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PLANNING PROPOSAL FOR LOT 3 DP 1195030, BUNGENDORE

Environmental Noise Assessment

18 August 2017

Queanbeyan-Palerang Regional Council

TJ750-01F02 (r3) Noise Assessment

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Document Details

Detail	Reference
Doc reference:	TJ750-01F02 (r3) Noise Assessment
Prepared for:	Queanbeyan-Palerang Regional Council
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Document Control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
04/08/2017	Generate Document	0-1	2	AC	MCH	MCH
18/08/2017	Final Report	-	3	AC	MCH	MCH

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1 Introduction

Renzo Tonin & Associates was engaged by Queanbeyan-Palerang Regional Council to provide an environmental noise assessment for the Planning Proposal for Lot 3 DP 1195030, located on Majara Street in Bungendore. The proposal is for the rezoning of the site from IN2 Light Industrial to R2 Low Density Residential. The purpose of the noise study was to determine potential impacts from existing industrial facilities to the west of the proposed site and future light industrial uses to the north of the site.

The report quantifies noise imission onto the site from the existing and future industrial uses surrounding the site. Industrial noise impacting the site is assessed in accordance with the NSW Environment Protection Authority's (EPA) 'Industrial Noise Policy' (INP – 2000) and other relevant policies, guidelines and/or legislations.

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

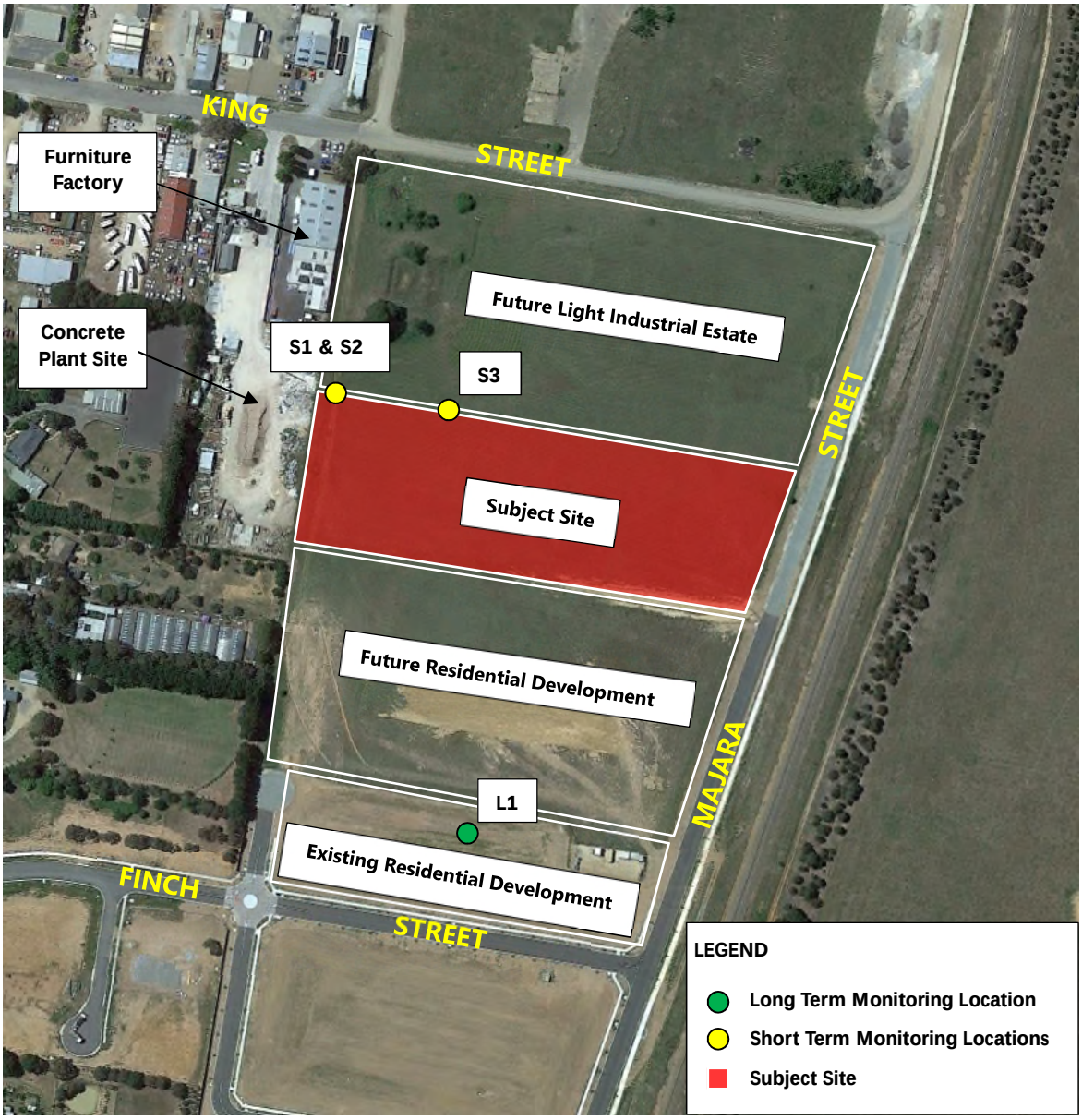
2.1 Site Description

The Site, Lot 3, DP 1195030 is located in the southeast of the rural township of Bungendore. The site is bounded by following features:

- Majara Street and a rail line are located to the east of the site. Rural farmlands are located further to the east of the Majara Street.
- Existing industrial facilities, including Bungendore Concrete and Uneke Furniture are located to the west of the site and share common boundaries with the site. It is understood that the operation of the industrial facilities is limited to the daytime hours of 7am to 6pm, Monday to Friday and 7am to 12pm on Saturdays. Additionally, the manager of the concrete plant advised that a compressor is activated around 6am that operates a pneumatic equipment on the silos.
- Future light industrial estate, fronting King Street is proposed to be located to the north of the site. The development of the proposed light industrial estate has been approved for 14 lots; however, it is currently a greenfield site and no industrial facilities have been constructed at the time of this assessment.
- A residential development along Finch Street is located to the south of the site, with a future residential development to be located between Finch Street and the subject site.

Figure 1 below shows the site, surrounds and monitoring locations.

Figure 1 – Site, Surrounds and Monitoring Locations



2.2 Assessment Methodology

The following methodology was used to assess the potential noise impacts from the existing and proposed industrial developments onto the subject site;

- Identify noise sources from the nearby industrial developments potentially affecting the subject site.
- Determine the noise immission from the existing nearby industrial developments onto the subject site.
- Determine existing background noise levels representative of the subject site without industrial noise.
- Use monitored ambient noise and background levels to establish noise goals in accordance with the standard noise criteria issued by the relevant authority.
- Determine the extent of noise impact from the industrial developments on the proposed residential site using predictive noise modelling software.
- Identify where noise emission from the site may exceed the relevant criteria.
- Where noise emission from the site is predicted to exceed the relevant criteria examine potential amelioration methods.

3 Existing Noise Environment

Criteria for the assessment of industrial noise are usually derived from the existing noise environment of an area. Appendix B of the NSW EPA's 'Industrial Noise Policy' (INP) outlines two methods for determining the background noise level of an area, being 'B1 – Long-term background noise method' and 'B2 – Short-term background noise method'. This assessment has used a combination of long-term and short-term noise monitoring.

As the noise environment of an area almost always varies over time, background noise levels need to be determined for the purpose of determining construction noise goals. The INP outlines the following standard time periods over which the background noise levels are to be determined:

- **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.

The INP also outlines methods for assessing 'shoulder periods' being shorter periods on either side of a standard period, where the standard period noise levels are not representative. For this project a shoulder period is considered for the period between 6am and 7am where the night time period background noise level is not representative. This was considered for the assessment of the compressor and pneumatic equipment at the concrete plant.

3.1 Noise Monitoring Locations

Long-term and short-term noise monitoring was undertaken at the following locations to determine existing L_{eq} industrial noise levels and background L_{90} noise levels at the subject site.

Table 3.1 – Noise Monitoring Locations

ID	Description
Long-Term Noise Monitoring	
Location L1	**15 Finch Street** The noise monitor was located in the rear yard of the residential property, approx. 150m to the south of the subject site, in the free field (ie. away from any buildings). Noise levels were dominated by natural sounds from flora and fauna. The noise environment at this location is considered representative of the subject site without noise from nearby industrial sites.
Short-Term Noise Monitoring	
Location S1, S2	**Lot 3 DP1195030 (The Site)** Noise monitors were located at the north-western side of the subject site and approx. 3.5m east of the common boundary fence with the adjoining concrete batch plant. The microphones of the monitors were located in the free-field at 1.5m (S1) and 4.5m (S2) above the ground level to represent ground floor and first floor levels of future residential dwellings. Noise levels were dominated by industrial noise from the concrete batch plant and furniture factory.

ID	Description
Location S3	**Lot 3 DP1195030 (The Site)** A noise monitor was located along the northern lot boundary of the site and approx. 55m east of the common boundary fence with the adjoining concrete batch plant. The microphone of the noise monitor was located in the free-field at 1.5m above the ground level. Noise levels were dominated by industrial noise from the concrete batch plant and furniture factory.

Figure 1 presents the monitoring locations and surrounding area.

3.2 Long-Term Noise Measurement Results

Long-term (unattended) noise monitoring was conducted from Tuesday 4th to Wednesday 12th July 2017 to quantify the existing ambient noise environment.

Weather information was obtained from the Bureau of Meteorology for the area over this monitoring period and any data adversely affected by rain, wind or extraneous noise were discarded.

