NSW GOVERNMENT

Redfern Station Upgrade – New Southern Concourse

Appendix E - Construction Noise and Vibration Strategy

Artist's impression of the proposed Redfern Station Upgrade - New Southern Concourse. Indicative only, subject to detailed design.

Transport for NSW | May 2020

Construction Noise and Vibration

DMS-ST-157

Standard – Applicable to Infrastructure and Place

Divisional Management System

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Document History

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1.0	13 Sept 11	912549	To provide practical guidance on how to minimise noises generated during the construction of projects.
2.0	11 Nov 11	912549	Updated to reflect Transport Projects Transition.
3.0	21 June 2016	1416544_10	Updated to current industry standards and to reflect transition from Transport Projects to Infrastructure & Services.
4.0	1 May 2018		Document is updated to: 1. Increase focus on the management of vibration impact Update Management Principles 3. Define I&S preferred working hours hierarchy Include community engagement methods Include noise monitoring/verification record.
4.1	24 Apr 2019	6266502_2	Rebranded to Infrastructure and Place.
4.2	18 Oct 2019	1416544	DMS prefix added to document numbers.

NSW GOVERNMENT

Construction Noise and Vibration Strategy

April 2018

Contents

Cover image: Building demolition at Wynyard for the Wynyard Walk project.
Image above: Sheet piling at Broadmeadow Station

1. Overview

1.1. Context & Commitment

Transport for NSW Infrastructure and Place Division (IP) leads the procurement and delivery of public transport infrastructure in NSW. The construction noise and vibration emissions associated with IP projects can often cause disturbance to commuters, pedestrians, adjacent communities and other stakeholders. This Construction Noise and Vibration Strategy (CNVS) outlines the approach to be taken to mitigate and manage construction noise and vibration from IP projects.

Guidance and principal requirements with regard to the management of noise and vibration from construction in NSW are contained in the:

- Interim Construction Noise Guideline (ICNG, Department of Environment and Climate Change 2009)
- Assessing Vibration: A technical guideline (AVTG, Department of Environment and Conservation 2006)

The ICNG and AVTG focus on applying a range of mitigation measures to minimise noise and vibration impact from construction rather than on achieving numerical objectives. These guidelines recognise that some construction noise and vibration is inevitable, and that it should be managed through the application of reasonable and feasible mitigation measures. The ICNG encourages organisations involved with construction, maintenance or upgrading works to develop their own best-practice techniques for managing construction noise and vibration.

Transport for NSW (TfNSW) is committed to avoiding or minimising noise and vibration impacts from all construction projects under it's control. The CNVS provides the methodology by which noise and vibration from IP construction projects can be assessed and mitigation measures identified and applied.

For many IP projects, construction works occur close to residences or other sensitive receivers. In addition, due to the impact of such works on infrastructure and services they are often required to be undertaken outside standard construction hours to minimise or avoid disruption to commuter services and/or road traffic on major roads, for example at night or over the weekend. Adverse community reaction to noise and vibration impact can often be managed by informing stakeholders of the potential impacts, the time periods over which these will occur and the proposed mitigation measures that will be employed to minimise the impacts.

IP is committed to engaging with the community affected by our projects though effective consultation and the provision of information regarding the noise and vibration impacts of our projects.

In preparing this strategy, consideration has also been given to guidance contained in the *Australian Standard AS 2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites* and the Roads & Maritime Services *Construction Noise and Vibration Guideline* (April 2016).

1.2. Scope

This strategy is applicable to all IP projects including urban centres, multimodal transport hubs and interchanges, and infrastructure installation and upgrades for buses, trains, light/heavy rail and ferries.

Typical construction projects covered by this strategy include (but are not limited to):

- Station upgrades – commuter car parks, easy access, transport interchanges
- Light rail infrastructure
- Bus priority infrastructure

- Heavy rail infrastructure
- Ferry fleet and infrastructure upgrades

The document may be used in the development of, or referred to, in:

- Environmental Impact Assessment (EIA) documents
- Design and construction environmental management documents
- Contract documents
- Approvals and licences (subject to the agreement of the relevant regulatory authority)

This document does not take precedence over approval or licence conditions and will be reviewed as required in response to the release of relevant guidelines, standards and policies dealing with construction noise.

