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PROPOSED WAREHOUSE AND DISTRIBUTION FACILITIES, MOOREBANK

Noise & Vibration Impact Assessment

8 July 2020

TL265-01F04 DA Acoustic Assessment_Construction and Operation (r9)

35 1982-2017 ACOUSTIC ENGINEERING EXCELLENCE

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1 Introduction

Renzo Tonin & Associates was engaged to undertake a Noise & Vibration Impact Assessment (NVIA) for the proposed modifications to warehouse and distribution facilities at Moorebank Logistics Park, 400 Moorebank Avenue, Moorebank. Noise and vibration impacts from the construction and operational phases of the project are addressed in this report in accordance with relevant Council and NSW Environment Protection Authority (EPA) requirements and guidelines.

There are concurrent modification applications pertaining to SSD 5066 and SSD 7709:

- Modification 1: SSD 5066 MOD 2
  - Amendment to the Concept Plan originally approved, via means of adjustment to the internal Moorebank Precinct West (MPW) boundaries; and
  - Amendment to the maximum building height established across selected portions of the Subject Site from approximately 21m up to and including 45m.
- Modification 2: SSD 7709 MOD 1
  - Amendment to the MPW Stage 2 internal operational boundaries, with respect to indicative built form proposed under SSD 7709, via means of reconfiguration of the MPW Stage 2 internal operational boundaries. Noting, this is consistent with the post-approvals provision for updated Development Layout Drawings to the NSW DPIE in relation to Condition B2 of SSD 7709;
  - Amendment to the maximum building height established across selected portions of the Subject Site from approximately 21m up to and including 45m with respect to future built form under MPW Stage 2; and
  - Operation of two (2) Warehouse and Distribution Facilities (High Bay Warehouses) across the Subject Site, including:
    - ancillary hardstand;
    - ancillary offices;
    - associated car parking; and
    - landscaping.

    Each of the above elements is consistent with the development consent (SSD 7709) and post-approval documentation as approved.

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

2 Project Description

2.1 Background Information

A NVIA is required for the proposed modification to warehouse and distribution facilities (JR & JN) at Moorebank Logistics Park in Moorebank Precinct West (MPW) under the MPW Concept Plan and Stage 1 Early Works (SSD 5066) and MPW Stage 2 (SSD 7709) development consents. The proposed site is part of the MPW Stage 2 development, comprising:

- Built form approved under SSD 7709 in contrast to what is being proposed under the subject Modifications, with respect to the revised concept layout, increase in height and indicative built form for the high bay warehouse.
- Assess the potential noise and vibration impacts / emissions anticipated for both the construction and operational phases of the proposed change to the development.

2.2 Applicable Regulatory Requirements

Replicated below are excerpts from SSD 5506 (MOD 1) condition E28 and E29. There are no numerical noise limits included in SSD 5506 (MOD 1).

Cumulative Impacts

E28. All future Development Applications must provide the timing for construction and operation on both the MPW and MPE sites and provide cumulative assessments for construction and operation on the MPW and MPE sites including, but not limited to:

b) noise and vibration impacts;

Interaction between MPW and MPE sites

E29. Any future Development Application that proposes the use of infrastructure on the MPE site or integration of operations across the MPW and MPE sites must:

a) demonstrate that there will be no overall increase in cumulative construction and operational environmental impacts;

The MPW Stage 2 Development Consent (SSD 7709) applies to the proposed distribution centre, in particular Part B - Specific Environmental Conditions relating to Noise and Vibration.

Part B of the MPW Stage 2 Development Consent dated 11 November 2019 sets out the following conditions pertaining to noise and vibration:

Noise Wall

B129. Prior to the commencement of operation of any part of the development, the Applicant must construct a 5 m high noise wall along the entire length of the western internal road as shown in **Appendix 1** (as detailed in the EIS and RtS Noise and Vibration Impact Assessment modelling).

Hours of Operation

B130. The permitted hours of operation are detailed in **Table 3**.

Table 3: Hours of Operation

Activity	Day	Time
Intermodal terminal facility including rail link connection	Monday – Sunday	24 hours
Warehouses	Monday – Sunday	24 hours
Freight village	Monday – Sunday	7 am to 6 pm

Intermodal Terminal Operational Noise Limits

B131. The Applicant must ensure that the noise generated by the overall precinct operations (defined as all activities approved for MPW and MPE) does not exceed the noise limits in **Table 4**.

Table 4: Operational Noise Limits dB(A)

Location (residential receivers)	Day $L_{Aeq,15 minute}$	Evening $L_{Aeq,15 minute}$	Night $L_{Aeq,15 minute}$	Night $L_{A1, 1 minute)}$
Casula	39 dB	35 dB	35 dB	52 dB
Glenfield	35 dB	35 dB	35 dB	52 dB
Wattle Grove	36 dB	35 dB	35 dB	52 dB

Notes: *To determine compliance with the $L_{Aeq,15 minute}$ noise limits, noise from the development is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 m of a dwelling where the dwelling is more than 30 m from the boundary. Where it can be demonstrated that direct measurement of noise from the project is impractical, the EPA may accept alternative means of determining compliance (see Chapter 7 of the NPI). The modification factors in Fact Sheet C of NPI must also be applied to the measured noise levels where applicable.*

To determine compliance with the $L_{A1,1 minute}$ noise limits, noise from the project is to be measured at 1 m from the dwelling façade. Where it can be demonstrated that direct measurement of noise from the project is impractical, the EPA may accept alternative means of determining compliance (see Chapter 7 of the NPI).

The noise emission limits identified above apply under meteorological conditions of:

(i) wind speeds of up to 3 m/s at 10 m above ground level; or

(ii) 'F' atmospheric stability class.

Construction Noise and Vibration Management Plan

B134. Prior to commencement of construction, the Applicant must prepare a Construction Noise and Vibration Management Plan (CNVMP) and submit it to the Planning Secretary for approval. The CNVMP must be consistent with the guidelines contained in the ICNG (DECC, 2009).

B135. The CNVMP must form part of the CEMP required by **Condition C2** and, in addition to the general management plan requirements listed in **Condition C1**, the CNVMP must include:

(a) identification of the work areas, site compounds and internal access routes;

(b) identification of the type and number of plant and equipment expected on site at the same time;

(c) details of construction activities and a construction program, including the identification of key noise and/ or vibration generating construction activities (based on representative construction scenarios) that have the potential to generate noise and/ or vibration impacts on surrounding sensitive receivers, particularly residential areas;

(d) identification of sensitive receivers (including heritage structures if relevant) and relevant construction noise management levels (NMLs) using the ICNG, vibration criteria using the *Assessing Vibration: a Technical Guide* (DECC 2006) (for human exposure) and vibration limits set out in the *German Standard DIN 4150-3: Structural Vibration effects of vibration on structures* (for structural damage);

(e) Identification of any construction activities predicted to exceed NMLs;

***Note**: The ICNG identifies 'particularly annoying' activities that require the addition of 5dB(A) to the predicted level before comparing to the construction NML.*

(f) identification of feasible and reasonable measures to be implemented to minimise and manage construction noise impacts, including, but not limited to, acoustic enclosures, erection of noise walls (hoardings), respite periods; and

(g) an **Out-of-hours Work Protocol** for the assessment, management and approval of works associated with the Moorebank Avenue/Anzac Road upgrade, the delivery of the rail link connection, and works required to be undertaken during rail corridor possessions, outside of the hours identified in **Condition B125**. The **Out-of-hours Work Protocol** must:

(i) detail an assessment of out-of-hours works against the relevant NMLs and vibration criteria,

(ii) provide detailed mitigation measures for any residual impacts (that is, additional to general mitigation measures), including extent of at-receiver treatments, and

(iii) include proposed notification arrangements.