The graphical recorded output from the long-term noise monitoring is included in APPENDIX C of this report. The graphs in APPENDIX C were analysed to determine a single assessment background level (ABL) for each day, evening and night period, in accordance with the NSW 'Industrial Noise Policy'.

Existing ambient and background noise levels at the long-term noise monitoring location (L1) are presented in Table 3.2 below and are considered representative of the noise environment at the subject site without existing industrial noise contributions.

Table 3.2 – Measured Existing Background (L_{90}) & Ambient (L_{eq}) Noise Levels, dB(A)

Monitoring Location	L_{A90} Background Noise Levels				L_{Aeq} Ambient Noise Levels			
	Shoulder[1]	Day[2]	Evening[3]	Night[4]	Shoulder[1]	Day[2]	Evening[3]	Night[4]
Location L1 – 15 Finch Street	36	36	29	22	48	47	38	40

Notes:
1. The shoulder period has been established for 6am to 7am. The shoulder period rating background level is taken to be the mid-point between the rating background levels between the two assessment periods that are on either side of the shoulder period.
2. Day: 7am to 6pm Monday to Saturday and 8am to 6pm Sundays & Public Holidays
3. Evening: 6pm to 10pm Monday to Sunday & Public Holidays
4. Night: 10pm to 7am Monday to Saturday and 10pm to 8am Sundays & Public Holidays

3.3 Short-Term Noise Measurement Results

Short-term noise measurements were undertaken during the morning of Wednesday 12th July 2017 from 7am to 8.30am to establish the existing industrial noise levels used to validate the noise model.

Investigation into the operation of the nearby industrial sites revealed the dominant noise source potentially impacting the subject site would be generated by the adjoining concrete batch plant. Through discussions with the management of the concrete plant it was confirmed that the operating hours are 7am to 6pm, Monday to Friday and 7am to 12pm on Saturdays. The number of concrete trucks entering the site and loaded with concrete during a day may be up to 20 based on demand and

weather. Primary operation of the concrete plant typically occurs between 7am and 8am daily and throughout the day as required. Typical activities include:

- Transfer of materials from elevated silos into concrete agitator trucks,
- Vibratory shaking of the silos to loosen materials,
- Mixing of materials in concrete agitator trucks,
- Operation of front end loader to transfer materials from storage bins to feeders,
- Wash out of concrete agitator trucks and equipment at the end of deliveries.
- Truck delivery of cement as required. This may occur once per fortnight or up to twice per week.

During the noise measurements, mechanical plant associated with the concrete plant was audible and continuous throughout its operations. Noise from vibratory shaking of the silos occurred for 1 to 5 minutes during the loading of each concrete truck and was clearly audible over the background noise environment. Mixing of the concrete in the agitator trucks was continuous for approximately 10 minutes per truck and was the main contribution to the noise environment during operations.

In addition to the loading and mixing process, intermittent noise was emitted from a pneumatic valve on the silo which provides a pulse of air approximately every 20 seconds, emitting a puff sound that is clearly audible over the background noise. It was confirmed by management of the concrete plant that air pulsing occurs while the compressor is operating. The compressor is usually switched on when staff arrive in the morning, typically between 6am and 6.30am, and switched off at the end of daily operations on the site, typically between 3pm and 5pm.

The duration of the process of loading and mixing the concrete in the trucks was approximately one hour. Once the process was complete and the concrete agitator trucks left the site, all plant appeared to be shut down and there was no significant noise emission from the site, with the exception of the pneumatic pulse from the silo, which is switched off at the end of daily operations.

Management of the concrete plant confirmed that the main activities relating to the concrete batching are located in the northern area of the site. The southern area of the site is used for storage and is not used for typical operational activities.

Activity from the adjacent furniture factory typically occurs between 7am and 5pm and includes operation of a dust collector and various woodworking machinery. The operations of the factory are considered small to medium scale with use of machinery understood to be intermittent and located within the factory building. Noise from the furniture factory was just audible at the monitoring location S1.

A summary of the short-term measurement results is presented in Table 3.3.

Table 3.3 – Measured Existing Industrial (L_{eq}) Source Noise Levels, dB(A)

Date	Time	Noise Source	Location	Microphone Height	$L_{Aeq, 15minute}$ (Plant On)	$L_{Aeq, 15minute}$ (Plant Off)[1]	L_{Aeq} Source Noise Level
12 July 2017	7.45am to 8.00am	Concrete plant	S1	1.5m	52	43	51
			S2	4.5m	55		55
			S3	1.5m	50		49
12 July 2017	8.00am to 8.15am	Furniture factory	S1	1.5m	48	43	46
			S2	4.5m	50		49
			S3	1.5m	48		46

Notes: 1. L_{A90} background noise level for the period from 6.45am to 7.00am at Location L1, immediately prior to operation of industrial noise sources

Table 3.4 – Measured Existing Industrial (L_{max}) Source Noise Levels - Pneumatic Air Puff, dB(A)

Date	Time	Noise Source	Location	Microphone Height	L_{Amax} Noise Level
12 July 2017	7.33am	Pneumatic air puff from concrete silo	S1	1.5m	52
			S2	4.5m	55
			S3	1.5m	50

Notes: 1. Short pulse of air occurring approximately every 20 seconds.

4 Acoustic Criteria

4.1 Industrial Noise Policy (INP)

The NSW Industrial Noise Policy (INP) assessment has two components:

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

4.1.1 Intrusive Noise Criteria

According to the INP, 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} descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A). The intrusiveness criterion is summarised as follows:

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5dB

It is noted that where the RBL is measured to be less than 30dB(A), then it is set to 30dB(A), in accordance with Section 3.1 of the INP.

4.1.2 Amenity Noise Criteria

The INP amenity criteria are designed to maintain noise level amenity for particular land uses, including residential and other land uses. The INP recommends base acceptable noise levels for various receivers, including residential, commercial, industrial receivers and other sensitive receivers in Table 2.1 of the INP. Noise from new sources need to be designed such that the cumulative effect does not produce levels that would significantly exceed the criterion.

Table 4.1 – INP Amenity Criteria, dB(A)

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended $L_{Aeq(Period)}$ Noise Level	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

Note:
1. 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 to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 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

4.1.3 Summary of Noise Goals

In accordance with the INP, noise impact should be assessed in terms of both intrusiveness and amenity. The applicable noise criteria were determined from the background and ambient noise monitoring carried out at the nearby residential location.

Given that the industrial facilities operate during the day time period, only the criteria for the day period are presented herein.

A summary of the project specific noise criteria is set out below.

Table 4.2 – Summary of Project Specific Noise Criteria, dB(A)

Type of receiver	Time of Day	Intrusiveness Criteria[1]	Amenity Criteria[2]
Residence	Day	36 + 5 = **41**	**55**

Notes: 1. Intrusiveness criteria determined based on daytime background noise levels monitored at Location L1
2. The daytime amenity criteria have been adopted for the residential type receivers in a suburban area

The table above shows that the intrusiveness criteria of 41dB(A) is more stringent than the amenity criteria of 55dB(A). Therefore, for a conservative approach, the intrusiveness criteria have been applied for the noise assessment.

4.2 Sleep Disturbance Criteria

Given that the intermittent pneumatic air puff from the concrete silo occurs from 6am, which is during the night time period, noise imission onto the proposed residential site has been assessed for its potential to disturb sleep. The NSW EPA has made the following policy statement with respect to sleep disturbance:

"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. The INP does not specifically address sleep disturbance from high noise level events.

Research on sleep disturbance is reviewed in the NSW Road Noise Policy. This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research, the EPA recognised that the current sleep disturbance criterion of an $L_{A1, (1\ minute)}$ not exceeding the $L_{A90, (15\ minute)}$ by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, the EPA will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or $L_{A1, (1\ minute)}$, that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy. Other factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events will occur

- time of day (normally between 10pm and 7am)

- whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

The $L_{A1, (1\ minute)}$ descriptor is meant to represent a maximum noise level measured under 'fast' time response. The EPA will accept analysis based on either $L_{A1, (1\ minute)}$ or $L_{A, (Max)}$."

Source: http://www.epa.nsw.gov.au/noise/applicnotesindustnoise.htm

Where the background noise levels are less than 40dB(A), some studies indicate that the above approach may result in noise limits that are unnecessarily strict.

In relation to maximum noise level events, the NSW 'Road Noise Policy' (NSW EPA, 2012) identifies several investigations into the impacts of intermittent and emerging noise sources on the disturbance of sleep. Reference is made to enHealth report (2004) which notes the following in relation to maximum noise level events:

"As a rule in planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) L_{Amax} more than 10 or 15 times per night."

The NSW 'Road Noise Policy' summaries the research on sleep disturbance to date as follows:

"maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep

one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly "

The above references identify that internal noise levels of 45dB(A) and up to 55dB(A), may have the potential to impact sleep but are unlikely to cause awakenings. On the assumption that there is a 10dB(A) outside-to-inside noise loss through an open window (see NSW 'Industrial Noise Policy', p17), the above references indicate that external noise levels of L_{Amax} 55 to 65dB(A) are unlikely to cause awakening reactions.

To assess the likelihood of sleep disturbance, an initial screening level of (L_{Amax} or $L_{A1(1min))} \leq L_{A90(15min)}$ + 15dB(A) is used. In situations where this results in an external screening level of less than 55dB(A), a

minimum screening level of 55dB(A) is set. Note that this is equivalent to a maximum internal noise level of 45dB(A) with windows open.

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

- The likely number of events that might occur during the night assessment period
- Whether events exceed an 'awakening reaction' level of $L_{A1(1min))}$ 65dB(A).