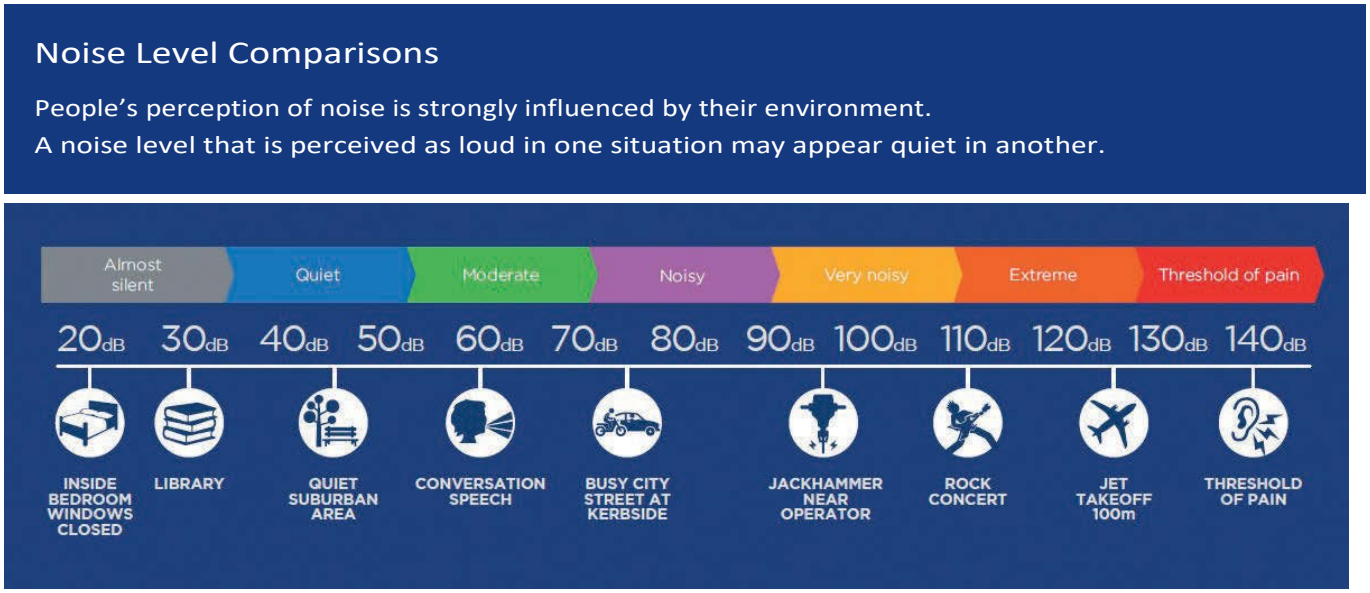
This strategy shall be considered by all personnel involved in the delivery of IP projects when assessing and managing noise and vibration impacts and is most relevant for:

- Project managers
- Environmental staff
- Delivery Partners to TfNSW
- Acoustical consultants

1.2.1. Work health and safety considerations

In addition to potential noise and vibration impacts on stakeholders and structures, construction noise and vibration can also have an adverse impact upon the health of workers.

It is advised that this document does not address occupational noise exposure. This is administered through the Work Health and Safety Act 2011 and Work Health and Safety Regulation 2017.



1.3. Objectives

The key objectives of this strategy are to:

1. Provide a consistent process for evaluating the construction noise and vibration impacts from IP projects by providing simple and detailed assessment methods, with a clear pathway to identifying the best approach for each project
2. To provide clarity on level of assessment required for construction noise and vibration before and during construction activities
3. Encourage organisations to undertake construction works during standard construction hours where feasible and reasonable to do so. Where out of hours works (OOHW) are required, providing a hierarchy of preferred working hours and procedure for mitigating and managing impacts from these works
4. Ensure proactive consultation with the community and other stakeholders, to facilitate effective project delivery with balanced stakeholder impacts
5. Implement reasonable and feasible noise and vibration mitigation measures on all projects that take into consideration the time of works and the likely extent and duration of impact
6. Verify noise assessments undertaken during the EIA stage prior to construction commencing to ensure that any changes to the project's design, scope, construction method or the mitigation measures proposed in the EIA are re-evaluated and any additional (or changes to the) mitigation measures are identified
7. Monitor the implementation and effectiveness of the project's noise and vibration mitigation measures

