WOOD & GRIEVE ENGINEERS

SICEEP South East Plot

Noise and Vibration Impact Assessment
Development Application – SSDA 9

Prepared for:

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Date:
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Project No. 27752-SYD-N
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Revision

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Revision

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1. Introduction

This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Application (referred to as SSDA 9) follows the approval of a staged SSD DA (SSDA 2) in December 2013. SSDA 2 sets out a Concept Proposal for a new mixed use residential neighbourhood at Haymarket referred to as "Darling Square", previously known as "The Haymarket". Darling Square forms part of the Sydney International Convention, Exhibition and Entertainment precinct (SICEEP) Project, which will deliver Australia's global city with new world class convention, exhibition and entertainment facilities and support the NSW Government's goal to "make NSW number one again".

More specifically this subsequent DA seeks approval for mixed use development within the South East development plot of Darling Square and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

1.1 Overview of Proposed Development

The proposal relates to a detailed ('Stage 2') DA for a mixed use residential development in the South East Plot of Darling Square together with associated public domain works. The Darling Square Site is to be developed for a mix of residential and non-residential uses, including but not limited to residential buildings, commercial, retail, community and open space. The South East Plot is one of six development plots identified within the approved Concept Proposal.

Under the Concept Proposal, the South East Plot is planned to accommodate a mixed use podium and three residential buildings (SE1, SE2, and SE3) above and within the podium structure. More specifically, this SSD DA seeks approval for the following components of the development:

- Demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC);
- Associated tree removal and planting;
- Construction and use of a predominantly 5 storey mixed use podium, including:
    - retail floor space and residential lobbies on Ground Level;
    - above ground parking;
    - residential apartments; and
    - communal facilities.
- Construction and use of three residential buildings above podium;
- Public domain improvements adjacent to the site;
- Provision of vehicle access to the development from Harbour Street;
- Landscaping works to the podium roof level; and
- Extension and augmentation of physical infrastructure / utilities as required.

1.2 Background

The NSW Government considers that a precinct-wide renewal and expansion of the existing convention, exhibition and entertainment centre facilities at Darling Harbour is required, and is committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of SICEEP.

Introduction

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create SICEEP.

Key features of the Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
  - Up to 40,000m2 exhibition space;
  - Over 8,000m2 of meeting rooms space, across 40 rooms;
  - Overall convention space capacity for more than 12,000 people;
  - A ballroom capable of accommodating 2,000 people; and
  - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, now called 'Darling Square', including apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain that has been increased by a hectare, including an outdoor event space for up to 27,000 people at an expanded Tumbalong Park; and
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

On 21 March 2013 a critical step in realising the NSW Government's vision for the SICEEP Project was made, with the lodgement of the first two SSD DAs with the (now) Department of Planning and Environment. The key components of these proposals are outlined below.

Public Private Partnership SSD DA (SSD 12_5752)

The Public-Private Partnership (PPP) SSD DA (SSDA 1) includes the core facilities of the SICEEP Project, comprising the new, integrated and world-class convention, exhibition and entertainment facilities along with ancillary commercial premises and public domain upgrades. SSDA1 was approved on 22 August 2013.

Concept Proposal (SSD 13_5878)

The Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Darling Square Site. SSDA2 was approved on 5 December 2013. The Stage 1 Concept Proposal approved the following key components and development parameters:

- Indicative staging of demolition and development of future development plots;
- Land uses across the site including residential and non-residential uses;
- Street and laneway layouts and pedestrian routes;
- Open spaces and through-site links;
- Six separate development plots, development plot sizes and separation, building envelopes, building separation, building depths, building alignments, and benchmarks for natural ventilation and solar access provisions;
- A maximum total gross floor area (non-residential and residential GFA);
- Above ground car parking including public car parking;

- Residential car parking rates;
- Design Guidelines to guide future development and the public domain; and
- A remediation strategy.

The Concept Proposal was modified on 26 November 2015 to increase the amount of non-residential GFA. This minor increase in GFA was allocated to the approved North-West Plot building to meet tenant requirements. In addition to the approval of SSDA2, the following approvals have been granted for various stages of Darling Square site:

- Darling Drive (part) development plot (SSDA3) for the construction and use of a residential building (student accommodation) and the provision of associated public domain works approved on 7 May 2014;
- North-West development plot (SSDA4) for the construction and use of a mixed use commercial development and public car park building and associated public domain works approved on 7 May 2014; and
- South-West development plot (SSDA5) – construction and use of a mixed use residential development and associated public domain works approved on 21 May 2014.
- North-East development plot (SSDA7) – construction and use of a mixed use residential development and associated public domain works approved on 16 April 2014.

Approval was also granted on 15 June 2014 for SSDA6 which includes the construction and use of the International Convention Centre (ICC) Hotel and provision of public domain works. Approval was also granted for SSDA8 on 16 October 2015 which comprised the ICC Hotel fitout, external lighting and subdivision.

This report has been prepared to support a detailed Stage 2 SSD DA for mixed use development and associated public domain works within Darling Square (SSDA 9), consistent with the Concept Proposal (SSDA 2).

1.3 Site Description

- The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.
- With an area of approximately 20 hectares, the SICEEP Site is generally bound by the light rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south (refer to Figure 1). The Darling Square Site is:
- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket;
- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south; and
- irregular in shape and occupies an area of approximately 37,700m2.

