Review of Environmental Factors
Barton Park Precinct

Appendix G: Acoustic Assessment (Renzo Tonin and Associates, 2021)

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Acoustics
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BARTON PARK PRECINCT, BANKSIA

Acoustic Assessment for REF

7 June 2021

Mode Design

TL847-01F02 Acoustic Assessment for REF (r4)

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1 Introduction

Renzo Tonin & Associates was engaged to undertake an operational noise assessment to support the Review of Environmental Factors (REF) for the proposed Barton Park Precinct development at Barton Park, Banksia.

The project will accommodate four sporting fields, four tennis courts, two multi-use courts, a training field, a play space, four carparks (241 spaces), a grandstand, football and tennis clubhouses and amenities. The primary aspect of noise emission will be from on-site vehicle movements associated with the carparks, people noise (players and spectators) and traffic generated on the public road system. Potential noise impacts onto the development (ie. sporting fields and club house) from road traffic and aircraft are also addressed.

The report quantifies noise emission from activities associated with the development and assesses operational noise on nearby sensitive receivers in accordance with the noise requirements of the NSW Noise Policy for Industry (NPfI) and the NSW Road Noise Policy (RNP).

APPENDIX A contains a glossary of acoustic terms used in this report.

2 Project description

2.1 Site description and development overview

The site is located in Banksia and is bound by Bestic Street to the south, Muddy Creek to the east, Barton Park Driving Range to the north and residential receivers to the west. The nearest residential receivers are located to the west at Oakleigh Avenue and south of Bestic Street. Figure 1 presents the subject site location.

The current and proposed use for Barton Park Precinct as provided by Bayside Council (Council) is outlined below.

Current and Proposed Use for Barton Park Precinct			
Field	**Daytime (7am to 6pm)**	**Evening (6pm to 10pm)**	**Night-time (10pm to 7am)**
Soccer fields	**Monday to Friday:** Only some school use on Thursday and Friday mornings (6 large buses once in and once out. Parked there though during period of use) **Saturday 8am-6pm:** 30 people per field (25 cars)[1] **Sunday 8am-5pm in winter:** 30 people per field (25 cars)[1]	**Monday to Friday 5pm-9.30pm:** 30 people per field (25 cars)[1] **Saturday 6pm-9.30pm:** 30 people per field (25 cars)[2]	No use from 10.00pm - 7.00am.
Tennis	**Monday to Friday 7am-6pm:** Average of 4 people per court per hour with (6 cars per hour)[2] Schools will bus in the kids on Thursday and Friday. (1 large bus once in and once out. Parked there though during period of use) **Weekends 7am-6pm:** Average of 4 people per court per hour with (6 cars per hour)[2]	**Saturday and Sunday 6pm-10pm:** Average of 4 people per court per hour with (6 cars per hour)[3]	
Multi-purpose	Average 6 people, 3 cars all day. No change over just casual drop in.		

Notes
1. 5pm technically falls under the daytime period but does not alter the maximum capacity assumed in the assessment
2. 90 min turnover - cross over time of 10 mins, so 150 car movements every 90 mins for 10-15 mins.
3. 60 min turnover – cross over time of 10 mins, so 12 car movements every 60min for 10-15 mins.

2.2 Acoustic aspects

Based on the proposed design and operational parameters, the following aspects are deemed to require acoustic assessment:

- On-site vehicle movements and carparking
- People noise from players and spectators
- Traffic noise on public roads
- Mechanical services plant and equipment noise

2.3 Acoustic assessment methodology

In order to assess the potential noise impact from the development the following methodology was used:

- Identify nearest most potentially affected receiver locations to the subject site
- Determine existing background noise levels at the nearest most potentially affected receiver locations
- Use measured background noise levels to establish noise goals in accordance with the relevant noise criteria
- Using predictive noise modelling, determine the extent of noise impacts from the proposal at potentially affected receiver locations
- Identify if noise emission from the area under investigation may exceed the relevant noise criteria, and
- Where noise emission from the area under investigation may exceed the relevant noise criteria, provide recommendations to reduce noise impacts from the site.

2.4 Reference material

The following documents have been referenced for this report:

- Varga Traffic Planning Pty Ltd, *Traffic and Parking Assessment Report (ref 20270)*, 29 October 2020
- Bayside Council, Barton Park Masterplan - Draft for Exhibition April 2020, dated 17 April 2020
- Site layout drawing (see Figure 2).
- Mode Design Architectural drawings for Barton Park Precinct
  - Site Plan AR-0100, dated 9/12/2020

- Football Clubhouse Ground Floor Plan AR-1000, dated 27/5/2021

2.5 Assessment locations

The identified assessment locations are outlined in Table 1 below and are shown in Figure 1. Whilst only these locations have been presented, assessment has been made to all of the nearest surrounding receivers.

Table 1: Assessment locations

ID	Address	Description
A1	30 Highclere Ave, Banksia	A single storey residential premises located to the west
A2	2 Oakleigh Ave, Banksia	A double storey residential premises located to the west
A3	16 Oakleigh Ave, Banksia	A single storey residential premises located to the west
A4	112 Francis Ave, Brighton-Le-Sands	A double storey residential premises located to the south, across Bestic Street
A5	2B Occupation Rd, Kyeemagh	A single storey residential premises located to the east, across Muddy Creek
A6	St George Randwick Hockey Club	A hockey club and sports field located to the east, across Muddy Creek.
A7	Barton Park Driving Range	A driving range located to the north.
A8	Bayside Mens Shed	A recreation club located to the east, across Muddy Creek.
A9	Brighton Fishos Club	A recreation club located to the east, across Muddy Creek.

Notes The assessment height that has been adopted is 1.5 metre above ground level for ground floor, plus 3.0 metres for additional floors.

