Wanda

Wanda Sydney

Acoustic Assessment for Entertainment Noise from Tower B

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Job number 247747

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1 Introduction

Arup has been commissioned by Wanda to carry out noise impact assessment for the Wanda Sydney development which comprises of mixed use with apartments (Tower A) and a premium hotel (Tower B).

This document provides an acoustic assessment of the entertainment noise emission from the Venues (spaces to be licensed or entertainment venues, e.g. rooftop bar terrace, Grand Ballroom, etc.) within the hotel in Tower B for their respective Development Applications. A separate assessment for industrial noise emission from Tower B has been conducted and detailed in the *Acoustic DA Report for Wanda Sydney Tower B.*

This document identifies key acoustic considerations for the spaces to Venues within the hotel and establishes relevant noise limiting criteria. It provides the noise predictions at noise sensitive receivers. This document also proposes the mitigation/management measures to meet the entertainment noise guidelines where noise could be a potential issue without acoustic mitigations.

A glossary of the acoustic terminology used in this document is presented in Appendix A.

1.1 Relevant regulations and documents

The following regulations and documents are identified as relevant to this assessment, and reviewed to form the assessment basis.

- Noise conditions for the licensed premises by the Liquor and Gaming NSW, *Noise guide for Local Government by EPA NSW (2013)*
- *City of Sydney Standard Conditions of Development Consent*
- Architectural Drawings set of *Wanda Vista Sydney One Tower B - DRAFT DA ISSUE* dated 2016-09-06

1.2 Development description

Wanda Sydney Tower B is a premium hotel building as a part of Wanda Sydney development. This site is located at Circular Quay, Sydney. As shown in Figure 1 below, the site is bounded by Alfred Street, Pitt Street and Rugby Place.

The development is generally surrounded by office/commercial buildings and hotel buildings besides the Cahill Expressway, Sydney Train line and ferry quays on the north.

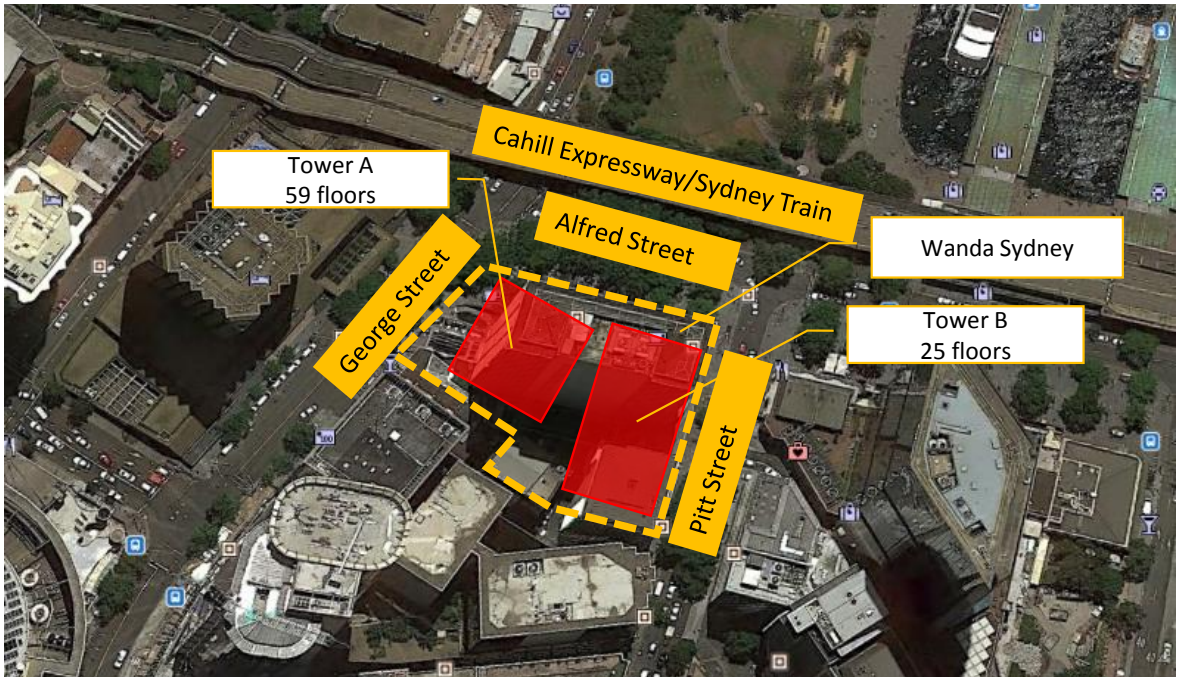

Figure 1: Location of Wanda Sydney

1.3 Entertainment noise sources and receivers

There are multiple subject venues located in different parts of the building. The configuration, purpose and functional usage of these venues are also distinctive. As a result, there are differences for each subject venue in terms of composition of noise sources, acoustic considerations, the most affected noise sensitive receivers and etc.

Based on the latest drawings, the subject venues that have potential entertainment noise issue are identified in Table 1. The most affect receivers for each subject venue are also summarised in Table 1. Further detail regarding relationship to nearest receivers is set out in the following sub-sections.

Table 1: Summary of entertainment venues and receivers

Subject venues	Description	Acoustic considerations/main noise source	Most affected receiver(s)
Grand Ballroom (L3)	Indoor event space Alcohol licence required	Patron Noise Amplified Sound Noise	(External Residential) Wanda Sydney Tower A apartment on L3/L4
Rooftop Bar (L24)/ BBQ Terrace (L25)	Outdoor bar area Alcohol licence required	Patron Noise	(External Residential) Wanda Sydney Tower A apartment above L24/L25
Karaoke (L24)	Indoor Karaoke space Alcohol licence required	Amplified Music Noise	(Internal Space) Bar (not considered to be noise sensitive) (Internal Space) Chinese Restaurant (not considered to be noise sensitive)
All Day Dining (L4)	Indoor dining space Alcohol licence required	Patron Noise Background Music Noise	(Commercial) 1 Macquarie Place

Subject venues	Description	Acoustic considerations/main noise source	Most affected receiver(s)
Chinese Restaurant A LA CARTE (L23)	High-end dining space Alcohol licence required	Patron Noise Background Music Noise	(Internal Space/Residential) Presidential Suite (Commercial) 1 Macquarie Place

1.3.1 Grand Ballroom

The Grand Ballroom is a double height space on Level 3 facing north. There are no residential premises immediately adjoining the Grand Ballroom within the building. The nearest most potentially affected receiver has been identified as an apartment on Level 3 of Wanda Sydney Tower A, as illustrated in Figure 2.