Introduction

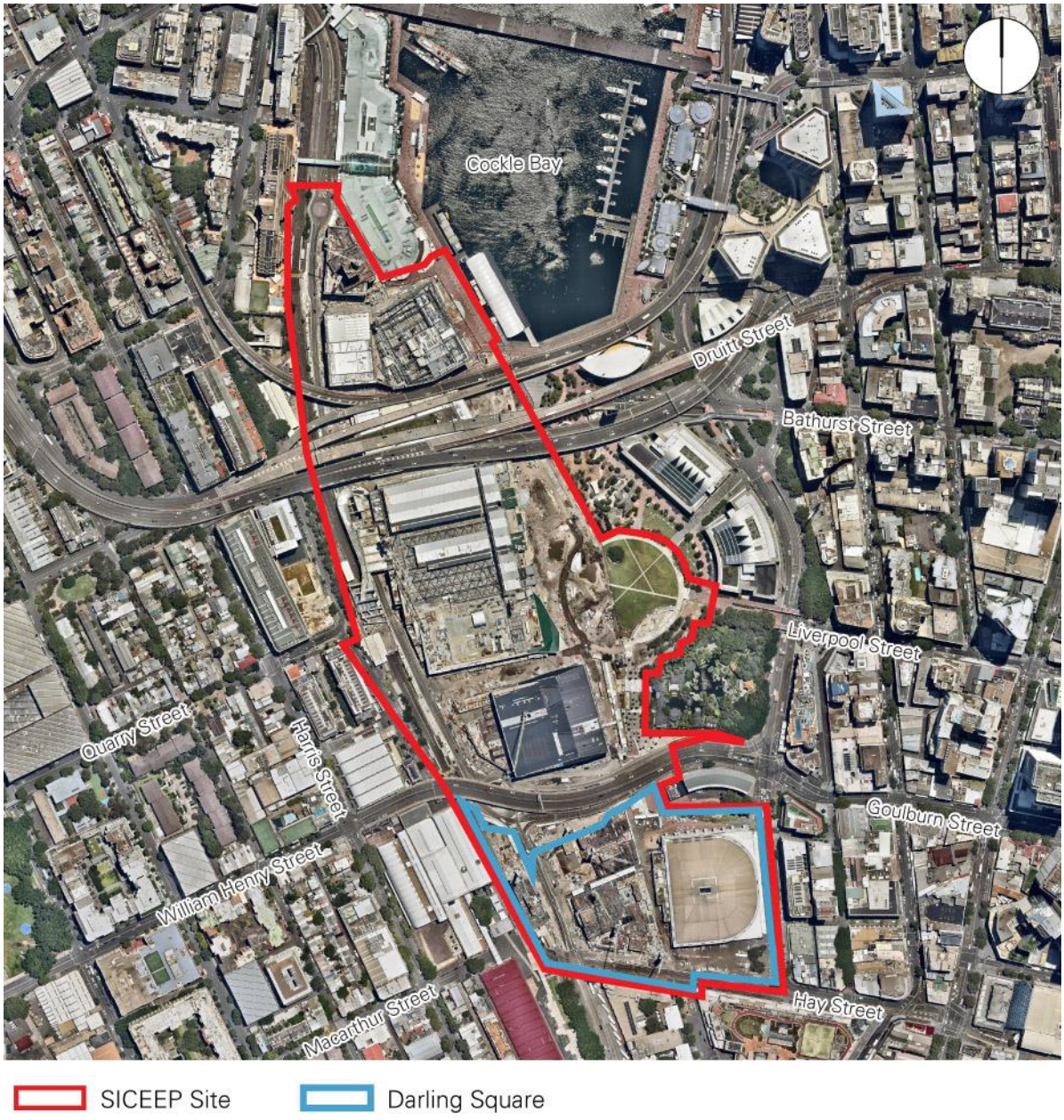


Figure 1 – Aerial Photograph of the SICEEP Site

The Concept Proposal DA provides for six (6) separate development plots across the Darling Square Site (refer to **Figure 2**):

1. North Plot;
2. North East Plot;
3. South East Plot;
4. South West Plot;
5. North West Plot; and
6. Western Plot (Darling Drive).

The Application Site area relates to the South East Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA.

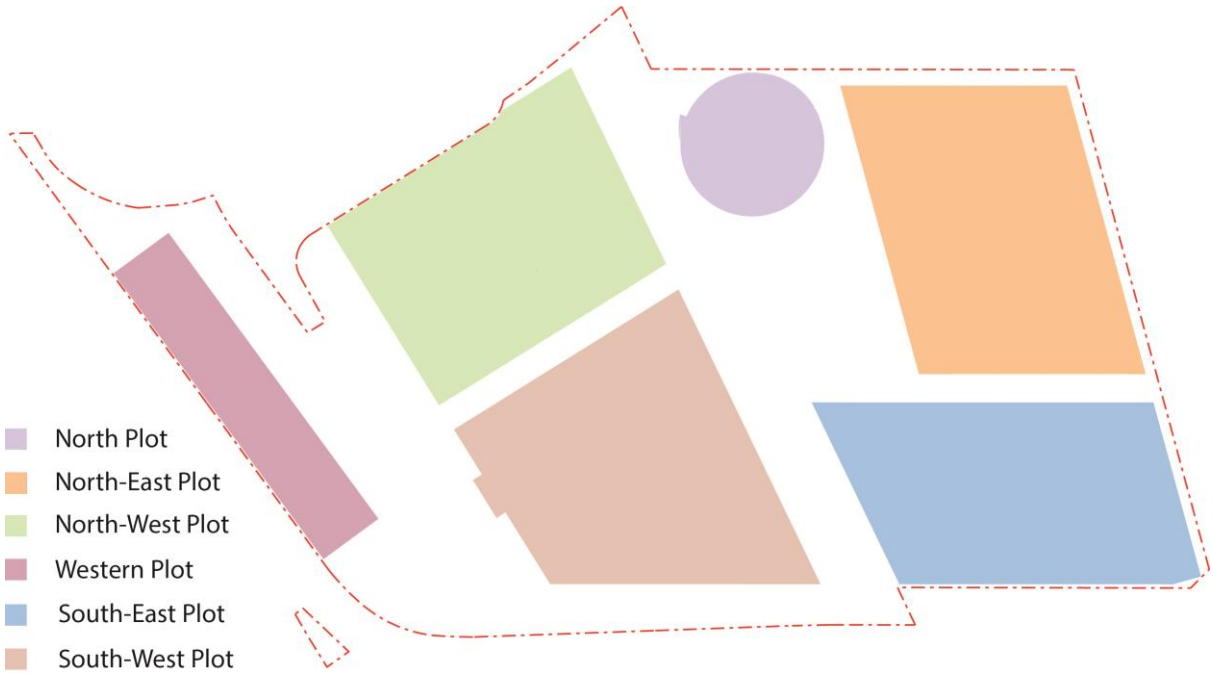


Figure 2 – Concept Proposal Development Plots

1.4 Planning Approvals Strategy

The SICEEP Project has resulted in the lodgement of numerous SSD DAs for the various components of the redevelopment project. Future applications will continue to be lodged in accordance with the Concept Proposal SSD DA for the remaining development plots of Darling Square Site.

2. Acoustic Report Overview

As part of the DA documentation process, Wood & Grieve Engineers has been engaged by Lend Lease to provide an acoustic assessment for the State Significant Development (SSDA9) located to the South East side of Darling Square (referred to as SE Plot in this report).

This assessment discusses the likely noise impact of the development upon the nearest most-affected receivers and also the potential noise intrusion upon the development. Where required by the City of Sydney Council, separate tenant-specific acoustic reports should be submitted for commercial and retail tenancies.

This assessment has been prepared considering the following documents:

- NSW Office of Environment & Heritage (OE&H) Industrial Noise Policy, 2000 (INP 2000)
- NSW Road Noise Policy, 2011 (RNP 2011)
- Lend Lease PCD Requirements
- AS/NZS 2107:2000: "Acoustics – Recommended design sound levels and reverberation times for building
- NSW Office of Environment and Heritage (OE&H) Interim Construction Noise Guideline (ICNG July 2009)
- NSW Environment Protection Authority (EPA) Noise Guide for Local Government, 2013
- Assessing Vibration: A Technical Guideline (DEC, 2006)
- Environmental Criteria for Road Traffic Noise (EPA, 1999)
- City of Sydney Development Control Plan (DCP), 2012

This report provides:

- A statement of compliance with the NSW noise guidelines and regulations consistent with the SEARSs requirements of previous development located on the same site for the proposed mixed-use development within the vicinity of the nearest potentially affected receivers (residential, commercial and public domain).
- Recommendations for noise mitigation measures for the proposed development in order to meet the applicable criteria when compliance is not achieved.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore this report shall not be relied upon as providing any warranties or guarantees.