3 Existing noise environment

Criteria for the assessment of operational noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

Fact Sheet B of the NSW EPA *Noise Policy for Industry* (NPfI) outlines two methods for determining the background noise level of an area, being 'B1 – Determining background noise using long-term noise measurements' and 'B2 – Determining background noise using short-term noise measurements'. 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 and ambient noise levels need to be determined for the operational times of the proposed development. For example, in a suburban or urban area the noise environment is typically at its minimum at 3am in the morning and at its maximum during the morning and afternoon traffic peak hours. The NPfI outlines the following standard time periods over which the background and ambient noise levels are to be determined:

- Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
- Evening: 18:00-22:00 Monday to Sunday & Public Holidays
- Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

3.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The long-term and short-term measurement locations are outlined in Table 2 and shown in Figure 1.

Table 2: Noise monitoring locations

ID	Address	Description
Long-term noise monitoring		
L1	4 Oakleigh Avenue, Banksia	The monitor was located at the facade in the backyard of the property. The noise monitoring location is considered representative of receiver locations A1 – A5.
Short-term noise monitoring		
S1	Whiteoak Reserve	The monitor was located in the free-field between 112 Francis Ave, Brighton-Le-Sands and Muddy Creek. The monitor was set back from Bestic Street the same distance that 112 Francis Ave, Brighton-Le-Sands is set back from the street. The noise monitoring location is considered representative of receiver location A4 but was not used to set criteria, see Section 3.3.

Figure 1: Site and noise monitoring locations

3.2 Long-term noise measurement results

Long-term noise monitoring was carried out from Wednesday 21 April to Wednesday 28 April 2021. The long-term noise monitoring methodology is detailed in APPENDIX B, and noise level-vs-time graphs of the data are included in APPENDIX C.

Table 3 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the NPfI.

Table 3: Long-term noise monitoring results, dB(A)

Monitoring location	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise levels		
	Day	Evening	Night	Day	Evening	Night
L1 - 4 Oakleigh Avenue, Banksia	43	46	40	49	49	45

Notes: Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
Evening: 18:00-22:00 Monday to Sunday & Public Holidays
Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays
As required by the NPfI, the external ambient noise levels presented are free-field noise levels. [ie. no façade reflection]

3.3 Short-term noise measurement results

Short-term noise measurements were undertaken during the evening of Wednesday 28 April 2021, in order to supplement the long-term noise monitoring.

The equipment used for noise measurements was an NTi Audio Type XL2 precision sound level analyser which is a class 1 instrument having accuracy suitable for field and laboratory use. The instrument was calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

A summary of the short-term measurement results is presented in Table 4.

Table 4: Short-term noise monitoring results

Location / Time	Measured noise level, dB(A)		Comments on measured noise levels
	L_{Aeq}	L_{A90}	
28 April 2021			
S1 – Whiteoak Reserve 18:00-18:15	69	61	The background L_{A90} was determined by distant traffic. The ambient L_{Aeq} noise level was determined by local traffic.

Comparison between the short-term measurement and the same 15-minute period measured at Monitoring Location L1 determined that during peak hour, residences along Bestic Street are exposed to significantly higher background noise levels (12 dB(A)). This situation would also be expected during the daytime period. Nevertheless, project intrusive noise levels have conservatively been based on the long-term noise monitoring, where lower noise levels were measured, for all residential receivers.

4 Project noise goals

There is no specific project noise goals within the Rockdale Development Control Plan (DCP) 2011 that is applicable to active recreational spaces. Accordingly, the below policy has been adopted for this project.

4.1 NSW Noise Policy for Industry

Noise impact is assessed in accordance with the NSW 'Noise Policy for Industry' (NPfI), 2017. The assessment procedure 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.

4.1.1 Project intrusive noise levels

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 background noise monitoring results and the proposed operating hours of the facility, the intrusiveness noise levels for residential receivers are reproduced in Table 5 below.

Table 5 Intrusiveness noise levels

Receiver	Intrusiveness noise level, $L_{Aeq,15min}$		
	Day	Evening	Night
Residences	43 + 5 = 48	43 (46) + 5 = 48	40 + 5 = 45

Notes: Day: 7:00 to 18:00 Monday to Saturday and 8:00 to 18:00 Sundays & Public Holidays
Evening: 18:00 to 22:00 Monday to Sunday & Public Holidays
Night: 22:00 to 7:00 Monday to Saturday and 22:00 to 8:00 Sundays & Public Holidays
Number in brackets represents the measured (actual) RBL value, however in accordance with NPfI community expectation that evening does not have a higher intrusive noise level than daytime.

4.2.2 Amenity noise levels

The project amenity noise levels for different time periods of day are determined in accordance with Section 2.4 of the NPfI. The NPfI recommends amenity noise levels ($L_{Aq,period}$) 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 receiver location. However, when assessing a single industrial development and its impact on an area, "project amenity noise levels" apply.

The recommended amenity noise levels applicable for the subject area are reproduced in Table 6 below.

Table 6: Recommended amenity noise levels

Type of Receiver	Noise Amenity Area	Time of Day	Recommended amenity noise level, $L_{Aeq,}$ dB(A)
Residential	Suburban	Day	55
		Evening	45
		Night	40
Active recreation (e.g. school playground, golf course, external areas of recreation club)	All	When in use	55

Notes:
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 - 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. The recommended amenity noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where stated otherwise.

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:

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

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.

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

The project amenity noise levels ($L_{Aeq,\ 15min}$) applied for this project are reproduced in Table 7 below, based on a 'suburban' noise amenity area.