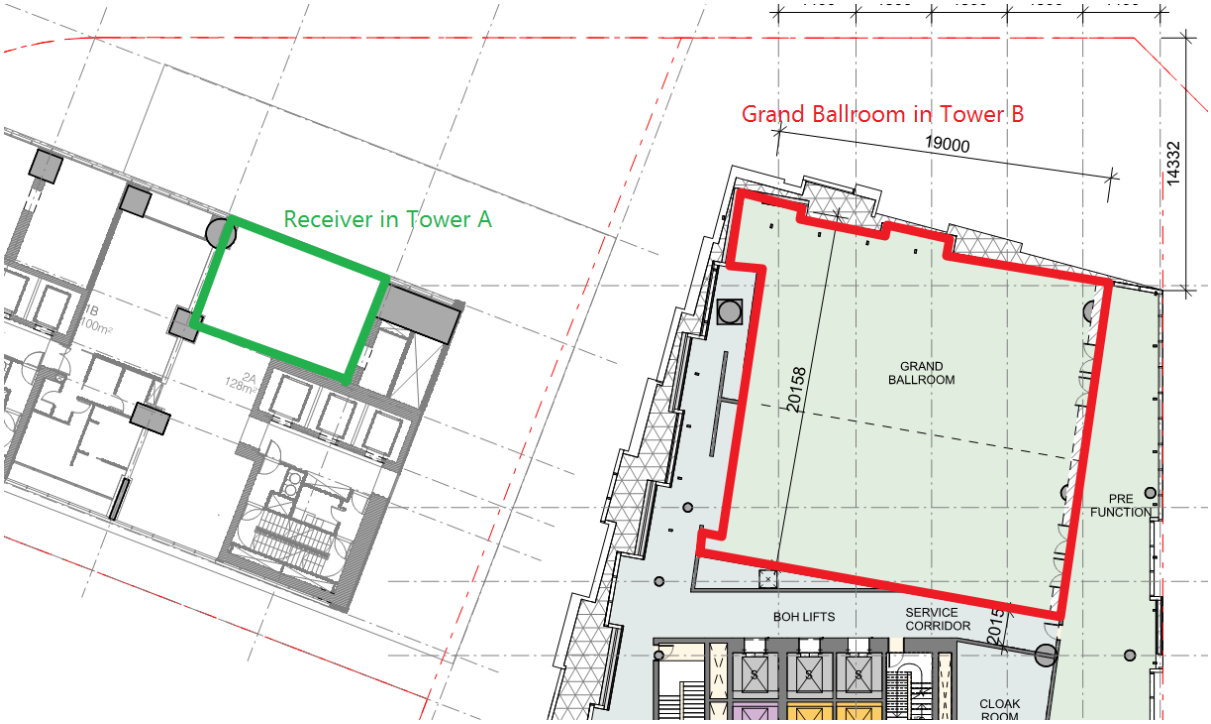

Figure 2: Grand Ballroom and the closest noise sensitive receiver

1.3.2 All Day Dining and Chinese Restaurant

As shown in Figure 3, All Day Dining is located on the Level 4 without habitable adjacencies and Chinese Restaurant is located on Level 23 adjacent to Presidential Suite (Level 22). Both spaces are indoor spaces with sealed glazed facade.

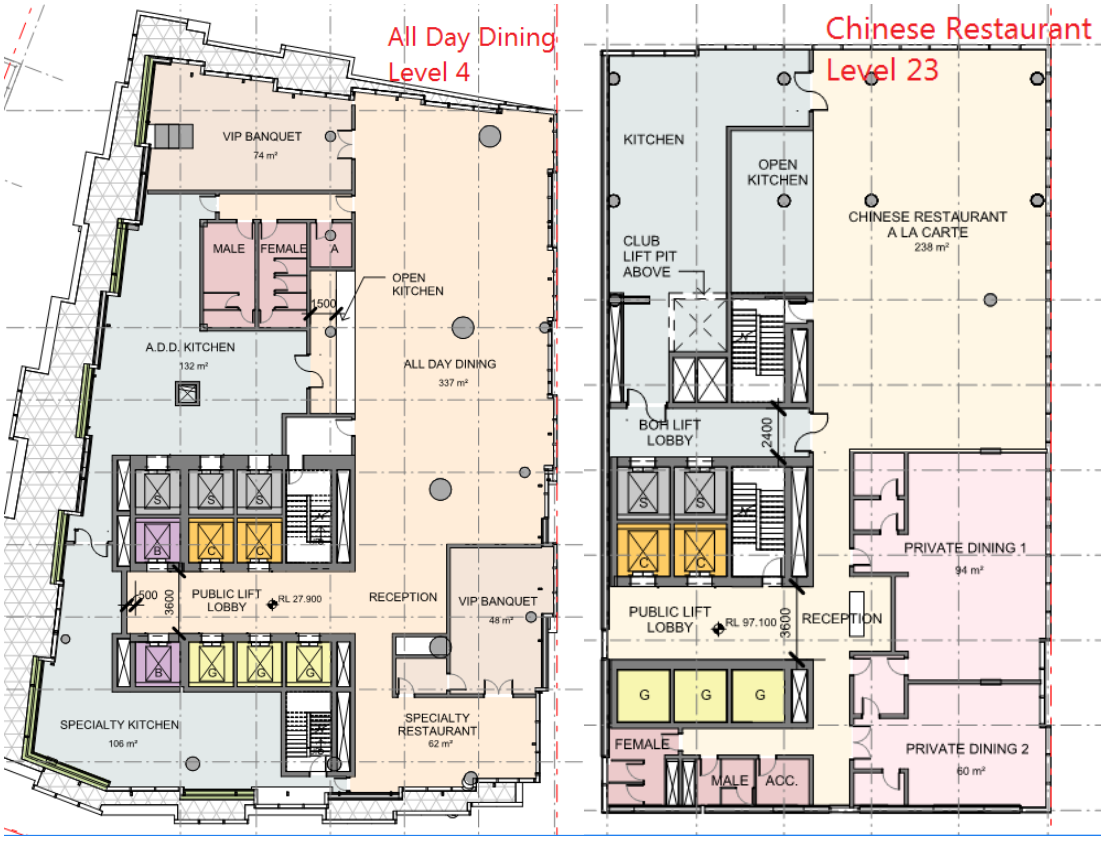

Figure 3: Location of the All Day Dining and Chinese Restaurant

1.4 Roof Bar and BBQ Terrace

Arup has carried out a study for the noise impact from the rooftop Terrace areas (Bar on Level 24 and Private BBQ Terrace on Level 25) to the apartment in Tower A.

Based on the drawing set issued on 6 September 2016, two outdoor Bar Terrace areas are located on Level 24 and Level 25 in Tower B. As illustrated in Figure 4 and Figure 5 below, the Bar Terrace on Level 25 is recessed from the one on Level 24.

The glazed façade extends to the top of the building, and as a result, the Bar Terrace on Level 24 will be partially enclosed by the façade system, with its roof open to the environment. It is understood that the door between Indoor Bar Area and Terrace will be open during operation.

The Terrace on Level 25 is covered by a roof and is open towards the void between Level 24/25.