3. Project Overview

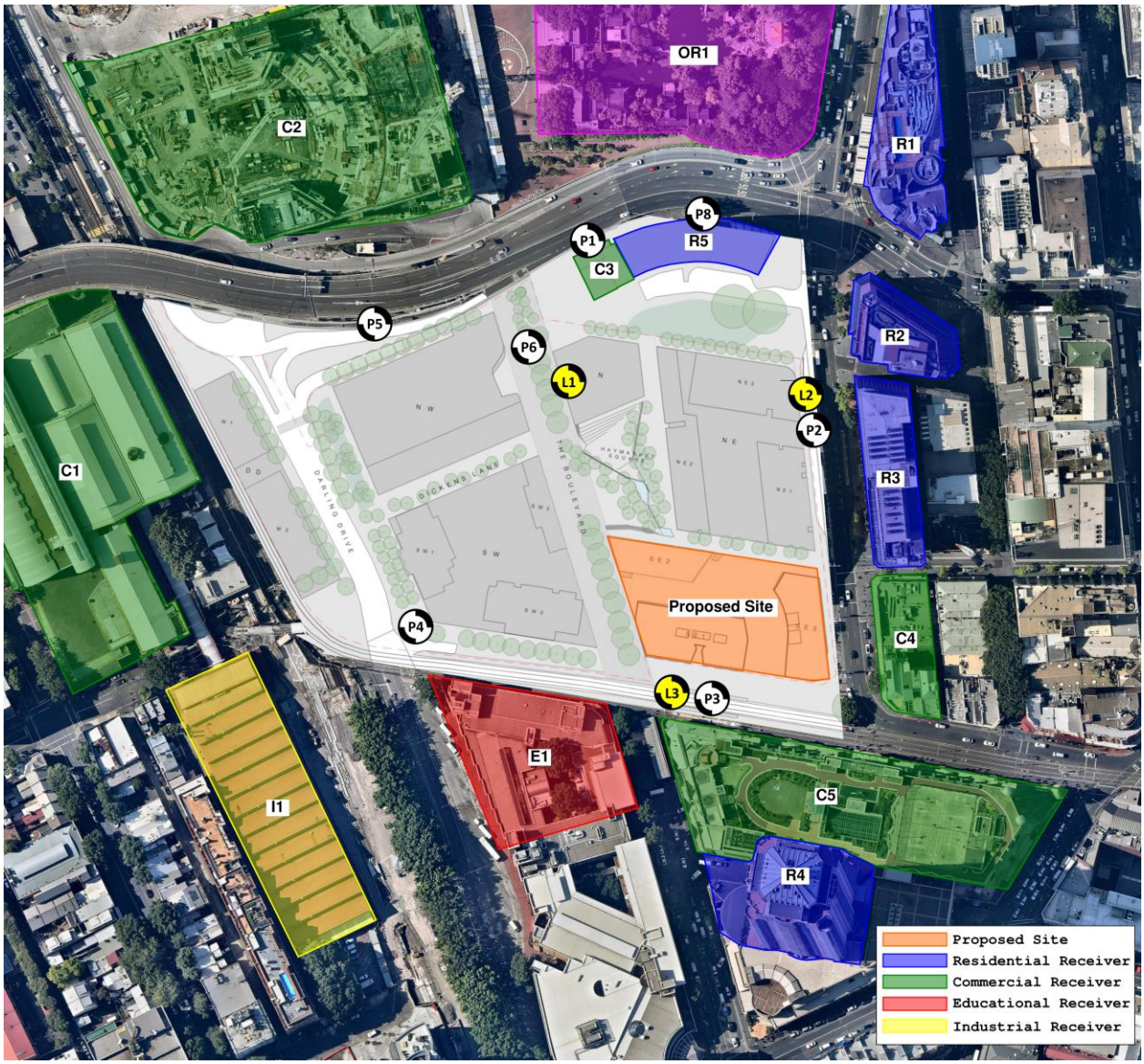
3.1 Site description

The proposed mixed use development is to be located at the South-Eastern side of Darling Square and associated public domain works. The site is bound Harbour St to the East as well as Hay St to the South-East. To the South of the site is an existing light rail line that travels throughout the city.

The nearest potentially affected noise receivers (shown in Figure 3) have been identified and categorized as follow:

- Residential Receivers (shown in Blue)
- Commercial Receivers (shown in Green)
- Industrial Receivers (shown in Yellow)
- Educational Receivers (shown in Red)
- Outdoor Recreational Receiver (shown in Magenta)

Figure 3: Aerial Site Map with Measurement Locations and Nearby Receivers



4. Noise Survey

4.1 Existing Noise Environment

The existing ambient and background noise level of the site is typical of an urban area with continuous traffic flow and within close proximity to commercial districts and exudes a continuous “urban hum” as defined in the OEH NSW Industrial Noise Policy (INP). During the evening and night-time periods there is evidently a decrease in ambient noise levels due to reduced traffic volume and foot traffic around the site and within the nearing surroundings. The existing background and ambient noise level is assessed using three given time periods as shown in the INP. The INP defines these periods as follows:

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

The noise monitoring locations are presented in Figure 3. The long term monitoring Locations L1 (Entertainment Centre’s Carpark), L2 (Entertainment Centre’s roof) and L3 (between Hay st and Quay St, near the tram stop) positioned away from any nearby mechanical plant located in the vicinity which could provide inaccurate results to the overall monitoring. These selected locations are considered to be representative of the ambient noise level of the areas surrounding the site.

In addition to the unattended noise monitoring, attended noise monitoring was conducted at locations P1 to P8.

4.1.1 Instrumentation

The equipment used for the noise survey was the following:

- ARL Environmental Noise Logger Ngara S/N 878005 used at (L1 in Figure 3)
- ARL Environmental Noise Logger EL-315 S/N 194639 used at (L2 in Figure 3)
- ARL Environmental Noise Logger EL-315 S/N 194678 used at (L3 in Figure 3)
- Hand-held sound spectrum analyzer Brüel & Kjær 2250 S/N 2709742.
- Brüel & Kjær Calibrator, S/N: 2709826 used for hand-held sound spectrum analyzer.
- Hand-held sound spectrum analyzer Svantek 958 S/N 15153.
- Svantek SV30A Calibrator, S/N: 17556 used for hand-held sound spectrum analyzer.

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

4.1.2 Attended Noise Survey

Table 1 presents a summary of the attended measurement results around the proposed development.

Table 1: Summary of short-term measurements

Measurement Location	Date/Start Time	$L_{Aeq,15min}$ dB(A)	$L_{A90,15min}$ dB(A)	Background Noise Description
P1	8/04/2015 18:13	60.2	56.3	Ambient noise dominated by exiting traffic on Pier St
	8/04/2015 19:14	63.2	59.1	Noise dominated by heavy vehicles
	13/04/2015 18:02	60.3	57.9	Consistent traffic noise Harbour/Pier St
P2	7/04/2015 13:10	66.3	60.5	Consistent traffic noise from Harbour St
	8/04/2015 16:26	66.8	63.2	
	8/04/2015 18:13	66.1	61.1	
	8/04/2015 22:38	64.3	57.2	Occupant noise from nearby restaurant
P3	8/04/2015 13:27	61.7	57.2	
	8/04/2015 16:49	63.8	61.2	Construction noise
	8/04/2015 18:33	61.9	57.4	
	9/04/2015 22:20	56.3	54.3	
P4	8/04/2015 18:52	66.7	55.9	Ambient noise dominated by exiting traffic on Darling Rd
	9/04/2015 22:02	62.6	50.7	
	13/04/2015 18:18	65.8	54.4	
P5	13/04/2015 17:03	74.5	65.2	Traffic noise on Pier St.
	13/04/2015 17:49	75.3	65.6	
	13/04/2015 8:51	76.0	69.9	Traffic noise on Pier St. and construction noise
P6	8/04/2015 18:13	60.2	56.3	Ambient noise dominated by exiting traffic on Pier St
	8/04/2015 19:14	63.2	59.1	Truck idling and moving nearby
	13/04/2015 17:21	58.7	54.8	Ambient noise dominated by exiting traffic on Pier St
	13/04/2015 17:36	58.1	54.3	
	13/04/2015 18:02	60.3	57.9	
P7	14/04/2015 9:33	71.2	67.7	Noise from nearby licensed premises

Note: Measurements taken at P5 and P8 were 10 minutes and 2 minutes in duration respectively.