Table 7 Project amenity noise levels

Type of Receiver	Noise Amenity Area	Time of Day	Recommended Noise Level, dB(A)	
			$L_{Aeq,\ Period}$	$L_{Aeq,\ 15min}$
Residence	Suburban	Day	55 – 5 = 50	50 + 3 = **53**
		Evening	45 – 5 = 40	40 + 3 = **43**
		Night	40 – 5 = 35	35 + 3 = **38**

Type of Receiver	Noise Amenity Area	Time of Day	Recommended Noise Level, dB(A)	
			$L_{Aeq, Period}$	$L_{Aeq, 15min}$
Active recreation area (hockey playing field / driving range / external areas of Brighton Fishos Club / Bayside Mens Shed)	All	When in use	55 – 5 = 50	50 + 3 = **53**

Notes: 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 - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
3. The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

4.2 Project noise trigger levels

In accordance with the NPfI the project noise trigger levels, which are the lower (i.e. more stringent) value of the project intrusiveness noise level and project amenity noise level, have been determined as shown in Table 8 below. The night-time criteria has been included to assess car movements associated with people leaving site after 10pm (courts close at 10pm).

Table 8 Project noise trigger levels

Receiver Location	$L_{Aeq, 15min}$ Project noise trigger levels, dB(A)		
	Day	Evening	Night
Residential receivers	48	43	38
St George Randwick Hockey Field (external)	53	n/a	n/a
Barton Park Driving Range (external)	53	n/a	n/a
Bayside Mens Shed (external)	53	n/a	n/a
Brighton Fishos Club (external)	53	n/a	n/a

Notes: 1. Conversion of trigger levels from internal to external for school classroom and place of worship assumes 10dB(A) loss from outside to inside through open window.

4.2.4 Sleep disturbance noise levels

The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. 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.

The sleep disturbance noise levels for the project are presented in Table 9.

Table 9: Sleep disturbance assessment levels

Receiver type	Assessment Level $L_{Aeq,15min}$	Assessment Level L_{AFmax}
Residential	40 + 5 = 45	40 + 15 = 55

4.3 NSW Road Noise Policy

4.3.1 Noise assessment criteria - residential land uses

Road noise impact is assessed in accordance with the NSW ‘Road Noise Policy’ (RNP), 2011. Table 10 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use. These criteria are for assessment against façade corrected noise levels when measured in front of a building facade. In Table 10, freeways, arterial roads and sub-arterial roads are grouped together and attract the same criteria.

Table 10: Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day 7:00am-10:00pm	Night 10:00pm-7:00am
Bestic Street (Sub-arterial Road)	Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,(15 hour)}$ 60 (external)	$L_{Aeq,(9 hour)}$ 55 (external)

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for sensitive developments near busy roads (see Appendix C10).

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

For existing residences and other sensitive land uses affected by *additional traffic on existing roads generated by land use developments*, any increase in the total traffic noise level (where the assessment criteria cannot be achieved) should be limited to 2 dB above that of the corresponding ‘no build option’.

5 Noise emission assessment

5.1 Noise sources

Noise emission from the subject site, as is assessable against the established noise goals, includes:

- On-site vehicle movements and carparking
- People noise from players and spectators
- Mechanical services plant and equipment

5.1.1 Vehicle movements and car parking

The development proposes 4 carparks with a total capacity of 241 spaces. The location of the carparks is shown in Figure 2.

Noise generated by car parking activities includes vehicle doors closing, vehicle engines starting, vehicles accelerating and vehicles moving. To assess this noise, the L_{Aeq} noise level was determined for the relevant time period based on the number of vehicle activities expected to occur during that period at the nearest affected residential premises.

Based on the information provided in Section 2.1, the worst-case carpark movements within any 15-minute period are outlined below.

Daytime (7am to 6pm)

- 2 school bus movements (for soccer or tennis) and 12 car movements (for tennis), or
- 162 car movements (150 for soccer / 12 for tennis)

Evening 6pm to 10pm

- 150 car movements (150 for soccer)

Night 10pm to 7am

- 12 car movements (for tennis). Note, all spectators and players associated with the soccer fields are expected to be off site by 10pm as the games will finish at 9:30pm.

Figure 2: Site plan

Measured data from our library was used for the assessment. The sound power levels generated by carpark activities on site are presented in the following table.

Table 11: Carpark activity sound power levels

Activity	Metric	Sound Power Level, dB(A) re. 1pW
Vehicle moving (10km/h)	Passby L_W L_{eq}	79
Bus moving (10km/h)	Passby L_W L_{eq}	106
Door Slam	SEL	86
Engine Start	SEL	92

5.1.2 Players and spectators

Player and spectator numbers associated with the various playing fields and courts is specified below. These numbers have been derived from the information within Section 2.1 and the *Varga Traffic Report, Section - Expected Operational Characteristics*. This is the typical worst-case scenario that has been used for the noise predictions.

Spectators have assumed to be predominantly located in the grandstand and western side of courts, between the playing fields and the carpark. For every player it has been assumed there will be one spectator. This is considered a conversative estimate and is likely to be lower, as the *Varga Traffic Report* assumes that the number of spectators/officials that will drive to site is only 25% of the number of players.

The sound power levels generated by players and spectators are presented in the following table. These have been determined from previous measurements conducted by Renzo Tonin and the Association of Australasian Acoustical Consultants (AAAC) 'Guideline for Child Care Centre Acoustic Assessment (Version 3.0) (AAAC Guideline)'.

Table 12: Player and spectator use during daytime and evening

Location/area	Number of people per area/court	Total number of people	$L_{Aeq(15min)}$ Sound Power Level, dB(A) re. 1pW
Players			
3 x full size soccer field	30	90	96 - per court
1 x 2/3 size soccer field	30	30	96 - per court
4 x tennis court	4	16	90[2]
2 x basketball (multipurpose courts)	3	6	90[2]
Play space (playground)	40	40	90[3]
Spectators			
Male spectators	-[1]	91	70 - raised male voice (per person)[4]
Female spectators	-[1]	91	67 - raised female voice (per person)[4]

Location/area	Number of people per area/court	Total number of people	$L_{Aeq(15min)}$ Sound Power Level, dB(A) re. 1pW

Notes
1. Predominantly located in the grandstand and western side of courts, between the playing fields and the carpark'
2. Based on measurements within Renzo Tonin library database, includes noise from basketball bouncing and tennis racket hitting ball
3. 20 x 2–3 year olds and 20 x 3–5 year olds (50% active play and 50% passive play)
4. Assumed 50% of people speaking at any one time

5.2 Noise Predictions and methodology

The noise predictions were based upon the site plan in Figure 2, and carried out in accordance with ISO9613 as implemented by CadnaA computer modelling program. The software takes into account sound radiation patterns, acoustic shielding and potential reflections from intervening building elements, and noise attenuation due to distance.