Therefore, based on the measured noise levels for the shoulder period from 6am to 7am, the initial screening level is as follows:

Initial Screening level - $L_{A90(15min)}$ + 15 = (36 + 15) = **51dB(A)**

It can be seen that the screening level was determined to be less than 55dB(A). Therefore, based on the above information, the sleep disturbance assessment levels for the project are presented in Table 4.3.

Table 4.3 – $L_{A1,1min}$ (or L_{Amax}) Sleep Disturbance Assessment Levels, dB(A)

Receiver Location	External Screening Level ($L_{A90,15min}$ + 15)	Awakening Reaction Level
All residential receivers	55[1]	65

Notes: 1. Initial screening level determined to be less than 55dB(A); therefore, external screening level set at 55dB(A)

5 Noise Assessment

5.1 Assessment of Measurement Results

An assessment of the measured noise levels presented in Table 3.3 from the existing industrial facilities was conducted and results are presented below.

Table 5.1 – Assessment of Existing $L_{Aeq(15min)}$ Industrial Noise Levels Impacting the Subject Site, dB(A)

Location	Microphone Height	Period	Criteria	$L_{Aeq(15min)}$ Measured Noise Level [1]	Complies?
Concrete Batch Plant					
Location S1	1.5m (ground floor)	Day	*41*	51	**No, exceeds by 10dB(A)**
Location S2	4.5m (first floor)			55	**No, exceeds by 14dB(A)**
Location S3	1.5m (ground floor)			49	**No, exceeds by 8dB(A)**
Furniture Factory					
Location S1	1.5m (ground floor)	Day	*41*	46	**No, exceeds by 5dB(A)**
Location S2	4.5m (first floor)			49	**No, exceeds by 8dB(A)**
Location S3	1.5m (ground floor)			46	**No, exceeds by 5dB(A)**

Notes: 1. L_{Aeq} noise contribution from industrial source, as presented in Table 3.3

The results presented above show that noise from the concrete plant and furniture factory exceed the criteria at the monitoring locations by up to 10dB(A) for a ground floor location and up to 14dB(A) for a first floor location. Therefore, noise mitigation measures would be required in order to achieve compliance with the INP criteria for residential developments.

5.2 Sleep Disturbance Assessment

In addition to the assessment of measured $L_{Aeq(15min)}$ noise levels, Table 5.2 below presents an assessment of the measured L_{Amax} noise levels from Table 3.4 for sleep disturbance. The measured L_{Amax} noise levels represent the noise from the pneumatic pulse of air from the concrete plant silos during the night time shoulder period from 6am to 7am that has the potential to cause sleep disturbance.

Table 5.2 – Assessment of Sleep Disturbance from Existing L_{Amax} Industrial Noise Levels, dB(A)

Location	Height	Period	Criteria	L_{Aeq} Measured Noise Level[1]	Complies?
Location S1	1.5m (ground floor)	Night shoulder (6am to 7am)	*55*	52	Yes
Location S2	4.5m (first floor)			55	Yes
Location S3	1.5m (ground floor)			50	Yes

Notes: 1. L_{Amax} noise contribution from industrial source, as presented in Table 3.4

The results above indicate that existing L_{Amax} noise levels from the concrete plant would comply with the applicable sleep disturbance external screening limit of 55dB(A) at the nearest point to the noise source on the subject site. Therefore, no noise mitigation measures would be required for sleep disturbance.

5.3 Noise Modelling Methodology

Noise modelling was undertaken in addition to on-site measurements of industrial noise levels to assist in determining the noise impact across the subject site and in turn determining reasonable and feasible noise mitigation measures. The noise model was calibrated using the on-site measured noise levels.

The 3D noise model was based upon aerial maps of the area and layout plans for the proposed light industrial subdivision to the north of the subject site. Noise predictions for the development were carried out in accordance with ISO9613 as implemented by the Cadna-A computer modelling software. The software takes into account sound radiation patterns, acoustic shielding and potential reflections from intervening building elements, and noise attenuation due to distance.

The following assumptions and mitigation measures were included for the purpose of noise predictions:

- As observed on site, a 2.5m high solid wall was located on the common boundary between the concrete plant and the furniture factory.
- Noise sources representing the concrete truck mixing and silo operation were modelled at a height of 3.5m above the ground level.
- Noise source representing movement of trucks around the concrete plant was modelled in the northern area of the site.
- Development of the approved light industrial subdivision adjacent to the northern boundary of the subject site was modelled based on the layout plans approved by Queanbeyan-Palerang Regional Council as part of DA.2015.172 (drawing no. 3002456-DA10 Rev 4, dated 11th March 2016).
- A 2m high acoustic fence was modelled along the common boundary between the subject site and the approved light industrial subdivision to the north, in accordance with Condition 10 of the Conditions of Consent issued for DA.2015.172.
- Noise sources associated with the approved light industrial subdivision to the north were assumed to include truck movements along the access roads within the site. It was assumed that up to 4 trucks per hour would access the site.
- The receiver height was assessed at 1.5m above the ground level to represent single storey dwellings.

5.4 Noise Modelling Results

Six scenarios have been assessed to represent the presence of the light industrial subdivision to the north of the subject site, the presence of dwellings on the subject site and the implementation of various noise walls along the northern and eastern boundaries of the subject site. The results are presented below.

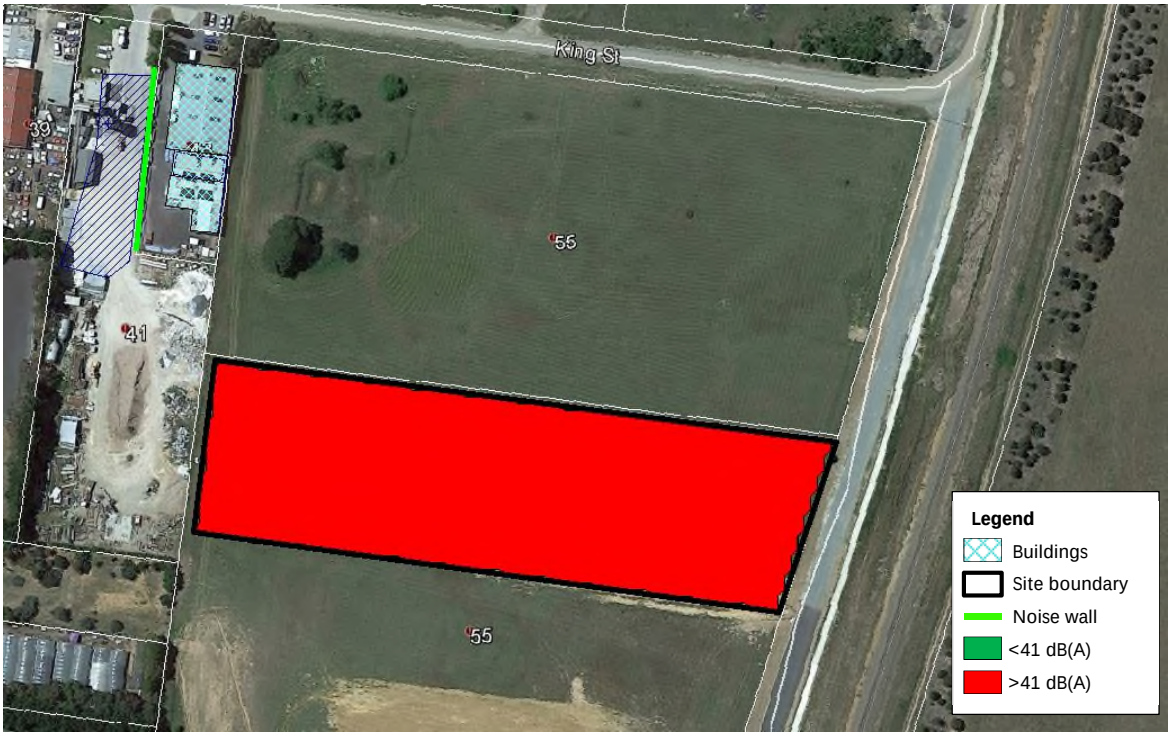
Noise modelling results are presented as noise contours maps covering the subject site, representing external noise levels on ground floor levels, applicable to single storey dwellings. The green shaded areas represent areas that comply with the 41dB(A) INP intrusiveness criterion.

5.4.1 Scenario 1

Scenario 1 represents the existing state of the subject site, where:

- No light industrial subdivision to the north of the subject site;
- No noise wall on the common boundary between the subject site and the concrete plant; and
- No dwellings on the subject site.

Figure 2 – Noise Modelling Results for Scenario 1



The modelling results for Scenario 1 show that noise impacts from the existing industrial sites would exceed the applicable criteria across the entire subject site based on the current situation, as there are no intervening structures to provide any shielding.

5.4.2 Scenario 2

Scenario 2 has been based on the following:

- Inclusion of approved light industrial subdivision to the north of the subject site;
- A 2m high noise wall on the common boundary between the subject site and approved light industrial subdivision;
- No noise wall on the common boundary between the subject site and the concrete plant; and
- No dwellings on the subject site.