A retractable roof has been designed to be able to enclose the space when noise becomes an issue. For the purpose of this assessment, this has been conservatively excluded from this noise prediction model. This retractable roof is considered to be a supplementary mitigation measure.

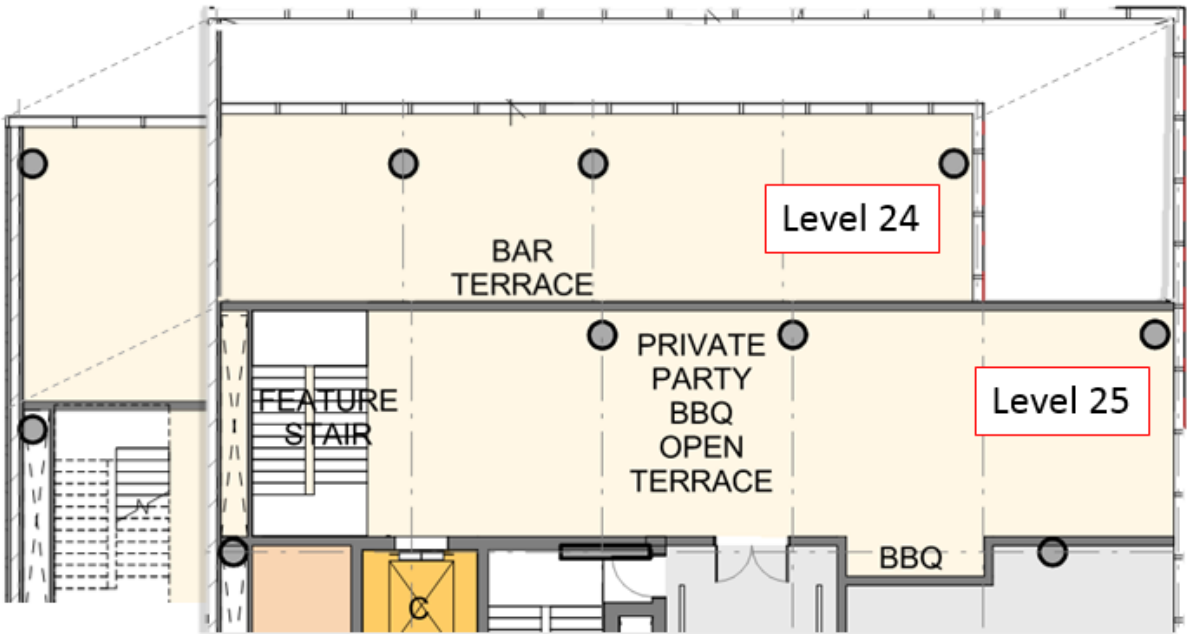

Figure 4: Bar Terrace on Level 24 and Level 25 (Plan View)

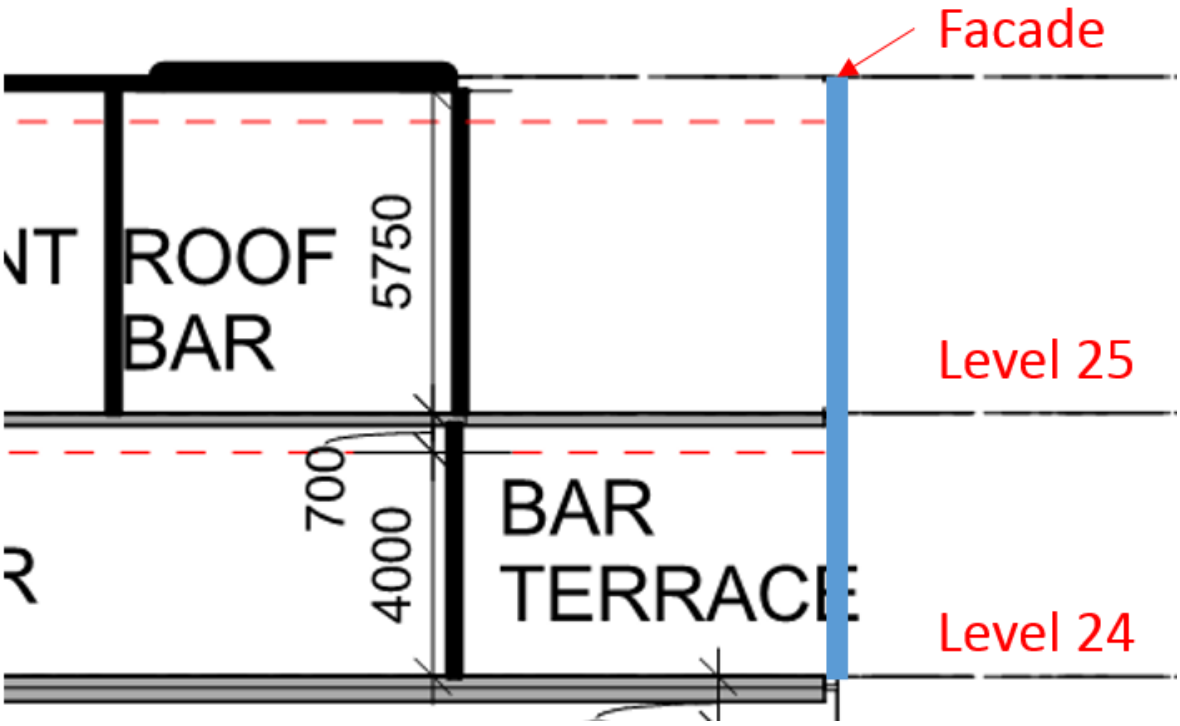

Figure 5: Bar Terrace on Level 24 and Level 25 (Section View)

The relative locations of affected apartments in Tower A (on every floor above the height of Bar Terrace) have been highlighted in Figure 6 below. We note that due to the acoustic barrier effect of the partial enclosure (i.e. glazed façade at perimeter) for the Bar Terrace, the most affected noise sensitive receiver will *NOT* be the apartment located at the same height of the Bar Terrace (i.e. not the apartment that has closest straight line distance). In this case, the most affected apartment is anticipated to be the unit on the higher level where the acoustic barrier effect is no longer beneficial.