5.2.1 Predictions

Table 13 and Table 14 respectively present the predicted noise emission levels at the identified assessment locations against the established noise goals for 'vehicle movements and car parking' operating a full capacity and 'players and spectators' operating at full capacity. Predictions are based on the information within Sections 5.1.1 and 5.1.2.

The information within Sections 5.1.1 and 5.1.2 is based on the 'vehicle movements and car parking' being at full capacity and 'players and spectators' being at full capacity. In reality, for a 15-minute period this will not occur. Table 15 presents the predicted noise emission levels based 'vehicle movements and car parking' and 'players and spectators' operating simultaneously but at 50% capacity.

Noise levels are predicted to comply with the established noise goals at the identified receivers for all time periods.

Table 13: Predicted noise levels, vehicle movements & carparking, $L_{Aeq,15min}$

Receiver ID	Predicted noise level, dB(A)				Noise goal, dB(A)		
	Day – Bus[1]	Day – Car[2]	Evening[3]	Night[4]	Day	Evening	Night
A1 - 30 Highclere Ave, Banksia	41	36	36	22	48	43	38
A2 - 2 Oakleigh Ave, Banksia	45	40	40	24	48	43	38
A3 - 16 Oakleigh Ave, Banksia	43	36	36	20	48	43	38
A4 - 112 Francis Ave, Brighton-Le-Sands	42	39	39	20	48	43	38
A5 - 2B Occupation Rd, Kyeemagh	31	30	30	9	48	43	38
A6 - St George Randwick Hockey Club	27	26	26	5	53		
A7 - Barton Park Driving Range	29	29	29	13	53		
A8 - Bayside Mens Shed	39	37	37	15	53		
A9 - Brighton Fishos Club	41	39	39	17	53		

Receiver ID	Predicted noise level, dB(A)				Noise goal, dB(A)		
	Day – Bus[1]	Day – Car[2]	Evening[3]	Night[4]	Day	Evening	Night

Notes
1. 2 school bus movements and 12 car movements
2. 162 car movements
3. 150 car movements
4. 12 car movements

Table 14: Predicted noise levels, players and spectators, $L_{Aeq,15min}$

Receiver ID	Predicted noise level, dB(A)		Noise goal, dB(A)	
	Day	Evening	Day	Evening
A1 - 30 Highclere Ave, Banksia	34	34	48	43
A2 - 2 Oakleigh Ave, Banksia	38	38	48	43
A3 - 16 Oakleigh Ave, Banksia	34	34	48	43
A4 - 112 Francis Ave, Brighton-Le-Sands	38	38	48	43
A5 - 2B Occupation Rd, Kyeemagh	29	29	48	43
A6 - St George Randwick Hockey Club	26	26	53	
A7 - Barton Park Driving Range	28	28	53	
A8 - Bayside Mens Shed	37	37	53	
A9 - Brighton Fishos Club	39	39	53	

Table 15: Predicted noise levels, all activities operating simultaneously, $L_{Aeq,15min}$

Receiver ID	Predicted noise level, dB(A)				Noise goal, dB(A)		
	Day – Bus[1]	Day – Car[2]	Evening[3]	Night[4]	Day	Evening	Night
A1 - 30 Highclere Ave, Banksia	38	35	35	22	48	43	38
A2 - 2 Oakleigh Ave, Banksia	42	39	39	24	48	43	38
A3 - 16 Oakleigh Ave, Banksia	40	35	35	20	48	43	38
A4 - 112 Francis Ave, Brighton-Le-Sands	40	38	38	20	48	43	38
A5 - 2B Occupation Rd, Kyeemagh	30	30	30	9	48	43	38
A6 - St George Randwick Hockey Club	27	26	26	5	53		
A7 - Barton Park Driving Range	29	28	28	13	53		
A8 - Bayside Mens Shed	38	37	37	15	53		
A9 - Brighton Fishos Club	40	39	39	17	53		

Notes
1. 1 school bus movements and 6 car movements
2. 81 car movements
3. 75 car movements
4. 6 car movements

5.2.2 Sleep disturbance

Sleep disturbance would most potentially be caused by vehicle doors closing and/or engine starting in the carpark area. The following noise levels from Renzo Tonin & Associates' database have been used for the assessment and are shown in Table 16.

Table 16: Sleep disturbance - Sound power levels

Activity	Sound power level, dB(A) re: 1pW
	$L_{1\ (1\text{-minute})}$
Vehicle door closing	96
Vehicle engine starting	97

Noise predictions at the identified assessment locations are presented in Table 17 below. Compliance is achieved for the $L_{Aeq(15min)}$ assessment and the L_{Amax} assessment.

Table 17: Sleep disturbance noise assessment

Assessment Location	Predicted Noise Level, dB(A)		Sleep disturbance assessment level, dB(A)	
	$L_{Aeq,15min)}$	L_{Amax}	$L_{Aeq,15min}$	L_{Amax}
A1 - 30 Highclere Ave, Banksia	22	42	45	55
A2 - 2 Oakleigh Ave, Banksia	24	45	45	55
A3 - 16 Oakleigh Ave, Banksia	20	43	45	55
A4 - 112 Francis Ave, Brighton-Le-Sands	20	45	45	55
A5 - 2B Occupation Rd, Kyeemagh	9	26	45	55

Note: Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

5.3 Mechanical plant and equipment

Mechanical plant associated with the development has the potential to impact on nearby noise sensitive properties. However, given the separation distance from the football and tennis clubhouses and the nearest assessment locations, mechanical plant is not likely to cause any acoustic issues. Mechanical plant is also not proposed to be operational during the night-time period.

