proprietary software Cadna/A (version 2017 build 157.4702) developed by DataKustik. Cadna/A 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 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 NSW Industrial Noise Policy (INP) presents guidelines for the consideration of meteorological effects on noise propagation. Specifically, temperature inversions and/or gradient winds should be modelled if each factor is a feature of the local environment. The following conditions for modelling temperature inversions or gradients winds are provided:

- Temperature inversions:
    - use default parameters for temperature inversions and drainage-flow wind speed where inversions are present for at least 30 percent of the total night time during winter as specified; or
    - use parameters determined by direct measurement. Wind data should be collected at a 10 m height.

- Gradient winds:
    - where there is 30 percent or more occurrence of wind speeds below 3 m/s (source-to-receiver component), then the highest wind speed (below 3 m/s) is used instead of the default.
    - where there is less than 30 percent occurrence of wind speeds of up to 3 m/s (source-to-receiver component), wind is not included in the noise prediction calculation.

In accordance with the requirements of the INP, the following scenarios have been considered:

- Day Periods - Source to receptor wind at 3 m/s representing a worst-case assessment of potential impacts for day-periods.
- Night Periods - Moderate temperature inversion with light source to receptor winds representing a worst-case assessment of potential impacts for night periods.

4.5 Predicted Noise Levels

Table 12 below presents predicted receptor noise levels during the operational phase of the proposed solar farm.

Review of the predicted noise levels confirms that compliance with the intrusive noise criteria established in accordance with the INP can be achieved for all receptors during the daytime operational hours under worst-case meteorological conditions.

Table 12: Predicted Receptor Noise Levels - Operational Phase during Daytime, dB(A)

Receptor	Predicted Operational Noise Levels, $L_{Aeq, 15min}$	Intrusive Noise Criteria [a)]	Comply (Y/N)
R1	38	40	Yes
R2	34	40	Yes
R3	24	40	Yes
R4	24	40	Yes
R5	27	40	Yes
R6	<10	40	Yes
R7	22	40	Yes
R8	<10	40	Yes
R9	<10	40	Yes
R10	<10	40	Yes
R11	<10	40	Yes
R12	<10	40	Yes
R13	11	40	Yes
R14	<10	40	Yes
R15	<10	40	Yes
R16	<10	40	Yes

Receptor	Predicted Operational Noise Levels, $L_{Aeq, 15min}$	Intrusive Noise Criteria [a)]	Comply (Y/N)
R17	16	40	Yes
R18	22	65 [b)]	Yes

[a)] Intrusive noise criteria for day periods

[b)] Acceptable noise criteria for when in use

5 ROAD TRAFFIC NOISE ASSESSMENT

5.1 Introduction

Noise impacts associated with vehicle movements during the operational phase of the WWSF 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 100 workers would participate in some form of carpooling. Therefore, the modelling has assumed an estimated maximum of 70 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 13. The maximum number of heavy vehicles accessing the site during the peak of the construction period is not expected to exceed 20 (i.e. generating a total of 40 heavy vehicle movements in a day).

Table 13 : Construction Phase Traffic Generation

Plant/Equipment	Description	Heavy Vehicles
Modules	576 modules per 40' container: 101,562 modules delivered on 176 semi-trailers	176
Mounting Frames	4 x 40' container per MWdc, inclusive of piles, torque tubers and all associated hardware, delivered on 130 semi-trailers.	130
Inverter Stations	13 x 2.2 MW inverter stations; delivered 2 per semi-trailer	7
Substation Major Equipment	Three (3) over-mass vehicle would be required to deliver transformer for the step-up substation	3
Concrete	Estimate 360 m^3 required for sub-station compound, inverter assembly foundations and security fence, would generate 33 X 11 m^3 concrete trucks.	33
Gravel	Estimated 5,000 m^3 of gravel (6,500 tonne) for upgrade of access road would be delivered in 42.5 tonne truck & dog trailers	153
Sand	Estimated 500m^3 of sand (~800 tonne) would be delivered in 50 tonne truck & dog trailers	19

Plant/Equipment	Description	Heavy Vehicles
Miscellaneous	Provision for miscellaneous deliveries based on five (5) incidental heavy vehicles a week for the 6-month construction period and two (2) trucks per week for the six-month should periods.	182
Total		**703**

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 14 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 14: 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	140	70 [a]
	Heavy	100 km/hr	40	0 [b]
East Bowman Road	Light	60 km/hr	140	70 [a]
	Heavy	40 km/hr	40	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 15 below presents the applicable road traffic noise criteria for existing residences affected by traffic on existing roadways generated by land use developments.

