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WELLINGTON NORTH SOLAR PLANT

Construction & Operational Noise & Vibration Assessment

18 January 2019

NGH Environmental

TJ917-01F01 Report (r8)

Sydney Melbourne Brisbane Gold Coast Kuwait
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Document details

Detail	Reference
Doc reference:	TJ917-01F01 Report (r8)
Prepared for:	NGH Environmental
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Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
27.04.2018	Generate report	0	1	NM	MCH	MCH
16.05.2018	Update report	-	2	NM	MCH	MCH
22.05.2018	Upgrade existing substation	-	3	NM	MCH	MCH
01.06.2018	Update report	-	4	NM	MCH	MCH
12.06.2018	Update transformer sound data and easements	-	5	NM	MCH	MCH
20.07.2018	Add cumulative operation noise assessment	-	6	NM	MCH	MCH
10.08.2018	Add cumulative construction noise assessment	-	7	NM	MCH	MCH
18.01.2019	Update easements	-	8	NM	MCH	MCH

Contents

List of tables

List of figures

1 Introduction

Renzo Tonin & Associates was engaged to conduct an environmental noise and vibration assessment of the proposed Wellington North Solar Plant located approximately seven kilometres north east of the town of Wellington in New South Wales as part of the Environmental Impact Statement (EIS) for the project. Noise and vibration impacts from the construction and operation phases of the project will be addressed in this report in accordance with the Secretary's Environmental Assessment Requirements (SEARs).

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Project Description

2.1 Background Information

The Wellington North Solar Plant project includes the construction and operation of a solar photovoltaic (PV) plant and associated infrastructure, with a capacity of approximately 300MW. The subject site is located approximately seven kilometres north east of the town of Wellington in New South Wales, within the Dubbo Regional Council Local Government Area (LGA).

2.2 Regulatory Requirements

Noise and vibration impacts are assessed in accordance with a number of policies, guidelines and standards, including:

- NSW 'Interim Construction Noise Guideline' (ICNG – Department of the Environment and Climate Change, 2009);
- NSW 'Noise Policy for Industry' (NPfI – Environment Protection Authority, 2017);
- 'Assessing Vibration: A Technical Guideline' (Department of the Environment and Climate Change, 2006); and
- NSW 'Road Noise Policy' (RNP – Department of Environment, Climate Change and Water, 2011)

2.3 Receiver Locations

The nearest affected receivers were identified through aerial maps as follows:

- **Receiver R1 – 104 Cobbora Road, Maryvale**
  Residential property located approximately 330m south of the project area.
- **Receiver R2 – 215 Cobbora Road, Maryvale**
  Residential property located approximately 135m west of the project area.
- **Receiver R3 – 301 Cobbora Road, Maryvale**
  Residential property located approximately 315m west of the project area.
- **Receiver R4 – 66 Campbells Lane, Bodangora**
  Residential property located approximately 110m north of the project area.
- **Receiver R5 – 6219 Goolma Road, Bodangora**
  Residential property located approximately 910m north-east of the project area.
- **Receiver R6 – Lot 5 DP 664334 Gladstone Road, Bodangora**
  Residential property located approximately 255m east of the project area.

- **Receiver R7 – 104 Gladstone Road, Bodangora**
  Industrial property located approximately 330m east of the project area.
- **Receiver R8 – Wellington Correction Centre**
  Correction centre located approximately 400m east of the project area and 270m south of the proposed easement.
- **Receiver R9 – 28 Cadia Place, Wuuluman**
  Residential property located approximately 1,220m south-east of the project area and 430m north of the proposed easement.
- **Receiver R10 – 6582 Goolma Road, Bodangora – Soil Conservation Service**
  Commercial property located within the project area and 550m west of the proposed easement.
- **Receiver R11 – 152 Bela Vista Lane, Montefiores**
  Residential property located approximately 1,300m south of the project area.
- **Receiver R12 – 6938 Goolma Road, Montefiores**
  Residential property located approximately 1,700m south of the project area.
- **Receiver R13 – 7009 Goolma Road, Montefiores**
  Residential property located approximately 3,500m south of the project area.
- **Receiver R14 – 59 Twelve Mile Road, Wuuluman**
  Residential property located approximately 1,600m south of the project area.
- **Receiver R15 – 6773 Goolma Road, Wuuluman**
  Residential property located approximately 3,300m south of the project area.
- **Receiver R16 – 6916 Goolma Road, Wuuluman**
  Residential property located approximately 1,200m south of the project area.
- **Receiver R17 – 79 Twelve Mile Road, Wuuluman**
  Residential property located approximately 1,600m south of the project area and 90m north of the proposed easement.
- **Receiver R18 – 7 Cadonia Drive, Wuuluman**
  Residential property located approximately 1,600m south of the project area and 90m north of the proposed easement.
- **Receiver R19 – 174 Twelve Mile Road, Wuuluman**
  Residential property located approximately 2,400m south-east of the project area and 150m south-east of the proposed easement.
- **Receiver R20 – 20 Cadonia Drive, Wuuluman**
  Residential property located approximately 1,800m south-east of the project area and 100m west of the proposed easement.

- **Receiver R21 – 26 Cadonia Drive, Wuuluman**
  Residential property located approximately 1,800m south-east of the project area and 170m west of the proposed easement.
- **Receiver R22 – 32 Cadonia Drive, Wuuluman**
  Residential property located approximately 1,800m south-east of the project area and 70m west of the proposed easement.
- **Receiver R23 – 243 Twelve Mile Road, Wuuluman**
  Residential property located approximately 1,900m south-east of the project area and 370m east of the proposed easement.

Figure 1 provides details of the site, surrounds and receiver locations.

2.4 Hours of Operation

2.4.1 Construction

Construction will occur during the following standard hours of construction:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 8:00am to 1:00pm
- No work on Sundays or public holidays

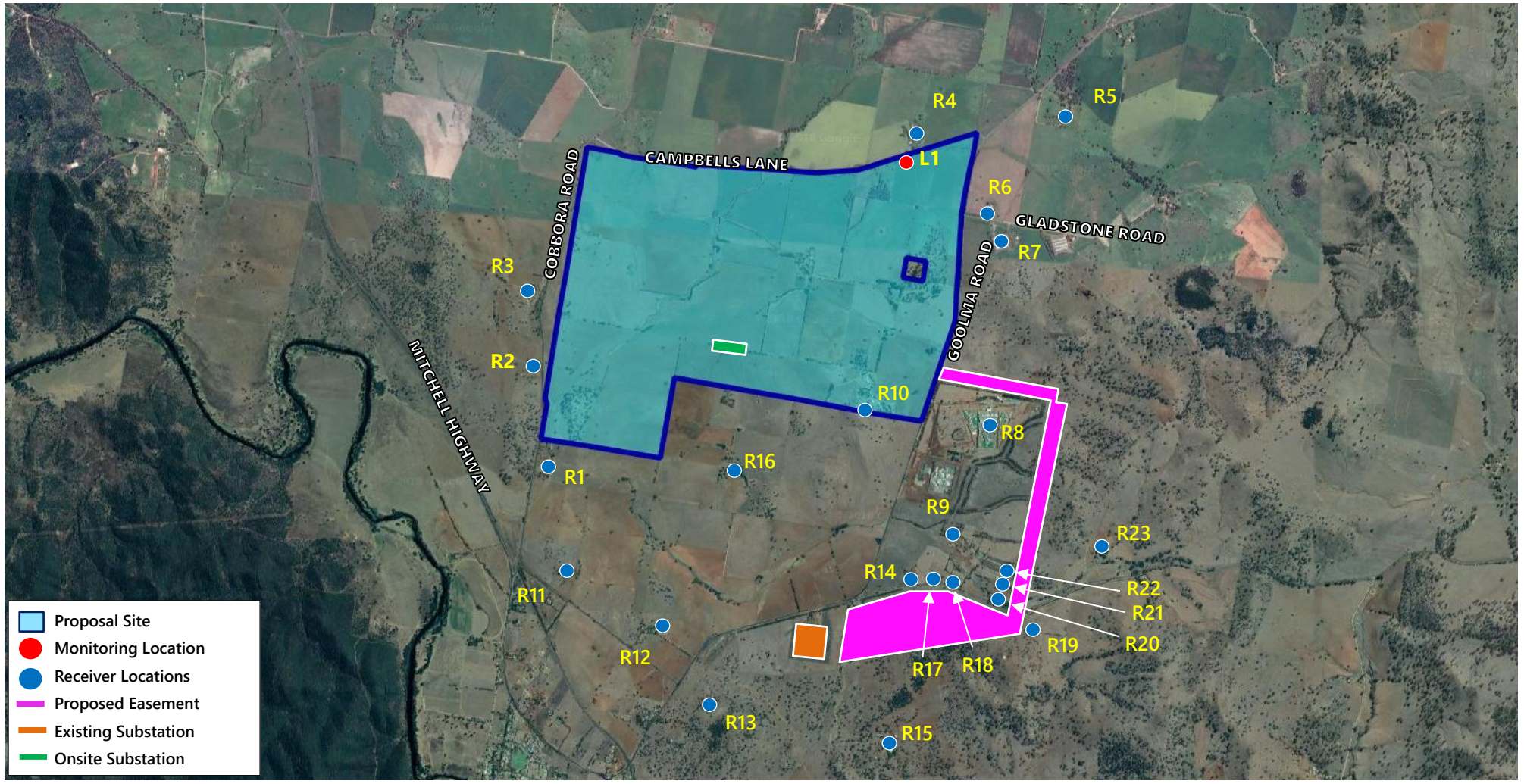
2.4.2 Operation

The solar farm will operate autonomously during times when there is sunlight. This will predominantly be during day and evening periods (7am-6pm and 6pm-10pm, respectively) throughout the year and potentially part of the night time period (prior to 7am) during the summer months.

Furthermore, there will be staff on site during the following standard hours:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 8:00am to 1:00pm

Figure 1 – Site, Surrounds and Receiver and Noise Monitoring Locations



3 Existing Noise Environment

Background noise varies over the course of any 24 hour period, typically from a minimum at 3am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NSW 'Noise Policy for Industry' (NPfI, 2017) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The NSW NPfI defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

3.1 Noise Monitoring Locations

Noise monitoring is to be undertaken at the nearest or potentially most affected receiver locations; or if this is not available, then at a location considered to have a noise environment representative of the nearest or potentially most affected receiver locations. In this case the representative location where noise monitoring was undertaken was as follows.

- **Location L1 – Coordinates: -32°29'0.48", 148°58'26.84" (near Receiver R4)**
  Noise monitor was installed in the 'free field' (ie. away from building facades) on the north eastern corner of the subject site. Noise data represents the background and ambient noise environment for receivers surrounding the project area.

To quantify the existing ambient noise environment, long-term (unattended) noise monitoring was conducted at Location L1 between Thursday 5th October and Thursday 12th October 2017.

Appendix A of this report presents a description of noise terms. Appendix B details the noise monitoring methodology and the graphical recorded outputs from long term noise monitoring are included in Appendix C. The graphs in Appendix C were analysed to determine an assessment background level (ABL) for each day, evening and night period in each 24 hour period of noise monitoring, and based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NSW NPfI.

3.2 Existing Background & Ambient Noise Levels

Existing background and ambient noise levels are presented in Table 3.1 below. The noise monitor was positioned outdoors in the 'free-field' (ie. away from building facades). Construction and operation

noise from the site should be assessed away from the facade at the potentially most affected residential boundaries and therefore, the representative noise levels listed in Table 3.1 are directly applicable.