Figure 3 – Noise Modelling Results for Scenario 2

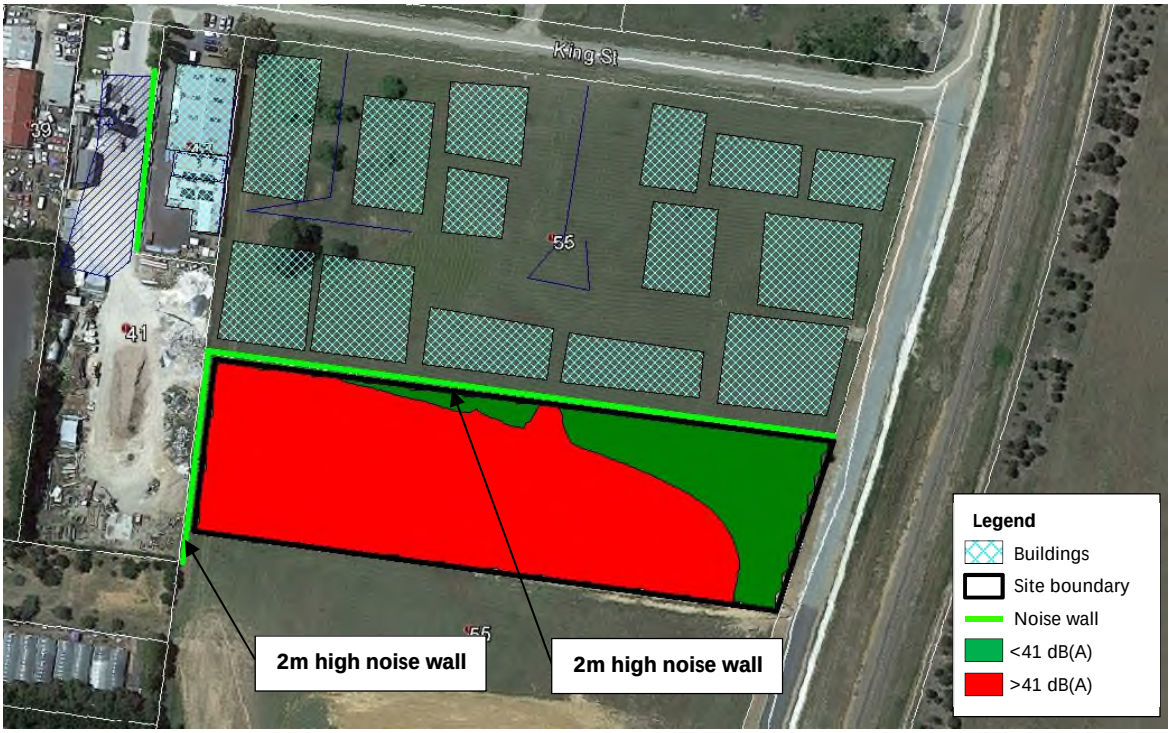
The modelling results for Scenario 2 show that if the approved light industrial subdivision to the north of the subject site is developed and a 2m high noise wall is constructed along the northern boundary, the buildings from the light industrial subdivision would provide some shielding of noise from the concrete plant and furniture factory to the eastern and northern areas of the subject site. However, the 2m high noise wall is not expected to provide significant noise shielding to the subject site. As a result, compliance with the applicable criteria is shown for parts of the northern and eastern areas of the subject site.

5.4.3 Scenario 3

Scenario 3 has been based on the following:

- Inclusion of approved light industrial subdivision to the north of the subject site;
- A 2m high noise wall on the common boundary between the subject site and approved light industrial subdivision;
- A 2m high noise wall on the common boundary between the subject site and the concrete plant; and
- No dwellings on the subject site.

Figure 4 – Noise Modelling Results for Scenario 3



The modelling results for Scenario 3 show that the results are very similar to the results for Scenario 2. It is noted that the 2m high noise walls provide minimal noise shielding and are only effective in areas directly behind the walls. As with Scenario 2, compliance with the criteria is shown for parts of the northern and eastern areas of the subject site.

5.4.4 Scenario 4

Scenario 4 has been based on the following:

- Inclusion of approved light industrial subdivision to the north of the subject site;
- A 2m high noise wall on the common boundary between the subject site and approved light industrial subdivision;
- No noise wall on the common boundary between the subject site and the concrete plant; and
- Inclusion of single storey dwellings on the subject site, representative of potential subdivision layout with dwellings positioned along the western boundary to optimise noise shielding effect.

Figure 5 – Noise Modelling Results for Scenario 4

The modelling results for Scenario 4 show that shielding is provided by the buildings within the light industrial subdivision to the north and the dwellings within the subject site. Positioning dwellings along the western site boundary is shown to be effective at providing shielding to other dwellings on the site such that compliance with the criteria is generally shown for the eastern and southern sides of the dwellings. However, noise impact on the western and northern sides of the dwellings would exceed the applicable criteria.

5.4.5 Scenario 5

Scenario 5 has been based on the following:

- No industrial subdivision to the north of the subject site;
- No noise wall on the common boundary between the subject site and approved light industrial subdivision;
- No noise wall on the common boundary between the subject site and the concrete plant; and
- Inclusion of single storey dwellings on the subject site, representative of potential subdivision layout with dwellings positioned along the western boundary to optimise noise shielding effect.

Figure 6 – Noise Modelling Results for Scenario 5

A comparison of the results for Scenario 4 and Scenario 5 show that the buildings and 2m high wall associated with the approved light industrial subdivision provides significant noise shielding benefits to the subject site. This scenario provides an appreciation of the noise impacts onto the subject site from existing industrial noise sources should the approved light industrial subdivision to the north not proceed.

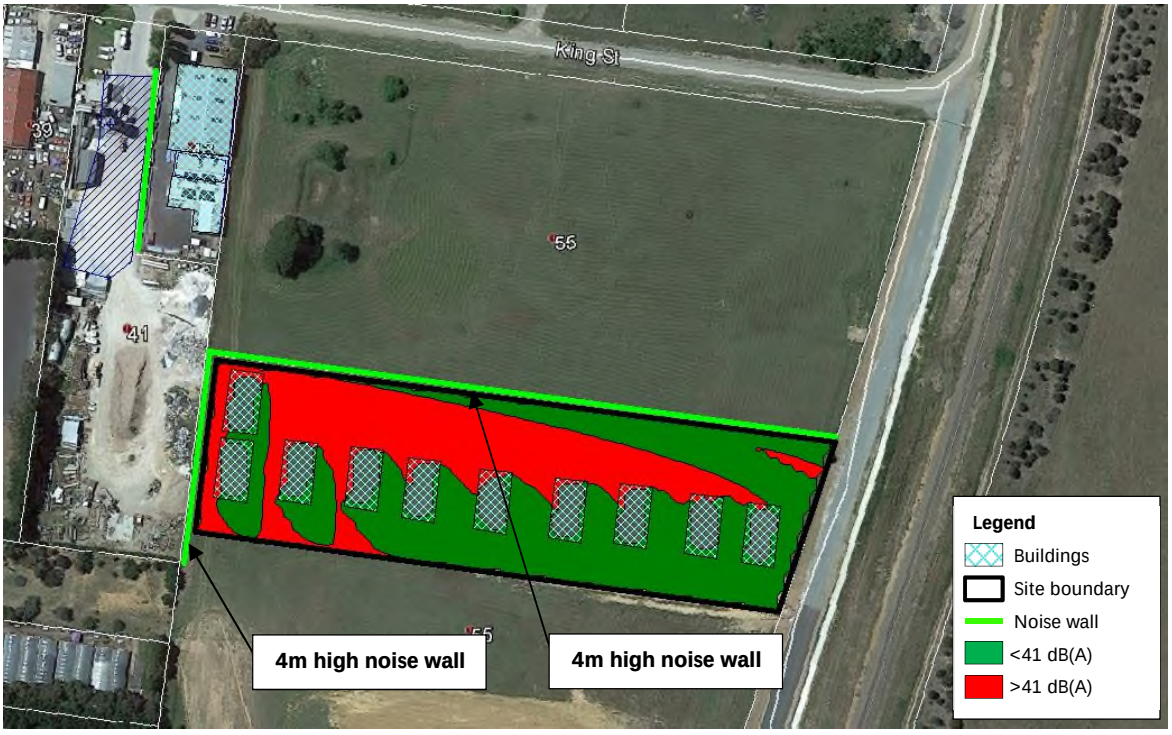
Noise shielding provided by the proposed dwellings within the subject site generally results in compliance with the applicable noise criteria for the eastern and southern sides of the dwellings. However, noise impact on the western and northern sides of the dwellings would exceed the applicable criteria.

5.4.6 Scenario 6

Scenario 6 has been based on the following:

- No light industrial subdivision to the north of the subject site;
- A 4m high noise wall on the northern boundary of the subject site;
- A 4m high noise wall on the common boundary between the subject site and the concrete plant; and
- Inclusion of single storey dwellings on the subject site, representative of potential subdivision layout with dwellings positioned along the western boundary to optimise noise shielding effect.

Figure 7 – Noise Modelling Results for Scenario 6



Scenario 6 is similar to that of Scenario 5, with the addition of 4m high noise walls on the northern and western site boundaries. A comparison of the results for Scenario 5 and Scenario 6 shows the noise shielding benefits that are provided by the 4m high noise walls. This scenario provides an appreciation of the noise impacts onto the subject site from existing industrial noise sources should the approved light industrial subdivision to the north not proceed.

Noise shielding provided by the proposed dwellings within the subject site generally results in compliance with the applicable noise criteria for the eastern and southern sides of the dwellings. However, noise impact on the western and northern sides of the dwellings would likely exceed the applicable criteria.

5.5 Discussion

The noise contours presented in Figure 2 to Figure 7 represent external noise levels on the ground floor levels of future proposed dwellings (ie. 1.5m above ground level).

Results show that the existing industrial facilities generate noise levels that exceed the INP intrusiveness criteria across the subject site. When the approved light industrial subdivision to the north of the site is developed, the industrial buildings are likely to provide some shielding of noise from the concrete plant and furniture factory.

The inclusion of 2m high noise walls along the northern and western site boundaries of the subject site would provide minimal shielding benefits as the noise sources at the concrete plant are generally located at heights more than 2m above the ground. Noise walls of 4m in height along the northern and western site boundaries would provide some shielding benefits; however, exceedances of the INP criteria are still predicted for the majority of the subject site. Noise walls of a greater height would provide a greater level of shielding; however, may not be reasonable and feasible in terms of constructability, cost, overshadowing and visual impacts.