1.4. Construction hours

Construction activities (including the delivery of plant and equipment) should be limited to the Standard Hours described in Table 1 below wherever feasible and reasonable. This helps reduce noise and vibration impacts by limiting potentially noisy and vibration causing construction activities to the day time, when background noise levels are higher, and by providing respite from construction noise and vibration during the evening, overnight and on weekends.

Table 1: Construction Hours[1,2]

Hour commencing	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
Monday																								
Tuesday																								
Wednesday								Standard											OOHW					
Thursday			OOHW					Hours											Period 1					
Friday			Period 2																Evening					
Saturday																								
Sunday									OOHW Period 1										OOHW					
Public Holiday									Day										Period 2					

[1] Standard construction hours are defined as: Monday to Friday 7:00am to 6:00pm and Saturdays from 8:00am to 1:00pm.

[2] Work outside of standard construction hours is defined as Out-of-Hours Work (OOHW) and can be divided into 2 periods of sensitivity. OOHW Period 1 is defined as Monday to Saturday 6:00pm to 10:00pm (evenings), Saturday 7:00am to 8:00am and 1:00pm to 10:00pm (day & evening) and Sunday and public holidays 8:00am to 6:00pm (days). OOHW Period 2 is defined as Monday to Saturday 10:00pm to 7:00am (nights) and Sundays and public holidays 6:00pm to 8:00am (nights).

In addition to the above,

- Construction activities with special audible characteristics (high noise impact, intensive vibration, impulsive or tonal noise emissions) should be limited to standard hours, starting no earlier than 8am; and to continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block, unless otherwise approved by TfNSW (see Section 6.1.1 and Additional Mitigation Measure Duration Reduction in Table 8)
- Blasting, where required, should be limited to between 9am and 5pm Monday to Friday and 9am and 1pm Saturday. There should be no blasting on Sundays or public holidays

Standard construction hours are typically set out in the approval conditions and/or Environment Protection Licence (EPL), if applicable, for each project, and may differ from those above where the impact has been assessed and approved as part of the EIA. The hours of construction stipulated in the EIA or EPL (if applicable) shall be implemented as a first preference.

Work outside these hours should only be conducted when it is not feasible or reasonable to work within standard hours. Any decisions to work outside of these hours shall be documented and assessed in the OOHW Application to justify this requirement.

Blasting and construction activities generating noise with special audible characteristics may be completed outside of the listed time restrictions if endorsed by the Associate Director Community Engagement (or nominated delegate) and approved by the Associate Director Environmental Management (or nominated delegate) or relevant authority. Note that strong justification would be required to support these activities being completed outside the recommended hours.

1.5. Operational noise

This strategy does not address operational noise from the site once construction is complete. Guidance for operational noise should be taken from:

- EPA (2013) Rail infrastructure noise guideline, NSW Environment Protection Authority
- EPA (2017) NSW Noise Policy for Industry, NSW Environment Protection Authority
- DECCW (2011) Road noise policy, NSW Department of Environment, Climate Change and Water
- Relevant EIA, Planning Approval Conditions and Technical Specifications and/or Standards for specific requirements regarding operational noise

2. Abbreviations and definitions

All terminology in this Standard is taken to mean the generally accepted or dictionary definition except for the following terms which have a specifically defined meaning:

Assessment location	An identified residence or other sensitive land use
a_{rms}	"Weighted Root Mean Squared Acceleration", a vibration parameter used to assess human response to continuous or intermittent vibration
Attenuation	The reduction in the level of noise or vibration
Assessment period	The time period in which an assessment is made, for example standard hours 7am-6pm
AS1055	Australian Standard, *AS1055:1997 – Acoustics – Description and measurement of environmental noise*
AS2436	Australian Standard, *AS2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites*
AVTG	NSW Department of Climate Change *Assessing Vibration – a technical guideline*, (OEH, 2006)
A-weighting	An adjustment made to the sound level measurement to approximate the response of the human ear
Background noise	The underlying level of noise present in the ambient noise, when extraneous noise is removed and in the absence of the noise under investigation. This is described using the LA90 descriptor, see Rating background level definition
BS5228	British Standard, *BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites*
BS7385	British Standard, *BS7385-2:1993 Evaluation and measurement for vibration in buildings*
CNVIA	Construction Noise & Vibration Impact Assessment, a supporting assessment to the Environmental Impact Assessment required under the *Environmental Planning & Assessment Act 1979*
CNVIS	Construction Noise & Vibration Impact Statement, an assessment prepared during the project delivery phase to confirm noise and/or vibration management
CNVMP	Construction Noise & Vibration Management Plan, a supporting management plan to the Construction Environmental Management Plan required during the project delivery phase for all IP projects
Construction	Includes the erection, installation, alteration, repair, maintenance, cleaning, painting, renewal, removal, excavation, dismantling or demolition of, or addition to, any building or structure, or any work in connection with any of these activities, that is done at or adjacent to the place where the building or structure is located. Construction works occur on a site for a limited time period only and may include pre-construction or enabling works for Projects
dB(A)	A measure of A-weighted sound levels.
DIN4150	German Institute for Standardisation, *DIN4150-3:1999-02 Structural vibration – Effects of vibration on structures*
Emergency works	Unforeseen works immediately needed to prevent the loss of life, damage to property or environmental harm

EMR	Environmental Management Representative. The EMR is appointed to a Project by the IP Associate Director, Environmental Management to provide advice in relation to the environmental compliance and performance of the Project
ENMM	NSW Roads & Traffic Authority, *Environmental Noise Management Manual* (December, 2001)
Environmental impact assessment (EIA)	A broad term that covers the range of assessments required under the Environmental Planning and Assessment Act 1979 and any related amendments to the Act.
EPA	NSW Environment Protection Authority
EPL	Environmental Protection Licence required by the *Protection of the Environment Operations Act 1997*
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities include traffic generated by holiday periods and special events such as concerts or sporting events. Normal daily traffic/transport noise is not considered to be extraneous
Feasible	A mitigation measure that can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements. When determining if a mitigation measure or work practice is feasible, consideration should be weighted towards engineering and safety constraints rather than cost-benefit of noise mitigation which is more appropriately assessed under the reasonableness test Implementing noise mitigation at the source is always the preferred method of noise control as it reduces the impact on the surrounding area. Control of noise in the path between the source and the receiver, or mitigation at the receiver usually requires measures to block the transmission of noise by means of barriers or architectural treatments to building façades. As the benefit from these measures only apply to a limited area, they should only be considered after exhausting all feasible options to control noise at the source[3]
Ground-borne noise	Noise heard within a building that is generated by vibration transmitted through the ground into the structure from construction works, sometimes referred to as 'regenerated noise' or 'structure-borne noise'. Ground-borne noise can be more noticeable than airborne noise for underground works such as tunnelling. The ground-borne noise levels are only applicable when ground-borne noise levels are higher than airborne noise levels
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes)
Internal noise level	Applies at the centre of the room in use that is most exposed to the construction noise, and can include both airborne and ground-borne noise
IP	Infrastructure and Place division of TfNSW
ICNG	NSW Department of Environment and Climate Change *Interim Construction Noise Guideline*, published July 2009
NPfI	NSW Environment Protection Authority, *NSW Noise Policy for Industry*, (EPA, 2017)
$L_{A1(1minute)}$	The A-weighted sound pressure level that is exceeded for 1% of the 1 minute measurement period
L_{Amax}	The "Maximum Noise Level" for an event, used in the assessment of potential sleep disturbance during night-time periods. The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (i.e. A-weighted)

[3] Draft Construction Noise Guideline (NSW EPA, June 2017).