In order to carry out a complete quantitative assessment of mechanical equipment, a complete specification of equipment is required. At this stage of the development, appropriate detail for mechanical plant is not typically available. A qualitative assessment has therefore been carried out and in-principle noise management measures outlined:

- Acoustic assessment of mechanical services equipment should be undertaken during the detailed design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria. Development Consent Conditions typically require detailed assessment of mechanical plant and equipment prior to issue of the Construction Certificate.

- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - procurement of 'quiet' plant
  - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
  - commercially available acoustic attenuators for air discharge and air intakes of plant
  - acoustically lined and lagged ductwork
  - acoustic barriers between plant and sensitive neighbouring premises
  - partial or complete acoustic enclosures over plant
- The specification and location of mechanical plant should be confirmed prior to installation on site.

6 Road traffic noise assessment

Additional noise from traffic generated by a development on the local road network is assessed against the RNP. The assessment involves consideration of the existing traffic noise levels and the potential change in noise as a result of the development.

Traffic generated by the development would access and depart the site via Bestic Street. Based on the *Varga Traffic Report*, Table 18 presents a summary of the existing (no build) and future (build) traffic volumes on Bestic Street during the day.

Table 18: Traffic flow assessment

Road	Existing two-way traffic volumes [vehicles][1]	Proposed two-way traffic volumes [vehicles][2]	Existing and proposed two-way traffic volumes [vehicles]	Predicted increase in noise level [dB]
Day 7:00am-10:00pm				
Bestic Street	9,775	1,500	11,275	0.6

Note: 1. Based on the *Varga Traffic Report,* weekend peak hour traffic data (which is lower than the weekday). Daytime traffic assumed to be 85% of the AADT and the AADT assumed to be 10 x peak hour traffic.

2. Based on 150 cars (75 cars entering and 75 leaving) every 90mins between 7am and 10pm

In accordance with the RNP, in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

For existing residences and other sensitive land uses affected by *additional traffic on existing roads generated by land use developments*, any increase in the total traffic noise level (where the assessment criteria cannot be achieved) should be limited to 2 dB above that of the corresponding 'no build option'.

As the predicted noise level increases presented in Table 18 are not more than 2dB(A), the road traffic noise generated by vehicles associated with the proposed development is considered to comply with RNP criteria.

7 Noise impact upon the development

7.1 Road traffic

The assessment of road traffic noise for non-residential land uses is assessed against the RNP. The nearest playing field to the public road network is Field 2 which is located 70m from Bestic Street. The RNP specifies a daytime (7am to 10pm) criteria of $L_{Aeq,15hr}$ 60 dB(A).

Noise predictions were based on a method developed by the United Kingdom Department of Environment entitled 'Calculation of Road Traffic Noise (1988)' known as the CoRTN88 method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board. The model predicts noise levels for free flowing traffic.

Based on the 'existing and proposed two-way traffic volumes' in Table 18, a daytime project traffic noise level of $L_{Aeq,15hr}$ 54 dB(A) was predicted which is well under the RNP criterion of 60 dB(A).

7.2 Aircraft

The assessment of aircraft noise has been made for the site. Assessment has been made against Australian Standard AS2021-2015 – '*Acoustics – Aircraft Noise Intrusion – Building Siting and Construction*' ('AS2021').

7.2.1 Building treatment

The building construction of the proposed development needs to be designed to reduce aircraft noise to the maximum internal noise levels stipulated in Table 3.3 of the Standard.

The only room on site that would warrant an assessment is the Club Room. Whist a Club Room is not specifically defined in AS2021, based on Table 3.3 of the Standard, Table 19 outlines the most applicable criteria relevant to the subject site

Table 19: Indoor design sound levels for determination of aircraft noise reduction (Table 3.3 from AS2021)

Building type and activity	Indoor design sound level*, dB(A)
Commercial buildings, offices and shops	
Shops	75

Building type and activity	Indoor design sound level*, dB(A)

Notes * These indoor design sound levels are not intended to be used for measurement of adequacy of construction. For measurement of the adequacy of construction against aircraft noise intrusion see Appendix D of the Standard.