Table 3.1 – Measured Existing Background (L_{90}) & Ambient (L_{eq}) Noise Levels, dB(A)

Location	L_{90} Background Noise Levels			L_{eq} Ambient Noise Levels		
	Day	Evening	Night	Day	Evening	Night
L1 (-32°29'0.48", 148°58'26.84")	27	34	26	49	46	47

The identified receivers surrounding the subject site are all classified as rural under NPfI guidelines. It was found that the background noise levels were typical for a rural area, with a day RBL less than 40dB(A), an evening RBL of 35 dB(A) and a night RBL less than 30 dB(A).

Based on Table 2.1 on page 10 of the NPfI, where background noise levels are less than the minimum assumed RBLs, the minimum assumed RBL's are adopted instead for all receiver locations nominated in Section 2.3. Therefore, the background noise levels have been set at the levels detailed in the fourth column of Table 3.2 below.

Table 3.2 – Rating Background Noise Level, dB(A)

Time of Day	Measured Existing Background (L_{90}), dB(A)	Minimum Assumed RBLs, dB(A)[1]	Applicable Rating Background Level, dB(A)
Day	27	35	**35**
Evening	34	30	**34**
Night	26	30	**30**

Notes: 1. In accordance with Table 2.1 of the NSW NPfI

4 Construction Noise Assessment

4.1 Construction Noise Management Levels

The NSW 'Interim Construction Noise Guideline' (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- *Use of L_{Aeq} as the descriptor for measuring and assessing construction noise*

  NSW noise policies, including the NPfI, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- *Application of reasonable and feasible noise mitigation measures*

  As stated in the ICNG, 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.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the length of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

4.1.1 Residential Receivers

Table 4.1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 4.1 – Noise Management Levels (NML) at Residential Receivers, dB(A)

Time of Day	Management Level $L_{Aeq\ (15\ min)}$	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 + 10dB(A)	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 75dB(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 + 5dB(A)	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 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Table 4.2 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring results presented in Table 3.1, the proposed construction hours and the above ICNG requirements. The receiver locations are marked in Figure 1.

Table 4.2 – Construction Noise Management Levels (NML) at Residential Receivers, dB(A)

Location Description	Day L_{A90} Background Noise Level (RBL)	Day Noise Management Level $L_{Aeq(15min)}$
All residential receivers (Receivers R1-R6, R9 & R11-R23)	35[1]	**45**

Notes: 1. Construction works occur during the daytime period only; hence, only the day period is assessed

4.1.2 Sensitive Land Uses

Table 4.3 sets out the ICNG noise management levels for other types of noise sensitive receiver locations applicable for this project.

Table 4.3 – Noise Management Levels (NML) at Other Noise Sensitive Land Uses, dB(A)

Land Use	Where Objective Applies	Management Level $L_{Aeq\ (15\ Min)}$
Receiver R7 – 104 Gladstone Rd, Bodangora (industrial receiver)	External noise level	75dB(A)
Receiver R8 – Wellington Correctional Centre (commercial receiver)	External noise level	70dB(A)
Receiver R10 – Soil Conservation Service (commercial receiver)	External noise level	70dB(A)

Notes: 1. Noise Management Levels only apply when premises are in use

4.2 Construction Noise Sources

Table 4.4 lists typical plant and equipment likely to be used by the contractor to carry out the necessary construction works within the proposal site depicted in Figure 1, while Table 4.5 details the equipment required to construct the easement for the Project.

Table 4.4 – Typical Solar Plant Construction Plant & Equipment & Sound Power Levels, dB(A)

Plant Item	Plant Description	Number of Items	L_{Aeq} Sound Power Levels, dB(A) re. 1pW Single Item
1	Small pile driving rig	10	114
2	Crane	4	110
3	Drum roller	4	109
4	Padfoot roller	4	109
5	Wheeled loader	3	109
6	Dump truck	6	108
7	30t Excavator	10	107
8	Grader	6	107
9	Chain trencher	4	104
10	Water truck	4	104
11	Telehandler	4	98
12	Forklift	4	90

Table 4.5 – Easement Construction Plant & Equipment & Sound Power Levels, dB(A)

Plant Item	Plant Description	Number of Items	L_{Aeq} Sound Power Levels, dB(A) re. 1pW Single Item
1	Crane	1	110
2	Dump truck	1	108
3	30t Excavator	1	107
4	Grader	1	107
5	Chain trencher	1	104
6	Water truck	1	104

The sound power levels for the majority of activities presented in the above table are provided by the client, based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the ICNG, information from past projects and/or information held in our library files.

4.3 Construction Noise Assessment

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area, and possible noise control treatments using CadnaA (version 2018) noise modelling computer program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The noise prediction models take into account:

- Location of noise sources and receiver locations;
- Height of sources and receivers;
- Separation distances between sources and receivers;
- Ground type between sources and receivers (soft); and
- Attenuation from barriers (natural and purpose built).

Noise levels at any receptors resulting from construction would depend on the above and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary substantially over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 4.6 presents construction noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant equipment associated with the works conducted within the proposal site. Table 4.7 refer to the noise levels likely to be experienced at the nearby affected receivers due to the construction of the easement. The noise level ranges represent the noise source being located at the furthest to the closest proximity to each receiver location.

Table 4.6 – Predicted $L_{Aeq,15min}$ Solar Plant Construction Noise Levels at Receiver Locations, dB(A)

Plant Item	Plant Description	Predicted $L_{eq(15min)}$ Construction Noise Levels																						
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23
Noise Management Level[1]		*45*	*45*	*45*	*45*	*45*	*45*	*75*[3]	*70*[2]	*45*	*70*[2]	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
1	Small pile driving rig	<20-39	<20-**49**	<20-42	<20-**47**	<20-31	<20-44	<20-40	<20-40	<20-29	<20-57	<20-28	<20-25	<20-20	<20-26	<20-<20	<20-34	<20-26	<20-26	<20-21	<20-23	<20-25	<20-25	<20-23
2	Crane	<20-35	<20-45	<20-38	<20-43	<20-27	<20-40	<20-36	<20-36	<20-25	<20-53	<20-24	<20-21	<20-<20	<20-22	<20-<20	<20-30	<20-22	<20-22	<20-<20	<20-<20	<20-21	<20-21	<20-<20
3	Drum roller	<20-34	<20-44	<20-37	<20-42	<20-26	<20-39	<20-35	<20-35	<20-24	<20-52	<20-23	<20-20	<20-<20	<20-21	<20-<20	<20-29	<20-21	<20-21	<20-<20	<20-<20	<20-<20	<20-20	<20-<20
4	Padfoot roller	<20-34	<20-44	<20-37	<20-42	<20-26	<20-39	<20-35	<20-35	<20-24	<20-52	<20-23	<20-20	<20-<20	<20-21	<20-<20	<20-29	<20-21	<20-21	<20-<20	<20-<20	<20-<20	<20-20	<20-<20
5	Wheeled loader	<20-34	<20-44	<20-37	<20-42	<20-26	<20-39	<20-35	<20-35	<20-24	<20-52	<20-23	<20-20	<20-<20	<20-21	<20-<20	<20-29	<20-21	<20-21	<20-<20	<20-<20	<20-<20	<20-20	<20-<20
6	Dump truck	<20-33	<20-43	<20-36	<20-41	<20-25	<20-38	<20-34	<20-34	<20-23	<20-51	<20-22	<20-<20	<20-<20	<20-<20	<20-<20	<20-28	<20-20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
7	30t Excavator	<20-32	<20-42	<20-35	<20-40	<20-24	<20-37	<20-33	<20-33	<20-22	<20-50	<20-21	<20-<20	<20-<20	<20-<20	<20-<20	<20-27	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
8	Grader	<20-32	<20-42	<20-35	<20-40	<20-24	<20-37	<20-33	<20-33	<20-22	<20-50	<20-21	<20-<20	<20-<20	<20-<20	<20-<20	<20-27	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
9	Chain trencher	<20-29	<20-39	<20-32	<20-37	<20-21	<20-34	<20-30	<20-30	<20-<20	<20-47	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-24	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
10	Water truck	<20-29	<20-39	<20-32	<20-37	<20-21	<20-34	<20-30	<20-30	<20-<20	<20-47	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-24	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
11	Telehandler	<20-23	<20-33	<20-26	<20-31	<20-<20	<20-28	<20-24	<20-24	<20-<20	<20-41	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
12	Forklift	<20-<20	<20-25	<20-<20	<20-23	<20-<20	<20-20	<20-<20	<20-<20	<20-<20	<20-33	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
Up to 3 (noisiest) plant operating concurrently		<20-41	<20-**51**	<20-45	<20-**49**	<20-33	<20-**46**	<20-42	<20-42	<20-31	<20-59	<20-31	<20-28	<20-23	<20-28	<20-<20	<20-36	<20-29	<20-28	<20-23	<20-26	<20-27	<20-27	<20-26

Notes:
1. Noise Management Levels for day period (ie. standard construction hours)
2. Noise Management Level for commercial type premises
3. Noise Management Level for industrial type premises
4. **Bold** font represents exceedance of the relevant NML

Table 4.7 – Predicted $L_{Aeq,15min}$ Easement Construction Noise Levels at Receiver Locations, dB(A)

Plant Item	Plant Description	Predicted $L_{eq(15min)}$ Construction Noise Levels																						
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23
Noise Management Level[1]		*45*	*45*	*45*	*45*	*45*	*45*	*75*[3]	*70*[2]	*45*	*70*[2]	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*	*45*
1	Crane	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-22	<20-24	<20-40	21-35	<20-33	<20-<20	<20-20	<20-23	<20-**59**	<20-29	<20-21	<20-**59**	<20-**60**	<20-**47**	<20-**53**	<20-**46**	<20-**60**	<20-37
2	Dump truck	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-22	<20-38	<20-33	<20-31	<20-<20	<20-<20	<20-21	<20-**57**	<20-27	<20-<20	<20-**57**	<20-**58**	<20-45	<20-**51**	<20-44	<20-**58**	<20-35
3	30t Excavator	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-21	<20-37	<20-32	<20-30	<20-<20	<20-<20	<20-<20	<20-**56**	<20-26	<20-<20	<20-**56**	<20-**57**	<20-44	<20-**50**	<20-43	<20-**57**	<20-34
4	Grader	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-21	<20-37	<20-32	<20-30	<20-<20	<20-<20	<20-<20	<20-**56**	<20-26	<20-<20	<20-**56**	<20-**57**	<20-44	<20-**50**	<20-43	<20-**57**	<20-34
5	Chain trencher	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-34	<20-29	<20-27	<20-<20	<20-<20	<20-<20	<20-**53**	<20-23	<20-<20	<20-**53**	<20-**54**	<20-41	<20-**47**	<20-40	<20-**54**	<20-31
6	Water truck	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-34	<20-29	<20-27	<20-<20	<20-<20	<20-<20	<20-**53**	<20-23	<20-<20	<20-**53**	<20-**54**	<20-41	<20-**47**	<20-40	<20-**54**	<20-31
Up to 3 (noisiest) plant operating concurrently		<20-<20	<20-<20	<20-<20	<20-21	<20-<20	<20-25	<20-27	<20-43	24-38	<20-36	<20-<20	<20-24	<20-26	20-**63**	<20-32	<20-24	21-**62**	22-**63**	<20-**50**	20-**57**	22-**50**	22-**63**	<20-40

Notes:
1. Noise Management Levels for day period (ie. standard construction hours)
2. Noise Management Level for commercial type premises
3. Noise Management Level for industrial type premises
4. **Bold** font represents exceedance of the relevant NML

Based on the construction noise levels presented in Table 4.6 the construction management levels at Receivers R2, R4 and R6 may be exceeded when construction works are conducted at the closest proximity to the receivers. For the proposed easement, Table 4.7 indicates that the construction noise management levels at Receivers R14 and R17-R22 may also be exceeded.