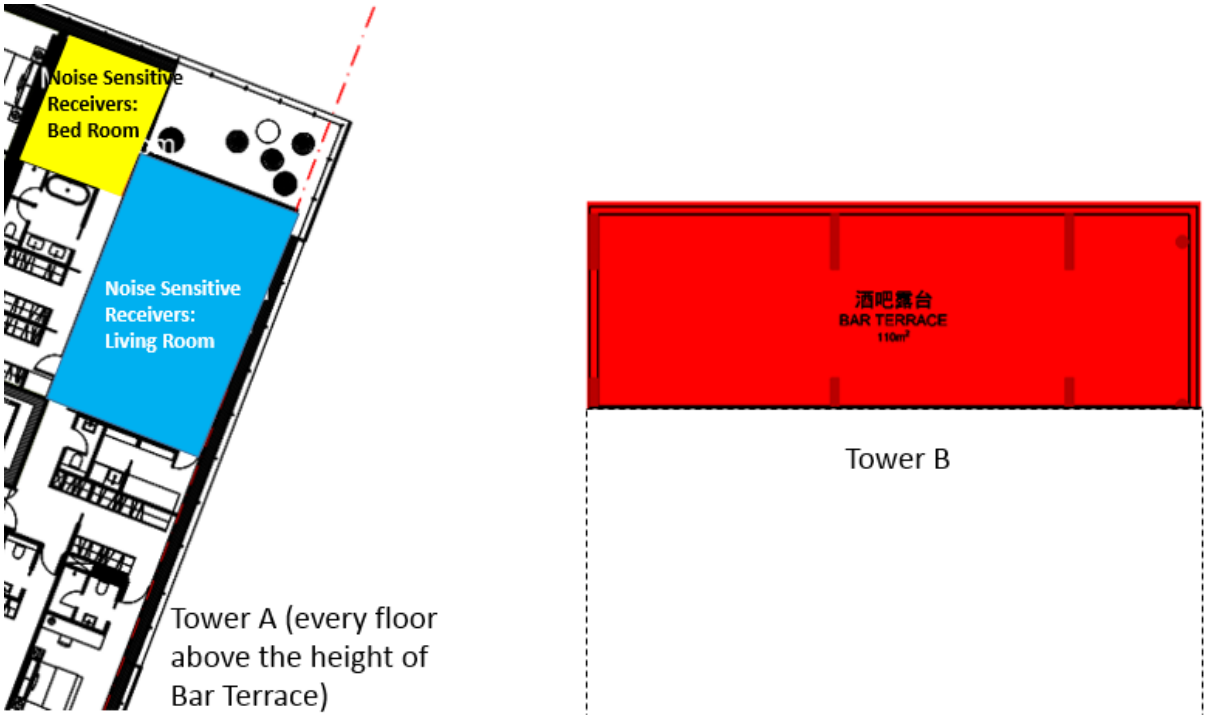

Figure 6: Noise Sensitive Receivers in Tower A

1.5 Karaoke

Karaoke is located at south eastern corner on Level 24, as shown in Figure 7 below. The most affected noise sensitive receiver is the Marriot Hotel to the south west.

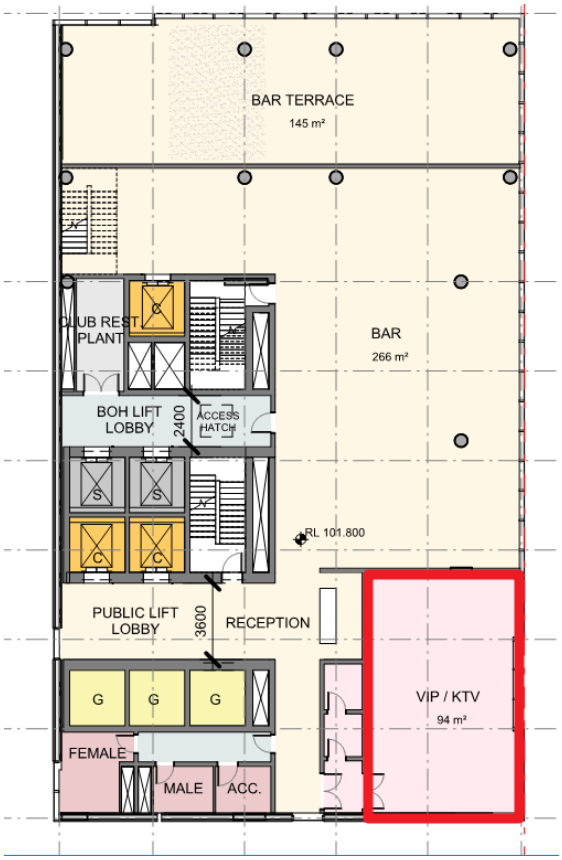

Figure 7: Location of the KTV

2 Existing acoustic environment

The Circular Quay area is characterised as a busy urban area, a transport hub for cars, trains, buses, ferries and cuisine ship, and a focal point for community celebrations (e.g. new year and Vivid Sydney). The existing noise environment is thus complex and dynamic.

Noise levels on the higher floors are greater than the lower floors since the angle of view to the Cahill Expressway, and therefore exposure to road traffic noise becomes greater and the externally located mechanical equipment noise from surrounding buildings increases as floor increases. After a certain height, the noise levels drop again due to distance attenuation.

Noise measurements have been conducted on site. Figure 8 illustrates the locations of measurements.

Figure 8: Long-term noise monitoring and short-term noise measurement locations

2.1 Rating Background Level (RBL)

The Rating Background Level (RBL), which stated in the *DA Acoustic Assessment Report* dated 15/6/2015 by Acoustic Logic, has been approved by the City of Sydney Council. The acoustic environment in the area of site is not changed. As such, it is appropriate to adopt this approved RBL for the purpose of this report. The RBLs have been summarised in Table 2 below.

Table 2: Approved Rating Background Levels (RBLs)

Floor	Time	RBL, $dBL_{A90,peroid}$
Level 1	Day	64
	Evening	64
	Night	61
Level 26	Day	65
	Evening	65
	Night	64

2.2 Attended noise monitoring

To assist in verifying the established RBLs and provide octave band levels, attended short term noise measurements were conducted on 2 June and 18 June 2016 at various locations (identified in Figure 8) to confirm and supplement the long term noise logging. Noise levels from the Cahill Expressway were also measured on 11 July 2016 at ground level. Where possible, attended measurements were conducted simultaneously with unattended noise logging to enable comparison of results between attended measurements and long term noise logging.

Results of the attended noise surveys are summarised in Table 3. Noise spectrum of the background noise levels has been established based on attended measurements.

Table 3: Attended noise monitoring results, $L_{90, 15mins}$

Location	Broadband dB(A)	Octave band centre frequency (Hz), dB								
		31.5	63	125	250	500	1k	2k	4k	8k
Typical Weekday - 2 June, 2016, 10.30-13.15										
Gold Fields House facing George Street (Location 1)	61	67	64	60	61	58	56	50	43	33
FairFax Building (Location 2)	62	67	64	63	61	59	58	53	46	35
Gold Fields House @ L26 facing West	66	68	65	63	61	61	63	57	47	34
Gold Fields House @ L26 facing South	65	70	65	63	62	61	61	56	50	38
Gold Fields House @ L26 facing North	67	69	66	66	61	61	63	58	48	34
Rugby Club	64	64	61	62	61	60	59	54	48	37
Typical Weekday, 11 July, 2016, 13.30 – 14.00										
Cahill Expressway (measured at the pavement of Cahill Expressway)	69	70	68	65	65	63	66	60	50	41
Saturday, 18 June, 2016, 12.00										
Gold Fields House facing George Street (Location 1)	61	68	63	60	60	57	56	51	43	32

3 Criteria and project noise goals

3.1 External noise limiting criteria

3.1.1 Noise conditions for licensed premises

The current noise conditions for the licensed premises by the Liquor and Gaming NSW are shown below. This noise conditions can be imposed to the licensee under NSW Liquor Act 2007 by the Director of Liquor and Gaming NSW. Note that the first two requirements below apply ***at the boundary*** of the affected residence rather than within the residence.