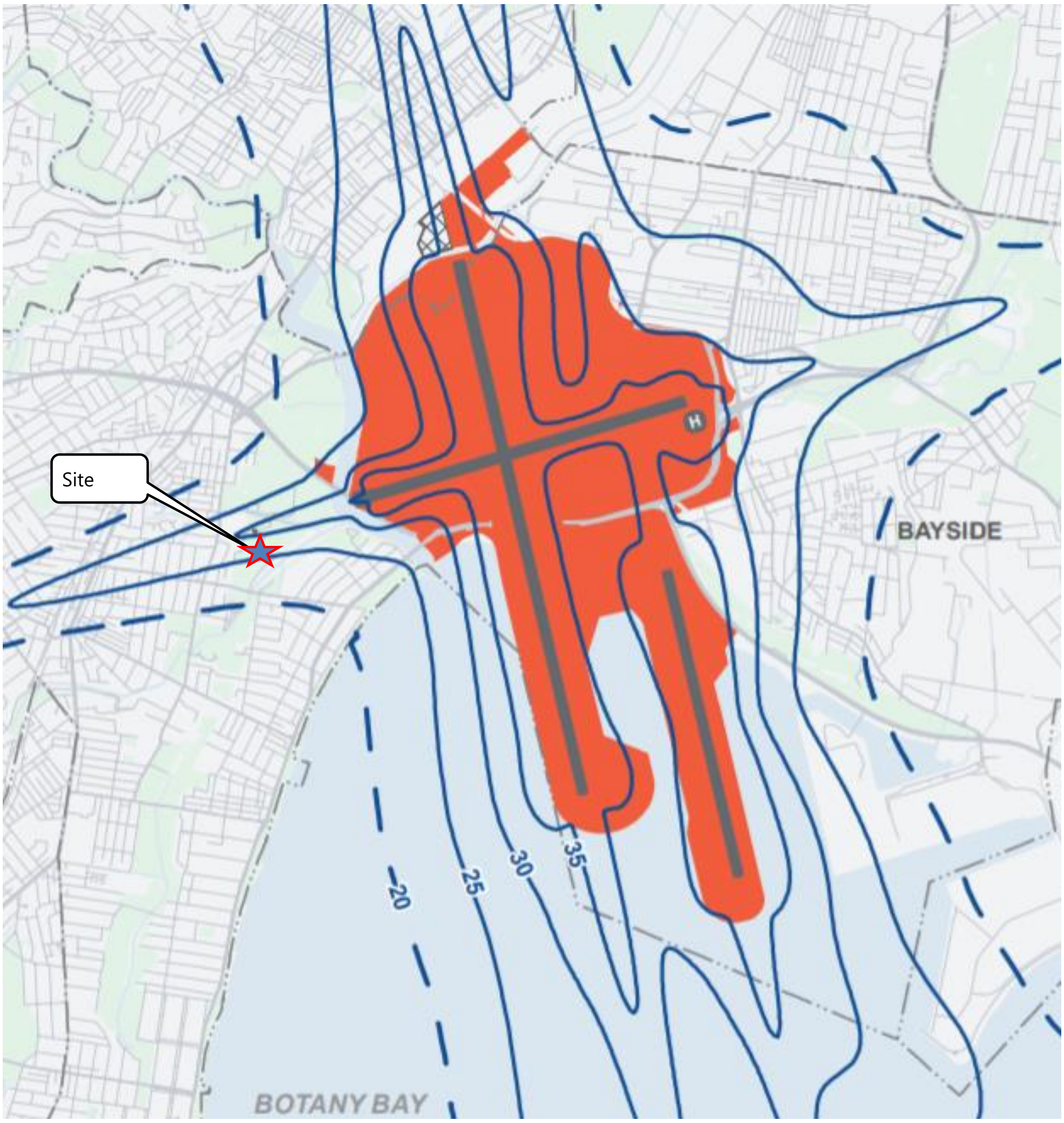
1. The indoor design sound levels in Column 2 are hypothesized values based on Australian experience. A design sound level is the maximum level (dB(A)) from an aircraft flyover which, when heard inside a building by the average listener, will be judged as not intrusive or annoying by that listener while carrying out the specified activity. Owing to the variability of subjective responses to aircraft noise, these figures will not provide sufficiently low interior noise levels for occupants who have a particular sensitivity to aircraft noise.
2. Some of these levels, because of the short duration of individual aircraft flyovers, exceed some other criteria published by Standards Australia for indoor background noise levels (see AS/NZS 2107).
3. The indoor design sound levels are intended for the sole purpose of designing adequate construction against aircraft noise intrusion and are not intended to be used for assessing the effects of noise. Land use planning authorities may have their own internal noise level requirements which may be used in place of the levels above.
4. For opera and concert halls and theatres, and for recording, broadcast and television studios and similar buildings where noise intrusion is unacceptable, specialist acoustic advice should always be obtained.
5. Certain activities in schools may be considered particularly noise sensitive and 50 dB(A) may be a more desirable indoor sound level to select for any teaching areas used for such activities. However, the effect of other noise sources should be considered.
6. The provisions of this Standard relating to different internal design sound levels for different indoor spaces could result in the use of different construction and materials in contiguous spaces, and require the construction of substantial barriers between habitable spaces, e.g. heavy self-closing internal doors, detracting from the amenity of the building. Therefore consideration should be given to a uniform perimeter insulation approach.

7.2.2 Aircraft noise assessment

Based on the ANEF 2039 chart the subject site is located within the ANEF 20 to 35 contours, as shown in Figure 3. The large ANEF range is due to the vastness of the site. The clubhouse is located within the ANEF 25 to 30 contours.

Whilst there is no specific requirements for outdoor recreation spaces, Barton Park is an existing outdoor recreation space and the development is not seeking a change of use. The development is considered in keeping with the existing use and no further assessment for outdoor spaces is considered necessary.

Figure 3: Subject site and ANEF overlay



7.2.2.1 Maximum aircraft noise levels

Aircraft noise exposure levels were calculated for the development site based on AS2021. Buildings are required to be designed to meet the relevant internal noise levels presented in Table 19. The Aircraft Noise Reduction ('ANR') for the building type construction is determined using the maximum external aircraft noise level and the indoor design sound level.

To determine resultant aircraft noise levels the following factors were considered as specified in the Standard;

- The site's position relative to each runway, including take-off and landing distances and runway centre line offsets;

- Elevation of the site compared with the elevation of the runways; and,
- Type of aircraft and associated maximum noise level during take-off and landing.

Using these factors, the resultant maximum noise levels were determined for each aircraft type. This calculation is not based on Australian Noise Exposure Forecast ('ANEF') contours but on the location of the site relative to the runways.

The proposed development site is most impacted by aircraft take offs from runways 25 and 07.

In accordance with Clause 3.1.4 of the Standard, "where there is evidence that the particular aircraft type and movement which produced that noise level do not constitute a typical operation, then the noise level can be ignored and the next lowest noise level selected".

Aircraft noise movement statistics were obtained from the Sydney Airport ANEF 2039 dated 23/08/2018.

In accordance with Clause 3.1.4, the upper 5% of movements are assumed to "not constitute a typical operation" and were excluded. The standard includes a comprehensive list of noise levels for all current aircraft including the popular Airbus A380, Boeing 737 aircraft and the Boeing 787 Dreamliner. Due to the infrequent use of runway operations impacting to the west of Sydney Airport, many international aircraft types have been excluded from the assessment.

The maximum external noise level resulting from aircraft flyovers has been calculated in accordance with AS2021.