L_{Aeq}	The A-weighted equivalent continuous (energy average) sound pressure level of the construction works under consideration over a defined period (such as 15-minutes, shown as $L_{Aeq(15\ minute)}$) Other descriptors may be used providing they can be justified as representing the characteristics of the construction noise. Note that during verification monitoring the L_{Aeq} should exclude other sources such as from industry, road, rail and the community
L_{A90}	The "Background Noise Level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction noise objectives are based on an allowance margin above the L_{A90} background noise levels, see Rating background noise level definition
Mandatory	Required by legislation. The Guideline specifies noise management levels that guide the need to apply work practices to minimise noise impacts, but the legislation does not make it compulsory, that is not mandatory, to meet these noise levels. However, the Guideline will be used when setting statutory (legally enforceable) conditions in a licence or consent
Most affected location(s)	Location(s) that experience (or will likely experience) the highest noise levelfrom the construction works under consideration. In determining these locations, existing background noise levels, noise source location(s), distance and any shielding between the construction works (or proposed works) and the residences and other sensitive land uses need to be considered
NML	Noise Management Level as defined by the NSW EPA and in compliance with the ICNG, see APPENDIX A. NMLs may be referred to as noise objectives in this document
NVSR	Noise and Vibration Sensitive Receiver
OOHW	"Out-of-Hours Work" referring to construction activities outside of the Standard Construction Hours (see page 8 or Section 1.4)
PPV	"Peak Particle Velocity" evaluated at the building footings and used to assess the risk of damage to structures
Proponent	The developer of the construction works under consideration
Rating background level (RBL)	The overall single-figure background noise level for each assessment period. Determination of the rating background level is by the method described in the *NSW Noise Policy for Industry* (EPA, 2017). This approach aims to result in the noise management level being met for at least 90% of the time periods (15 minutes each) over which reactions of annoyance can occur
Reasonable	Selected from those mitigation measures that are feasible. Involves judging whether the overall noise benefits provide significant social, economic or environmental benefits. Factors to be considered include: 1. Likely noise impact, including: • existing and future noise levels and projected changes in noise levels; • the number of people likely to be affected; and • any noise criteria specified by appropriate regulatory authorities through licences, consents or conditions. 2. Noise mitigation benefits, including: • the cumulative noise reduction from the proposed work practices or noise abatement measures;

- likelihood of the work practices or noise abatement measures to reduce noise during the construction stage, and preferably also the operational stage of the project; and
- consideration of the total number of noise sensitive receivers benefiting from noise mitigation.

3. Effectiveness and cost-benefit of noise mitigation, including:
   - total cost of mitigation measures, considering the physical attributes of the site, such as topography and geology, and the financial cost to project given benefit expected;
   - noise mitigation costs compared with total project costs allowing for capital and maintenance;
   - impact of disruption to essential transport and utility networks, for example main roads, railways, water, gas and electricity supply; and
   - risk to worker safety, including during live traffic (road or rail) conditions.
4. Community views, including:
   - engagement on the aesthetics and any other impact associated with work practices and abatement measures;
   - preferences for work scheduling and respite periods for work outside recommended standard hours; and
   - establishing which practices or measures have support from the affected community[4].

RING	NSW Environment Protection Authority, *Rail infrastructure noise guideline*, (NSW EPA, 2013)
RNP	NSW Department of Environment, Climate Change and Water *Road noise policy*, (DECCW, 2011)
Rough Sleeper	Rough sleepers are persons with no shelter or who are living in non-conventional accommodation. Non-conventional accommodation includes: living on the streets, sleeping in parks, squatting, staying in cars or railway carriages, or living in improvised dwellings
Sensitive Receiver	A sensitive receiver may refer to persons, facilities, structures or organisms that can be impacted by noise and/or vibration such as residents, students, specialist medical equipment, heritage structures and marine mammals etc. Further detail on receivers other than residential receivers is provided in Section 8.3.1 and Appendix A
Short-term maintenance works	Maintenance or repair of infrastructure, where the works are not likely to affect an individual or sensitive land use for more than three weeks in total
Special audible characteristics	Refers to noise with characteristics that can cause annoyance and disturbance, containing noticeable factors such as tonality, low frequency noise, impulsive or intermittent noise events. These characteristics may not be considered noisy in quantitative sense. Refer to APPENDIX C, Table 19 for specific plant and equipment identified as having special audible characteristics
SPL	Sound Pressure Level
SWL	Sound Power Level
TfNSW	Transport for New South Wales
Vibration	The term for the perception of continuous, impulsive or intermittent shaking, pulsing or trembling caused by construction activities. Vibration to be measured and assessed as outlined in Appendix A of this strategy

[4] Draft Construction Noise Guideline (NSW EPA, June 2017).