4.1.3 Un-attended Noise Survey

The three noise loggers (L1, L2 and L3) were set to record statistical noise levels and continuously monitor ambient and background noise levels from 8/04/2015 to the14/04/2015. The data collected by two of the noise loggers are also

shown graphically below in Figure 4 and Figure 5. As L2 did not record meaningful data, the results as given in the Renzo Tonin and Associates Noise and Vibration Assessment (reference no. TG965-01F03 (r4) NE Plot DA) were utilized.

The equipment recorded the noise levels over 15-minute intervals from which, the statistical and equivalent noise levels were determined.

Table 2 presents the results of the continuous equivalent sound pressure levels (L_{Aeq}), and the Rating background noise levels (L_{A90}) (see Appendix 1 for definitions).

Table 2: Summary of Existing Noise Levels

Location (Refer to Figure 3)	Equivalent Noise Level $L_{eq,period}$ dB(A)			Rating Background Noise Level dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	69	59	56	58	55	51
L2	64	63	60	61	59	53
L3	64	60	58	59	56	51

Note: The results presented in Table 3 are consistent with the results presented in the Renzo Tonin and Associates SSDA7 report

Figure 4: Graphical Representation of Long term measurement location L1

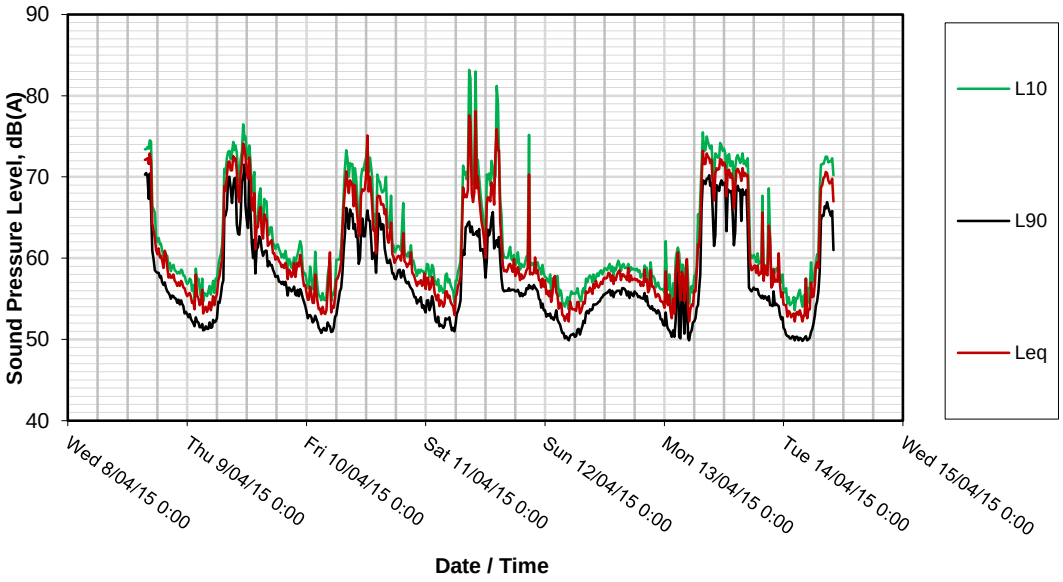
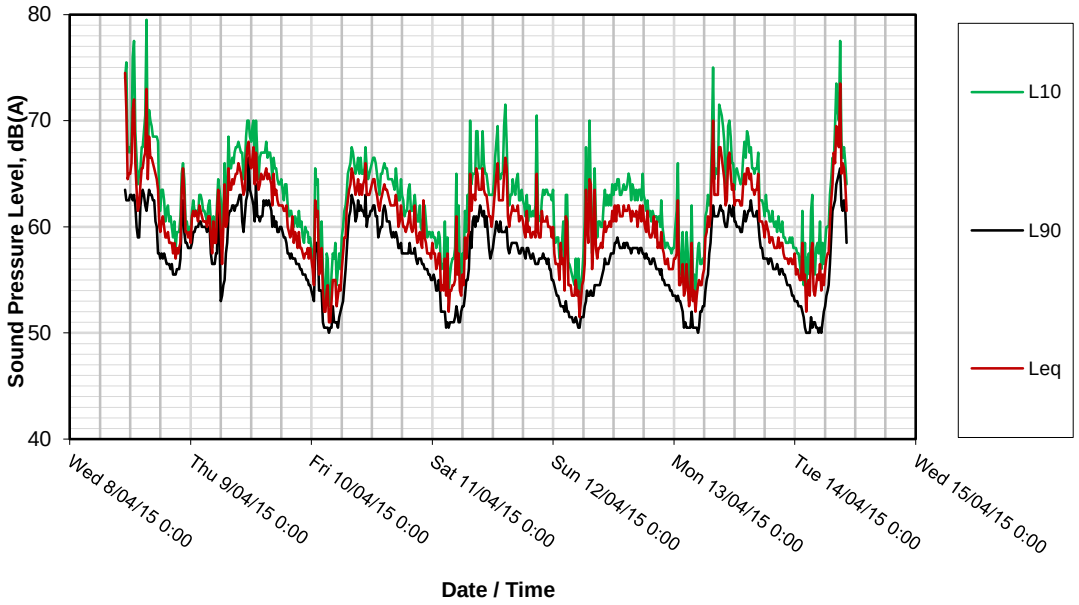


Figure 5: Graphical Representation of Long term measurement location L3



5. Noise and Vibration Criteria

The Noise and Vibration Criteria for this State Significant Development is based upon the Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning and Environment.

The SEARSs requirements promote the use of the following guidelines and policies:

- NSW Industrial Noise Policy (EPA (EPA, 2000)
- Interim Construction Noise Guideline (DECC, 2009)
- Assessing Vibration: A Technical Guideline (DEC, 2006)
- Environmental Criteria for Road Traffic Noise (EPA, 1999)

Relevant policies also set out in Item 1of the SEARs include:

- State Environmental Planning Policy – Infrastructure 2007
- Development Near Rail Corridors and Busy Road-Interim Guideline

In addition to the above, other relevant standards, guidelines and policies have been adopted, these include:

- City of Sydney Development Control Plan 2012
- DIN 4150-Part 3 “Structural vibration in buildings – Effects on structures”
- BS 7385: Part 2: 1993 Evaluation and Measurement for vibration in Buildings: Guide to damage levels from ground-borne vibration

5.1 External Noise Emission

5.1.1 Industrial Noise Policy (INP) 2000

The NSW Office of Environment and Heritage (OEH) sets out noise criteria in its Industrial Noise Policy (INP) to control the noise emission from industrial noise sources. The external noise due to noise emission of mechanical services is addressed following the guideline in the NSW OEH’s INP.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established the most stringent for each considered assessment period (day, evening, night) is adopted as the project-specific noise level (PSNL).

Based on these criteria and the results of noise survey, the project-specific noise criteria has been established at the boundary of the nearest residential premises so as to determine the criteria for the noise emission by the building services of the proposed development. In this case, given there is industry presence in the site’s surrounding, there is need to consider both the amenity and intrusiveness criteria.