The table below shows the maximum design noise level at the development site from the Boeing 737-800.

Table 20: Maximum noise levels at assessment location as per AS2021

Aircraft Type	Mode of Operation	Maximum Noise Level dB(A)
Boeing 737-800	Take-off from Runway 25/07	94

It should be noted that variations in flight paths and aircraft operational characteristics may generate external noise levels greater than calculated here.

The required ANR for areas in the proposed development are as follows:

Table 21: Required aircraft noise reduction for the proposed development

Area	Required ANR
Commercial buildings, offices and shops	
Shops	19

7.2.3 Recommendations

Results from Table 20 were used to calculate internal noise levels within the proposed development. Noise calculations were conducted using the OutsideIn Glazing Spreadsheet developed by Renzo Tonin and Associates which take into account external noise levels, facade transmission loss and room sound absorption characteristics.

The recommendations for indicative building element constructions of the Club Room that would be required to comply with the nominated noise criteria are outlined below. The recommendations are in-principle only, are not to be used for construction and will need to be re-assessed at the detailed design stage.

- Walls (R_W 52) – indicative construction - standard brick veneer construction
- Roof (R_W 42) – indicative construction - metal deck roof with 50mm thick insulation and sisalation hard under the roof sheeting. A suspended plasterboard ceiling (10mm plasterboard) with R3.0 bulk insulation in the ceiling cavity.
- Windows, sliding doors, glazed doors (R_W 32) – Indicative construction - 6.38mm laminated glass with acoustic seals.
- Door (R_W 33) – 40mm thick solid core door with acoustic perimeter seals.

8 Conclusion

Renzo Tonin & Associates has carried out an acoustic assessment to support an approval under Part 5 of the EP&A Act for the proposed Barton Park Precinct development at Barton Park, Banksia. The assessment also supports the Grandstand development application within the Barton Park Precinct.

The main aspect with regards to acoustic relates to noise emission from onsite vehicle movements & car parking and player & spectator noise. The proposed works have been assessed against relevant Environmental Protection Authority and Department of Planning, Industry and Environment noise policies at the nearest sensitive receivers. It has been established that noise from the proposed development is predicted to comply at all surrounding receiver for all periods.

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.

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
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.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
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. 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 LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our environment:

threshold of hearing	0 dB	The faintest sound we can hear, defined as 20 micro Pascal
	10 dB	Human breathing

	almost silent	20 dB	
		30 dB	Quiet bedroom or in a quiet national park location
	generally quiet	40 dB	Library
		50 dB	Typical office space or ambience in the city at night
	moderately loud	60 dB	CBD mall at lunch time
		70 dB	The sound of a car passing on the street
	loud	80 dB	Loud music played at home
		90 dB	The sound of a truck passing on the street
	very loud	100 dB	Indoor rock band concert
		110 dB	Operating a chainsaw or jackhammer
	extremely loud	120 dB	Jet plane take-off at 100m away
	threshold of pain	130 dB	
		140 dB	Military jet take-off at 25m away

dB(A)	A-weighted decibel. 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 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. The dB(C) level is not widely used but has some applications.
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.
DIN	German Standard
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999
ENMM	Environmental Noise Management Manual, Roads and Maritime Services (Transport for NSW)
EPA	Environment Protection Authority
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
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.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.

Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007
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.
INP	NSW Industrial Noise Policy, EPA 1999
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.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	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).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.

NCG	Noise Criteria Guideline, Roads and Maritime Services (Transport for NSW)
NMG	Noise Mitigation Guideline, Roads and Maritime Services (Transport for NSW)
Noise	Unwanted sound
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, NSW, May 2013
RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australia. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
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 by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w.
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 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 of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.

Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w.

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)
RTA07 (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 4231 calibrator. No significant drift in calibration was observed.

B.2 Meteorology during monitoring

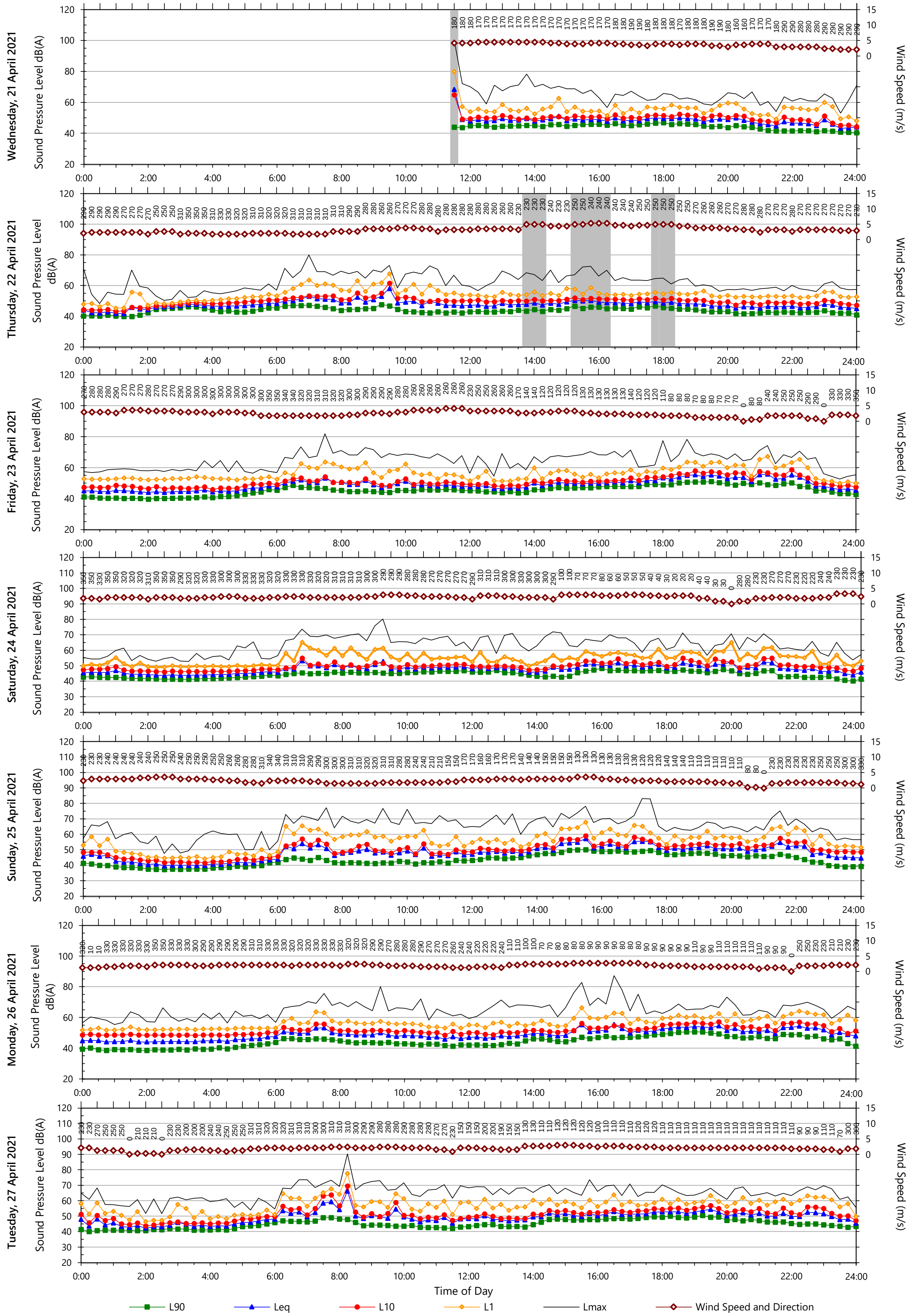
Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW INP. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative 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 Noise monitoring logger graph