Operational Noise Management Plan

B136. Prior to commencement of operation, the Applicant must prepare an Operational Noise Management Plan (ONMP) and submit it to the Planning Secretary for approval. The ONMP must be prepared by a suitably qualified and experienced person(s).

B137. The ONMP must for part of the OEMP and, in addition to the general management plan requirements listed in **Conditions C5** and **C6**, the ONMP must include monitoring and reporting as required under **Conditions B139**, **B140** and **B141**.

Mechanical Plant and Other Noisy Equipment Monitoring

B138. Prior to construction of the freight terminal, freight village and each warehouse, the Applicant must submit to the Secretary a Noise Assessment for Mechanical Plant and other noisy equipment to demonstrate that plant and equipment has been selected to meet the overall noise limits specified in **Table 4**.

B139. The Applicant must carry out noise monitoring of mechanical plant and other noisy equipment for a minimum period of one week where valid data is collected following operation/ occupation of the freight terminal, freight village and each warehouse. The monitoring program must be carried out by a suitably qualified and experienced person(s) and a **Monitoring Report for Mechanical Plant** must be submitted to the Planning Secretary within two months of operation of the freight terminal and occupation of each tenancy to verify predicted mechanical plant and equipment noise levels.

Site Noise Monitoring and Reporting

B140. Within 12 months of operation of the intermodal terminal facility; occupation of the first warehouse, 50% occupation of the site and 100% occupation of the site, or as otherwise agreed by the Planning Secretary, the Applicant must undertake **Operational Noise Monitoring** to compare actual noise performance of the project against predicted noise performance and prepare an **Operational Noise Report** to document this monitoring. The Report must include, but not necessarily be limited to:

(a) noise monitoring to assess compliance with the predicted operational noise levels and the noise limits specified in **Table 4**;

(b) a validation by predictive modelling of the operational noise levels in terms of criteria and noise goals established in the Road Noise Policy (RNP, EPA, 2001);

(c) sleep disturbance impacts compared to those determined in documents specified under **Condition A3**;

(d) impacts associated with annoying characteristics such as prominent tonal components, impulsiveness, intermittency, irregularity and dominant low-frequency content;

(e) methodology, location and frequency of noise monitoring undertaken, including monitoring sites at which project noise levels are ascertained, with specific reference to locations indicative of impacts on sensitive receivers;

(f) any required recalibrations of the noise model taking into consideration factors such as actual traffic numbers and heavy vehicle proportions;

(g) an assessment of the performance and effectiveness of applied noise mitigation measures together with a review and if necessary, reassessment of all feasible and reasonable mitigation measures;

(h) identification of additional measures to those predicted in the documents specified under **Condition A3**, that would be implemented with the objective of meeting the criteria outlined in the RNP and NPI (EPA, 2017), including timing of implementation;

(i) details of any complaints and enquiries received in relation to operational noise generated by the project between the date of commencement of operation and the date the report was prepared; and

(j) procedures for the management of operational noise and vibration complaints.

The Operational Noise Report is to be verified by a suitably qualified and experienced noise and vibration expert.

The Operational Noise Report must be submitted to the Planning Secretary and the EPA within 60 days of completing the operational noise monitoring referred to in (a) above or as otherwise agreed by the Planning Secretary.

The conditions that require noise monitoring (B139 and B140) will not be directly addressed in this report as the monitoring can only be undertaken when the proposed development has been completed and in operation.

As the western access ring road is a shared road to all MPW users, mitigation measures reducing noise from the use of this road from a whole of MPW perspective. As such, noise from the use of the western access ring road by Woolworths' Distribution Centre has been excluded from this NVIA, as it is subject to a whole of MPW review.

2.3 Receiver Locations

The identified most sensitive noise receiver locations pertaining to this NVIA are outlined in Table 2.1 and shown on Figure 1.

Table 2.1: Receiver Locations

Receiver ID	Address	Description
R1	9 Casula Road, Casula	Residential property located approximately 635m west of the project area.
R2	Casula Powerhouse Arts Centre, 1 Powerhouse Road, Casula	Educational property located approximately 510m north-west of the project area.

Receiver ID	Address	Description
R3	All Saints Catholic Senior College, Leacocks Lane, Casula	Educational property located approximately 796m west of the project area.

Figure 1: Receiver locations

2.4 Hours of Operation

The proposed hours of operation for the industrial estate is provided below:

- Monday to Sunday: 24 hours per day

The proposed hours of operation satisfy Condition B130 of the Development Consent.

2.5 References

The following documentation was referenced for this report:

- Moorebank Precinct West (MPW) Stage 2 Development Consent dated 11 November 2019 [ref: 191111 MPW Stage 2 Development Consent] (*MPW Development Consent*)
- Moorebank Precinct West (MPW) Noise Impact Assessment Report dated October 2016 prepared by Wilkinson Murray [ref: 2016-10-25 Appendix N_Noise Impact Assessment & Best...] (*WM Acoustic Report*)
- Mechanical plant design package by Bestec dated 13 November 2019 [ref: WOOLWORTHS DC NSW JR WAREHOUSE - 2019.11.25 BESTEC CONCEPT (A)]
- Technical Note NTS2 - UNDC Traffic Generation Assumptions for Distribution Centre, Moorebank Logistics Park prepared by Ason Group dated 17 January 2020 [ref: 1255tn01v1 TN_JR-JN Preliminary traffic analysis Issue I] (*Traffic Report*)
- Woolworths Janus Precinct DA Concept Drawing Pack prepared by Bell Architecture dated 19 June 2020 [ref: BAS190054 Janus Precinct DA Concept Drawing Pack - Revision E]
- Woolworths Janus Masterplan DA Concept Drawing Pack prepared by Bell Architecture dated 19 June 2020 [ref: BAS190054 Janus Master Plan DA Concept Drawing Pack - Revision E]
- Woolworths DC Proposed JR Concept Drawing Pack prepared by Bell Architecture dated 19 June 2020 [ref: BAS190054 JR Concept Drawing Pack - Revision E]
- Woolworths DC Proposed JN Concept Drawing Pack prepared by Bell Architecture dated 19 June 2020 [ref: BAS190087 JN Concept Drawing Pack - Revision F]

3 Construction Noise Assessment

3.1 Hours of operation

Construction activities for the Proposal are to take place during construction hours detailed in Condition B125, which are 7:00am to 6:00pm Monday to Friday, 8:00am to 1:00pm on Saturday with no work performed on Sundays and Public Holidays.

If construction works are required to take place outside of the hours specified in Condition B125, and they have strong justification, then they are to be undertaken in accordance with the Construction Noise and Vibration Management Plan (CNVMP) prepared for MPW Stage 2 SSD 7709 (Renzo Tonin, January 2020) and in accordance with the Out-of-Hour Protocol developed in accordance with condition B135.

3.2 Construction Noise Management Levels

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

The key components of the guideline that are incorporated in this NVIA include:

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

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

- Application of reasonable and feasible noise mitigation measures

- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.

- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

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

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

3.2.1 Residential Receivers

Table 3.1 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 3.1: Noise Management Levels at Residential Receivers

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

Table 3.2 provides the Noise Management Levels (NML) for the noise sensitive residential receiver areas applicable to this NVIA as identified in Section 2.3.

Table 3.2: Construction Noise Management Levels at Residential Receivers, dB(A)

Receivers	Applicable Noise Management Levels, dB(A)
Wattle Grove	52
Wattle Grove North	46
Casula	51
Glenfield	54

3.2.2 Sensitive Land Uses

Table 3.3 sets out the ICNG noise management levels for other types of noise sensitive receiver locations applicable for this project. Furthermore, Section 4.1.2 of the ICNG stipulates that a conservative estimate of the difference between the internal and external noise levels is 10dB(A) for buildings other than residences. Based on this assumption, an education facility with an internal noise management level of 45dB(A) has an equivalent external noise management level of 55dB(A). The external noise management levels have been adopted for this NVIA.

Table 3.3: Noise Management Levels at Other Noise Sensitive Land Uses

Receivers	Applicable Noise Management Levels, dB(A)
R2, R3	55
Industrial receivers	75

3.3 Construction Scenarios

The scope of the construction works is outlined below. The construction noise assessment was conducted for three different construction scenarios:

- **Scenario 1 -** Site establishment (installation of hoardings, tree clearing and establishment of construction facilities within the site boundary).
- **Scenario 2 -** Civil works (minor excavation works to level site, building foundation works and slab construction).
- **Scenario 3 -** Building works (installation of building footings, erection of warehouses/ offices, installation of internal services, fit-out works and landscaping).

The proposed duration of each stage is as follows:

- Scenario 1: 1-month programme
- Scenario 2: 5-month programme
- Scenario 3: 16-month programme

3.4 Construction traffic

Construction traffic on the site, including the internal access route, is included as part of the construction noise assessment of the work activities identified in Section 3.3. Additional noise from traffic generated by a development on the public road network is assessed against the EPA Road Noise Policy. The assessment involves consideration of the existing traffic noise levels and the potential change in noise as a result of the development's construction activities.

Access to the site will be from the M5 Motorway and Moorebank Avenue. On these busy roads, any additional traffic generated by the construction proposed modification to the development, would be negligible. Construction traffic from the site on public roads is predicted to be consistent with the MPW Stage 2 SSD 7709 assessment not to have a significant noise impact and is not further addressed in this report.

Construction traffic would be managed in accordance with the approved CNVMP prepared for MPW Stage 2 SSD 7709 (Renzo Tonin, January 2020).

3.5 Construction Noise Assessment

Construction activities for the proposed modification to the development are predicted to be consistent with the assessed and approved construction noise impacts under MPW Stage 2 SSD 7709. A feasible and reasonable approach towards noise mitigation and management measures would be applied to manage noise levels to reduce the impact from construction noise.

Construction activities would be managed in accordance with the approved Construction Noise and Vibration Management Plan prepared for MPW Stage 2 SSD 7709 (Renzo Tonin, January 2020).

3.6 Construction Noise Mitigation and Management Measures

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

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

3.6.1 General Engineering Noise Controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 “Guide to Noise Control on Construction, Demolition and Maintenance Sites”, are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C of AS2436 presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C of AS2436 presents the relative effectiveness of various forms of noise control treatment.

Table 3.4 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates’ opinion based on experience with past projects.

Table 3.4: Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise control method	Practical examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

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

3.6.2 Noise Management Measures

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

- Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work should be switched off.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.

- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

Where the noise level still exceeds the NML even after all feasible and reasonable noise management measures have been implemented, then consideration may be given to implementing time restrictions and/or providing periods of repose for residents, where feasible and reasonable. That is, daily periods of respite from noisy activities may also be scheduled for building occupants during construction hours.

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

3.7 Construction Related Road Traffic Noise

Construction traffic on site will not alter in respect of the proposed modification and remains in accordance with the construction traffic assessment as approved for MPW Stage 2 SSD 7709. The impact from noise due to construction traffic on public roads is consistent with the MPW Stage 2 SSD 7709 assessment and consent and is considered negligible as per the assessment in WM Acoustic Report. Construction road traffic noise would be managed in accordance with the approved CNVMP (Renzo Tonin, January 2020) prepared under condition B134 and B135 of the MPW Stage 2 SSD 7709 consent.

4 Construction Vibration Assessment

The main types of impacts associated with the construction of the Project have been identified as the following:

- disturbance to building occupants; and
- potential damage to buildings.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The International System of Units (SI unit) for distance is the metre (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared (m/s2).

Construction vibration goals are summarised below.

4.1 Disturbance to Buildings Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 4.1 provides definitions and examples of each type of vibration.

Table 4.1: Types of Vibration

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

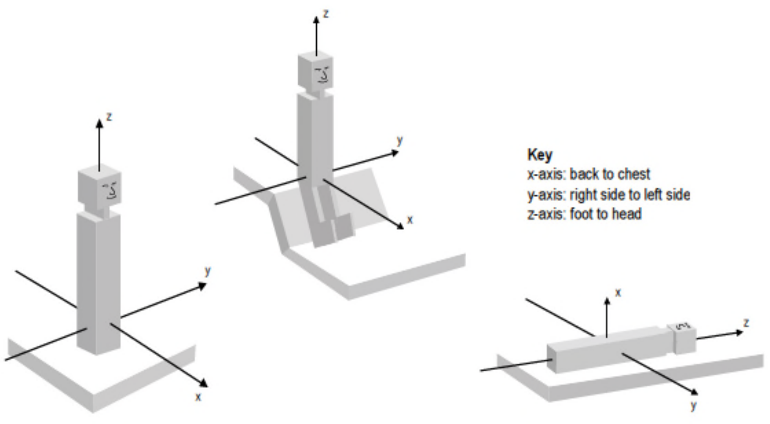
Notes: 1. Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

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

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

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2: Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced in Table 4.2.

Table 4.2: Preferred and Maximum Levels for Human Comfort

Location	Assessment Period[1]	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive Vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Note: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 4.3.

Table 4.3: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Note: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

4.2 Structural Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 x higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

Within DIN4150-3, damage is defined as "*any permanent consequence of an action that reduces the serviceability of a structure or one of its components*" (p.4). The Standard also outlines:

> *"For buildings as in lines 2 and 3 of Tables 1, 4 or B.1, the serviceability is considered to have been reduced if, for example*
>
> - *cracks form in plastered or rendered surfaces of walls;*
> - *existing cracks in a structure are enlarged;*
> - *partitions become detached from load-bearing walls or floor slabs.*
>
> *These effects are deemed 'minor damage. " (DIN4150.3:2016, p.6)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

4.2.1 British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 4.4 sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" (p.5).

Table 4.4: BS 7385 Structural Damage Criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic		50	
		Minor[2]		100	
		Major[2]		200	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes:
1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

4.2.2 German Standard

German Standard DIN 4150 - Part 3 (2016) '*Vibration in buildings - Effects on Structures*' (DIN 4150-3:2016), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3:2016 presents the recommended maximum limits over a range of frequencies (Hz), measured at the foundations, in the plane of the uppermost floor of a building or structure or vertically on floor slabs. The vibration limits at the foundations increase as the frequency content of the vibration increases. The criteria are presented in Table 4.5, applicable for the type of receivers surrounding the site.