- *The L_{A10}* noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz–8kHz inclusive) by more than 5dB between 7:00 am and 12:00 midnight at the boundary of any affected residence.*
- *The L_{A10}* noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz–8kHz inclusive) between 12:00 midnight and 7:00 am at the boundary of any affected residence.*
- *Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 7:00 am.*

** For the purpose of this condition, the L_{A10} can be taken as the average maximum deflection of the noise emission from the licensed premises.*

In addition to this noise conditions for the licensed premises, City of Sydney also has standard conditions for the Entertainment Noise from licensed premises as shown below.

(a) The $L_{A10,\ 15\ minute}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,\ 15minute}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) by more than 5dB between the hours of 7.00am and 12.00 midnight when assessed at the boundary of any affected residence.

(b) The $L_{A10,\ 15\ minute}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,\ 15\ minute}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) between the hours of 12.00 midnight and 7.00am when assessed at the boundary of any affected residence.

(c) Notwithstanding compliance with (a) and (b) above, noise from the use when assessed as an $L_{A10,\ 15\ minute}$ enters any residential use through an internal to internal transmission path is not to exceed the existing internal $L_{A90,\ 15\ minute}$ (from external sources excluding the use) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed within a habitable room at any affected residential use between the hours of 7am and 12midnight. Where the $L_{A10,\ 15\ minute}$ noise level is below the threshold of hearing, Tf at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 226: 2003- Normal Equal-Loudness-Level Contours then the value of Tf corresponding to that Octave Band Centre Frequency shall be used instead.

(d) Notwithstanding compliance with (a), (b) and (c) above, the noise from the use must not be audible within any habitable room in any residential use between the hours of 12.00 midnight and 7.00am.

(e) The $L_{A10,\ 15\ minute}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,\ 15\ minute}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) by more than 3dB when assessed indoors at any affected commercial premises.

Note: The $L_{A10,\ 15\ minute}$ noise level emitted from the use is as per the definition in the Australian Standard AS1055-1997 Acoustics – Description and measurement of environmental noise. The background noise level $L_{A90,\ 15\ minute}$ is to be determined in the absence of noise emitted by the use and be representative of the noise sensitive receiver. It is to be determined from the assessment L_{A90} / rating L_{A90} methodology in complete accordance with the process listed in the NSW EPA Industrial Noise Policy and relevant requirements of AS1055.1997.

3.1.2 Assessment criteria

Based on the noise conditions, the assessment criteria for entertainment noise has been established. For the purpose of this assessment, noise from any venue that requires alcohol licence should meet criteria summarised in Table 4. External noise limiting criteria for subject venues that do not need an alcohol license has been summarised in Table 5.

Table 4: Entertainment noise criteria for subject venues that require alcohol licence

Time	**Type of Receiver**	**Maximum noise levels in each octave band centre frequency, dB$L_{A10,15mins}$**
7.00am to 12.00 midnight	Residence	Background Noise Level ($L_{A90,15mins}$) at the boundary of the most affected residence+5
	Residence through internal transmission	Background Noise Level ($L_{A90,15mins}$) when assessed within a habitable room
	Commercial	Background Noise Level ($L_{A90,15mins}$) +3 when assessed indoor of the most affected commercial premises
12.00 midnight to 7.00am	Residence	Background Noise Level ($L_{A90,15mins}$) at the boundary of most affected residence+0 *And* Inaudible within any habitable room in any residential use.
	Commercial	We are assuming the noise criteria for the commercial premises are not applicable during 12.00 midnight to 7.00am, as the commercial premises are closed during the period.

Table 5: Entertainment noise criteria for venues that do not need an alcohol license

Type of Receiver	**Maximum noise levels in each octave band centre frequency, dB$L_{Aeq,15mins}$**
Residence/ Commercial	Comply with NSW INP criteria *And* Background Noise Level ($L_{A90,15mins}$) +3, when assessed inside any habitable room or noise sensitive commercial premises

3.2 Derivation of inaudible noise target in Tower A apartments

The internal criteria for Tower A apartments, as presented in Figure 9, has given consideration to both the apartment fan coil unit noise levels and the threshold of hearing (the Fletcher-Munson Equal Loudness Curve - Pure Tone for Minimum Audible Field, as defined by ISO 226). Note that the projected FCU noise at 63 Hz is *below* the MAF curve. The

inaudibility targets have been set as L_{10} octave levels being 8 dB below the projected FCU noise except where this would be below the Minimum Audible Field. This 8 dB threshold is derived from work by Moore[1] who looked at the audibility of pure tones against broadband background noise. Phillips, Eager and Tonin[2] presented results that showed music noise could be above the ambient noise at 63 Hz and still be inaudible provided noise at other frequencies was below the ambient by 5dB. As noted above, reducing entertainment noise to the threshold of hearing at all frequencies would neither be practicable or desirable because of the intra-apartment noise issues that could result.

The proposed entertainment noise criterion shown in Figure 9 is equivalent to 30 dB(A). At this level, the entertainment noise would add less than 1 dB to the 38 dB(A) noise level allowable for the noise from other sources.