It is noted that construction noise levels at all receivers are predicted to be less than the highly noise affected level of 75dB(A) for all construction stages of the solar plant project.

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise management measures be applied to reduce noise levels as much as possible to manage the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 4.5 below.

4.4 Cumulative Construction Noise Assessment

Construction activities associated with the recently approved Wellington Solar Plant (Wellington South Solar Plant) may potentially occur at the same time as construction works required for the proposed Wellington North Solar Plant. As a result, some of the nominated receivers may be impacted by construction noise from both solar plants concurrently. However, not all receivers identified in Section 2.3 have been included in the Wellington South Solar Plant noise and vibration assessment [ref: TJ643-01F01 Report (r5), dated 24 November 2017], as they were not identified as one of the nearest affected receivers and therefore were predicted to comply with the NMLs established within the report.

For a conservative cumulative assessment, the receivers that have been identified as being the nearest affected receiver for both the North and South Solar Plants (ie. Receivers R1, R2 and R8-R14) a cumulative construction noise assessment has been undertaken for the scenario where both solar plants are being constructed at the same time; although, it is highly unlikely the two solar plants will be constructed concurrently due to the different timelines of the projects and the timing of approvals.

The cumulative construction noise assessment was conducted for two different scenarios:

- **Scenario 1 –** Concurrent construction of Wellington South Solar Plant and Wellington North Solar Plant (within the proposal site).
- **Scenario 2 –** Concurrent construction of Wellington South Solar Plant and the proposed easement.

The cumulative assessment for Scenario 1 assumes that the same construction plant and equipment are being used at both solar plants concurrently during the construction of the solar plants. Table 4.8 presents cumulative construction noise levels likely to be experienced at the nearby affected receivers based on the works conducted in Scenario 1.

The plant and equipment used to construct the solar plant slightly differ to the plant and equipment used for the construction of the easement, demonstrated in the comparison of Table 4.4 and Table 4.5.

Due to the differing equipment a conservative approach has been adopted in Scenario 2, where it is assumed that the three (3) noisiest plant items from each work site are operating concurrently. Table 4.9 present the cumulative construction noise levels for Scenario 2.

Table 4.8 – Predicted $L_{Aeq,15min}$ Cumulative Plant Construction Noise Levels from North and South Solar Plants, dB(A)

Plant Item	Plant Description	Predicted $L_{eq(15min)}$ Construction Noise Levels																								
		R1			R2			R8			R9			R10			R11			R12			R13			R14		
Noise Management Level[1]		*45*			*45*			*70[2]*			*45*			*70[2]*			*45*			*45*			*45*			*45*		
	Work Areas	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]	South	North	Cumul.[3]
1	Small pile driving rig	23-**47**	<20-39	23-**47**	23-34	<20-**49**	23-**49**	23-42	<20-40	23-44	23-36	<20-29	23-37	21-45	<20-57	22-57	23-31	<20-28	23-33	23-38	<20-25	23-38	23-36	<20-20	23-36	23-42	<20-26	23-42
2	Crane	<20-43	<20-35	<20-43	<20-30	<20-45	<20-45	<20-38	<20-36	<20-40	<20-32	<20-25	<20-33	<20-41	<20-53	<20-53	<20-27	<20-24	<20-29	<20-34	<20-21	<20-34	<20-32	<20-<20	<20-32	<20-38	<20-22	<20-38
3	Drum roller	<20-42	<20-34	<20-42	<20-29	<20-44	<20-44	<20-37	<20-35	<20-39	<20-31	<20-24	<20-32	<20-40	<20-52	<20-52	<20-26	<20-23	<20-28	<20-33	<20-20	<20-33	<20-31	<20-<20	<20-31	<20-37	<20-21	<20-37
4	Padfoot roller	<20-42	<20-34	<20-42	<20-29	<20-44	<20-44	<20-37	<20-35	<20-39	<20-31	<20-24	<20-32	<20-40	<20-52	<20-52	<20-26	<20-23	<20-28	<20-33	<20-20	<20-33	<20-31	<20-<20	<20-31	<20-37	<20-21	<20-37
5	Wheeled loader	<20-42	<20-34	<20-42	<20-29	<20-44	<20-44	<20-37	<20-35	<20-39	<20-31	<20-24	<20-32	<20-40	<20-52	<20-52	<20-26	<20-23	<20-28	<20-33	<20-20	<20-33	<20-31	<20-<20	<20-31	<20-37	<20-21	<20-37
6	Dump truck	<20-41	<20-33	<20-41	<20-28	<20-43	<20-43	<20-36	<20-34	<20-38	<20-30	<20-23	<20-31	<20-39	<20-51	<20-51	<20-25	<20-22	<20-27	<20-32	<20-<20	<20-32	<20-30	<20-<20	<20-30	<20-36	<20-20	<20-36
7	30t Excavator	<20-40	<20-32	<20-40	<20-27	<20-42	<20-42	<20-35	<20-33	<20-37	<20-29	<20-22	<20-30	<20-38	<20-50	<20-50	<20-24	<20-21	<20-26	<20-31	<20-<20	<20-31	<20-29	<20-<20	<20-29	<20-35	<20-<20	<20-35
8	Grader	<20-40	<20-32	<20-40	<20-27	<20-42	<20-42	<20-35	<20-33	<20-37	<20-29	<20-22	<20-30	<20-38	<20-50	<20-50	<20-24	<20-21	<20-26	<20-31	<20-<20	<20-31	<20-29	<20-<20	<20-29	<20-35	<20-<20	<20-35
9	Chain trencher	<20-37	<20-29	<20-37	<20-24	<20-39	<20-39	<20-32	<20-30	<20-34	<20-26	<20-<20	<20-27	<20-35	<20-47	<20-47	<20-21	<20-<20	<20-23	<20-28	<20-<20	<20-28	<20-26	<20-<20	<20-26	<20-32	<20-<20	<20-32
10	Water truck	<20-37	<20-29	<20-37	<20-24	<20-39	<20-39	<20-32	<20-30	<20-34	<20-26	<20-<20	<20-27	<20-35	<20-47	<20-47	<20-21	<20-<20	<20-23	<20-28	<20-<20	<20-28	<20-26	<20-<20	<20-26	<20-32	<20-<20	<20-32
11	Telehandler	<20-31	<20-23	<20-31	<20-<20	<20-33	<20-33	<20-26	<20-24	<20-28	<20-20	<20-<20	<20-21	<20-29	<20-41	<20-41	<20-<20	<20-<20	<20-<20	<20-22	<20-<20	<20-22	<20-20	<20-<20	<20-20	<20-26	<20-<20	<20-26
12	Forklift	<20-23	<20-<20	<20-23	<20-<20	<20-25	<20-25	<20-<20	<20-<20	<20-20	<20-<20	<20-<20	<20-<20	<20-21	<20-33	<20-33	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20	<20-<20
Up to 3 (noisiest) plant operating concurrently		25-**49**	<20-41	26-**50**	25-36	<20-**51**	26-**51**	25-44	<20-42	26-46	25-39	<20-31	26-39	23-47	<20-59	24-60	25-33	<20-31	26-35	25-40	<20-28	26-41	25-39	<20-23	26-39	25-44	<20-28	26-44

Notes:
1. Noise Management Levels for day period (ie. standard construction hours)
2. Noise Management Level for commercial type premises
3. Overall noise contribution from construction noise from South and North Solar Plants
4. **Bold** font represents exceedance of the relevant NML

Table 4.9 – Predicted $L_{Aeq,15min}$ Cumulative Construction Noise Levels from South Solar Plant and Proposed Easement, dB(A)

Plant Item	Plant Description	Predicted $L_{eq(15min)}$ Construction Noise Levels																								
		R1			R2			R8			R9			R10			R11			R12			R13			R14		
Noise Management Level[1]		*45*			*45*			*70*[2]			*45*			*70*[2]			*45*			*45*			*45*			*45*		
	Work Areas	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]	South	Easement	Cumul.[3]
Up to 3 (noisiest) plant operating concurrently[4]		25-**49**	<20-<20	25-**49**	25-36	<20-<20	25-36	25-44	<20-43	26-47	25-39	24-38	28-42	23-47	<20-36	25-47	25-33	<20-<20	25-33	25-40	<20-24	25-40	25-39	<20-26	25-39	25-44	20-**63**	27-**63**

Notes:
1. Noise Management Levels for day period (ie. standard construction hours)
2. Noise Management Level for commercial type premises
3. Overall noise contribution from construction noise from South Solar Plant and proposed easement
4. Up to 3 noisiest plant for each work area operating concurrently
5. **Bold** font represents exceedance of the relevant NML

The results presented in Table 4.8 indicate possible exceedances above the NML for Receivers R1 and R2. The exceedance at Receiver R1 is mainly due to the construction of the South Solar Plant, which was initially identified as exceeding the NML in the Wellington South Solar Plant's noise and vibration assessment [ref: TJ643-01F01 Report (r5), dated 24 November 2017]. The construction of the North Solar Plant is the main contributor to the exceedance at Receiver R2, which has been identified in Section 4.3.

For the cumulative construction noise levels of the North Solar Plant's proposed easement and the South Solar Plant construction works, Receivers R1 and R14 exceed the NML. The exceedance at Receiver R1 is only due to the construction works from the South Solar Plant, while the construction of the proposed easement leads to an exceedance at Receiver R14.

Therefore, the predicted cumulative noise impact from the construction of the South and North Solar Plant and its proposed easement does not identify any new exceedances at nearby affected receivers.

Additionally, the cumulative construction noise levels of the South Solar Plant and the North Solar Plant, and the proposed easement, are predicted to be less than the highly noise affected level of 75dB(A), as shown in Table 4.8 and Table 4.9.

4.5 Construction Noise Mitigation and Management Measures

The following recommendations provide in-principle feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

4.5.1 General Engineering Noise Controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 "Guide to Noise Control on Construction, Demolition and Maintenance Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 4.10 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 4.10 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical Noise Reduction Possible in Practice		Maximum Noise Reduction Possible in Practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 4.11 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 4.11 – Noise Control Measures for Likely Construction Plant

Plant Description	Screening	Acoustic Enclosures	Silencing	Alternative Process
Small pile driving rig	✔	✖	✔	✔
Crane	✔	✔	✔	✖
Drum roller	✔	✖	✔	✖
Padfoot roller	✔	✖	✔	✖
Wheeled loader	✔	✖	✔	✖
Dump truck	✔	✖	✔	✖
30t Excavator	✔	✖	✔	✖
Grader	✔	✖	✔	✖
Chain trencher	✔	✖	✔	✔
Water truck	✔	✖	✔	✖
Telehandler	✔	✖	✔	✖
Forklift	✔	✖	✔	✖

4.5.2 Noise Management Measures

In addition to physical noise controls, the following general noise management measures should be followed:

- Use less noisy plant and equipment, where feasible and reasonable.

- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

Where noise level exceedances cannot be avoided, then consideration may be given to implementing time restrictions and/or providing periods of repose for residents, where feasible and reasonable. That is, daily periods of respite from noisy activities may also be scheduled for building occupants during construction hours.