Table 4.5: DIN 4150-3:2016 Structural Damage Criteria

Group	Type of structure	Vibration velocity, mm/s				
		At foundation in all directions at frequency of			Plane of floor uppermost storey in horizontal direction	Floor slabs, vertical direction
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20

4.3 Vibration Sources

The following plant and equipment have the potential to generate vibration:

- Jackhammer
- Grader
- Trucks
- Excavator with bucket
- Roller

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated to receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Table 4.6 below presents the recommended minimum working distances for vibration generating plant.

Table 4.6: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m			
	Cosmetic damage			Human disturbance
	Commercial and industrial buildings[1]	Dwellings and similar structures[1]	Sensitive structures (e.g. heritage)[1]	Residences Day[2]
Jackhammer	5	5	5	5
Grader	5	5	5	10
Truck traffic (over irregular surfaces)	5	5	10	20
Excavator <=30 Tonne (travelling/ digging)	5	10	10	20
Vibratory Roller	5	15	20	40

Notes:
1. Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration.
2. Daytime is 7 am to 10 pm;

Site specific buffer distances for vibration significant plant items must be measured on site. Unlike noise, vibration cannot be 'predicted'. There are many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

4.4 Potential Vibration Impacts

Based on the vibration data presented in Section 4.3 above, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 4.7 below. The assessment is relevant to all residential and industrial buildings and other similar type structures in the project area.

The assessment is based on vibration-generating equipment being operating at the closest location to nearby buildings. When vibration-generating equipment operates further from the closest point, the predicted vibration levels will reduce along with the probability of adverse comment and risk of structural damage.

Table 4.7: Potential Vibration Impact Assessment

Receiver location	Approx. distance to nearest buildings from works (m)	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
R1-R3	Minimum distance greater than 500 m	Dwellings	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Not required
R4-R5	Minimum distance greater than 400 m	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Not required

Receiver location	Approx. distance to nearest buildings from works (m)	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
Note:	[1] The sources of vibration levels are vibratory roller. If alternative equipment with higher vibration levels are used, there is an additional risk.				

For receivers surrounding the project, it is unlikely that there will be any adverse vibration impacts to buildings in the surrounding area.

Recommendations for reduction potential vibration impacts, including minimum working distances for construction pant are provided in Section 4.5 below.

4.5 Vibration Mitigation

4.5.1 Vibration Management Measures

Although the vibration impacts for the construction of the project are generally low, the following vibration management measures are provided to minimise vibration impacts from construction activities.

1. A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers, vibration testing of actual equipment on site would be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

4. Notification by letterbox drop would be carried out for all occupied buildings within 100m of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property.

5 Operational Noise Assessment

5.1 Applicable Noise Criteria

The criteria that are applicable to the project are those defined for MPW Stage 2 Development Consent clause B131, presented in Section 2.2. However, these noise limits are applicable to all activities that are approved for MPW and MPE. As such, the project only forms a portion of these activities.

From the noise modelling, it is determined that the design of the project site is controlled by the identified noise sensitive receivers in Casula. Since the receivers in Casula are identified as the most critical and the controlling assessment locations, this NVIA focuses on these receivers.

Based upon the SSD 7709 B131 Table 4 noise limits, initial site-noise quota allocations of 32 dB(A), 28 dB(A) and 28 dB(A) $L_{Aeq\ 15min}$ for the day, evening and night-time periods respectively, were provided for the development. Following initial screening modelling and to meet the conditions of consent, these were lifted to $L_{Aeq\ 15min}$:

- day - 36 dB(A)
- evening - 32 dB(A)
- night - 32 dB(A)

By addressing the requirements of SSD 7709 and the above allocated noise quota, this will address the requirements of SSD 5066 MOD 1.

5.2 Noise Sources

The noise sources associated with the proposal for assessment are as follows:

- mechanical Plant
- vehicle movements and car parking
- loading dock activities

5.2.1 Mechanical Plant

The specific type of mechanical plant and their location on site are yet to be finalised at this early development approval stage of the project. However, based on the several options of mechanical plant design provided by the client, the worst-case scenario design Bestec Concept (A) has been adopted for the purpose of this NVIA.

Table 5.1 details the mechanical plant used for this NVIA.

Table 5.1: Mechanical Plant Noise Sources, dB(A)

Mech Plant	Number of Units	Area Served	Brand & Model No.	Sound Pressure Level, dB(A)	Calculated / reported Sound Power Level, dB(A)
Chiller Unit	3	Warehouse	Carrier 30XB 1700	70 @ 10m	104
Air Handling Unit	10	Warehouse	Fusion Modulair VPAC 180SE	58 @ 5m	86
Air Handling Unit	14	Warehouse	Carrier 39HQ 21.14	no detail provided	104 (based on Chiller Unit noise level)

Note: Plant and equipment not listed above has not been assessed.

5.2.2 Vehicle Movements

5.2.2.1 Traffic Volumes and Composition

The following table presents a summary of the forecasted vehicle movements from the Traffic Report.

Table 5.2: Predicted Hourly Traffic Movements and Composition

Time	Light vehicles		B-doubles		Semi-trailers		Total		
	Entry	Exit	Entry	Exit	Entry	Exit	Entry	Exit	Two-way
12:00 AM	0	22	12	15	9	5	21	42	63
1:00 AM	0	0	11	14	12	7	23	21	44
2:00 AM	0	0	16	13	8	6	24	19	43
3:00 AM	26	0	14	10	4	11	44	21	65
4:00 AM	104	1	17	10	6	9	127	20	147
5:00 AM	261	5	21	18	14	22	296	45	341
6:00 AM	104	15	13	20	11	32	128	67	195
7:00 AM	26	5	11	18	12	24	49	47	96
8:00 AM	0	1	10	18	14	20	24	39	63
9:00 AM	0	0	14	13	35	34	49	47	96
10:00 AM	0	0	14	12	45	35	59	47	106
11:00 AM	22	0	11	11	35	38	68	49	117
12:00 PM	89	26	10	11	26	31	125	68	193
1:00 PM	224	104	10	13	32	29	266	146	412
2:00 PM	89	261	9	10	28	36	126	307	433
3:00 PM	22	104	17	12	34	37	73	153	226
4:00 PM	0	26	15	13	34	31	49	70	119
5:00 PM	0	0	14	13	24	19	38	32	70
6:00 PM	0	0	13	9	37	16	50	25	75
7:00 PM	1	0	10	12	20	17	31	29	60
8:00 PM	5	22	12	13	18	17	35	52	87
9:00 PM	15	89	16	11	18	13	49	113	162

Time	Light vehicles		B-doubles		Semi-trailers		Total		
	Entry	Exit	Entry	Exit	Entry	Exit	Entry	Exit	Two-way
10:00 PM	5	224	19	13	18	9	42	246	288
11:00 PM	1	89	11	18	13	9	25	116	141
Daily Total	**994**	**994**	**320**	**320**	**507**	**507**	**1,821**	**1,821**	**3,642**

Based on the above table, it can be seen that for the day period (7.00am to 6.00pm), the highest hourly traffic movements occur between 2:00pm and 3:00pm; for the evening period (6.00pm to 10.00pm) the highest hourly movements occur between 9:00pm and 10:00pm; and for the night period (10.00pm to 7.00am) the highest hourly movements occur between 5:00am and 6:00am.

Based on the traffic results presented in Table 5.2, the predicted highest hourly traffic movements and compositions used for the noise impact assessment in this report are presented in the following table.