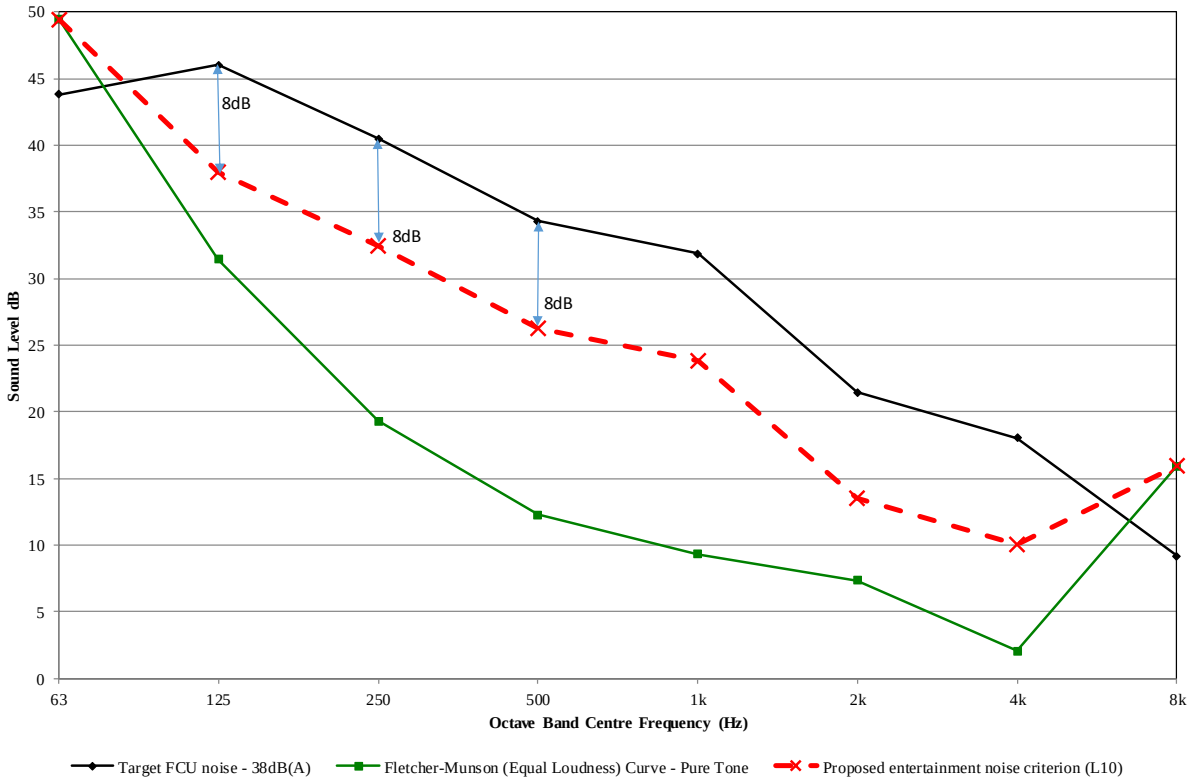

Figure 9: Comparison of the projected FCU noise and the Minimum Audible Field and the Proposed Criterion

The noise target specified in Table 6 is aimed to achieve the inaudibility of entertainment noise in the apartment as required by the council during 12.00 midnight to 7.00am.

Table 6: Entertainment noise criterion in the apartment of Tower A

Habitable Area in Apartment	Assumption of Building Service Noise Level	Octave band centre frequency (Hz), dB							
		63	125	250	500	1k	2k	4k	8k
Bedroom/ Living Room	38 dB(A)	49	38	32	26	24	13	10	16

[1] Moore, B (1975) Mechanisms of masking J. Acoustic Society of America 57(2), pp391-399

[2] A preliminary investigation into the determination of the inaudibility level of mechanical plant and music noise in the presence of ambient background noise. Stanley Rodney Phillips, David Eager and Renzo Tonin. Paper Number 28, Proceedings of ACOUSTICS 2011

3.3 Project noise goals

From the measured background noise levels, applicable noise criteria and consideration of internal conditions for Tower A, the project noise have been established and are presented in Table 7.

Table 7: Project noise goals

Location	Period	Octave band centre frequency (Hz), dB							
		63	125	250	500	1k	2k	4k	8k
Residential (Level 3) – External For Wanda development and Marriot Hotel	Day	68	66	65	63	67	60	49	36
	Evening	68	66	65	63	67	60	49	36
	10pm – 12am	68	66	65	63	67	60	49	36
	12am – 7am	60	58	57	55	59	52	41	28
Residential (Level 26) – External For Wanda development and Marriot Hotel	Day	70	71	65	66	67	62	52	38
	Evening	70	71	65	66	67	62	52	38
	10pm – 12am	70	71	65	66	67	62	52	38
	12am – 7am	64	65	59	60	61	56	46	32
Tower A - Bedroom/ Living Room (internal)	12am – 7am	49	38	32	26	24	13	10	16
Grand Ball Room (Commercial on Level 3)	When in use	66	64	63	61	65	58	47	34
Chinese Restaurant (Commercial on Level 23)	When in use	68	69	63	64	65	60	50	36

4 Assessment methodology and inputs

4.1 General assumptions

4.1.1 Predicting noise from patrons

Noise from general activity is notoriously difficult to predict because of the complex relationship between the noise source and the ambient level of noise particularly the 'Lombard Effect' where people tend to speak louder to overcome the noise from people talking. This results in a feedback effect, leading to an overall increase in noise level.

A recent paper[3] has proposed a methodology for predicting this. Measurements by Arup have shown that this methodology provides reasonable agreement with actual examples for small crowds. The spectrum components of the crowd noise are based on a typical conversational speech spectrum in the database of Arup.

It also worth noting that this crowd noise prediction method assumes a situation at a bar or pub. As the crowd noise is also related to the situational context and social group. The patron noise from a high-end restaurant or dining area is very likely to be much quieter than from a bar. As such, it is appropriate to assume the crowd noise level in a high-end restaurant/dining area is at least 5 dB lower.

The noise levels of the crowds for each subject venue are established in subsections of Section 5 based on the expected occupancies.

4.1.2 Assumptions of background music noise

For some types of subject venues (e.g. Restaurant), there might be light music playing in the space to provide a sense of atmosphere. Such background music playing is usually characterised as quiet, light and soft. It also sometimes gives benefits for sound masking and speech privacy.

The assessment in this document assumes that background-like music sound power level is 5 dB higher than the crowd noise across the space, as a worst case, to allow the music to be heard by the crowd. The spectrum of the background music is established based on the measurements in the Arup database.

Note that the actual noise levels and spectrum content of background music are very variable and dependant on how the space is used and choices made by the venue management.

4.1.3 Assumptions of foreground amplified music

For some types of subject venues (e.g. Grand Ballroom), the amplified music is anticipated for events, such as music performance, wedding, etc.

[3] Prediction of Noise from Small to Medium Sized Crowds M.J. Hayne (1), J.C. Taylor (1), R.H. Rumble (1) and D.J. Mee

The foreground music noise is usually the dominate noise source in the venues, and thus the focus concern in assessments of venues with foreground music events. The characters of the amplified music, such as sound pressure levels and spectrum compositions, vary in accordance with the type of the music/event. As such, for the purpose of this assessment, it is appropriate to assume amplified music noise based on the type of venue/events.

In general, the assumptions (noise levels and spectrum compositions) are established using the various measurement data in Arup database.

4.2 Venues

After consulting with Wanda and the Architect, the acoustic considerations and assumptions for each venue is summarised in the following sub-sections.