Noise and Vibration Criteria

Intrusiveness Criteria

The NSW OEH INP states the following:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB(A)."*

The intrusiveness criterion can be summarised as follows:

$L_{Aeq,\ 15\ minute} \leq$ RBL background noise level plus 5 dB(A)

The intrusiveness criterion for the closest residential receivers is presented in Table 3 below. The resultant values from L2 and L3 have been used in this assessment as they are the most indicative locations to represent ambient background noise level at the residential receivers. It should be noted that the Intrusiveness criteria is only applicable to residential receivers.

Table 3: EPA INP Intrusiveness Criteria

Receiver Refer to Figure 3	Period	Noise Descriptor – dB(A)	Noise Criteria
R1	Daytime 7am – 6pm	$L_{Aeq,15min} \leq L_{90,15min} + 5$	66
	Evening 6pm – 10pm		64
	Night 10pm – 7am		58
R2	Daytime 7am – 6pm	$L_{Aeq,15min} \leq L_{90,15min} + 5$	66
	Evening 6pm – 10pm		64
	Night 10pm – 7am		58
R3	Daytime 7am – 6pm	$L_{Aeq,15min} \leq L_{90,15min} + 5$	66
	Evening 6pm – 10pm		64
	Night 10pm – 7am		58
R4	Daytime 7am – 6pm	$L_{Aeq,15min} \leq L_{90,15min} + 5$	64
	Evening 6pm – 10pm		61
	Night 10pm – 7am		56
R5	Daytime 7am – 6pm	$L_{Aeq,15min} \leq L_{90,15min} + 5$	66
	Evening 6pm – 10pm		64
	Night 10pm – 7am		58

Amenity Criteria

The OEH INP amenity criteria have been considered within this project in order to prevent continuing increases of noise levels from developments. This phenomenon is often referred to as 'noise creep'.

The NSW OEH INP states the following:

> "To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the INP. Meeting the acceptable noise levels in table 2.1 will protect against noise impacts such as speech interference, community annoyance and to some extent sleep disturbance. These levels represent best practice for assessing industrial noise sources, based on research and a review of assessment practices used overseas and within Australia."

The relevant parts from Table 2.1 of the INP have been summarised below in Table 4.

Noise and Vibration Criteria

Table 4: Amenity Criteria for External Noise Levels

Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
			Acceptable	Recommended Maximum
Residence	Urban	Day	60	65
		Evening	50	55
		Night	40	45
Commercial premises	All	When in use	65	70
School Classroom – Internal	All	Noisiest 1-hour period when in use	35	40
Area specially reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Industrial premises	All	When in use	70	75

Using the procedure outlined within the INP, the criteria shown above in Table 4 has been adjusted in order to determine the receiver specific amenity noise criteria. These criteria are shown below in Table 5.

Table 5: Adjusted Amenity Criteria for Residential Receivers

Receiver	Indicative Noise Amenity Area	Time of Day	Descriptor	Adjusted Criteria
R1	Urban	Day	L_{Aeq} dB(A)	50
		Evening	L_{Aeq} dB(A)	40
		Night	L_{Aeq} dB(A)	35
R2	Urban	Day	L_{Aeq} dB(A)	50
		Evening	L_{Aeq} dB(A)	40
		Night	L_{Aeq} dB(A)	35
R3	Urban	Day	L_{Aeq} dB(A)	50
		Evening	L_{Aeq} dB(A)	40
		Night	L_{Aeq} dB(A)	35
R4	Urban	Day	L_{Aeq} dB(A)	50
		Evening	L_{Aeq} dB(A)	40
		Night	L_{Aeq} dB(A)	35
R5	Urban	Day	L_{Aeq} dB(A)	50
		Evening	L_{Aeq} dB(A)	40
		Night	L_{Aeq} dB(A)	35
C1	All	When in use	L_{Aeq} dB(A)	65
C2	All	When in use	L_{Aeq} dB(A)	65
C3	All	When in use	L_{Aeq} dB(A)	65
C4	All	When in use	L_{Aeq} dB(A)	65
C5	All	When in use	L_{Aeq} dB(A)	65
OR1	All	When in use	L_{Aeq} dB(A)	50
E1 - Internal	All	Noisiest 1-hour period when in use	L_{Aeq} dB(A)	40
I1	All	When in use	L_{Aeq} dB(A)	70

Modifying Factor Adjustments

> *"Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account the potential annoying character of the noise, an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table 4.1 of Chapter 4 of the NSW OEH INP (see Table 6 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 6: Table 4.1 NSW OEH INP – Modifying Factor Corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: - **5 dB** or more if the centre frequency of the band containing the tone is above 400 Hz - **8 dB** or more if the centre frequency band containing the tone is 160 to 400 Hz inclusive - **15 dB** or more if the centre frequency of the band containing the tone is below 160 Hz	5 dB[2]	Narrow-band frequency analysis may be required to precisely detect occurrence.
Low Frequency Noise	Measurement of C-weighted and A-weighted level	Measure / assesses C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	5 dB[2]	C-weighting is designed to be more responsive to low-frequency noise, especially at higher overall levels
Impulsive Noise	A-weighted fast response and impulsive response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB	Apply difference in measured levels as the correction, up to a maximum of 5 dB.	Characterised by a short rise time of 35 milliseconds (ms) and decay time of 1.5s.
Intermittent Noise	Subjectively assessed	Level varies by more than 5 dB	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	On event in any 24-hour period	0 to – 20 dB(A)	The acceptable noise level may be increased by an adjustment depending on duration of noise.
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Notes:
1. Corrections to be added to the measured or predicted levels.

2. Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range.

5.1.2 Project Specific Noise Levels (PSNL)

The project specific noise criteria have been established using the most stringent values of the Intrusiveness and Amenity criteria (as shown previously). Table 7 below shows the project specific noise criteria for the industrial noise associated with the proposed development.

Table 7: Project Specific Noise Levels from Industrial Noise Sources

Receiver (Refer to Figure 3)	Period	Descriptor	PSNL dB(A)
All Residential Receivers	Day	L_{Aeq} dB(A)	50
	Evening	L_{Aeq} dB(A)	40
	Night	L_{Aeq} dB(A)	35
All Commercial Receivers	When in use	L_{Aeq} dB(A)	65
All Industrial Receivers	When in use	L_{Aeq} dB(A)	70
All Recreational Receivers	When in use	L_{Aeq} dB(A)	50
All Educational Receivers – Internal	Noisiest 1-hour period when in use	L_{Aeq} dB(A)	40

5.2 Retail Uses and Licensed/Un-licensed Premises

As the individual retail tenancies have not been defined yet and lease agreement with tenants have not been finalised, the noise criteria have not been defined for retail uses and licensed/un-licensed premises. The noise emission criteria from the NSW Liquor Administration Board (LAB) shall be applied to any music/entertainment and patrons from the licensed premises. The applicable noise criteria associated with these premises includes the following:

Table 8: NSW Liquor Act 2007 Noise Criteria

Period	Octave Band Centred Frequencies (Hz)	Noise Descriptor dB(A)
7:00am – 12:00am	From 31.5Hz to 8000Hz	$L_{A10,\,Oct} \leq L_{A90,\,Oct} + 5$
12:00am – 7:00am	From 31.5Hz to 8000Hz	$L_{A10,\,Oct} \leq L_{A90,\,Oct} + 0$

Further to the criteria shown in Table 8 , 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 7:00am.

5.3 Traffic Generation Criteria

Road traffic noise impact is assessed in accordance with the introduced NSW Road Noise Policy (Office of Environment and Heritage July 2011) which supersedes the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN).The criterion divides land use developments into different categories and lists the respective criteria for each case.