Table 5.3: Hourly Traffic Movements and Compositions

Period of the day	Light vehicles		B-doubles		Semi-trailers	
	Entry	Exit	Entry	Exit	Entry	Exit
Day (7:00am to 6:00pm)	89	261	9	10	28	36
Evening (6:00pm to 10:00pm)	15	89	16	11	18	13
Night (10:00pm to 7:00am)	261	5	21	18	14	22

5.2.2.2 Carparking activities

Noise generated by car park activities includes vehicle doors closing, vehicle engines starting, vehicles accelerating and vehicles moving. To assess this noise, the $L_{Aeq\ 15\text{-}minute}$ noise level at the nearest affected residential premises was determined for each relevant time period based on the number of vehicle movements expected to occur during that period. For the purpose of this NVIA, it is assumed that the number of vehicles utilising each on-site carpark are distributed in proportion to the total available on-site carpark area. The carpark activity distribution for the purpose of this NVIA is summarised in Table 5.4 for the highest one-hour period for the day, evening and night periods.

Table 5.4: Car Parking Activity Distribution

Area ID	Car Parking Area	Area Size (m^2)	% of Total Available Area	Number of Cars for Highest One-Hour		
				Day	Evening	Night
C1	Car Park Ground	10,723	33%	117	35	89
C2	Car Park Level 1	10,723	33%	117	34	89
C3	Car Park Level 2	10,723	33%	116	34	88
Total parking Area		**32,169**	**100%**	**350**	**104**	**266**

The sound power levels generated by carpark activities on site are presented in the following table.

Table 5.5: Carpark Activity Sound Power Levels

Activity	Metric	Sound Power Level, dB(A) re. 1pW
Vehicle moving (10km/h)	Passby L_W	79
Door Slam	L_W+10log(t)	86
Engine Start	L_W+10log(t)	92

For vehicles exiting the basement carpark and moving up the access ramp, a +5dB(A) adjustment has been added to the predicted noise levels.

5.2.3 Loading Dock Activities and On-Site Truck Movements

Trucks would arrive empty and enter the site to access loading docks in a forward direction, reverse into the loading bays and exit the site loaded with products in a forward direction.

Modelling of truck movements and loading dock operations have been based upon sound power levels measured and established by Renzo Tonin & Associates and are set out in the following table.

Table 5.6: Loading Dock Activity Sound Power Levels

Activity	$L_{Aeq\ 15\text{-}minute}$ Sound power level, dB(A) re. 1pW	Modelled Source Height Above Ground Level (m)
Truck moving - empty (<30km/h)	102[2]	2.0
Truck moving - loaded (<30km/h)	103[2]	2.0
Truck reversing alarm	92[1]	2.0
Forklift	90	1.5
Air brake, partial (single event)	77	0.5
Air brake, full release (single event)	91	0.5

Notes: 1. +5dB(A) added to source level to account for tonality in accordance with NPfI
2. Calculated based on typical Woolworths' fleet truck noise measurements on 18 February 2020

It is noted that for loading and unloading activities within internal loading docks during the day, evening and night-time periods, warehouse doors will be open. For loading and unloading activities that occur externally it is assumed that the activities will mostly comprise of forklift noise presented in the table above.

5.3 Noise Predictions

5.3.1 Prediction Methodology

Noise emissions were predicted by modelling the noise sources, receiver locations, topographical features of the intervening area and possible noise control treatments, using CadnaA (version 2020) noise modelling computer software. The software calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site. The noise prediction model takes into account:

- location of noise sources and receiver locations
- height of sources and receivers
- separation distance between sources and receivers
- ground type between sources and receivers
- attenuation from barriers (natural and purpose-built)
- the location and extent of MPW site elements (natural and man-made structures) on and off site and all of the surrounding area, as approved under SSD 7709
- meteorological effects

At relatively large distances from the noise source, meteorological effects are taken into account in the noise prediction because the resultant noise levels at receivers can be influenced by meteorological conditions, particularly temperature inversions and winds.

The meteorological conditions that are specified in Condition B131 have been adopted for the assessment. These adverse meteorological parameters comprise a ‘D' atmospheric stability class with 3m/s winds or ‘F' atmospheric stability class during the evening and night-time periods (as per Fact Sheet D of NPfI), because this atmospheric stability class does not ordinarily occur during the day.

For consistency with the NPfI and in addition to modelling under adverse meteorological conditions, modelling was also conducted for calm meteorological conditions for the night period using ‘D' atmospheric stability class with 0m/s wind.

A summary of model inputs is provided below.

Table 5.7: Modelling Inputs

Input Parameters	Description
Ground absorption	Numeric values varied between 0 (hard surface) to 1 (soft ground). Value of 0.75 was used to represent the ground between the proposed site and the receivers.
Receiver heights	1.5 metre above ground level for ground floor and 4.5m above ground level for first floor receivers
Modelling standard	CONCAWE
Meteorological effects	
Weather category / Stability Class	Calm meteorological conditions: ‘D' atmospheric stability class with 0m/s wind Adverse meteorological conditions: ‘D' atmospheric stability class with 3m/s winds or ‘F' atmospheric stability class (for evening and night only as per Fact Sheet D of NPfI)
Wind direction	Worst-case direction to the receiver
Wind speed	0m/s for calm condition and 3m/s for adverse condition

5.3.2 Noise Prediction Results and Assessment

Based on the traffic volumes and compositions for vehicle movements associated with the site, the noise source levels presented in Section 5.2 and the above noise modelling methodology, the predicted noise impacts at the nominated receiver locations are presented in the following table, which includes preliminary noise mitigation measures for mechanical plant as set out in Section 5.6.1 and the two scenarios of with and without the installation of onsite noise barriers considered feasible and reasonable.

Table 5.8: Predicted $L_{Aeq, 15min}$ Operational Noise Levels, dB(A)

Receiver	Predicted $L_{Aeq, 15min}$ Noise Level (dBA)				Noise Criteria (dBA)[5]			Exceedance (dB)[6]
	Day[1,3]	Evening[1,3,4]	Night[1] Calm[2]	Night[1] Adverse[3,4]	Day[1]	Evening[1]	Night[1]	
No noise barrier within the site								
R1 - 9 Casula Road, Casula	**40**	**38**	34	**39**	39	35	35	Up to 4
R2 - Casula Powerhouse Arts Centre, 1 Powerhouse Road, Casula	38	36	32	37	45 (external, when in use)			0
R3 - All Saints Catholic Senior College, Leacocks Lane, Casula	35	33	29	34	45 (external, when in use)			0
Mitigated design[7] - 8m high noise barriers within the site up to 325m in total length								
R1 - 9 Casula Road, Casula	39	**37**	32	**37**	39	35	35	Up to 2
R2 - Casula Powerhouse Arts Centre, 1 Powerhouse Road, Casula	38	36	31	36	45 (external, when in use)			0
R3 - All Saints Catholic Senior College, Leacocks Lane, Casula	35	32	28	33	45 (external, when in use)			0

Notes:
1. Daytime = 7.00am-6.00pm; Evening = 6.00pm-10.00pm; Night = 10.00pm-7.00am.
2. 'D' atmospheric stability class with 0m/s wind - calm or neutral meteorological conditions
3. 'D' atmospheric stability class with 3m/s winds - adverse meteorological conditions
4. 'F' atmospheric stability class (evening and night-time only as per Fact Sheet D of NPfI) - adverse meteorological conditions
5. Noise criteria as per Table 4 in Condition B131 of SSD 7709.
6. Exceedances of up to 7dB (no noise barrier within the site) and 5dB (mitigated design) are predicted when assessed against the allocated noise quota levels as presented in Section 5.1.
7. Design aimed to implement feasible and reasonable mitigation to achieve the allocated noise quota levels

The predicted noise levels presented in Table 5.8 indicate that noise associated with the operation of the proposed site would not comply during day, evening and night-time periods. Exceedances up to 4dB of the operational noise limits in Condition B131 of SSD 7709 are modelled without any additional on-site noise mitigation measures. Exceedances were modelled to reduce to an upper level of 2dB with noise barriers up to 8m high at locations where found to be feasible on site.