Positioning dwellings along the western site boundary was shown to be effective in providing shielding benefits to other dwellings to the east of the site. However, noise impact to the external areas of these dwellings would likely exceed the INP criteria. Internal amenity may be achieved through the acoustic treatment of the dwellings.

Recommendations for in-principal noise control solutions to reduce noise impact to residential dwellings is provided in the following section.

6 Recommendations

The following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. This information is presented for the purpose of the preparation of the proposed residential zoning and shall not be used for construction unless otherwise approved in writing by an acoustic consultant. Assistance of an acoustic consultant must be sought at the detailed design phase of these works to provide the necessary design details and specifications prior to construction.

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, build ability, fitness for purpose and the like.

Methods available to mitigate industrial noise include, but are not limited to;

1. Reducing noise at source,
2. Noise walls or barriers,
3. Land-use planning, site design, building layout and building treatment.

It is not within the developer's control to change or reduce noise at the source. Therefore, only Options 2 and 3 are viable options for reducing industrial noise levels for the subject site.

6.1 Noise Walls

As discussed in Section 5.5, noise walls located along the northern and western site boundaries may provide some shielding from industrial noise upon the subject site. It is noted that noise walls of up to 2m high were shown to have minimal benefits. It is recommended that further acoustic advice be sort regarding the optimum height of noise walls once lot boundaries have been established.

The construction of the noise wall can be from any durable material with sufficient mass to prevent direct noise transmission e.g. masonry, fibrous-cement, lapped and capped timber fence, polycarbonate, or any combination of such materials, provided they withstand the weather elements. A natural barrier of trees or shrubs is not an effective noise screen.

A noise wall can be very effective for mitigating industrial noise as long as there are no breaks in the barrier. However, in areas where the noise wall will be discontinuous (for example, for drainage purposes) an overlap of at least three times the width of the gap should exist in between the two sections of the noise wall.

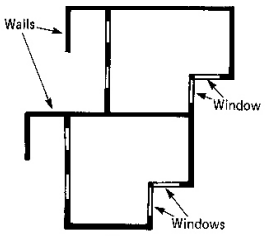
6.2 Site and Building Design

Residential dwellings constructed in noise affected areas can be designed so that their layouts minimise noise in studying, living and sleeping areas. Additionally, courtyards and open space areas can be located away from the noise source, using the building as a buffer to obtain a quiet outdoor environment. Within the building itself, locate less sensitive rooms closest to the industrial noise source,

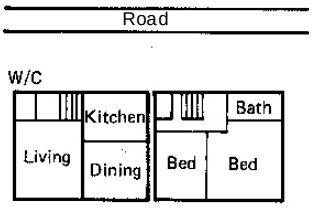
so that these essentially form a barrier between the industrial noise source and noise sensitive rooms such as bedrooms and study's. Where possible, locate the building further away from the industrial noise source, thereby reducing industrial noise at the facade.

Figure 8 below provides examples of 'self protecting' building design with reference to road traffic noise, which would also be applicable to industrial noise.

Figure 8 – Examples of 'Self-Protecting' Buildings



(a)



(b)

a) Building shape provides shielding for the windows and the solid wing wall provides a quiet courtyard.

b) Arrangement of rooms to minimise traffic noise problems.

(Nelson P 1987 p11/16)

Using the above site and building design concepts, the use of "quiet house" dwellings adjacent to the boundaries with the industrial developments can be incorporated into the site. Quiet house dwellings may also consist of double storey buildings which will provide additional shielding of noise to other properties within the residential subdivision area.

It is noted that "quiet house" dwellings should incorporate the following principles:

- All "quiet house" dwellings should be designed as two-storey dwellings.
- Where feasible, dwellings should be attached to each other to create a continuous acoustic type barrier.
- Living and sleeping areas should be located away from the noise source, while wet areas, utility rooms and non-habitable areas should be designed to form a buffer zone and block the noise to the living and sleeping areas.
- If a bedroom on the first floor cannot be shielded by a bathroom or other non-habitable area, the bedroom facade facing the noise source should be blanked out with no opening windows.
- Extra acoustic treatment to the dwellings should be considered in addition to planning of room layouts to further reduce noise to sensitive areas.

6.3 Building Treatment

Building treatment should only be considered for residential dwellings where the INP criteria is exceeded and other noise mitigation measures are either exhausted or are not cost effective.

Any building treatment should be designed to achieve the internal noise levels set out in Australian Standard 2107:2016 'Recommended design sound levels and reverberation times for building interiors' (AS2017:2016).

AS2017:2016 recommends design criteria for conditions affecting the acoustic environment within occupied spaces that take into account the function of the area(s). The sound levels are to apply for a fully fitted out and completed building, but excluding occupant noise. The Standard is applicable to steady-state or quasi-steady state sounds such as mechanical services equipment, industrial noise and road traffic noise intrusion, but not intended for transient or variable sources such as aircraft noise, railways and construction noise.

The noise level ranges from the Standard for residential dwellings are reproduced in the table below.

Table 6.1 – Recommended Design Sound Levels for Residential Dwellings, dB(A)

Type of occupancy/ activity	Design Sound Level ($L_{Aeq,t}$) Range
Houses and apartments in suburban areas or near minor roads –	
Living areas	30 to 40
Sleeping areas (night time)	30 to 35
Work areas	35 to 40
Apartment common areas (e.g. foyer, lift lobby)	45 to 50

Building treatment options that may be considered in order to achieve the AS2107:2016 internal criteria are:

- Provide glazing with sufficient acoustic performance for windows facing the noise source including the installation of acoustic seals for operable windows.
- Provide doors with sufficient acoustic performance for doors facing the noise source including the installation of acoustic seals.
- Facades facing the noise source should be of masonry construction.
- If the internal criteria can only be achieved with windows and doors closed, then fresh air mechanical ventilation (eg. acoustic wall ventilators) should be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

It is noted that the recommended options provided are preliminary and should be used for the planning process only. Where the rezoning of the site is approved, more detailed noise assessments should be undertaken during the detailed design stage of the project.

7 Conclusion

An assessment of industrial noise impact on the proposed rezoning of Lot 3 DP 1195030, located on Majara Street in Bungendore, from IN2 Light Industrial to R2 Low Density Residential has been undertaken.

Industrial noise impacting the site has been assessed in accordance with the NSW Environment Protection Authority's (EPA) 'Industrial Noise Policy' (INP) 2000.

On-site measurements of existing industrial noise were assessed to exceed the INP intrusiveness criteria. Additionally, measured maximum noise levels for the assessment of sleep disturbance were determined to comply with the applicable sleep disturbance external screening limit and the limit for awakening reactions within the subject site.

Noise contours at receiver heights of 1.5m representing ground floor levels of dwellings were prepared for the day time period for various scenarios based on various noise wall and building configurations.

In-principle noise control recommendations in the form of site and building design and building treatment are provided for consideration during the planning process for areas within the proposed residential subdivision where noise exceedances were predicted through the noise contours.

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 100dBThe sound of a rock band 115dBLimit of sound permitted in industry 120dBDeafening
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)
RTA06 (NTi Audio XL2, with low noise microphone)	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 4230 or 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 INP. 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

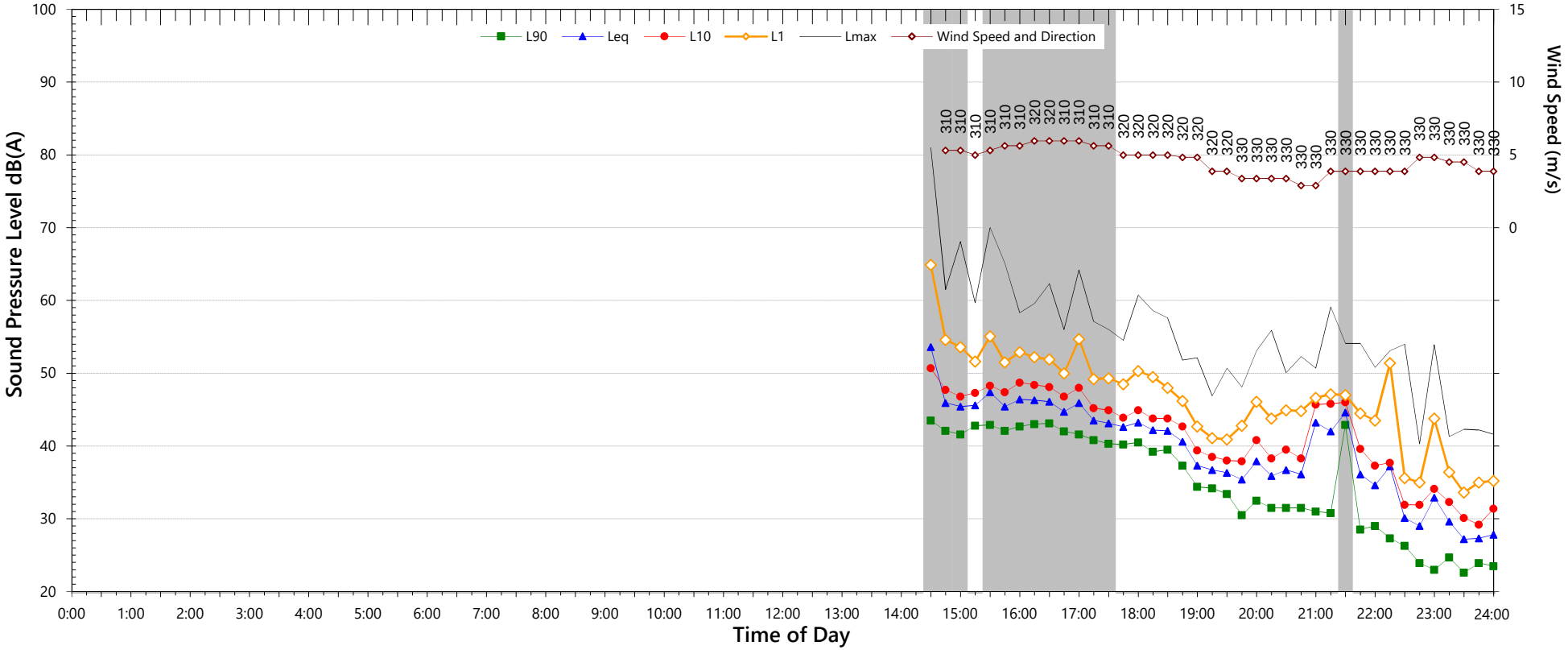
Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise 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