The category that is relevant to the proposed use of the site is shown in Table 9:

Table 9: NSW Road Noise Policy – Traffic noise assessment criteria

Road Category	Type of project/land use	Assessment Criteria – dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Freeway/ arterial/ Sub-arterial roads	3. 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)

In the event that the traffic noise at the site is already in excess of the criteria noted above, the NSW RNP states that the primary objective is to reduce the existing level through feasible and reasonable measures to meet the criteria above. If this is not achievable, Section 3.4.1 Process for applying the criteria – Step 4 states that for existing residences affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise should be limited to 2 dB above that of the corresponding 'no build option'.

5.4 Internal Noise Levels Criteria

For the residential areas of the development the Lend Lease PCD internal noise limits are applicable. The interior noise level requirements for apartments with windows in a closed position are shown below in Table 10.

Table 10: Lend Lease PCD Requirements for Internal Noise

PCD Ref No.	Area within Apartment	Window Position	Internal Noise Criteria $L_{eq,1hr}$ dB(A)*
37.001	Sleeping areas	Closed	35
	Living areas	Closed	45

Note:* The noise descriptor and period has been defined by WGE based on good practice and previous similar projects.

Australian/New Zealand Standard 2107:2000

For the areas not covered by the Lend Lease PCD requirements, internal noise level guidelines from the Australian Standard AS/NZS 2107:2000: "Acoustics – recommended design sound levels and reverberation times for building interiors" are proposed.

These recommended internal noise levels are presented in Table 11.

Table 11: Recommended Sound Levels and Reverberation Times AS/NZS 2107:2000

Type of occupancy/activity	Recommended design sound level, L_{eq}, dB(A)		Recommended Reverberation Time, s
	Satisfactory	Maximum	
Small retail stores (general)	45	50	See note 3
Show rooms	45	50	See note 3
Enclosed car park	55	65	-

Note: 3) – Reverberation time should be minimised as far as practicable for noise control.

Noise and Vibration Criteria

City of Sydney Development Control Plan (DCP) 2012 (For Information Only)

In accordance with the acoustic amenity for mixed-use developments in Section 4 of the City of Sydney DCP 2012, the requirements for internal noise levels are as follow:

The repeatable maximum $L_{Aeq\ (1\ hour)}$ for residential buildings and serviced apartments must not exceed the following levels:

a) for closed windows and doors:
  I. 35dB for bedrooms (10pm-7am) and;
  II. 45dB for main living areas (24 hours)

b) for open windows and doors:
  I. 45dB for bedrooms (10pm-7am) and;
  II. 55dB for main living areas (24 hours)

Where natural ventilation of a room cannot be achieved, the repeatable maximum $L_{Aeq\ (1hour)}$ level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:

a) 38dB for bedrooms (10pm-7am); and
b) (b) 48dB for main living areas (24 hours).

Due to the residential stage of the project being administered and assessed by the Department of Planning and Environment, the City of Sydney DCP criteria is not applicable and is provided for information only.

The Lend Lease PCD provides design criteria that are generally consistent with the NCC 2015 Part F5 and City of Sydney DCP acoustic performance requirements.

Nevertheless, in the Lend Lease PCD there are two discrepancies from the NCC 2015 Part F5 and the Sydney City Council DCP 2012.

These discrepancies include:

- The City of Sydney DCP 2012 has more stringent impact sound insulation performance requirements for floors in comparison with the PCD, which is consistent with the NCC 2015 Part F5 acoustic performance requirements

- The PCD has an acoustic sound insulation performance requirement for intra-tenancy partitions within sole occupancy units. Whereas there is no similar requirement within the NCC 2015 Part F5 or the City of Sydney Council DCP 2012.

5.5 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the NSW Office of Environment and Heritage. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW OEH ICNG (July 2009) were specifically referenced. The limits presented in Table 12 apply.

Table 12: NSW OEH ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & Public Holidays	Noise Affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school, for works near schools, or mid-morning or mid-afternoon for works near residences) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

Note: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Source: Chapter 4 (Table 2 Sec 4.1.1) of NSW DECCW ICNG

5.6 Construction Vibration Criteria

The NSW OEH guideline entitled "Assessing vibration: A technical Guideline" is proposed in order to assist in preventing uncomfortable conditions as a result from vibration .The guideline does not address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent, these vibration classifications have been categorised in the given criteria.

5.6.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 13. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 13: RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

5.6.2 Human Comfort – Intermittent Vibration Criteria

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 14: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

5.6.3 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN 4150-Part 3 “Structural vibration in buildings – Effects on structures” and British Standard BS7385-Part 2: 1993 “Evaluation and Measurement for Vibration in Buildings”. Table 15 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn’t occur.

Table 15: Guideline value of vibration velocity, v_i, for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 16 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 16: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Un-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4Hz increasing to 20 mm/s at 15Hz	20 mm/s at 15Hz increasing to 50mm/s at 40Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4Hz and above	

5.6.4 Construction Vibration Objectives

Table 17 indicates the construction vibration criteria applicable to the residential properties located adjacent to the development site.

Table 17: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives			Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $mm/s^{1.75}$ (VDV)	
		z-axis	x- and y-axis		
Residential	Daytime	10-20	7-14	0.2-0.4	5
	Night time	7-14	5-10	0.13-0.26	5

6. Noise Impact Assessment

6.1 Operational Noise Assessment

6.1.1 Overview

The operational noise assessment has been conducted based on the preliminary mechanical design. The following noise sources are associated with the development, and details about expected noise levels from these sources are given in the ensuing sub-sections.
The main operational noise sources associated with the development are as follow:

- Mechanical Services Equipment including;
  - External VRV units servicing the commercial and larger retail spaces
  - External condenser units servicing the smaller retail spaces and the residential apartments
  - Car Park exhaust fans
  - Toilet exhaust fans
  - Kitchen exhaust fans
  - Garbage exhaust fans
  - Stair pressurisation fans
- Activity associated with retail/commercial activities including;
  - Patron noise
  - Music
  - Traffic
  - Loading dock activities
- Traffic noise from surrounding roadways
- Car-park noise

These noise sources have been used to predict the worst case scenario in terms of noise impact from the proposed development on the various nearby noise-sensitive receiver types, as identified in Figure 3.

6.1.2 Mechanical Plant Noise

For the purpose of our calculation, it has been assumed that all the mechanical equipment is operational on a 24 hour basis as a worst case scenario. Therefore, acoustic recommendations are provided in order to achieve resultant noise levels at the nearest sensitive residential receivers that comply with the night time criterion, which is the most stringent criterion, as listed in Section 5.1.2

Noise emissions from the proposed operations were modeled using a 3D acoustic modeling software namely SoundPlan Version 7.1. Noise emissions from the operational noise sources were calculated for the nearest and potentially most affected residential receiver locations. Noise emissions were determined by modeling the noise sources, receiver locations, and topographical feature. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise emission from the site. This model is recognised by regulatory authorities around Australia and is endorsed by the NSW OEH for the use in projects of this scale.

The model was run considering the site having no specific meteorological characteristics such as dominant wind direction and speed or temperature therefore it was considered under neutral conditions. The predicted noise levels at the receiver locations are indicated in Table 18. Appendix 2 shows the predicted noise map of the area considering the proposed mitigation measures.