The night period was found to be the critical and controlling period. Under calm (or neutral) meteorological conditions, compliance is achieved. However, under adverse meteorological conditions, exceedances reach 5dB over the noise quota for this subject site.

A detailed investigation into noise barriers at various heights and locations across the site was undertaken to determine which noise barriers are feasible and reasonable - this investigation is further detailed in Section 5.5. Physical noise mitigation measures beyond the proposed 8m noise walls within the site were found not to be feasible and reasonable. Implementation of noise mitigation measures across the various mechanical plant are anticipated to reduce noise contributions from mechanical plant. These measures would be confirmed during the course of detailed design.

As the project noise criteria for sleep disturbance is based on the Development Consent, it has been considered and no further and more detailed assessment is considered necessary. Moreover, the proposed site will be developed on an existing warehouse area with similar noise source levels to that assessed in the WM Acoustic Report and therefore, not expected to generate higher L_{Amax} noise levels. Therefore L_{Amax} noise levels are very unlikely to result in sleep disturbance at the surrounding area as per Section 7.4 of WM Acoustic Report.

5.4 Noise Mitigation Considerations

The following recommendations provide in-principle noise mitigation options to respond to project acoustic requirements, following confirmation of detailed design and material and plant selection. Further consideration of opportunities for noise mitigation relevant to identified noise sources would be considered and applied during detailed design to achieve outcomes consistent with the existing consent. Assistance of an acoustic consultant would be sought during the detailed design phase of the project in order to confirm all details and specifications required to inform the Monitoring Report for Mechanical Plant (CoC B139); the Operational Noise Monitoring (CoC B140) and the Operational Noise Monitoring Report (CoC B140).

Before committing to any form of construction or committing to any contractor, advice should be sought from an acoustic consultant to ensure that adequate provisions are made for any variations which may occur as a result of changes to the project.

Indicative noise controls and their beneficial impact are identified in the table below:

Table 5.9: Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise control method	Practical examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine silencing	Residential class mufflers	5 to 10	5 to 10	20	20

Noise control method	Practical examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Associates	AS 2436	Renzo Tonin & Associates
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

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

5.5 Feasible and Reasonable Noise Mitigation Investigation

A review of potential noise barriers as shown in the areas indicated in Figure 3 below has been undertaken. Presented in Table 5.10 is a summary of the noise barrier options that have been considered during the design development process, with comments provided on their feasibility and reasonableness with regards to this project.

Figure 3: Extent of 'feasible and reasonable' mitigation option

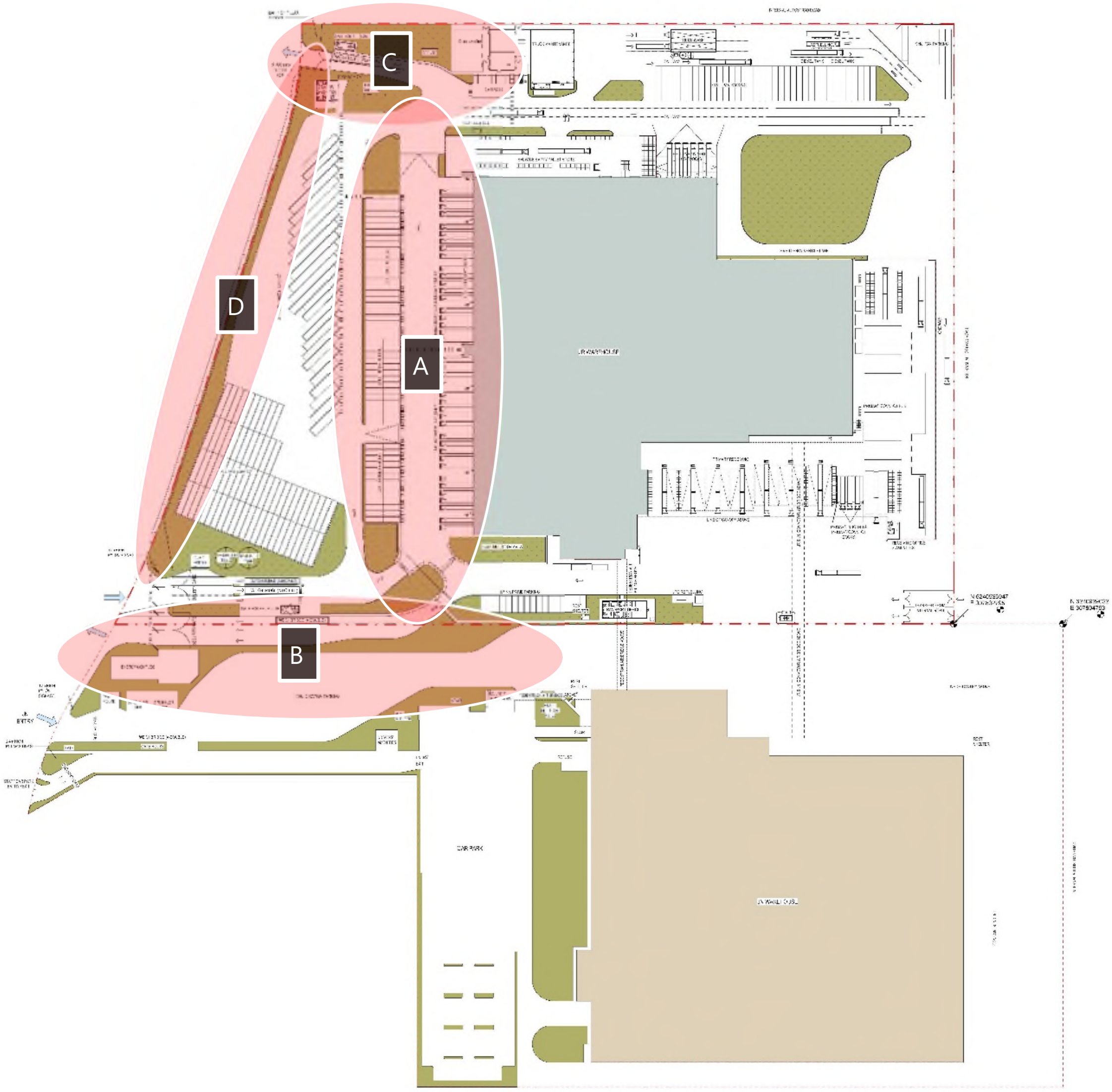


Table 5.10: Summary of investigated noise mitigation options

Noise mitigation area	Estimated noise benefit	Comments on feasibility/ reasonableness	Design result
A - enclosed structure	Overall a 3 dB reduction in L_{Aeq} noise levels to receivers located to the west of site	Safety - Roof structures would require columns for support. The columns will impact truck movements and notably reversing safety. Fire Egress - The Internal Automation Configuration of the building relies upon Fire Egress from the Western Frontage of the Building. The introduction of the awning would extend the travel distances beyond allowable limits. Estimated cost is $8.63M, which equates to $2,88M per dB. This is not considered reasonable and will not achieve overall compliance.	Not feasible and reasonable