4.2.1 Grand Ballroom

Table 8: Acoustic considerations and assumptions for the Grand Ballroom

Acoustic Considerations	**Assumptions**
Opening Hours	9.00am to 1.00am
Alcohol Licence Required?	YES
Occupancy and Patron Noise Level	Maximum 164 people at the same time L_w - 100 $dBL_{A10,15mins}$
Amplified Music Noise Level	Based on the possible events defined by Wanda, a live band (including acoustic drums/percussion) with an average sound pressure level of 100 $dBL_{A10,15min}$ from the stage/band has been assumed, with the spectrum shown in Table 9. Similar noise levels are also possible for other amplified music. At these music noise levels, the internal sound level will be determined by music, rather than patron noise.
Most Affected Noise Sensitive Receiver	Tower A residence on L3 of Wanda Sydney
Grand Ballroom Building envelope	The glazed facade of the Grand Ballroom has been designed to be *8.5mm acoustic laminate – 16mm airgap – 12.5mm acoustic laminate (R_w 46)* as specified in *Acoustic Report for Wanda Sydney Tower B.* It is noted that the specification has been determined on the basis of noise ingress to the ballroom. The control of noise emission, as demonstrated in this assessment could be addressed by a low specification system.

Table 9: Grand Ballroom Music Noise spectrum assumption, L_p

Broadband $L_{A10,15mins}$	**Octave band centre frequency (Hz), $L_{10,15mins}$, dB**							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
100	94	95	97	94	96	93	87	80

4.2.2 All Day Dining and Chinese Restaurant

Table 10: Acoustic considerations and assumptions for All Day Dining and Chinese Restaurant

Acoustic Considerations	All Day Dining	Chinese Restaurant
Opening Hours	6.00am to 10.00am 11.00am to 3.00pm 5.00pm to 1.00am	11.00am to 2.30pm 5.30pm to 1.00am
Alcohol Licence Required?	YES	YES
Occupancy and Patron Noise Level [4]	Maximum 74 people at the same time 95-5=90 $dBL_{A10,15mins}$ * As mentioned in Section 4.1.1, the noise level from a formal restaurant is considered to be lower than the social groups in a bar/pub context. -5 dB(A) is given to account for this.	Maximum 58 people at the same time 94-5=89 $dBL_{A10,15mins}$ * As mentioned in Section 4.1.1, the noise level from a formal restaurant is considered to be lower than the social groups in a bar/pub context. -5 dB(A) is given to account for this.
Background Noise Music	89 $dBL_{A10,15mins}$ (high-end restaurant soft music)	89 $dBL_{A10,15mins}$ (high-end restaurant soft music)
Building envelope design	The façade has been assumed as *6mm/12mm gap/6mm*, with an acoustic rating of R_w 32, as detailed in *Acoustic Report for Wanda Sydney Tower B.*	The façade has been assumed as *6mm float /12mm gap/6mm float*, with an acoustic rating of R_w 32, as detailed in *Acoustic Report for Wanda Sydney Tower B.*

Table 11: Chinese Restaurant Music Noise spectrum assumption, Lp

Broadband $L_{A10,15mins}$	**Octave band centre frequency (Hz), $L_{10,15mins}$, dB**							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
89	82	82	87	88	82	73	65	65

4.2.3 Rooftop

Table 12: Acoustic considerations and assumptions for L24 and L25 Rooftop bars

Acoustic considerations	Level 24 and Level 25
Opening hours	10.00am to 1.00am
Alcohol licence required?	YES
Occupancy and patron noise level [5]	L24 = 137 patrons, 6 staff [6] L25 = 35 patrons, 6 staff 101 $dBL_{A10,15mins}$ Assumes that the maximum occupancies are reached on both floor as the worst case. The sound power level will drop 4 dB if the number of people is halved.
Amplified music	It is uncertain at this stage whether background music will be provided on the Bar Terrace.

[4] Based on the methodology defined in Section 3.3.
[5] Based on the methodology defined in Section 3.3.
[6] This occupancy includes the populations of both indoor bar and terrace. The door between the indoor bar and terrace will be kept open, the noise will be freely transfer to the terrace area. In addition, it is also anticipated that people are likely to stay in the terrace area for a better view. As such, it is appropriate to adopt this occupancy to estimate the crowd noise as the worst case.

Acoustic considerations	Level 24 and Level 25
	To enable a comparison of scenarios with/without music noise, it is assumed that sound power level of music is 5 dB higher than the crowd noise across the area for a general situation (to allow the music to be heard by people on the terrace). This is equivalent to 'background music' rather than a live concert which would require much higher sound levels. Based on the assumed crowd noise level in Section 4.1.1, the music sound power level is assumed as sound pressure level 106 dBL_{A10}. The noise spectrum is based a typical rock music in the Arup sound level database. A 3 dB contingency has been included in the prediction to provide safety factor for the background noise level changes and the variation of the bar noise.

Table 13: Noise spectrum assumption, L_w

Overall Sound Power Level, $dBL_{A10,15mins}$	Octave band centre frequency (Hz), $dBL_{A10,15mins}$							
	63	125	250	500	1k	2k	4k	8k
106	100	101	103	100	102	99	93	86

4.2.4 Karaoke

Table 14: Acoustic considerations and assumptions for Karaoke

Acoustic considerations	Karaoke
Opening hours	7.00pm to 2.00am
Alcohol licence required?	YES
Occupancy and patron noise level	Maximum 20 people at the same time 87 $dBL_{A10,15mins}$
Amplified music noise	95 $dBL_{A10,15mins}$ with noise spectrum as per Table 15
Building envelope design	The façade glass of the KTV has been assumed as 6mm float/12mm air gap/6mm float glass, with an acoustic rating of R_w 32, in accordance with *Acoustic Report for Wanda Sydney Tower B.*

Table 15: Karaoke noise spectrum assumption, L_p

Overall noise level, $dBL_{A10,15mins}$	Octave band centre frequency (Hz), $dBL_{A10,15mins}$							
	63	125	250	500	1k	2k	4k	8k
95	85	89	91	91	91	86	86	85

5 Entertainment noise assessment

5.1 Grand ballroom

The transmission loss of the façade glass and distance attenuations have been considered in the prediction. However, the barrier effect and angle of view have not been included in the prediction as a conservative approach. Table 16 summarises the predicted noise levels at the most affected receiver.

Table 16: Predicted Entertainment Noise at most affected apartment on Level 3 in Tower A

Time	Overall noise level, $L_{A10,15mins}$	Octave band centre frequency (Hz), $L_{10,15mins}$, dB								Compliance with the criteria?
		63	125	250	500	1k	2k	4k	8k	
All	41 (Outside Receiver Façade)	55	53	45	32	30	25	8	1	YES
12.00am to 7.00am	13 (Within the nearest habitable room of Residential Receiver)	30	25	17	0	0	0	0	0	YES

5.1.1 Recommendations and conclusion

We conclude that the entertainment noise impact from the Grand Ballroom meet the criteria specified in Table 7.

The following noise management guidelines are recommended if noise becomes an issue:

- Reduce the volume of the amplified music when noise becomes an issue.
- Prepare a management plan and fast response to noise complaints;

5.2 All Day Dining and Chinese Restaurant

The All Day Dining and Chinese Restaurant are fully enclosed spaces with low impact uses proposed, and therefore considered to be low risk in terms of noise break-out.