3. Applying the Construction Noise & Vibration Strategy

The CNVS may be applied at any stage of project assessment and delivery, but will primarily be applicable during the EIA, development of the construction noise and vibration management plan and when assessing OOHW. Figure 1 below presents a quick reference diagram for each section of the CNVS.

Figure 1: Application of the CNVS

Environmental Impact Assessment	• To determine noise environments, noise & vibration impacts and construction noise objectives in the EIA Phase, see Section 4 • Identify Construction Noise & Vibration Impact Assessment (CNVIA) assessment method – Section 7 • Identify standard and additional mitigation measures for the Delivery Phase – Section 8
Management in the Delivery Phase	• Verifying and managing noise & vibration impact in the Project Delivery Phase, See Section 5 • Prepare Construction Noise & Vibration Management Plan including OOHW Protocol – Sections 5, 6, 7 & 8 • Confirm standard and additional mitigation measures for the Delivery Phase – Section 8
OOHW in the Delivery Phase	• Out-of-Hours Working justification, assessment and approval processes in the Delivery Phase, See Section 6 • Determine Construction Noise & Vibration Impact Statement (CNVIS) assessment method – Section 7 • Determine and implement standard and additional mitigation measures for the Delivery Phase – Section 8
Impact Assessment Method	• Approach to Construction Noise & Vibration Impact Statements (CNVIS), See Section 7 • Simple CNVIS, See Section 7.1 • Detailed CNVIS, See Section 7.2
Mitigation	• Determining mitigation measures in the EIA and Delivery Phases • Standard mitigation measures, See Section 8.1 • Additional mitigation measures and their application, See Section 8.2

4. Environmental impact assessment

As part of the EIA process, the impacts on nearby receivers of airborne noise, ground-borne noise and ground-borne vibration generated during the construction of a project are evaluated. This assessment shall be undertaken by an acoustic consultant or suitably experienced environmental representative (for low risk projects in agreement with TfNSW). The assessment shall form part of the EIA documentation (e.g. Review of Environmental Factors) that is considered by the approval authorities. The noise and vibration construction assessment:

- Is based on an initial design, scope and construction methodology for the project
- Identifies sensitive receivers, the existing background noise levels and construction noise and vibration objectives (see APPENDIX A)
- Identifies the feasible and reasonable noise and vibration mitigation measures (including any project specific measures[5]) that are required to mitigate any predicted exceedance of the construction noise and vibration objectives

A noise and vibration assessment should be included in the project documentation placed on public display. This will include the construction noise and vibration objectives for the project and any accompanying mitigation measures. Comments received from stakeholders on the proposed mitigation measures for the project shall be considered and if deemed necessary, changes shall be made to the proposed mitigation plan, prior to the project being approved or licensed. APPENDIX A describes in detail the construction noise and vibration assessment process.

4.1. Impact Assessment Method

A Construction Noise and Vibration Impact Assessment (CNVIA) known as a 'quantitative assessment' may be undertaken as part of the EIA process. A CNVIA must be prepared in accordance with the requirements of APPENDIX A.

The level of detail for a CNVIA/S will vary depending on the scale of the works and the likely noise and vibration impacts. The assessment may be conducted as a simple or detailed assessment, as outlined below:

- Simple assessment: Where noise and vibration objectives are unlikely to be exceeded. For example, the construction of a chain wire safety fence as part of preparatory works during the daytime or evening period. See Section 7.1
- Detailed assessment: Larger projects, where noise and vibration objectives will likely be exceeded will require more detailed assessment of the potential noise and vibration impacts. The construction of a new bridge outside standard construction hours over a period of 4 weeks would require a detailed assessment of the potential noise and vibration impacts. See Section 7.2

Risk factor principles are provided in the notes of Figure 3, page 26.