Some items of plant may exceed noise limits even after noise treatment is applied. To reduce the overall noise impact, the use of noisy plant may be restricted to within certain time periods, where feasible and reasonable and to be negotiated with Council and the residents. Allowing the construction activities to proceed, despite the noise exceedance may be the preferred method in order to complete the works expeditiously.

5 Operational Noise Assessment

5.1 Operational Noise Criteria

Noise impact from the general operation of the proposed solar farm is assessed against the recently released NSW 'Noise Policy for Industry' (NPfI, 2017). The assessment procedure in terms of the NPfI has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the project noise trigger level which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

5.1.1 Intrusive Noise Impacts

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq,15min}$ descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

$L_{Aeq,15minute}$ Intrusiveness noise level = Rating Background Level (RBL) plus 5dB(A)

Based on the RBLs set in Table 3.2, the intrusiveness noise level for the residential receivers are determined in Table 5.1.

Table 5.1 – NPfI Intrusive Noise Level at Residential Receivers, dB(A)

Period	Rating Background Level, dB(A)	Intrusiveness Noise Level, $L_{Aeq,15min}$, dB(A)
Daytime	35	35+5 = **40**
Evening	34	34+5 = **39**
Night-time	30	30+5 = **35**

5.1.2 Protecting Noise Amenity

The project amenity noise levels for different time periods of a day are determined in accordance with Section 2.4 of the NSW NPfI. The NPfI recommends amenity noise levels ($L_{Aeq, period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for **total** industrial noise experienced at a receiver location. However, when assessing a **single** industrial development and its impact on an area, "project amenity noise levels" apply.

To ensure that the total industrial noise level (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level that applies for each new industrial noise source is determined as follows:

$$L_{Aeq,period}\ \textbf{Project amenity noise level} = L_{Aeq,period}\ \textbf{Recommended amenity noise level} - \textbf{5dB(A)}$$

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$$L_{Aeq,15min} = L_{Aeq,period} + 3dB(A)$$

The policy, in accordance with the NPfI, applies an adjustment of (+3 dB) to the recommended noise levels ($L_{Aeq,\ period}$) in order to standardise the time periods for the intrusiveness and amenity noise levels. The project amenity noise levels ($L_{Aeq,\ 15min}$) applied for this project are reproduced in Table 5.2.

It is noted that the residential receivers in the vicinity of the site have been categorised as being in n 'rural' area in accordance with Table 2.3 of the NPfI.

Table 5.2 – NPfI Project Amenity Noise Levels, dB(A)

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended Noise Level	
			$L_{Aeq,\ Period}$	$L_{Aeq,\ 15min}$
Residence	Rural	Day	50 – 5 = 45	45 + 3 = **48**
		Evening	45 – 5 = 40	40 + 3 = **43**
		Night	40 – 5 = 35	35 + 3 = **38**
Commercial Premises	All	When in use	65 – 5 = 60	60 + 3 = **63**
Industrial Premises	All	When in use	70 – 5 = 65	65 + 3 = **68**

Notes:
1. Monday-Saturday, Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

5.2 Summary of Project Noise Trigger Levels

In accordance with the NPfI the project noise trigger level, which is the lower (ie. more stringent) value of the project intrusiveness noise level and project amenity noise level, has been determined and reproduced in Table 5.3 below.

Table 5.3 – Project Noise Trigger Levels, dB(A)

Receiver Location	$L_{Aeq, 15min}$ Project Noise Trigger Levels		
	Day	Evening	Night
Receiver R1 – 104 Cobbora Rd, Maryvale	40	39	35
Receiver R2 – 215 Cobbora Rd, Maryvale	40	39	35
Receiver R3 – 301 Cobbora Rd, Maryvale	40	39	35
Receiver R4 – 66 Campbells Ln, Bodangora	40	39	35
Receiver R5 – 6219 Goolma Rd Bodangora	40	39	35
Receiver R6 – Lot 5 DP 664334 Gladstone Rd, Bodangora	40	39	35
Receiver R7 – 104 Gladstone Road, Bodangora[4]	68	68	68
Receiver R8 – Wellington Correction Centre[4]	63	63	63
Receiver R9 – 28 Cadia Pl, Wuuluman	40	39	35
Receiver R10 – 6582 Goolma Road, Bodangora – Soil Conservation Service[4]	63	63	63
Receiver R11 – 152 Bela Vista Ln, Montefiores	40	39	35
Receiver R12 – 6938 Goolma Rd, Montefiores	40	39	35
Receiver R13 – 7009 Goolma Rd, Montefiores	40	39	35
Receiver R14 – 59 Twelve Mile Road, Wuuluman	40	39	35
Receiver R15 – 6773 Goolma Road, Wuuluman	40	39	35
Receiver R16 – 6916 Goolma Road, Wuuluman	40	39	35
Receiver R17 – 79 Twelve Mile Road, Wuuluman	40	39	35
Receiver R18 – 7 Cadonia Drive, Wuuluman	40	39	35
Receiver R19 – 174 Twelve Mile Road, Wuuluman	40	39	35
Receiver R20 – 20 Cadonia Drive, Wuuluman	40	39	35
Receiver R21 – 26 Cadonia Drive, Wuuluman	40	39	35
Receiver R22 – 32 Cadonia Drive, Wuuluman	40	39	35
Receiver R23 – 243 Twelve Mile Road, Wuuluman	40	39	35

Notes:
1. Monday-Saturday, Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
4. Project Noise Trigger Levels only apply when premises are in use.

5.3 Operational Noise Sources

The proposed solar farm considers two options for the configuration of the PV panels:

1. Fixed configuration, where the panels would be placed on fixed frames running in rows from east to west and tilted to the north; or
2. Single axis tracking, where the panels would be in rows configured in a north to south direction and the panels would track the sun from east to west throughout the day.

The single axis tracking system involves the panels being driven by motors to track the arc of the sun to maximise the solar effect. Hence, the tracking motors are a potential source of mechanical noise and therefore, has been included for a more conservative assessment. Up to a total of 13,367 tracking motors (NexTracker or equivalent) will be employed to drive the solar panels and are to be evenly distributed across the solar farm area. The tracking motors would turn no more than five (5) degrees every 15 minutes and would operate no more than one (1) minute out of every 15 minute period.

In addition to the trackers, the site will require the operation of up to 155 inverters (Ingeteam 1640TL B630) which will be evenly distributed across the solar farm area. A new substation will also be located near the southern end of the site. The dominant noise source from the new substation will be from two (2) 175MVA transformers. Furthermore, it is proposed that the existing substation located to the south of the project site and along Goolma Road may be upgraded with two (2) additional 175MVA transformers alongside the two (2) existing 375MVA transformers. The sound power level data for the existing 375MVA transformers were provided by the client and were measured to be 96dB(A) each. To provide a conservative assessment it was assumed that all the existing and proposed transformers have the same sound power level as the existing larger 375MVA transformer.

During operations, it is assumed that four (4) staff members will attend site daily during the day time period to inspect the equipment. It is also assumed that each staff member will travel around the subject site in a light vehicle.

Based on the above, the following table lists associated plant and equipment likely to be used for the operation of the proposed solar farm and their corresponding sound power levels.

Table 5.4 – Typical Operational Plant and Equipment & Sound Power Levels

Plant Item	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re. 1pW
1	Tracker Motor (up to 13,367 in total)	78 (each)
2	Ingeteam 1640TL B630 Inverters (up to 155)	88 (each)
4	New 175MVA transformer (4 in total)	96 (each)[1]
5	Existing 375MVA transformers (2 in total)	96 (each)[1]
6	Light vehicle (4 in total)	88 (each)

Notes: 1. Based on sound power level data provided by the client

The sound power levels for the plant and equipment presented in the above table are provided by the manufacturer, information from past projects and/or information held in our library files.

5.4 'Modifying Factor' Adjustments

Further to the above and in accordance with the NPfI, where the character of the noise in question is assessed as particularly annoying (ie. if it has an inherently tonal, low frequency, impulsive or intermittent characteristic), then an adjustment of 5dB(A) for each annoyance aspect, up to a total of 10dB(A), is to be added to the predicted value to penalise the noise for its potential increase in annoyance.

Table C1 in Fact Sheet C of the NSW NPfI provides definitive procedures for determining whether a penalty or adjustment should be applied from increased annoyance. For the assessment of the solar farm, the noise from the inverters and transformers are considered to be tonal in nature. Therefore, a 5dB(A) penalty has been applied to the predicted noise contributions from the inverters and transformers.

5.5 Operational Noise Assessment

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area, and possible noise control treatments using CadnaA (version 2018) noise modelling computer program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The noise prediction models takes into account:

- Location of noise sources and receiver locations;
- Height of sources and receivers;
- Separation distances between sources and receivers;
- Ground type between sources and receivers (soft); and
- Attenuation from barriers (natural and purpose built).

Furthermore, in accordance with the NPfI noise predictions were prepared for each of the following meteorological conditions:

1. Calm & isothermal conditions (acoustically neutral) – no wind and no temperature inversion
2. Slight to gentle breeze – 3m/s wind velocity at 10m from ground level between each noise source and each noise receiver (as per NPfI default wind conditions). Wind direction was based on wind travelling from the source to the receiver.
3. Moderate temperature inversion – applicable for noise predictions during night time periods only

Table 5.5 below present the predicted noise levels for the worst case scenario based on concurrent operation of all the plant and equipment shown in Table 5.4. The tracker motors were time corrected based on their operation of one (1) minute out of a 15 minute period.

Table 5.5 – Predicted $L_{Aeq,15min}$ Operational Noise Levels at Receiver Locations, dB(A)

Receiver Location	Project Noise Trigger Levels[1]			Predicted Operational Noise Levels, $L_{Aeq, 15min}$									Comply? (Yes/No)
				Calm & Isothermal Conditions			Slight to Gentle Breeze			Moderate Temperature Inversion[2]			
	Day	Evening	Night	Solar Plant	Upgraded Substation	Cumulative[4]	Solar Plant	Upgraded Substation	Cumulative[4]	Solar Plant	Upgraded Substation	Cumulative[4]	
Receiver R1	*40*	*39*	*35*	24	<20	24	30	22	31	30	22	30	Yes
Receiver R2	*40*	*39*	*35*	30	<20	30	34	<20	34	34	<20	34	Yes
Receiver R3	*40*	*39*	*35*	28	<20	28	33	<20	33	33	<20	33	Yes
Receiver R4	*40*	*39*	*35*	28	<20	28	32	<20	32	33	<20	33	Yes
Receiver R5	*40*	*39*	*35*	<20	<20	<20	26	<20	26	26	<20	26	Yes
Receiver R6	*40*	*39*	*35*	28	<20	28	33	<20	33	33	<20	33	Yes
Receiver R7[3]	*68*	*68*	*68*	26	<20	26	32	<20	32	32	<20	32	Yes
Receiver R8[3]	*63*	*63*	*63*	25	<20	26	31	24	32	31	24	31	Yes
Receiver R9	*40*	*39*	*35*	<20	23	24	26	29	31	26	29	31	Yes
Receiver R10[3]	*63*	*63*	*63*	31	<20	31	34	25	35	35	25	35	Yes
Receiver R11	*40*	*39*	*35*	<20	<20	21	26	24	28	26	24	28	Yes
Receiver R12	*40*	*39*	*35*	<20	24	25	25	30	31	25	30	31	Yes
Receiver R13	*40*	*39*	*35*	<20	27	27	22	33	33	22	33	33	Yes
Receiver R14	*40*	*39*	*35*	<20	28	28	25	33	34	25	33	34	Yes
Receiver R15	*40*	*39*	*35*	<20	28	28	21	33	33	21	33	33	Yes
Receiver R16	*40*	*39*	*35*	27	22	28	33	28	34	33	28	34	Yes
Receiver R17	*40*	*39*	*35*	<20	26	26	<20	31	32	25	31	32	Yes
Receiver R18	*40*	*39*	*35*	<20	24	25	<20	30	30	24	30	31	Yes
Receiver R19	*40*	*39*	*35*	<20	<20	20	21	26	27	21	26	27	Yes
Receiver R20	*40*	*39*	*35*	<20	21	22	20	28	28	23	28	29	Yes
Receiver R21	*40*	*39*	*35*	<20	21	22	21	28	28	23	28	29	Yes
Receiver R22	*40*	*39*	*35*	<20	20	21	21	27	28	23	27	28	Yes
Receiver R23	*40*	*39*	*35*	<20	<20	<20	21	24	26	22	24	26	Yes