15 Finch St, Bungendore

Tuesday, 4 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	-	29.0	21.8
LAeq	-	39.2	41.8

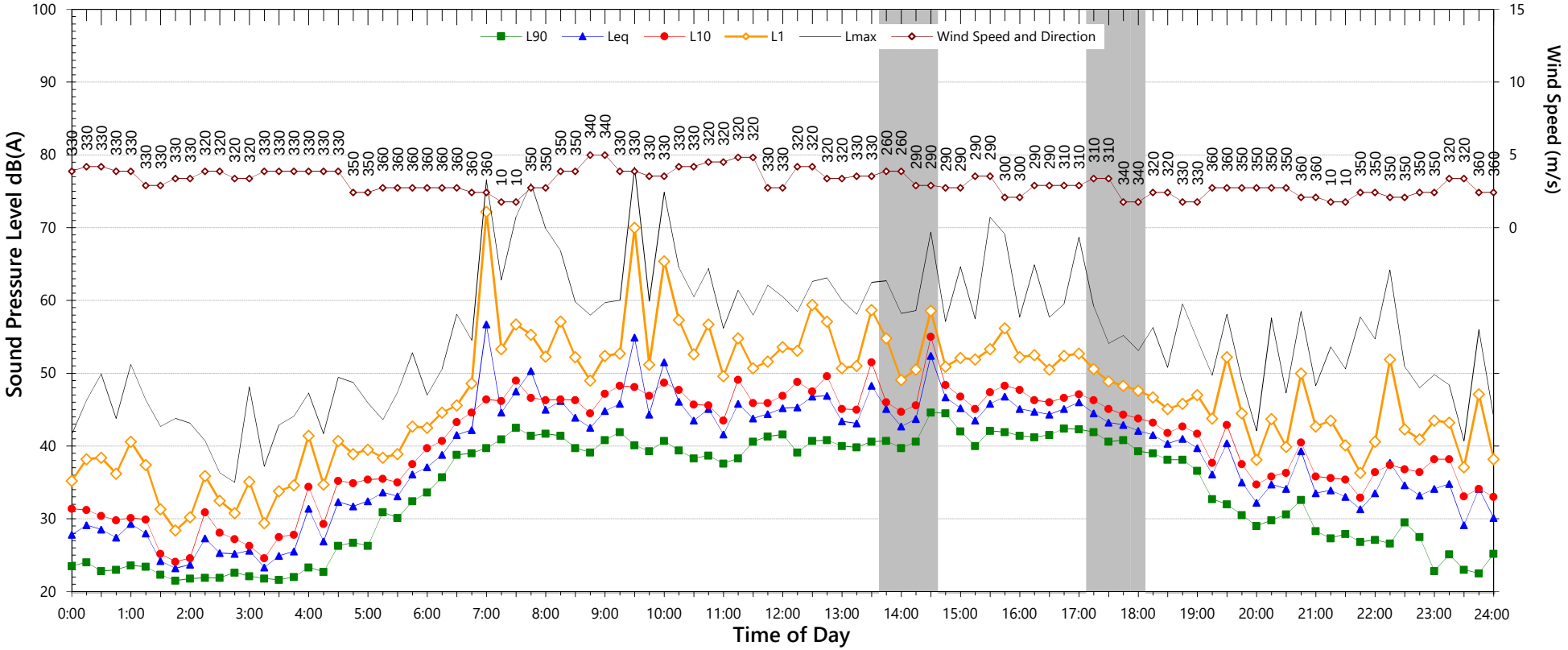
Notes:

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

15 Finch St, Bungendore

Wednesday, 5 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	38.7	27.1	21.2
LAeq	46.7	37.5	39.7

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
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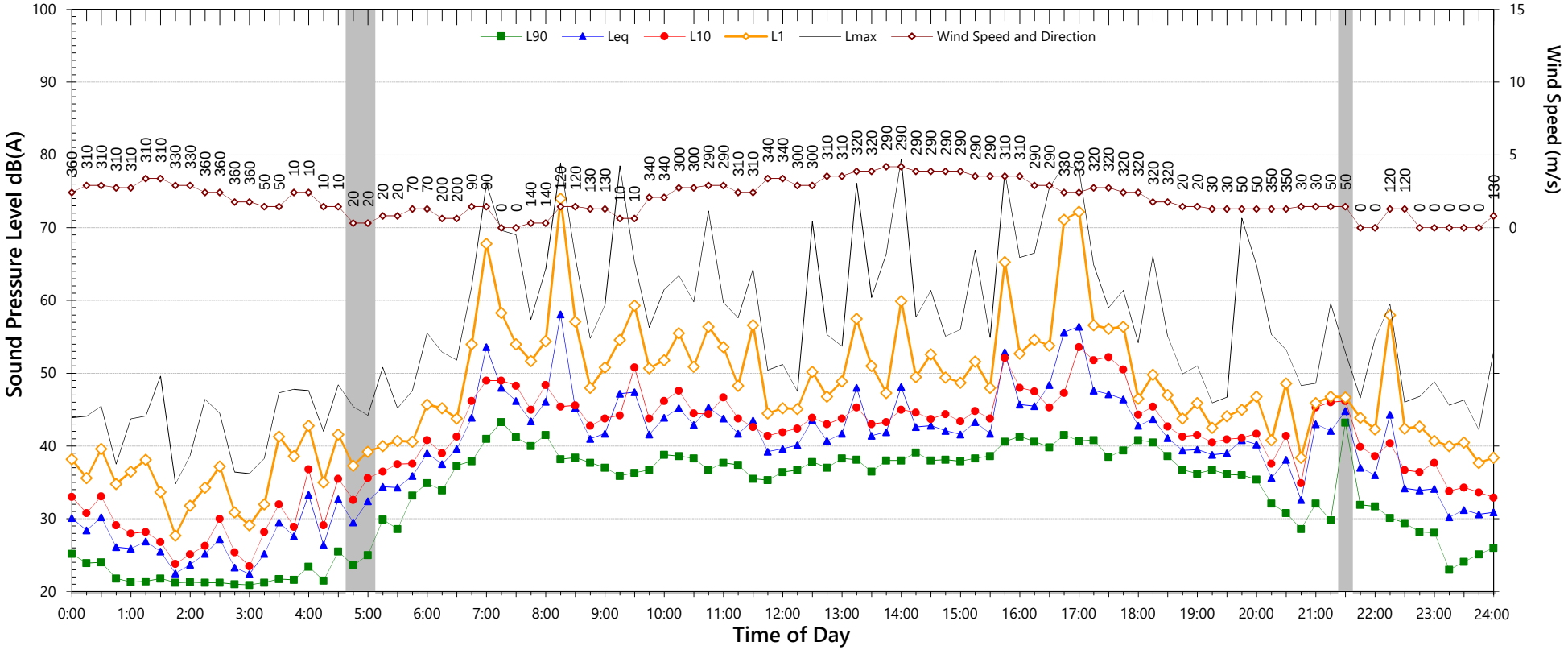
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

15 Finch St, Bungendore

Thursday, 6 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	36.4	29.8	22.0
LAeq	48.1	40.0	39.0