Table 18: Predicted Noise Levels with Implemented Mitigation Measures

Receiver Location (See Figure 3)	Predicted Noise Level dB(A)	Night Time Criterion dB(A)	Compliance (Yes/No)
R1	22.7	35	Yes
R2	26.6	35	Yes
R3	34.8	35	Yes
R4	34.4	35	Yes
R5	26.2	35	Yes
C1	31.4	65	Yes
C2	25.5	65	Yes
C3	24.1	65	Yes
C4	33.9	65	Yes
C5	56	65	Yes
OR1	20	50	Yes
E1 - Internal	35.4*	40	Yes
I1	35.7	70	Yes

Note: * This is based on the assumption of an open window (i.e. 10dB transmission loss)

6.1.3 Mitigation Measures

Plant Rooms

Acoustic louvres will be required for the plant rooms in order to meet the given criteria. The acoustic louvres are to meet or exceed the transmission loss values presented below in Table 19.

Table 19: Proposed Insertion Loss Values Acoustic Louvre's

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Noise Reduction (dB)	5	8	13	20	23	23	19	17

Rooftop Plant

Amelioration measures for the mechanical plant located on the roof will be considered during the Design Development stage so as to comply with the outlined criteria at the nearest sensitive receivers. These amelioration measures could include but not limited to the following:

- Positioning mechanical plant away from nearby receivers
- Acoustic attenuators fitted to duct work
- Screening around mechanical plant
- Acoustic insulation within duct work

6.2 External Noise Intrusion Assessment

The sound insulation performance of the building envelope is to conform to the Lend Lease PCD requirements. These requirements call for the building envelope to achieve an acoustic performance such that the following internal noise criteria are met with windows closed:

The sound insulation performance of the building envelope will be assessed based on the existing ambient noise levels, entertainment noise, retail activities and patrons' noise as well as noise associated with local traffic. This assessment will be conducted concurrently with the design process.

6.3 Retail/Commercial Noise Assessment

The future tenants of retail / commercial space within the South East Plot will hold the responsibility for achieving the applicable noise criteria for licensed/unlicensed premises (see Section 5.2).

Notwithstanding the above the most sensitive receivers with respect to the retail uses will be residential apartments within the Darling Square precinct. The noise intrusion will be considered during the design development of the project to ensure suitable amenity is provided inside residential apartments whilst also permitting reasonable use of the retail premises.

- Residential premises exposed to high external noise levels as a result of retail type and public realm activities will need to close windows in order to meet acceptable acoustic amenity objectives within dwellings. Alternative solutions for ventilation will be provided where windows and doors are required to be closed;
- Awnings / canopies are to be provided to retail areas; and
- The building envelope (primarily glazing system and floor/ceiling of first floor apartments above retail) will be designed to mitigate the intrusion of noise from external sources, Retail type premises will be designed such that they minimise noise transfer via the floor/ceiling to first floor apartments where they are located below a residential apartment.
- Noise from licenced premises shall not be audible within any habitable room of nearby residential premises between 12:00 midnight and 7:00am.

Consideration will be given to noise generated by typical activities within Haymarket Square and along the Boulevard. The acoustic strategy for addressing this aspect of the project may include a combination of measures and controls to both the retail uses and residential apartments, such as acoustically absorptive finishes within retail premises or acoustic barrier such as acoustic ceilings at the retail/residential interface.

Ultimately these conditions will be included within the lease agreement for the tenant to implement noise mitigation as appropriate to conduct their activities and protect the resident's amenity.

6.4 Loading Dock/Waste Collection Noise Assessment

An acoustic assessment for the garbage and waste collection has been conducted. The assessment assumes that the roller shutter door as indicated on the architectural drawings is open during waste collection operations. The emitted noise from the garbage truck was modelled using a 3D model in Soundplan 7.1 in accordance with the methods outlined in ISO 9631-2.

It is expected that ~2 collections are expected per week during the Day period as defined in the INP.

The noise levels used in the assessment are shown below in Table 20.

Table 20: Sound Power Level for Garbage Truck

Source	Sound Power Level L_{Amax}(SWL) re 10^{-12} W dB						
	Octave Band Centre Frequency (Hz)						
	63	125	250	500	1000	2000	4000
Garbage Truck Unloading Bins	97	96	93	95	95	92	91
Truck loading/unloading	97	97	96	97	97	97	97

Using the assessment methods outlined above, the predicted noise levels at the nearing sensitive receivers are summarized below in Table 21.

Table 21: Predicted Noise Levels from Garbage collection

Receiver Location (See Figure 3)	Predicted Noise Level dB(A)	Day Time Criterion dB(A)	Compliance (Yes/No)
R1	16.9	50	Yes
R2	26.5	50	Yes
R3	35	50	Yes
R4	0	50	Yes
R5	0	50	Yes
C1	0	65	Yes
C2	0	65	Yes
C3	0	65	Yes
C4	42.2	65	Yes
C5	27.3	65	Yes
OR1	0	50	Yes
E1 - Internal	1.2	40	Yes
I1	0	70	Yes

6.4.1 Waste Operations Acoustic Mitigation Measures

In order to minimize noise within the surroundings, the following waste operations measures are proposed:

- Garbage collection to be undertaken during the daytime period (Refer to INP)
- Bottles are to be broken up away from the site

6.5 Car-Park Noise Assessment

The noise relating to the car-park within the South East Plot podium levels has been assessed using the methodologies as presented in document prepared by the Bavarian State Office for the environment entitled 'Parking Area Noise'.

The assumptions used within the assessment have been based from the information as presented within the Hyder Consulting Transport and Traffic Noise Assessment for SSDA9 (Report no. TIA.SEDA V.01). The assumptions made in the calculations include the following:

- 265 car-parking bays
- Area of capark as indicated in DA architectural drawings
- Smooth concrete car park surface

It should be noted that the Evening period is not incorporated within the Parking Area Noise methodology therefore has not been assessed within this report. Notwithstanding that, the car-park noise has been assessed using the Day and Night periods.

The predicted noise levels associated with the car-park noise has been tabulated and is shown below in Table 22.

Table 22: Car Park Noise Assessment Results

Receiver Location (See Figure 3)	Period	Predicted Noise Level $L_{Aeq,1hour}$ dB(A)	INP Criteria (See Section 5.1.2)	Compliance (Yes/No)
R1	Day (AM Peak)	30.3	50	Yes

	Night	14.5	35	Yes
R2	Day (AM Peak)	30.9	50	Yes
	Night	15.1	35	Yes
R3	Day (AM Peak)	49.7	50	Yes
	Night	34.9	35	Yes
R4	Day (AM Peak)	32.1	50	Yes
	Night	16.3	35	Yes
R5	Day (AM Peak)	34.1	50	Yes
	Night	18.3	35	Yes
C1	Day (AM Peak)	22.8	65	Yes
	Night	7		
C2	Day (AM Peak)	27.4	65	Yes
	Night	11.6		
C3	Day (AM Peak)	32.4	65	Yes
	Night	16.6		
C4	Day (AM Peak)	56.4	65	Yes
	Night	40.6		
C5	Day (AM Peak)	36.1	65	Yes
	Night	20.3		
OR1	Day (AM Peak)	28	50	Yes
	Night	12.2		
E1	Day (AM Peak)	36.1	40 (internal)	Yes
	Night	20.3		
I1	Day (AM Peak)	25	70	Yes
	Night	9.2		

As described in Table 22, the resultant noise from the car-park within the South East Plot meets the Industrial Noise Policy criteria for the Day and Night periods. Although consideration should be given to the design of the North East Plot development to incorporate these predicted noise levels so as to avoid external noise intrusion.