Table 15: 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 Cadna/A (version 2017 build 157.4702) 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 16 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 16 below confirms that compliance with the RNP is predicted. Despite this, adverse amenity impacts due to peak traffic levels generated by the proposed construction works is considered unlikely.

Table 16: 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)	54	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)	26	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 17 and Table 18 present the criteria for continuous and impulsive vibration and intermittent vibration, respectively.

Table 17: 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 18: 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 19 presents vibration criteria for assessing the potential for building damage.

Table 19: 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 20 identifies the vibration source levels for the equipment and likely to be used for the construction of the solar farm.

Table 20: 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 20), 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 above formula has been considered for predicted PPVs at various distances from construction equipment. Based on the above information, Table 21 presents PPV predictions for the various construction equipment.

Table 21: 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	0.01-0.02	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 21 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 heavy vehicle movements 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 CONCLUSIONS AND RECOMMENDATIONS

Terrain Solar propose to construct a 26 MW solar farm (to be known as the Wagga Wagga Solar Farm) on one land parcel (Lot 15 on DP1108978). The area surrounding the proposed development is sparsely populated with dominant activities including a range of agricultural and rural uses with future industrial development associated with the Bomen Urban Release Area anticipated to the north and west..

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 R3;
- For piling activities, it is recommended that the following approach is adopted:
    - Stage 1: Undertake consultation with the residents;
    - Stage 2: If possible procure piling rigs with a maximum SWL of 107 dB(A);
    - Stage 3: Where quieter piling rigs are unable to be sourced and consultation with Receptors 1 and 2 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 R1 and R2 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.

Overall, based on the results of the assessment, the risk of adverse impacts as a result of the proposed Wagga Wagga Solar Farm is considered to be low and complies with all applicable criteria. 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.

APPENDIX B: BACKGROUND NOISE MONITORING

Background noise monitoring was undertaken by Atkins Acoustics in the vicinity of the Project Site in 2007[a]. Four locations were monitored; the closest and most representative noise monitoring location was 78 Bavin Road (R3), which is 300 m south of receptor R6 in this report.

Table B1 presents the background noise monitoring results for 78 Bavin Road.

Table B1: Background Noise Monitoring Results

Date	Assessment Background Level L_{A90}			Equivalent Continuous Level L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
Location R3: 78 Bavin Street						
Thursday 11 Oct	-	32.1	28.6	-	41.0	43.2
Friday 12 Oct	42.7	35.3	29.9	51.8	44.9	42.7
Saturday 13 Oct	35.4	28.2	26.1	46.4	37.6	40.1
Sunday 14 Oct	34.3	30.4	26.7	45.5	41.2	42.6
Monday 15 Oct	34.3	37.2	39.1	45.3	43.2	45.8
Tuesday 16 Oct	43.7	33.2	27.2	52.3	44.1	42.6
Wednesday 17 Oct	29.1	26.5	30.2	47.4	39.1	45.6
Thursday 18 Oct	35.3	37.4	36.7	47.1	50.0	45.6
Friday 19 Oct	38.6	29.7	26.5	49.8	40.3	43.3
Saturday 20 Oct	32.0	-	-	45.5	-	-
RBL	**35.3**	**32.1**	**28.6**			
Ambient L_{Aeq}				**48.7**	**44.0**	**43.8**

[a] Noise Planning Assessment – Industrial Land Study – Bomen (Atkins Acoustics, 2008)

GEOLYSE PTY LTD
WAGGA WAGGA – DEVELOPMENT CONSENT
Reference: 10934

R_0
DATE OF RELEASE: 13/02/2018

Assured Monitoring Group

Geolyse Pty Ltd
PO Box 1963
Orange NSW 2800

ATTN: Andrew Brownlow [abrownlow@geolyse.com]

Dear Andrew,

Terrain Solar propose to construct a 26 MW solar farm on one land parcel (Lot 15 on DP1108978). As part of the approvals process, Assured Monitoring Group Pty Ltd was commissioned to prepare a noise impact assessment to assess the potential noise risks associated with the proposed solar farm. This assessment report was subsequently issued to the City of Wagga Wagga for approval.