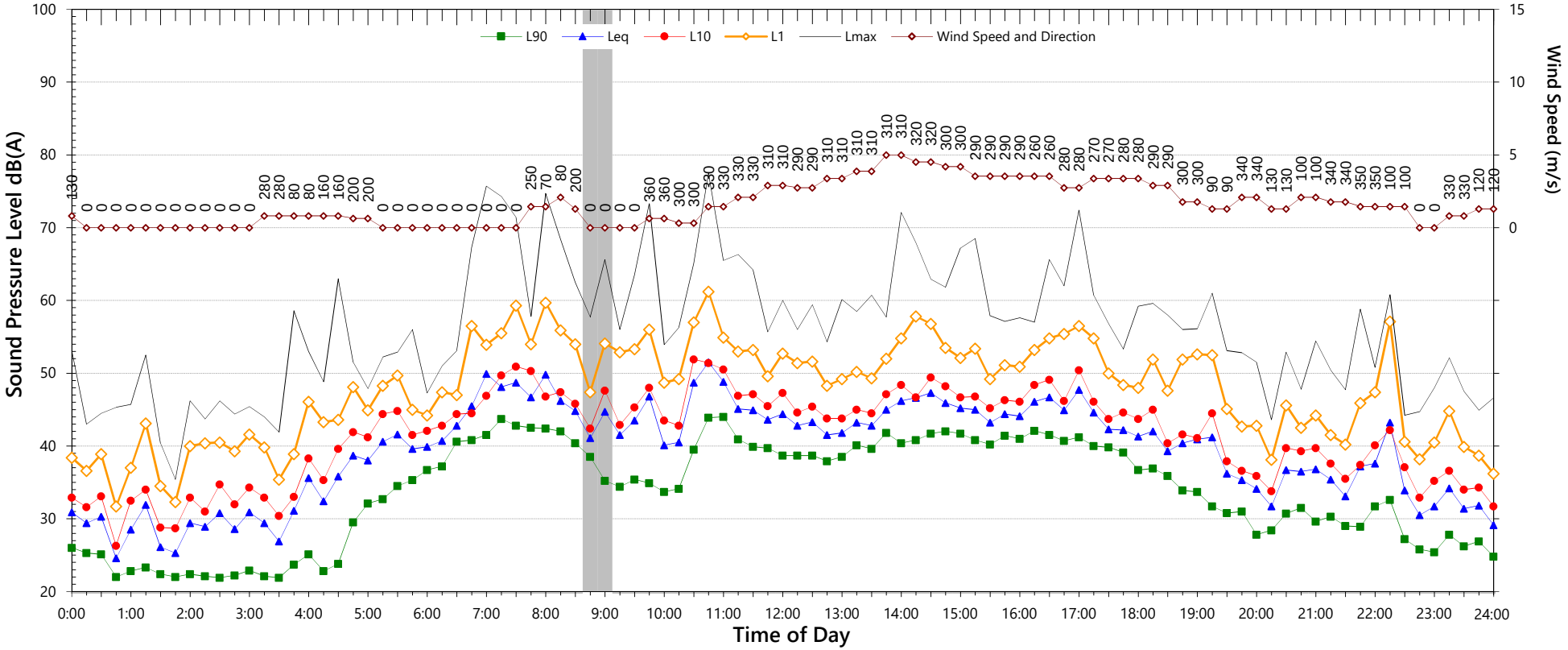
Notes:

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

15 Finch St, Bungendore

Friday, 7 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	35.4	28.4	22.7
LAeq	45.7	38.1	35.5

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
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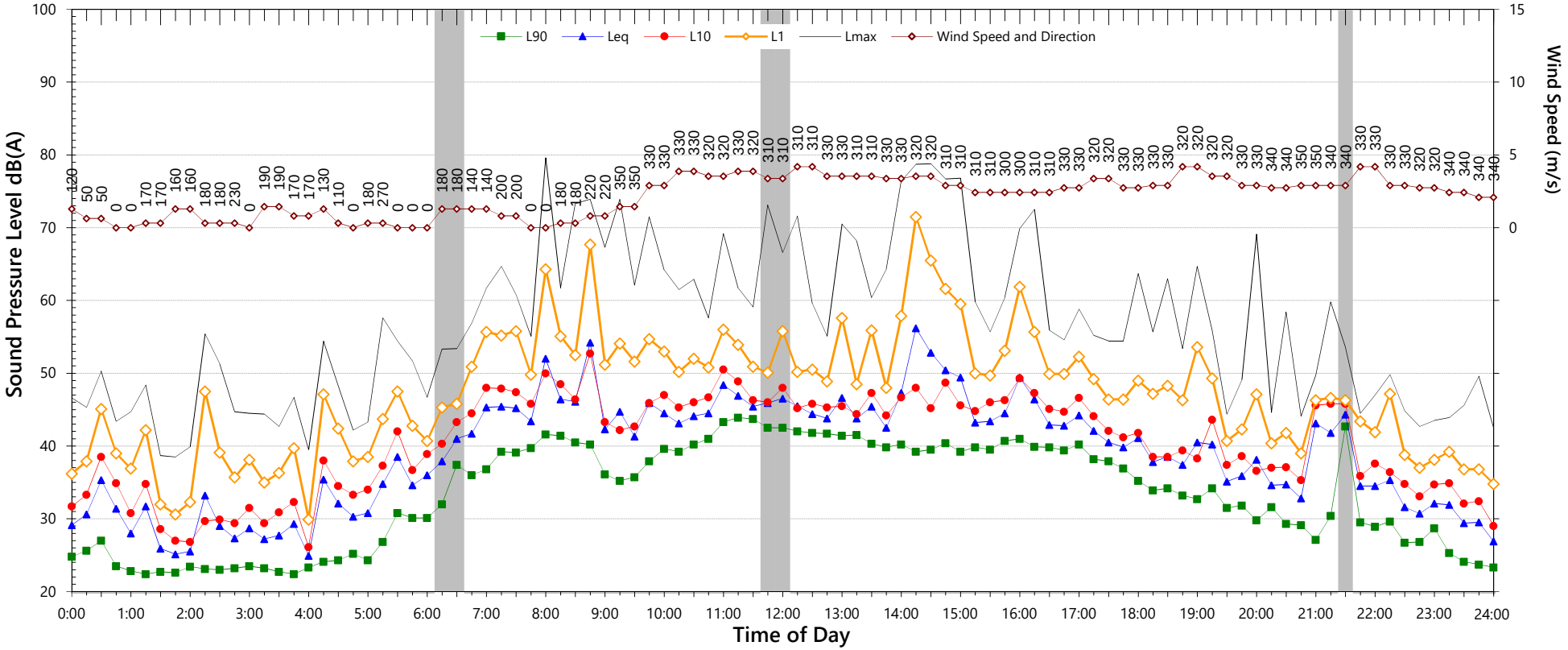
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

15 Finch St, Bungendore

Saturday, 8 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	36.9	28.9	21.4
LAeq	47.4	38.4	40.8

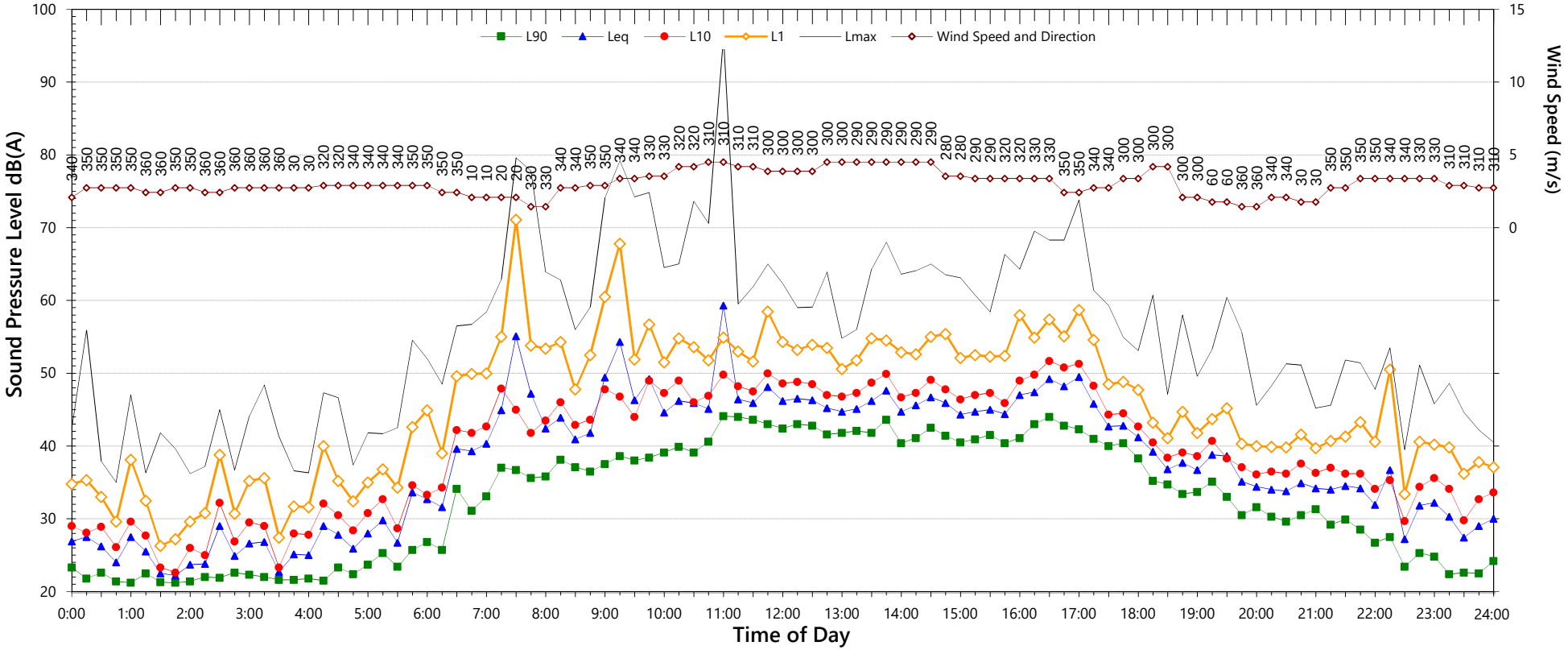
Notes:

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

15 Finch St, Bungendore

Sunday, 9 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	38.1	28.5	21.9
LAeq	48.3	36.1	34.4