Noise mitigation area	Estimated noise benefit	Comments on feasibility/ reasonableness	Design result
A - 8m high noise barrier	Overall a 2 dB reduction in L_{Aeq} noise levels to receivers located to the west of site	Visibility restrictions at entry/ exit to site. Operational issues and restrictions introduced with no visibility between truck docks and pan parking. Increases danger for people working in isolated locations on the site and negates all passive surveillance*. Introduced safety concerns with trucks exiting and entering site and within the site due to elimination of site lines and over reliance on technological solutions for surveillance and security. Estimated cost is $5,15M, which equates to $2,58M per dB. This is not considered reasonable and will still not achieve overall compliance; however, has been allowed for in the design. 8m high noise barriers throughout the facility are not in keeping with any other industrial design or any other Woolworths Distribution Centre throughout Australia.	Feasible but not reasonable; however, has been allowed for in Table 5.8
B - 8m high noise barrier	Overall a 2 dB reduction in L_{Aeq} noise levels to receivers located to the west of site when combined with Noise mitigation area A	Visibility restrictions at entry/ exit to site. Operational issues with no visibility of truck docks and pan parking. Reduces the flexibility of the site for changes in process as safety procedures, systems and operations evolve. Safety concerns with trucks exiting and entering site and within the site. Increases danger for people working in isolated locations on the site and negates all passive surveillance*. Estimated cost is $3,80M, which if considered independently from Noise Mitigation Area A is not reasonable; however, has been partially allowed for in the design. 8m high noise barriers throughout the facility are not in keeping with any other industrial design or any other Woolworths Distribution Centre throughout Australia.	Feasible but not reasonable; however, has been partially allowed for in Table 5.8

Noise mitigation area	Estimated noise benefit	Comments on feasibility/ reasonableness	Design result
C - 8m high noise barrier	Overall a 1 dB reduction in L_{Aeq} noise levels to receivers located to the west of site when combined with Noise mitigation areas A & B	Visibility restrictions at entry/ exit to site. Operational issues with no visibility of truck docks and pan parking. Reduces the flexibility of the site for changes in process as safety procedures, systems and operations evolve. Safety concerns with trucks exiting and entering site and within the site. Increases danger for people working in isolated locations on the site and negates all passive surveillance*. Estimated cost is $1,10M. This is not reasonable due to a very minimal cost per dB benefit, especially when considered independently from Noise Mitigation Areas A and B. 8m high noise barriers throughout the facility are not in keeping with any other industrial design or any other Woolworths Distribution Centre throughout Australia.	Not feasible and reasonable
D - 8m high noise barrier	Overall a 1 dB reduction in L_{Aeq} noise levels to receivers located to the west of site when combined with Noise mitigation areas A, B & C	Visibility restrictions at entry/ exit to site. Operational issues with no visibility of truck docks and pan parking. Reduces the flexibility of the site for changes in process as safety procedures, systems and operations evolve. Safety concerns with trucks exiting and entering site and within the site. Increases danger for people working in isolated locations on the site and negates all passive surveillance*. Estimated cost is $5,72M per dB. This is not considered reasonable. 8m high noise barriers throughout the facility are not in keeping with any other industrial design or any other Woolworths Distribution Centre throughout Australia.	Not feasible and reasonable

Note: * Woolworths has issues with men and women working and operating on the external hard-stand areas and driver amenity areas at night and under isolated circumstances. Having a visual connection and audible connection to all of these areas is central to preserving the welfare of our team members and visitors to the site. The acoustic walls on the site would remove these connections which serve to protect our staff from risk of external intruders to the site, or internal issues.

All estimated cost exclude GST.

Following a detailed review of mitigation options, and a feasible and reasonable review through each of the options (and combinations) presented in Figure 3 and Table 5.10, the lowest achievable predicted noise level was 37 dB(A) $L_{Aeq\ 15\ minute}$ as presented in in Table 5.8.

5.6 Recommended Noise Mitigation & Management Measures

5.6.1 Noise Barriers

In addition to the shielding provided by all the off-site natural and man-made structures, including the SIMTA B129 obligation under SSD7709 Approval - Woolworths proposes to construct on-site noise barriers to a total 325m length and height no greater than 8m.

The final configuration of the on-site noise barriers will be designed and configured in accordance with B138 of the SSD7709 Approval, once all mechanical plant and other noisy equipment have been selected. No further noise mitigation of structures are anticipated by Woolworths in making this submission.

The construction of a noise barrier can be from any durable material with sufficient mass to prevent direct noise transmission (eg. masonry, steel, fibrous-cement, timber, acrylic or polycarbonate) selected to withstand weather elements.

In addition to the above, all noise barriers should give regard to the following to maintain acoustic integrity and to perform effectively as noise barriers:

- any penetrations through the fabric of the fence should be sealed airtight
- all joints and gaps between fence panels / planks should be sealed airtight
- any gaps between the fence and the ground / retaining walls should be filled to ensure that the fence provides appropriate noise attenuation

5.6.2 Roller Doors

Any roller door that is not servicing a truck should be closed at all times.

5.6.3 Mechanical Plant and Equipment

Mechanical plant associated with the development has the potential to impact on nearby residential properties. However, as details for mechanical plant are not final at this stage of the development, the following in-principle noise management measures are provided for mechanical plant servicing the proposed development.

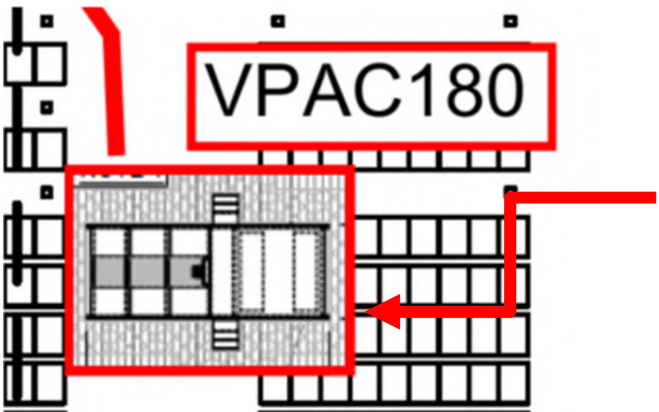
- Acoustic assessment of mechanical services equipment should be undertaken during the detailed design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria. Development Consent Conditions typically require detailed assessment of mechanical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

- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - procurement of 'quiet' plant
  - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
  - commercially available acoustic attenuators for air discharge and air intakes of plant
  - acoustically lined and lagged ductwork
  - acoustic barriers between plant and sensitive neighbouring premises
  - partial or complete acoustic enclosures over plant
- The specification and location of mechanical plant should be confirmed prior to installation on site, and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery - Mechanical Vibration*'.

These measures would be incorporated into, and be consistent with the Operational Noise Management Plan, required under condition B136, prior to commencement of operation.