In response, the City of Wagga Wagga have issued a Request for Information (RFI) to the applicant. This letter provides feedback on the comments provided in the RFI. Specific issues identified are discussed further in the following sections.

1 COMMENTS ON NOISE IMPACT ASSESSMENT

The City of Wagga Wagga provided the following comments in relation to the Noise Impact Assessment undertaken:

1. *The NSW Industrial Noise Policy (2000) was replaced with the Noise Policy for Industry (NPfI) (2017) in October 2017 and should be referenced as applicable in the Noise Assessment report. There are some changes between the two policies and the report should be reviewed to ensure compliance with the revised and updated criteria.*

In accordance with the "*Implementation and transitional arrangements for the Noise Policy for Industry*" (NSW EPA, 2017), where the environmental assessment commenced before release of the new policy, the application can be determined based on NSW Industrial Noise Policy (2000) for a period of up to one (1) year from the date of release of the Noise Policy for Industry (2017).

The Noise Impact Assessment was originally completed on 10th October 2017, prior to the release of the updated Policy on 27th October 2017. Hence, in this case, assessment of the development against the Industrial Noise Policy 2000 is considered appropriate. Regardless, a review of the noise criteria considered in the assessment has confirmed that the outcomes of the assessment would remain unchanged were it to be undertaken in accordance with the Noise Policy for Industry 2017.

2. *With regard to the noise impact assessment the predicted receptor noise levels are for the daytime only. As this is a facility that has the capability to be operational on a 24-hour basis I would imagine that at certain times of the year the tilt of the panels could occur prior to 7am and after 6pm (the standard daytime hours). Please provide an assessment of all times of the day that there is the potential for noise from the tracking motors associated with the installation and compliance with acceptable noise levels.*

Noise emissions from the tracking motors occur for approximately one minute out of each 15-minute period (providing for up to five degrees rotation per hour) during sunlight hours. Where these tracking motors are assumed to operate continuously throughout the 'night' periods, receptor noise levels are predicted to be less than 20 dB(A) at all receptors. This level of noise is significantly lower than the 35 dB(A) noise criterion during night periods.

3. *The sound power levels provided in Table 11 of the Noise Assessment are far greater than the predicted noise levels. Please can the report be expanded to clarify how the source noise levels are effectively reduced by 50% especially the invertor stations that are in close proximity to residential properties.*

The noise levels presented in Table 11 are Sound Power Levels (SWL), which are a logarithmic quantification of energy released from the equipment. When sound waves travel, the energy emitted is dissipated through absorption (air and ground), distance attenuation and diffraction from obstacles such as terrain variation, barriers and buildings. As a result, the predicted noise levels at the receptors will always be below the SWL.

The noise modelling undertaken considers the sound power level for each noise source along with information regarding its acoustical usage (how often it emits noise at that level), the distance between noise source and receptor, terrain height variation, the type of ground cover in the area and the effect of meteorological conditions to predict receptor noise levels. Hence the difference between the results presented in the impact assessment and the sound power levels in Table 11 represents the cumulative effect of these components.

We trust the above provides sufficient information to resolve the queries raised. Where additional information is required please do not hesitate to contact us.

2 DOCUMENT CONTROL

Table 1: Document Approval

	Name	Position Title	Signature	Date
Author	Craig Beyers	Manager Consulting Services		13/02/2018

Table 2: Revision Register

Revision	Date	Name	Issued to	Comment
R_0	13/02/2018	Craig Beyers	A. Brownlow	Initial release