[5] For example: physical structures such as construction noise barriers, acoustic sheds, dwelling treatments, acoustic barriers around noisy plant, operational noise barriers erected early, etc. or special construction methods such as penetrating cone fracture or controlled blasting in place of conventional rock breaking, etc.

5. Management in the Delivery Phase

The EIA documentation is generally based on an initial 'concept' design and construction methodology. Typically, as the design of a project is further developed following its approval, the construction methodology and staging is altered, triggering further assessment.

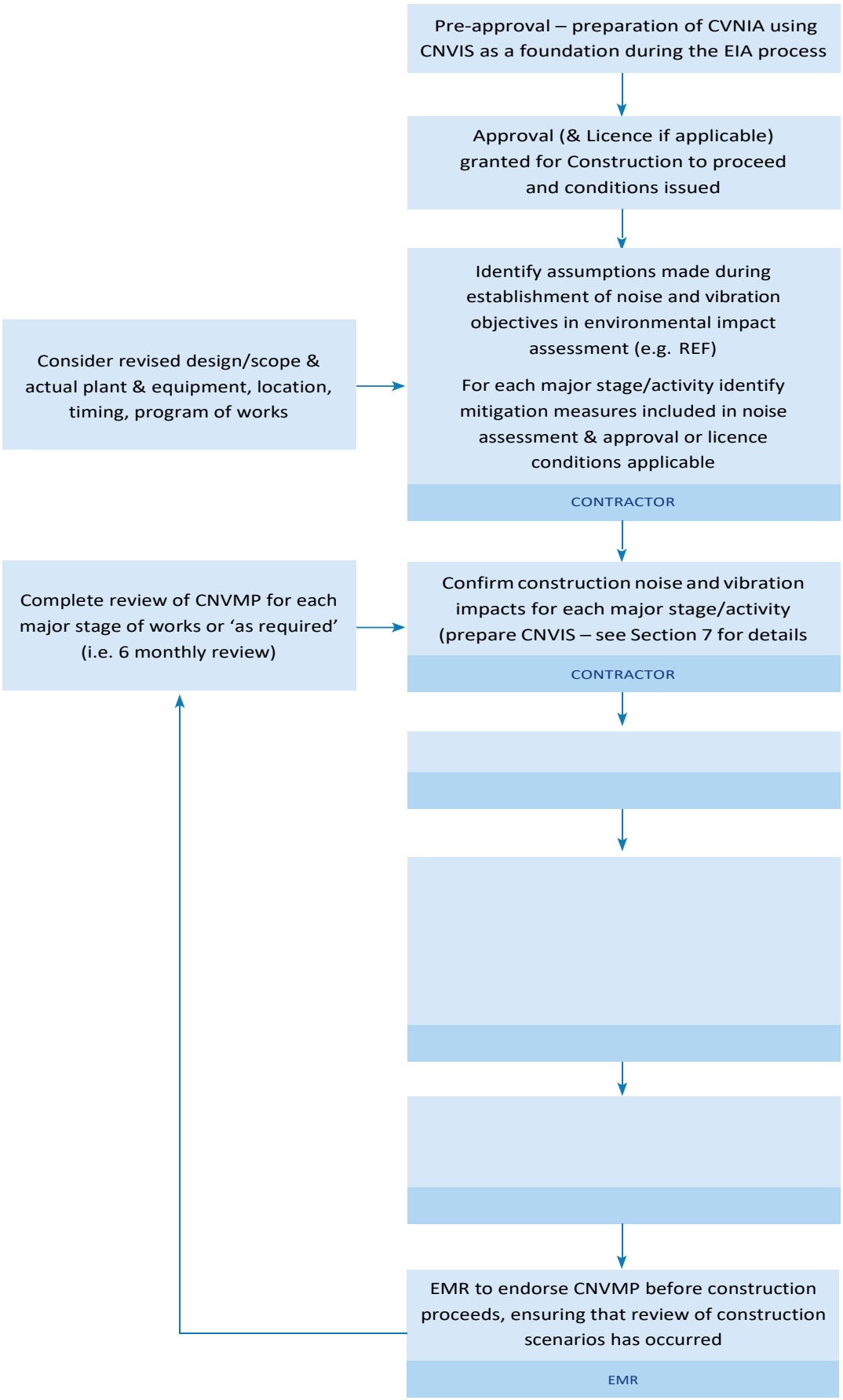
To ensure the adequacy of the noise and vibration mitigation measures for the final design and construction method, a Construction Noise and Vibration Impact Statement (CNVIS) will be undertaken. This process is outlined in Figure 2. The CNVIS should be used as the basis on which to develop the Construction Noise & Vibration Management Plan (CNVMP)[6] for the project. The CNVIS may be updated or a separate CNVIS prepared for each major stage of works or activity and the CNVMP revised as required. The CNVMP must form part of the Construction Environmental Management Plan (CEMP) for all IP projects.