The predicted noise levels are summarised in Table 17. Note the predicted noise levels at immediate outside the façade have complied with the criteria, it is anticipate that the resultant noise levels at receivers will be compliant to the criteria specified in Table 7. This has been assessed against the **noise spectrum** in accordance of assessment guidelines and requirements in Table 7. The vertical sound insulation will be designed to meet the requirements specified in Table 7.

Table 17: Predicted noise levels at noise sensitive receivers

Time	Location	Noise level		Noise level in adjacent space	
		Predicted noise levels	Compliance	Predicted noise levels	Compliance
All	All Day Dining on Level 2	22 $dBL_{A10,15min}$ (immediate outside source façade)	YES [1] [2]	36 $dBL_{A10,15min}$ (in Grand Ball Room on Level 3)	YES [1]

Time	Location	Noise level		Noise level in adjacent space	
		Predicted noise levels	Compliance	Predicted noise levels	Compliance
	Chinese Restaurant on Level 23	20 $dBL_{A10,15min.}$ (immediate outside source façade)	YES [1] [2]	25 $dBL_{A10,15min}$ (in Presidential Suite on Level 22)	YES [1]

Note:

1- Assessment has been completed against the noise spectrum in accordance of assessment guidelines and requirements in Table 7, however presented in overall terms for ease of presentation.

2- The predicted noise spectrum outside the façade of the Residential has met the Night Time criteria specified in Table 7. It is reasonable to expect that the indoor noise level will be lower and thus meet the Night Time criteria.

5.2.1 Recommendations and Conclusions

We conclude that noise impact to atmosphere from All Day Dining and Chinese Restaurant is not an issue.

5.3 Level 24 and 25 Rooftop bar

The predicted noise levels with retractable roof open (i.e. dose not enclose the bar) to the most affected apartment are summarised in Table 18. This has been assessed against the **noise spectrum** in accordance of guidelines and requirements in Table 7.

As mentioned in Section 1.4, for the purpose of this assessment, the retractable roof has been conservatively excluded from this noise prediction model. The retractable roof is considered to be a supplementary mitigation measure.

Table 18: Predicted noise levels (with retractable roof open, i.e. retractable roof does not enclose the bar) at the most affected apartment in Tower A

Time	Spaces in the most affected apartment in Tower A	Crowd noise only		Crowd noise with music	
		Predicted noise levels	Compliance	Predicted noise levels	Compliance
7.00am – midnight	Bedroom	61 $dBL_{A10,15min}$ outside façade	Y	68 $dBL_{A10,15min}$ outside facade	N
	Living Room	62 $dBL_{A10,15min}$ outside facade	Y	69 $dBL_{A10,15min}$ outside facade	N
Midnight – 7.00am	Bedroom	24 $dBL_{A10,15min}$ in the bedroom [7]	N (Marginal, with shortfalls at mid frequencies)	30 $dBL_{A10,15min}$ in the bedroom	N

5.3.1 Recommendations and conclusions

The predicted noise levels shown in Table 18 indicate that noise from the Bar Terrace on Level 24/25 will meet the entertainment noise criteria if there is only crowd noise (i.e. no music) during the period of 7.00 am - midnight.

[7] This is assuming 38 dB(A) building service noise in the apartment.

There are small shortfalls at mid-frequencies (250Hz and 500Hz) to achieve inaudibility in the bedroom during Night Time (midnight - 7.00am) with crowd noise only. As the exceedance is small (less than 2 dB at 250Hz and 500Hz) and crowd noise is dynamic and variable, it is recommended that management/control procedures are conducted after midnight to reduce noise impact, if noise becomes an issue. This may include limiting the number of people on the terrace at the same time.

Results indicate that the entertainment noise requirements will not be met if there is a music playing in the bar terrace with retractable roof open (i.e. dose not enclose the bar).

In comparison with previous assessment (assuming fully opened terrace, i.e. no façade), the noise impact to the Tower A is generally reduced due to the reduced the occupancy and partial enclosure (façade) in the bar terrace area. This is especially true for apartments at the similar height of the bar terrace, as the acoustic barrier effect is very beneficial in this zone (approximately 15 dB attenuation).

The acoustic barrier effect provided by façade becomes less effective as height increases, and this happens more rapidly than the gain of noise distance attenuation; thus, the noise level at Tower A will reach the peak on approximately 35m above the height of Level 24 in Tower B and then decline gradually again. As such, to mitigate the noise impact for these higher level apartments, the most effective way is to enclose the opening to the top with the retractable roof.

The following mitigation measures are recommended as follow:

1. The resultant noise levels at the boundary of the apartment will be significantly higher if music is playing in the outdoor area. Thus, we recommend to not allow music in the bar terrace unless the space is completely enclosed. Note music could potentially be playing in the indoor area. However, additional management procedures should be prepared. This may include that if the noise becomes an issue, shut the door between terrace and indoor area.
2. Enclose the Bar Terrace to reduce noise emission to the Tower A. This will allow more people into the bar space at the same time, and it enables music playing and holding more flexible events. It is recommended that the retractable roof system should be closed to enclose the bar when noise becomes an issue.

5.4 Karaoke

KTV will be designed to be a fully enclosed space with adequate sound separation performance to prevent noise break-out as well as noise break-in.

Table 19 summarises the predicted noise levels at the most affected receivers.

Table 19: Predicted entertainment noise at most affected receivers

Receivers	Broadband, $dBL_{A10,15mins}$	Octave band centre frequency (Hz), $dBL_{A10,15mins}$								Compliance with criteria?
		63	125	250	500	1k	2k	4k	8k	
Marriott Hotel (Outside the Facade)	16	22	23	23	9	1	0	0	0	YES [8]
Chinese Restaurant on Level 23 (within the building)	37	38	42	42	35	27	17	11	8	YES

5.4.1 Recommendations and conclusions

We conclude that the entertainment noise impact from the Karaoke meet the criteria specified in Table 7.

At this stage, the following has been allowed to further reduce the noise break-out.

- Resilient mount ceiling, and/or
- Acoustic wall lining, and/or
- Resilient mount ceiling in the Chinese Restaurant below.

[8] The predicted noise spectrum outside the façade of the Marriott Hotel has met the Night Time criteria specified in Table 7. It is appropriate to predict that the indoor noise level will be lower and thus met the Night Time criteria.

6 Conclusion

On the basis of the information above, it is concluded that the proposed entertainment venues can operate successfully within the City of Sydney and the NSW state guidelines. Where there is a potential risk of noise issue to the noise sensitive receivers, mitigation measures or management plans have been recommended to meet the requirements of guidelines and minimise the noise impact.

With the inclusion of the mitigation recommendations detailed in this report, there is predicated to be no adverse impact from Tower B Entertainment Noise upon the development or offsite receivers.

Appendix A

Acoustic Terminology

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.