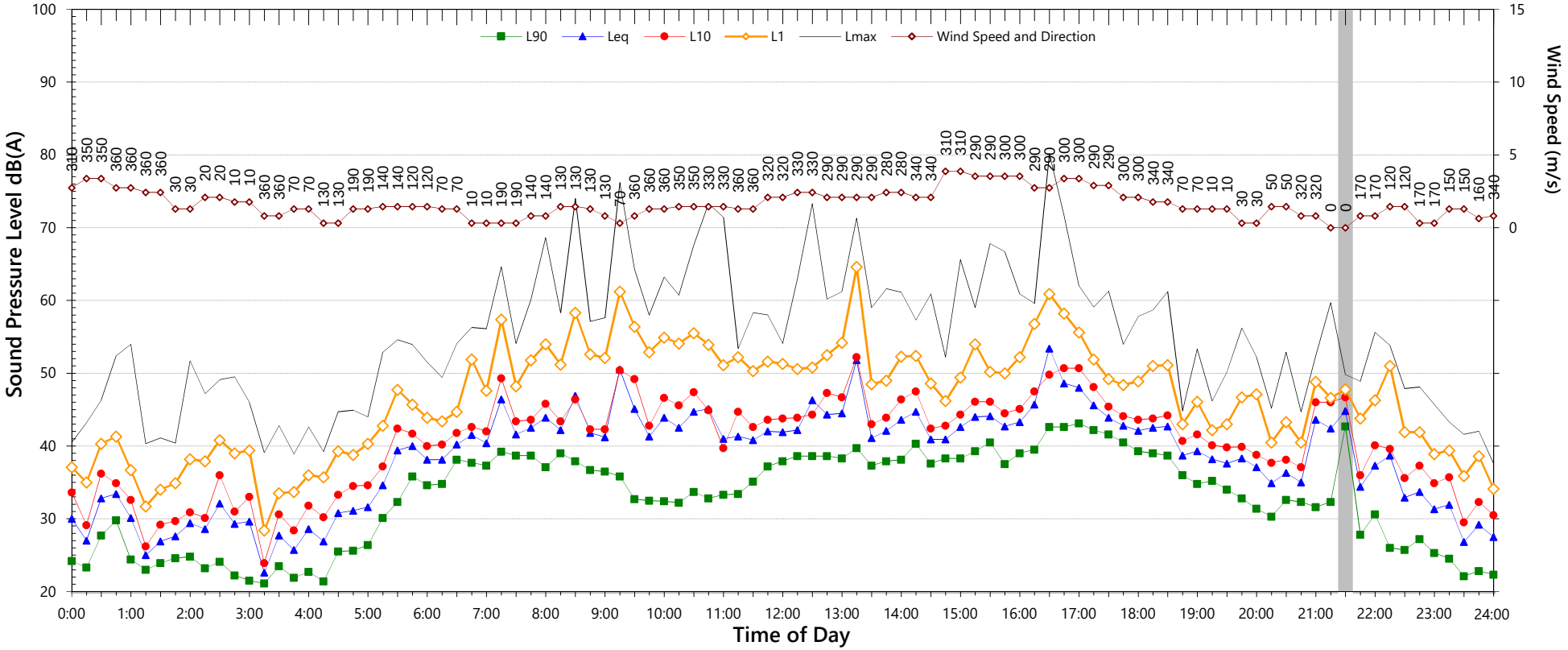
Notes:

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

15 Finch St, Bungendore

Monday, 10 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	32.8	30.3	21.8
LAeq	45.3	39.6	37.9

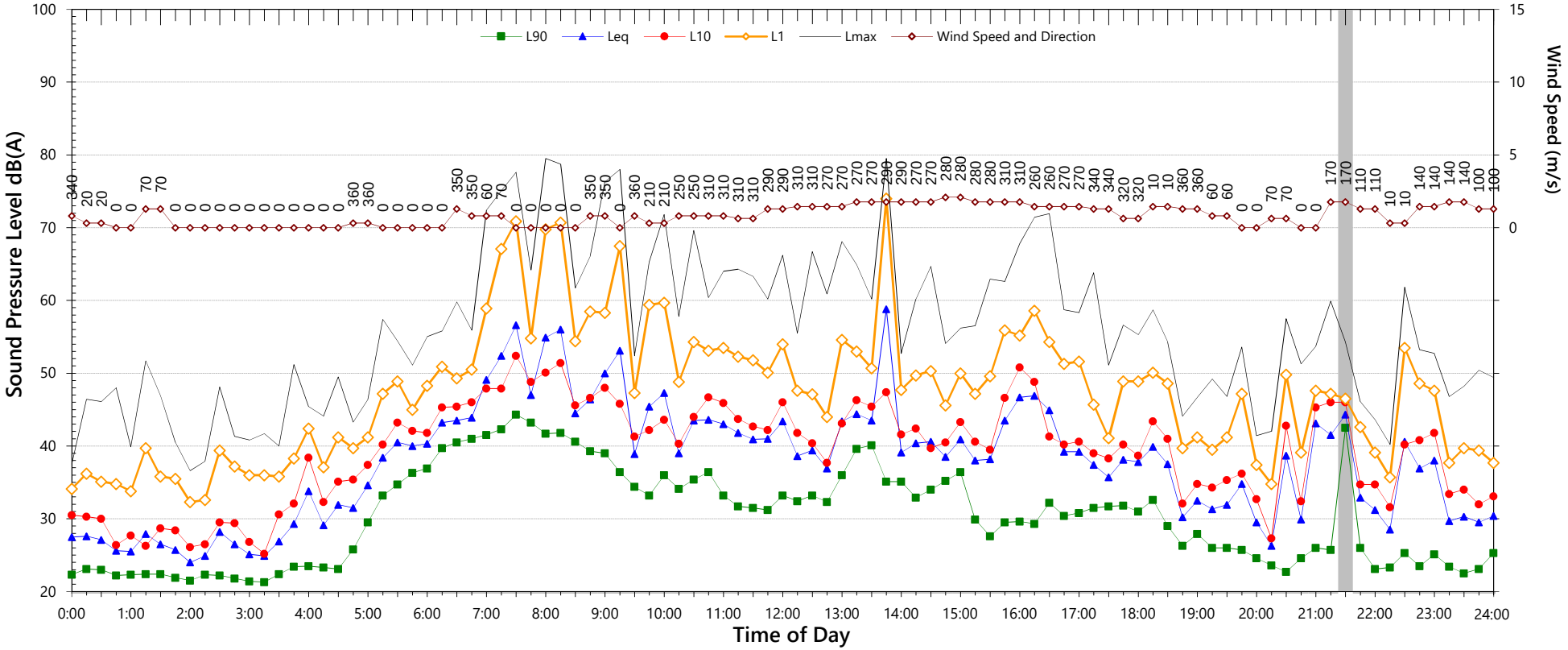
Notes:

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

15 Finch St, Bungendore

Tuesday, 11 July 2017



NSW Industrial Noise Policy (Free Field)			
Descriptor	**Day**[2]	**Evening**[3]	**Night**[4 5]
L_{90}	29.9	23.1	21.7
LAeq	48.5	36.8	43.9

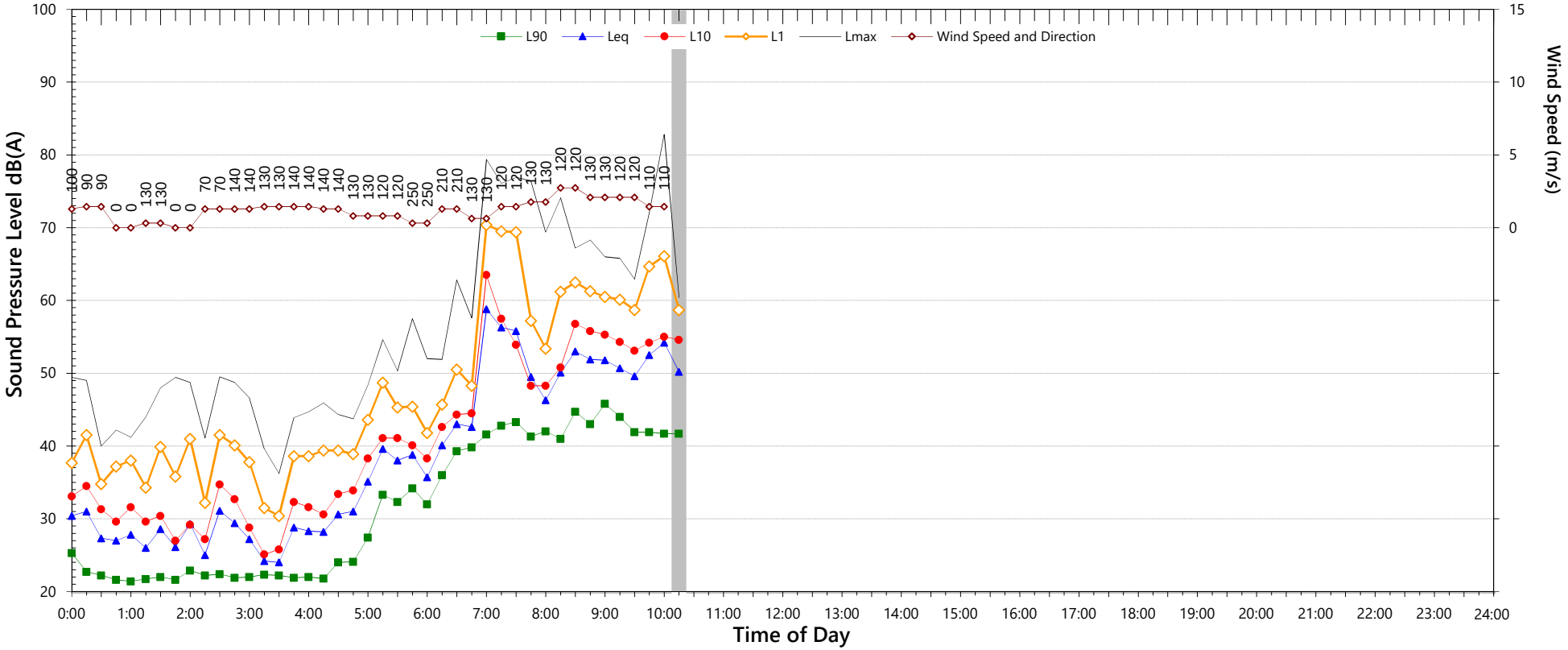
Notes:

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

15 Finch St, Bungendore

Wednesday, 12 July 2017



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

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
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