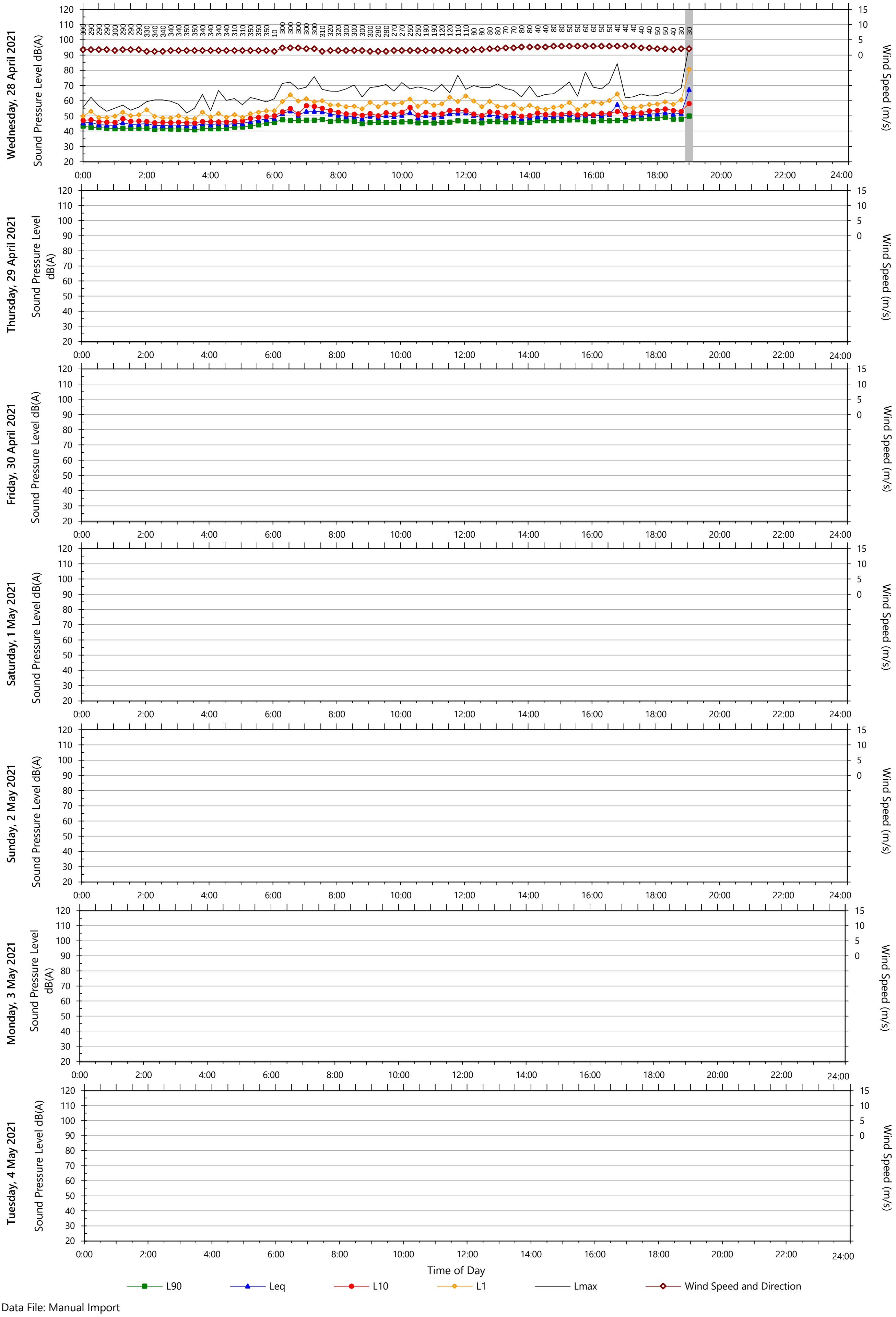
Unattended Monitoring Results **Location: Backyard**



Data File: Manual Import

Template: QTE-26 Logger Graphs Program (r36)

Unattended Monitoring Results **Location: Backyard**



Data File: Manual Import

Template: QTE-26 Logger Graphs Program (r36)