Receiver Location	Project Noise Trigger Levels[1]			Predicted Operational Noise Levels, $L_{Aeq, 15min}$									Comply? (Yes/No)
				Calm & Isothermal Conditions			Slight to Gentle Breeze			Moderate Temperature Inversion[2]			
	Day	Evening	Night	Solar Plant	Upgraded Substation	Cumulative[4]	Solar Plant	Upgraded Substation	Cumulative[4]	Solar Plant	Upgraded Substation	Cumulative[4]	

Notes:
1. Trigger levels for Day, Evening and Night periods
2. Applicable for the night time period only
3. When in use
4. Overall noise contribution from solar plant and the upgraded substation

Based on the predicted noise levels presented in the table above, operational noise levels from the proposed solar farm and the upgraded substation at the nearest receivers comply with the nominated project trigger levels under all scenarios and meteorological conditions for all sensitive receiver locations. Furthermore, the predicted cumulative noise levels from the operation of the solar farm and the upgraded substation comply with the project trigger levels for each receiver under all scenarios and meteorological conditions.

Therefore, no further reasonable and feasible noise mitigation measures are required to reduce operational noise impacts.

5.6 Cumulative Operation Noise Assessment

It is likely that the Wellington South Solar Plant would be operating concurrently with the Wellington North Solar Plant. Therefore, cumulative noise impacts at the nearest affected receivers due to both solar plants operating have been considered. As highlighted in Section 4.4, not all receivers identified in Section 2.3 have been included in the Wellington South Solar Plant noise and vibration assessment [ref: TJ643-01F01 Report (r5), dated 24 November 2017], as they were not identified as one of the nearest affected receivers and therefore were predicted to comply with the project trigger levels established within the report.

An assessment of the cumulative operational noise from the Wellington North Solar Plant, the upgraded substation and the Wellington South Solar Plant has been quantified for the receivers that have been identified as being the nearest affected receiver for both the North and South Solar Plants (ie. Receivers R1, R2 and R8-R14). The cumulative noise levels are presented in Table 5.6 for the applicable meteorological conditions.

Table 5.6 – Predicted $L_{Aeq,15min}$ Cumulative Operational Noise Levels at Receiver Locations, dB(A)

Receiver Location	Project Noise Trigger Levels			Predicted Operational Noise Levels, $L_{Aeq, 15min}$												Comply? (Yes/No)
				Calm & Isothermal Conditions				Slight to Gentle Breeze				Moderate Temperature Inversion[1]				
	Day	Evening	Night	North Solar Plant	Upgraded Substation	South Solar Plant	Cumulative[3]	North Solar Plant	Upgraded Substation	South Solar Plant	Cumulative[3]	North Solar Plant	Upgraded Substation	South Solar Plant	Cumulative[3]	
Receiver R1	*40*	*39*	*35*	24	<20	25	28	30	22	30	33	30	22	30	33	Yes
Receiver R2	*40*	*39*	*35*	30	<20	<20	30	34	<20	25	35	34	<20	25	35	Yes
Receiver R8[2]	*63*	*63*	*63*	25	<20	26	29	31	24	32	35	31	24	32	35	Yes
Receiver R9	*40*	*39*	*35*	<20	23	27	29	26	29	31	34	26	29	31	34	Yes
Receiver R10[2]	*63*	*63*	*63*	31	<20	28	33	34	25	33	37	35	25	33	37	Yes
Receiver R11	*40*	*39*	*35*	<20	<20	22	25	26	24	28	31	26	24	28	31	Yes
Receiver R12	*40*	*39*	*35*	<20	24	25	28	25	30	31	34	25	30	31	34	Yes
Receiver R13	*40*	*39*	*35*	<20	27	22	28	22	33	28	34	22	33	28	34	Yes
Receiver R14	*40*	*39*	*35*	<20	28	31	33	25	33	35	**37**	25	33	35	**37**	**No**

Notes:
1. Applicable for the night time period only
2. Commercial receiver assessed only for when in use
3. Overall noise contribution from Wellington North Solar Plant, upgraded substation and Wellington Solar Plant
4. **Bold** font indicates exceedance

From Table 5.6 it can be seen that the predicted noise levels generally comply at all receiver locations under all scenarios and meteorological conditions. However, under noise enhancing weather conditions, the predicted cumulative noise levels at Receiver R14 exceed the criterion by 2dB(A) during the night period. The exceedance at R14 is mainly attributed to the noise emissions from the South Solar Farm, which predicts noise levels equal to the night time Project Noise Trigger Level of 35dB(A). When the noise emissions from the upgraded substation is considered, it is predicted to increase the overall noise levels by 2dB(A) at the receiver and therefore yielding an exceedance of 2dB(A) at Receiver R14.

In accordance with Table 4.1 and Table 4.2 of the NPfI, a 2dB(A) exceedance is considered to be negligible as a 2dB(A) change in noise level is not discernible or noticeable to the average person. Therefore, the predicted noise levels at Receiver R14 are determined to be acceptable in accordance with the NPfI and no further reasonable and feasible noise mitigation measures are required.

5.7 Sleep Disturbance Assessment

To assess the likelihood of sleep disturbance, the potential of maximum noise level events from premises during the night-time period has been considered in this assessment. In accordance with NPfI, a detailed maximum noise level event assessment should be undertaken where the subject development night-time noise levels at a residential location exceed:

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

Where there are noise events found to exceed the initial screening level, further analysis is undertaken to identify:

- The likely number of events that might occur during the night assessment period,
- The extent to which the maximum noise level exceeds the rating background noise level.

During the night time period, only mechanical plant will be operating, including the tracking motors, inverters and the substations. Noise emissions from these plant items are considered to be continuous with no potential for high peak noise level events. Therefore, the L_{Amax} noise levels experienced at the identified receivers will be similar to the predicted $L_{Aeq,15min}$ noise levels shown in Table 5.5. Hence, it is expected that both the $L_{Aeq,15min}$ and L_{AFmax} will be well below the nominated sleep disturbance criteria of 40dB(A) and 52dB(A), respectively.

6 Vibration Assessment

Vibration generating activities would occur only during the construction phase of the project. There are no vibration generating activities expected during the operational phase. As the nearest identified receivers are in excess of 50m from the subject site, structural damage due to vibration is not expected. Assessment for vibration impact on human comfort is assessed in accordance with EPA requirements.

6.1 Vibration Criteria

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's 'Assessing Vibration; a technical guideline' (DECC, 2006). The guideline provides criteria which are based on British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 6.1 provides definitions and examples of each type of vibration.

Table 6.1 – Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

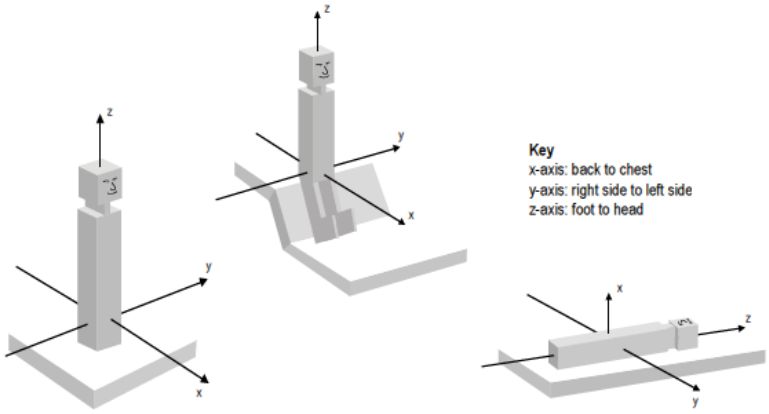
The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *"Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472)."*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as

illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2 – Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced in Table 6.2 for the applicable receivers.

Table 6.2 – Preferred and Maximum Levels for Human Comfort

Location	Assessment Period[1]	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7:00am to 10:00pm and Night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 6.3 for the applicable receiver type.

Table 6.3 – Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

Notes: 1. Daytime is 7:00am to 10:00pm and Night-time is 10:00pm to 7:00am

6.2 Potential Vibration Impacts

Based on the proposed plant items presented in Table 4.4, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 6.4 below. The assessment is relevant to the identified receiver locations.

Table 6.4 – Potential Vibration Impacts for Identified Receivers

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts	Vibration Monitoring
Receiver R1	330m	Residential	Very low risk of adverse comments	Not required
Receiver R2	135m	Residential	Very low risk of adverse comments	Not required
Receiver R3	315m	Residential	Very low risk of adverse comments	Not required
Receiver R4	110m	Residential	Very low risk of adverse comments	Not required
Receiver R5	910m	Residential	Very low risk of adverse comments	Not required
Receiver R6	225m	Residential	Very low risk of adverse comments	Not required
Receiver R7	330m	Commercial	Very low risk of adverse comments	Not required
Receiver R8	270m	Commercial	Very low risk of adverse comments	Not required
Receiver R9	430m	Residential	Very low risk of adverse comments	Not required
Receiver R10	75m	Commercial	Low risk of adverse comments	Not required
Receiver R11	1300m	Residential	Very low risk of adverse comments	Not required
Receiver R12	1400m	Residential	Very low risk of adverse comments	Not required
Receiver R13	1200m	Residential	Very low risk of adverse comments	Not required
Receiver R14	60m	Residential	Low risk of adverse comments	Not required

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts	Vibration Monitoring
Receiver R15	900m	Residential	Very low risk of adverse comments	Not required
Receiver R16	760m	Residential	Very low risk of adverse comments	Not required
Receiver R17	90m	Residential	Very low risk of adverse comments	Not required
Receiver R18	90m	Residential	Very low risk of adverse comments	Not required
Receiver R19	150m	Residential	Very low risk of adverse comments	Not required
Receiver R20	100m	Residential	Very low risk of adverse comments	Not required
Receiver R21	170m	Residential	Very low risk of adverse comments	Not required
Receiver R22	70m	Residential	Low risk of adverse comments	Not required
Receiver R23	370m	Residential	Very low risk of adverse comments	Not required

The potential for adverse comments to vibration impacts during the construction works was determined to be low to very low due to the large distances between the receiver locations and the construction activities. Therefore, additional vibration mitigation measures and vibration monitoring are not required at the identified receiver locations during construction works associated with the project.

7 Road Traffic Noise Assessment

Noise impact from the potential increase in traffic on the surrounding road network due to construction and operational activities is assessed against the NSW 'Road Noise Policy' (RNP, 2011). The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for sensitive receivers that are potentially affected by road traffic noise associated with the construction and operation of the subject site, with the aim of preserving the amenity appropriate to the land use.