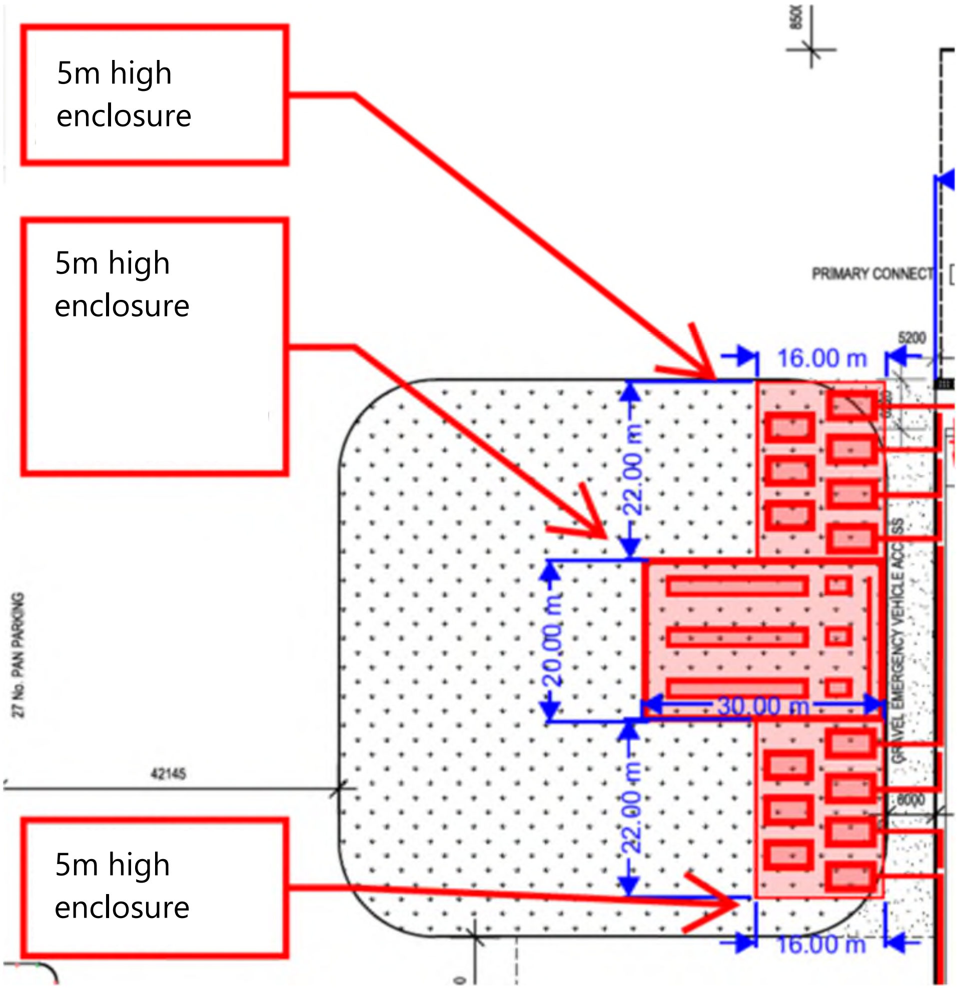
Figure 4 and Figure 5 show in-principle the acoustic enclosures recommended to reduce noise contributions from mechanical plant and equipment. Acoustically absorptive finishes on the internal faces of the acoustic enclosures is recommended to reduce the reverberant build-up of noise inside the enclosures.

Figure 4: Extent of enclosure for JR rooftop air handling units



3m high enclosure

Figure 5: Extent of enclosure for JR plantroom



5.6.4 Operational Noise Monitoring

Noise monitoring for MPW during operations is required under consent conditions B136 to B140. Any noise complaints received will be investigated and where noise levels are established to have exceeded the noise limits under the respective assessment weather conditions, feasible and reasonable amelioration measures will be investigated in discussion with a qualified acoustic consultant to mitigate future occurrences.

5.6.5 Operational Noise Management

As the project has predicted residual exceedances of the project noise goals following the implementation of all feasible and reasonable mitigation measures, it is important for the site's Operational Noise Management Plan (per Condition B131) to include monitoring and the mechanisms for management to review and incorporate any opportunities to modify operations to reduce noise emissions over the facility's life time.

As part of the site's Operational Noise Management Plan, not only should reviewing the site noise emissions against the predicted noise levels in this NVIA be incorporated, there should also be regular reviews of on-site noise mitigation and management practices to incorporate and capture opportunities for reductions of site noise emissions with considerations of at minimum the following:

- Review of noise reduction opportunities during changes or refinements of site noise generating activities
- Reviewing noise levels of plant, equipment and activities, during both ongoing compliance checks and in response to complaints.
- Improvements in Best Management Practice (BMP), as defined in the NPfI.
- Improvements in Best Available Technology Economically Achievable (BATEA), as defined in the NPfI.

6 Conclusion

Renzo Tonin and Associates has completed an environmental noise and vibration impact assessment of the proposed modifications to the subject warehouse and distribution facilities at Moorebank Logistics Park, 400 Moorebank Avenue, Moorebank.

Construction noise and vibration would be managed in accordance with the approved Construction Noise and Vibration Management Plan prepared for MPW Stage 2 SSD 7709. In-principle recommendations are provided in Section 3.6 to limit the potential impact of noise generated by construction activities.

Based on the plant and equipment proposed to be used for the site establishment and building works and the large separation distances, vibration impacts are negligible and therefore not likely to result in structural damage to buildings at the nearest affected receivers and there is a low risk of adverse comments from occupants of residences due to construction vibration.

Operational noise impacts from the proposed warehouse and distribution facilities with all feasible and reasonable mitigation measures implemented, are predicted to exceed the noise quota for the site, by up to 5 dB at the nearest and worst-affected residential receivers in Casula during adverse meteorological conditions, even with all feasible on-site noise mitigation measures implemented. Under calm (or neutral) meteorological conditions, compliance is achieved everywhere with the feasible on-site noise mitigation measures implemented.

Key noise sources that required mitigating are on-site truck movements, loading dock activities and mechanical plant and equipment.

A detailed review of feasible and reasonable mitigation measures was undertaken, and the implementation of mitigation measures to mechanical plant and equipment with some noise barrier arrangements, was found to assist in mitigating the loading dock activities. However, feasible and reasonable mitigation measures within the site are not able to be implemented to sufficiently mitigate the onsite truck movements to achieve the allocated noise quota.

With all feasible mitigation measures implemented, 37dB(A) was modelled under adverse meteorological conditions, resulting in an exceedance of the quota level by up to 5dB, and an exceedance of the overall B131 condition's noise level by up to 2dB, at the worst-affected receiver in Casula. Under calm (or neutral) meteorological conditions, both the allocated noise quota and the overall B131 condition's noise limits are achieved. physical noise mitigation measures investigated beyond the proposed 8m noise barriers within the site, were found not to be feasible and reasonable. However, further long-term noise monitoring is a requirement under SSD7709 B140 and will be detailed within the site's Operational Noise Management Plan to assist in managing operational noise from the entire MPW precinct.

In-principle recommendations are provided in this assessment to manage potential impact of noise generated by construction and operation activities to be considered for inclusion within the site's Operational Noise Management Plan, as required under condition B136.

APPENDIX A Glossary of Terminology

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

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

Decibel [dB]	The units of sound measurement. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear, defined as 20 micro Pascal 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications.
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.
DIN	German Standard
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999
EPA	Environment Protection Authority
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007

Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
INP	NSW Industrial Noise Policy, EPA 1999
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Noise	Unwanted sound
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, NSW, May 2013

RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australa. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.

Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w.