Further to the criteria as shown in Table 1, the NSW Road Noise Policy also considers noise on sleep disturbance. The following information has been recapitulated from extensive research:

- Maximum external noise levels below 60–65 dB(A) are unlikely to awaken people from sleep
- One or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly
- Where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided
- As a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dB(A) L_{AMax} more than 10 or 15 times per night

Based on the previously shown research, it is of our opinion that there will be a low risk of sleep disturbances to the nearby residents due to car-park noise.

6.6 Traffic Noise Generation Assessment

The road traffic generation noise assessment has been undertaken using the evening peak hour traffic volumes for Harbour St as provided by Hyder Consulting (presented in Table 23). Harbour St is likely to be the most affected street in terms of traffic noise due to the proximity of the development to nearby residential receivers as well as the street being the proposed entry way into the car-park. The existing and predicted increase in PM peak hour traffic volumes are presented below in Table 23.

Table 23: Existing and Increased Traffic Flows

Location	Period	Traffic Volume (VPH)	
		Existing	Existing + Increased
Harbour St	Total (PM peak hour)	439	500

The predicted increase in traffic noise has been based on the methodologies given in the UK Department of Transport 'Calculation of Road Traffic Noise' (CoRTN) document. This model describes noise emitted by a constant traffic flow. The model uses standard curves to approximate vehicle noise levels. It also assumes the traffic can be broken into two broad categories: cars, and heavy vehicles. The source sound levels used in this project to model traffic noise levels are contained within the calculation algorithms of the noise model. Furthermore, the model was verified and calibrated using the short-term noise monitoring results obtained for this project. The values presented in Table 24 compare the existing noise levels estimated by the model with the estimated noise levels expected from an increase in vehicle movements associated with the proposed development.

Table 24: Predicted Increase in Traffic Noise Levels (AM/PM Peak hours)

Route to/from Site	Existing Noise Levels Day $L_{Aeq(1hr)}$	Predicted Noise Levels Day $L_{Aeq(1hr)}$	Predicted Increase in Traffic Noise, dB(A)
Harbour St	66.8	67.4	0.6

As shown in Table 24, the maximum predicted increase in traffic noise due to the development is 0.6dB(A), which is within the limits given in the Road Noise Policy criteria (as shown in Section 5.3. For this reason we understand that the traffic generated by the proposed development will not have an adverse impact on the existing residents.

6.7 Construction Noise Assessment

The noise associated with construction activities at the boundary of the nearest sensitive receivers will typically be assessed as part of the Construction Noise and Vibration Management Plan that would be requested by the Department of Planning as part of the SEARS'.
The Construction Noise and Vibration Management Plan will present the result of the predicted noise and vibration levels at the boundary of the potentially most affected receivers. The predictive noise and vibration models will be based on a construction program and type of equipment being used for the construction.
The construction noise and vibration against which these predicted noise and vibration levels will be assessed have been established and presented within the Section 5.5 and 5.6 of this report.

According to AS 2436 – 2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* the following techniques could be applied to minimize the spread of noise and vibrations to the potential receivers.

If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimized. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures such as screens.

Screening
On sites where distance is limited, the screening of noise may be beneficial and this should be taken into account during the planning stages.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, sound insulation measures may be necessary to protect workers inside the buildings.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. A noisy, stationary plant can be placed in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficiency when operating the equipment.

Where such noise barriers are not practical, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen any noise-sensitive areas from the plant. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant equipment that operate on a 24-hour basis may not be an irritating source of noise during the day but may be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite an effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

In many cases it is not be practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant or to build-in at the early stages protective features required to screen traffic noise.

Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any of the materials suggested in Appendix D.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the receiver, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (diesel operated)
An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from it.

Reversing and warning alarms
Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternative warning alarms capable of providing a safe system of work that are equal to or better than the traditional ‘beeper’, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

(a) Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal-frequency 'beep') are less intrusive when heard in the neighbourhood.
(b) Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
(c) Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, providing safety considerations, are not compromised.
(d) Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
(e) Spotters or observers.

The above methods should be combined, where appropriate.

7. Vibration Impact Assessment

7.1 Construction Vibration

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type. Due to the lack of information regarding this at the early stages of the development, an accurate calculation of the vibration impacts cannot be predicted.

It is required that a Construction Noise Vibration Management Plan (CNVMP) is conducted prior to construction in order to manage construction noise/vibration as well as to perform high level predictions to avoid non-compliances with the given vibration criteria as shown in Section 5.6. In addition, the use of noise and vibration monitoring during construction will be essential in order to ascertain the extent of vibration and noise generated in and around the site.

Further to the above, generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the transport for NSW 'Construction Noise Strategy' document. This document presents the safe construction working limits for Cosmetic Damage to adjacent structures (in accordance with BS 7385) and Human Comfort (OH&E).

Table 25: Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Vibratory Roller	<50 kN (Typically 1-2 tonnes)	5m	15m to 20m
	<100 kN (Typically 2-4 tonnes)	6m	20m
	<200 kN (Typically 4-6 tonnes)	12m	40m
	<300 kN (Typically 7-13 tonnes)	15m	100m
	>300 kN (Typically 13-18 tonnes)	20m	100m
	>300 kN (> 18 tonnes)	25m	100m
Small Hydraulic Hammer	(300kg – 5 to 12t excavator)	2m	7m
Medium Hydraulic Hammer	(900kg – 12 to 18t excavator)	7m	23m
Large Hydraulic Hammer	(1600kg – 18 to 34t excavator)	22m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	20m
Pile Boring	≤800mm	2m	N/A
Jackhammer	Hand held	1m	Avoid contact with structure

Based on the information presented above in Table 25 and the proximity from the South East Plot to the nearby receivers, it is expected that the human comfort vibration levels may be exceeded during construction. Vibration measures have been provided in the subsequent section as to prevent such exceedances.

7.2 Vibration Amelioration Measures

Amelioration measures are recommended to be utilised during construction in order to minimise the transmitted vibration around the site. These measures include the following:

- Monitor vibration levels using attended/un-attended methods during construction so as to manage potential excessive vibration
- Manage construction program so as to minimise heavy machinery operating concurrently to each other
- Prepare dilapidation reports on adjacent structures and monitor the effects
- As far as practical, locate heavy machinery away from nearby sensitive receivers

8. Conclusion

A noise impact assessment for the proposed South East plot has been conducted. This document forms part of the documentation package to be submitted to the state authorities as part of the DA process.

This report has provided criteria, in-principle treatment and design requirements which aim to achieve the proposed statutory criteria.

The establishment of the noise criteria was based on noise surveys which monitored ambient and background noise levels using both hand held sound level meters and long-term noise monitors at representative locations around the site.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed development have been established based on Council requirements and state policy guidelines.

Operational noise assessments have been conducted and amelioration measures have been provided where required.

The assessment of operations noise concluded that the given criteria will be met with the implementation of the proposed mitigation measures.

The information presented in this document shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of air-conditioning units, layout of equipment, modifications to the buildings and introduction of any additional noise sources.

Appendix 1 - Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
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. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	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.

Appendix 1 - Glossary of Acoustic Terms

Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.
L_{Amax}	The maximum A-weighted sound pressure level measured over a period.
L_{Amin}	The minimum A-weighted sound pressure level measured over a period.
L_{A1}	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted 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	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Rating Background Level	The rating background level is the median assessment background level over all days for each period.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level 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 Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.

Appendix 2 – Sound Maps of Industrial Sources

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