Vehicle access to the subject site will be via Campbells Lane. Based on information provided by the client, the maximum trips per day throughout the construction stage are presented in Table 7.1. The trips per day were multiplied by a factor of two (2) in the noise prediction model, as it assumes that each single trip will enter and exit through Campbells Lane. Furthermore, vehicle movements will only occur during the day time period when construction works occur. Therefore, to determine the average hourly vehicle movements to and from the site, the daily vehicle movements were divided by 11 to represent the weekday construction hours from 7am to 6pm.

Table 7.1 – Summary of the Estimated Construction Traffic Volumes During Peak Construction

Vehicle Type	Trips per Day	Movements per Day[1]	Average Hourly Movements[2]
Cars/ light vehicles	17	34	3
Trucks/ heavy vehicles	52	104	10

Notes: 1. Movements per day based on 2 x trips per day, representing vehicles entering and exiting the site
2. Average hourly movements based on movements per day ÷ 11, representing construction hours from 7am to 6pm

During the operational stage, vehicle access to the site will be maintenance vans and delivery trucks (4 x site staff light vehicle and 5 x miscellaneous courier deliveries per week) which would occur on an irregular basis. Therefore, traffic noise impacts during the operational stage of the project would be minimal and insignificant and will not be assessed further.

7.1 Road Traffic Noise Criteria

Based on functionality, Campbells Lane is categorised as a local road. For existing residences affected by additional traffic on existing local roads generated by land use developments, the following RNP road traffic noise criteria apply.

Table 7.2 – RNP Road Traffic Noise Criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment Criteria, dB(A)	
		Day 7am – 10pm	Night 10pm – 7am
Local road	6. Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,(1\ hour)}$ 50 (external)

A traffic survey to determine existing traffic volumes along Campbells Lane was undertaken by GHD and detailed in the 'Traffic and Parking Assessment' (ref 4131379, dated May 2018). The existing traffic volumes recorded are reproduced in the table below.

Table 7.3 – Exiting Traffic Volumes Along Campbells Lane

Campbells Lane	Average Weekday AM Peak Hour[1]	Average Weekday PM Peak Hour[1]	Saturday Peak Hour[1]	Weekday Heavy Vehicle %	Weekend Heavy Vehicles %	Speed Limit[2]
Westbound	2	3	1	12%	7%	100 km/h
Westbound	2	5	4			

Notes: 1. Vehicles per hour
2. Speed limit provided in Table 2-3 of the 'Traffic and Parking Assessment' prepared by GHD

7.2 Predicted Road Traffic Noise

From Table 7.3, the existing worst case hourly traffic volumes along Campbells Lane occur during the weekday PM peak hour period. Furthermore, the average hourly vehicle movements presented in Table 7.1 were used to represent the additional traffic along Campbells Lane during construction of the project. Results of the road traffic noise predictions are presented in the table below.

Table 7.4 – Predicted Road Traffic Noise Contribution Levels Along Public Roads, dB(A) $L_{Aeq(1\ Hour)}$

Receiver	Criteria	Traffic Movements		Speed (km/h)	Approx. Distance to Road	Predicted Noise Level	Exceed?
		Light Vehicle	Heavy Vehicle				
Nearest receivers	$L_{Aeq,\ (1\ hour)}$ *55*	11 (8 + 3)	11 (1 + 10)	100	110m	55	No

From the above table, traffic noise levels along Campbells Lane due to additional traffic during the construction stage of the project is predicted to comply with applicable noise criterion at the nearest affected receivers.

As the construction traffic noise levels are temporary and comply with the RNP criteria set above, it indicates that the traffic noise levels due to the construction works for the solar farm would not adversely affect the existing residences along Campbells Lane.

8 Conclusion

Renzo Tonin and Associates has completed an environmental noise and vibration assessment of the proposed Wellington North Solar Plant.

Noise emissions from the construction phase of the project were predicted to exceed the construction noise management levels at the nearest affected receivers. In-principle recommendations are provided in Section 4.5 to limit the potential impact of noise generated by construction activities to acceptable levels.

Noise emissions from the operational phase of the project were predicted to comply with the nominated criteria at the nearest affected receivers.

Given the large separation distance between the nearest affected receivers and the subject site, vibration impacts resulting in structural damage to buildings at the nearest affected receivers are determined to be negligible and there is low risk of adverse comments from occupants of dwellings due to construction vibration.

Road traffic noise impacts on residential properties along the access route were found to comply with the relevant RNP criteria.

APPENDIX A Glossary of Terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Long-Term Noise Monitoring Methodology

B.1 Noise Monitoring Equipment

A long-term unattended noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave Band Data	Logger Location(s)
RTA04 (CESVA SC310)	Type 1	1/1	L1

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

B.2 Meteorology During Monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW NPfI. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative of the noise monitoring location(s). However, the data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is typically 1.5m above ground level (and less than 3m). The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B.3 Noise vs Time Graphs

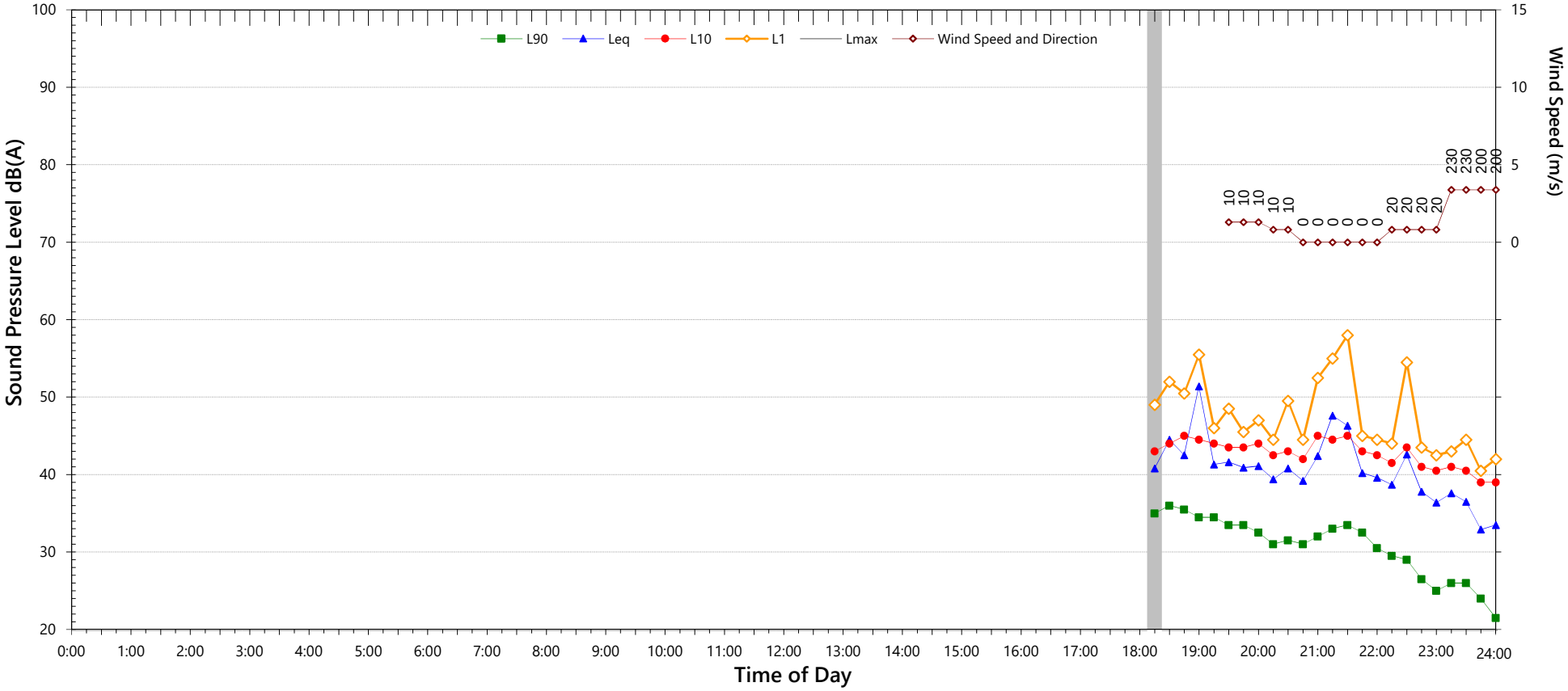
Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband dB(A) results.

APPENDIX C Long Term Noise Monitoring Results

Unattended Noise Monitoring Results

Location L1

Thursday, 5 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	-	31.0	18.5
LAeq	-	44.3	45.0

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	46.8	47.5
$L_{eq\ 1hr}$ upper 10 percentile	50.4	53.6
$L_{eq\ 1hr}$ lower 10 percentile	43.1	28.9

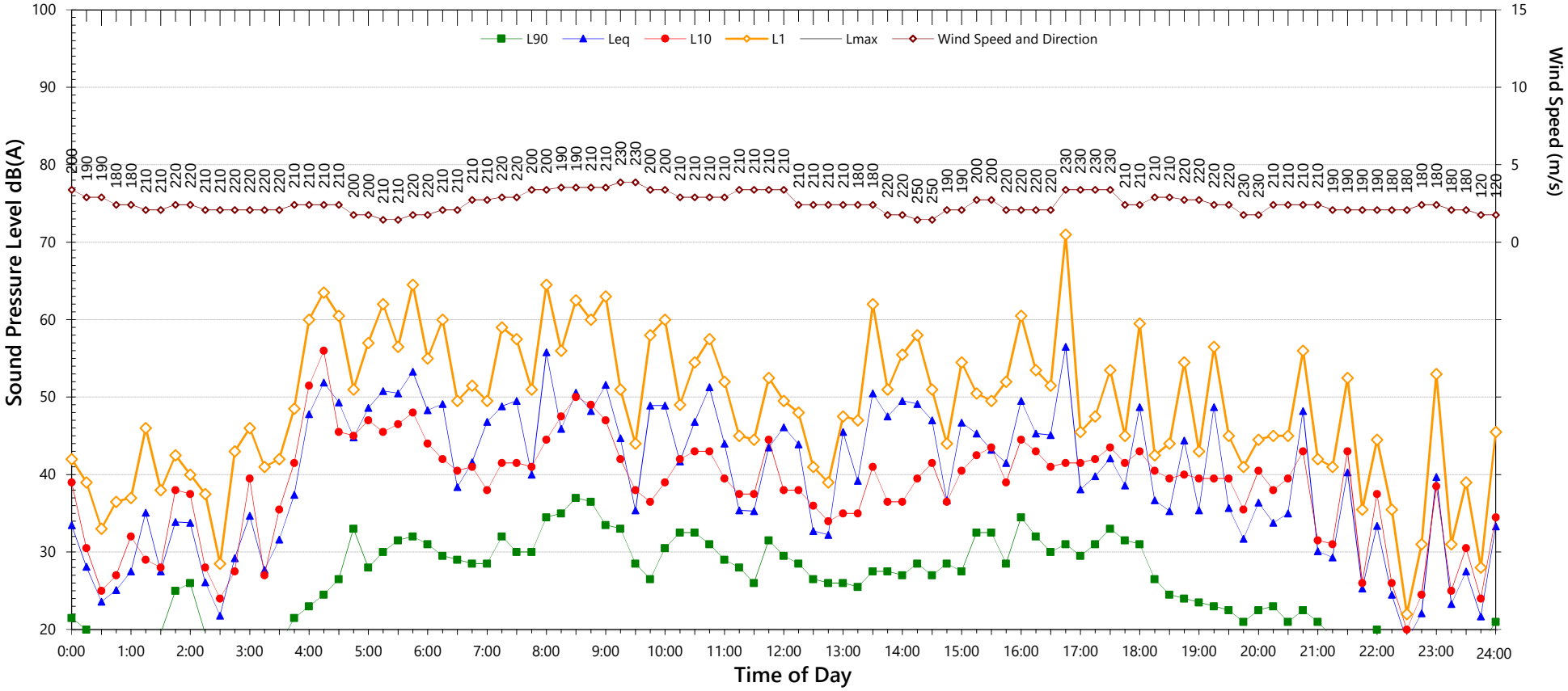
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Friday, 6 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	26.5	19.0	18.0
LAeq	47.9	41.2	47.6

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	49.4	50.1
$L_{eq\ 1hr}$ upper 10 percentile	53.8	55.1
$L_{eq\ 1hr}$ lower 10 percentile	40.7	30.5

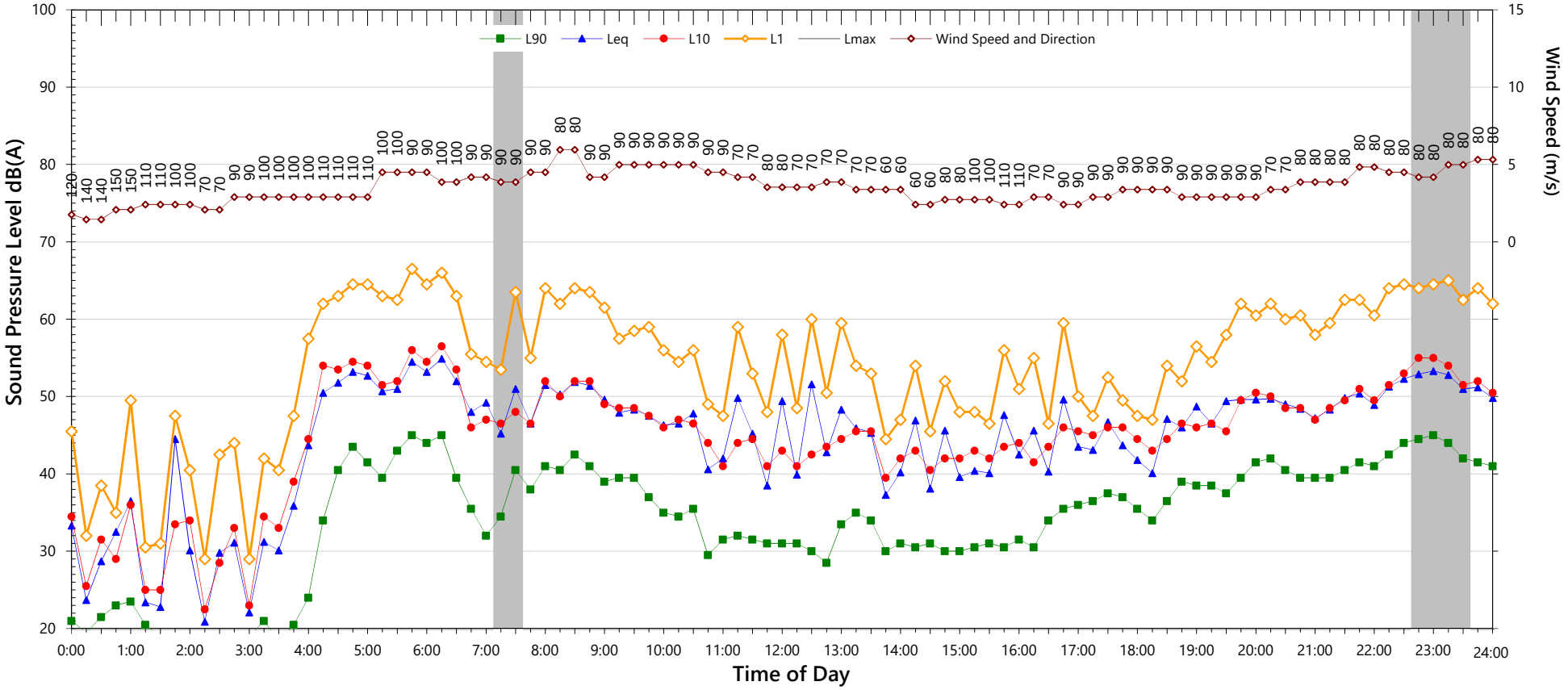
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Saturday, 7 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	30.0	36.5	25.5
LAeq	46.9	48.5	49.1

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	49.9	51.8
$L_{eq\ 1hr}$ upper 10 percentile	52.8	55.7
$L_{eq\ 1hr}$ lower 10 percentile	46.1	37.6

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

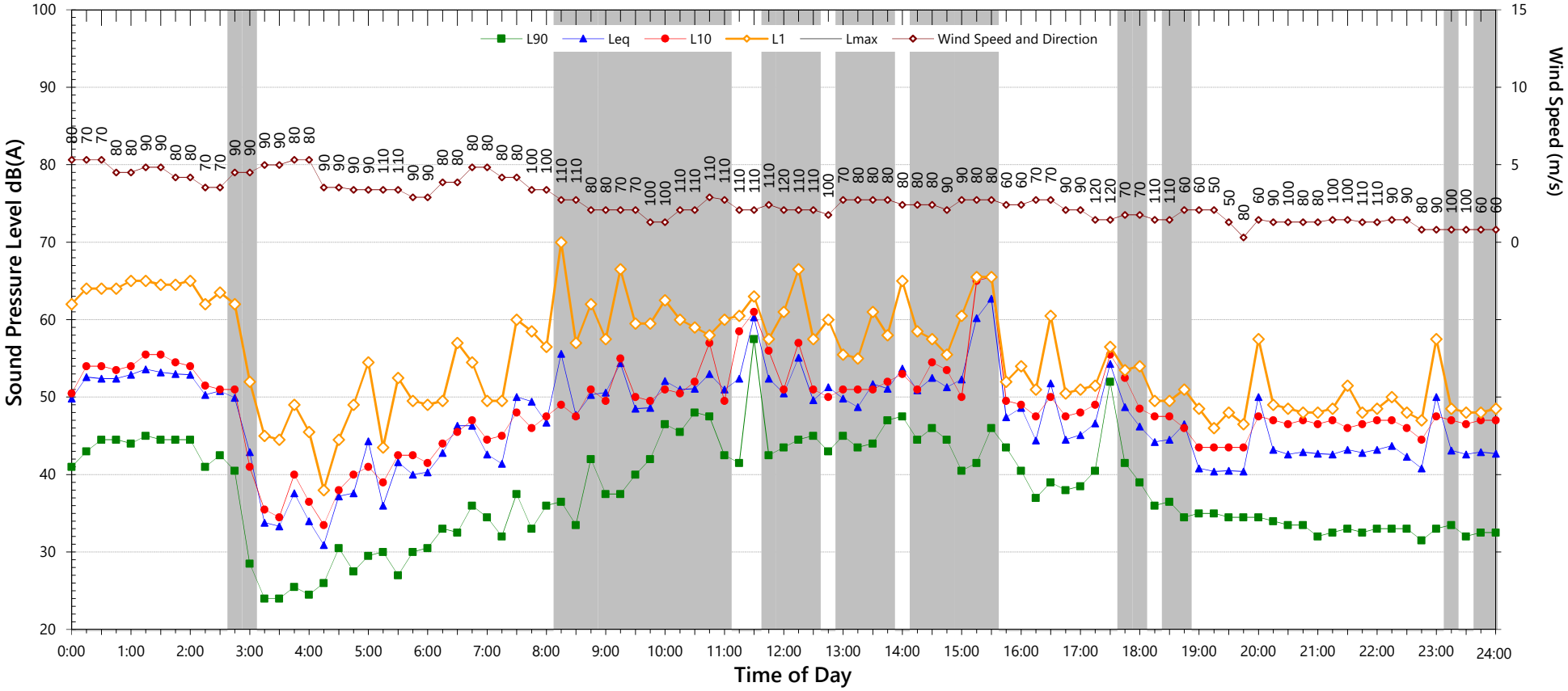
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Sunday, 8 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	38.0	32.5	29.0
LAeq	52.8	43.7	48.4

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	52.3	50.9
$L_{eq\ 1hr}$ upper 10 percentile	60.2	55.2
$L_{eq\ 1hr}$ lower 10 percentile	45.3	45.0

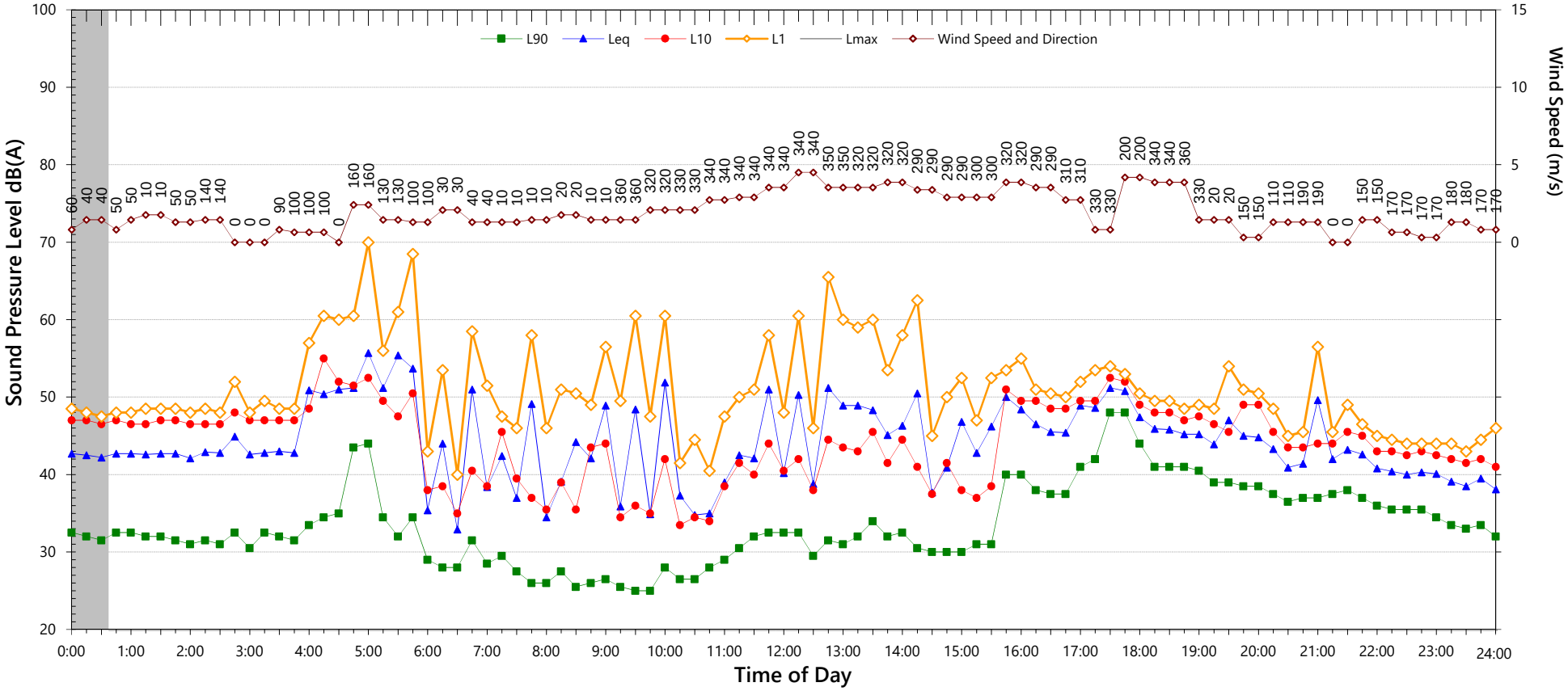
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Monday, 9 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	26.0	36.5	23.5
LAeq	47.0	44.8	45.2

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	49.0	47.7
$L_{eq\ 1hr}$ upper 10 percentile	51.9	52.5
$L_{eq\ 1hr}$ lower 10 percentile	42.8	36.3

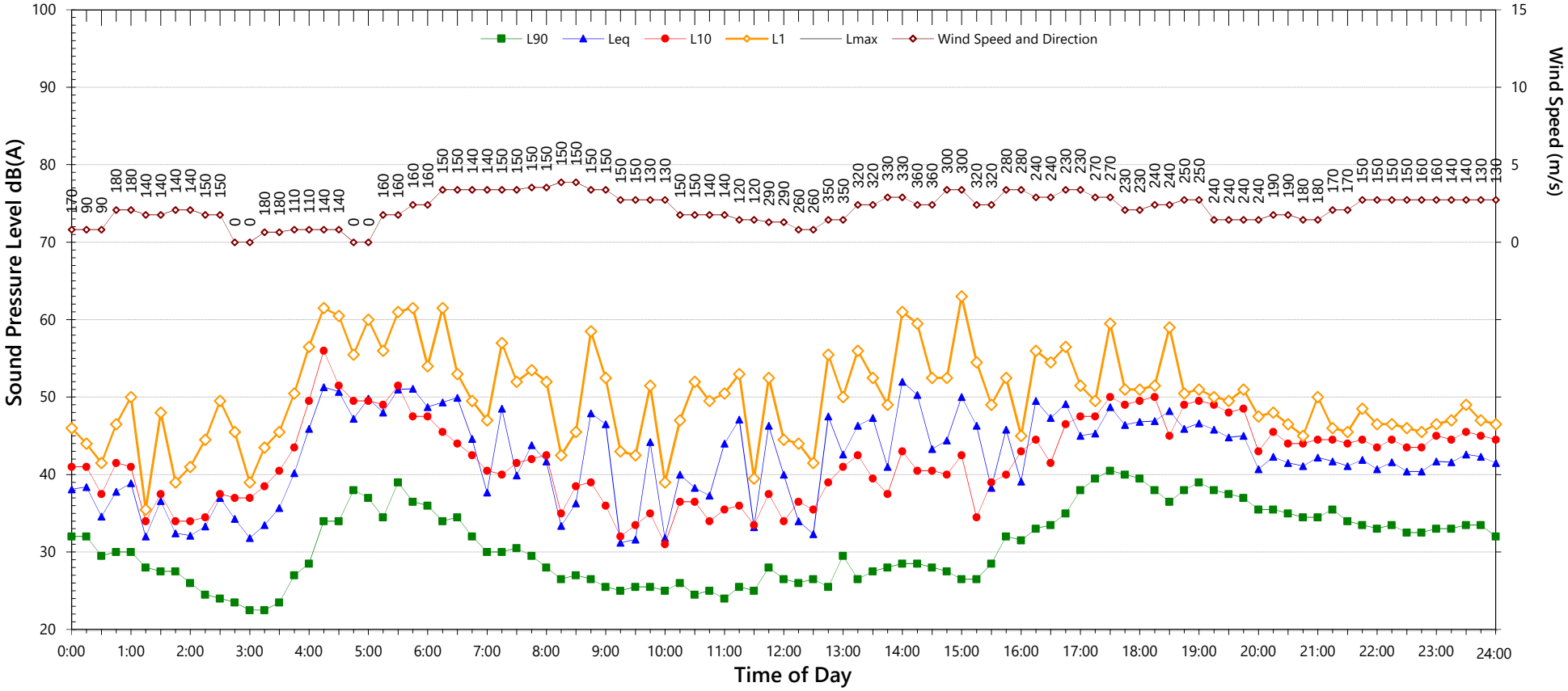
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Tuesday, 10 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	25.0	33.5	30.0
LAeq	45.5	44.3	45.6

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	47.7	48.1
$L_{eq\ 1hr}$ upper 10 percentile	50.7	52.2
$L_{eq\ 1hr}$ lower 10 percentile	42.4	43.4

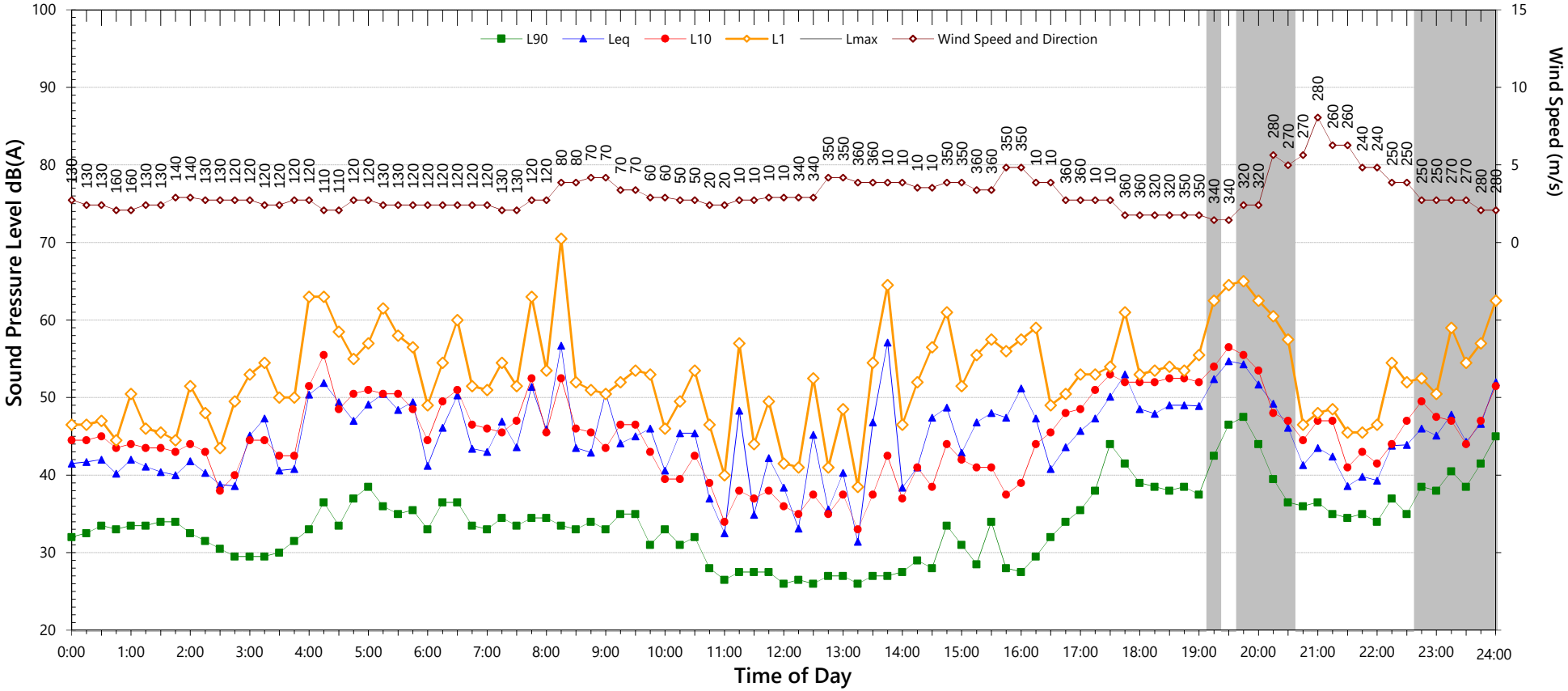
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Wednesday, 11 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	26.5	34.5	32.0
LAeq	48.0	47.9	42.4

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	50.5	44.9
$L_{eq\ 1hr}$ upper 10 percentile	56.0	46.4
$L_{eq\ 1hr}$ lower 10 percentile	43.1	41.7

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

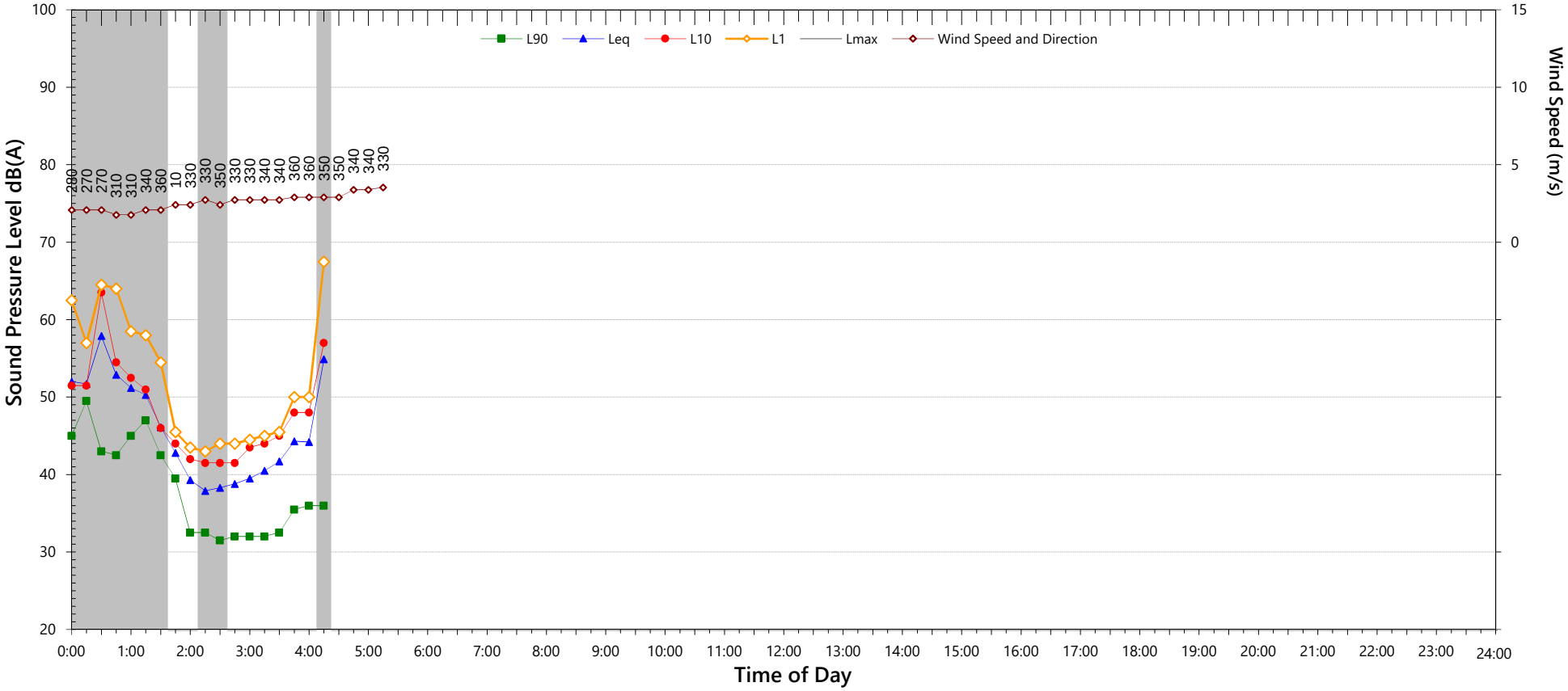
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

Location L1

Thursday, 12 October 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	-	-	-
LAeq	-	-	-

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	-	-
$L_{eq\ 1hr}$ upper 10 percentile	-	-
$L_{eq\ 1hr}$ lower 10 percentile	-	-

Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)