The level of detail for a quantitative CNVIS will vary depending on the scale of the works and the likely noise and vibration impacts. The assessment may be conducted as a simple or detailed assessment, as outlined in Section 7.

The CNVMP assessment process outlined in Figure 2 will need to be approved by the Environmental Management Representative (if applicable). The noise and vibration impact assessments should be undertaken in accordance with the guidance provided in this strategy and the relevant Environment Protection Licence conditions (if applicable). More detail on the assessment process is provided in Section 7.

[6] NB: Any changes to the project must be consistent with the environmental assessment documentation and project approval and cannot cause significant additional impacts on the environment or stakeholders.

Figure 2: Construction noise and vibration assessment review procedure[7]



[7] If considered necessary (i.e. noise measurements are more than 5 years old), RBL measurements may be confirmed through the implementation of this procedure.

6. OOHW assessment

Construction work may need to be completed outside the recommended standard construction hours where required to maintain a safe work environment and avoid or minimise impacts to operational transport infrastructure and services or to utilities networks, including limiting disruption to pedestrians, commuters, traffic or utilities. For example construction activities within operational rail corridors often need to be undertaken during track possessions that are scheduled by the railway network operator, typically during periods of lower commuter use (overnight, weekends and holiday periods).

Box 1 on the following page contains a sample of typical practices under which OOHW may be permitted.

The procedure for assessing and approving / rejecting proposals for OOHW is set out in Figure 3. The key features of the procedure include:

- All applications for out of hours work must be made on the approved form and accompanied by the required information
- The approval pathway will be determined on a risk-based approach on a case-by-case basis to ensure that OOHW are approved by the appropriate delegate. Low risk activities may include work that is no more than 5dBALeq(15minutes) above RBL during any period, with no sleep disturbance potential and occurring for no longer than 6-weeks in the same Noise Catchment Area (NCA). High risk activities may include work with high impact noise, or during more sensitive times, where receivers will be significantly affected by construction noise
- Out of hours work with low risk factors (see Figure 3) may be approved by the Environmental Management Representative (EMR) for the project unless otherwise specified by an approval or licence condition. If there is no EMR assigned to the project, approval must be given by the IP Senior Manager Environment (SME)
- Out of hours work with medium or high risk factors (see Figure 3) may be approved by the SME for the project unless otherwise specified by an approval or licence condition
- Applications for approval of out of hours work with medium or high risk factors (including those requiring the EPA's approval) must be supported by a CNVIS or other acoustic assessment prepared in accordance with the guidance in Section 7 and relevant licence conditions
- Out of hours work with a high factor can only be approved by the SME, Associate Director Environmental Management or the Department of Planning & Environment (whichever is applicable) following endorsement by the EMR

Note that OOHW for activities covered by an EPL may be subject to a separate approval process and is the responsibility of the licence holder (see footnote[8]).

[8] This form is not used for applications for out of hours work covered by an EPL. The licence holder will have their own procedure covering such applications.

Box 1: Works permitted outside of standard construction hours

- any works which do not cause noise emissions to be more than 5dBA higher than the Rating Background Level (RBL) at any nearby residential property and/or do not exceed the noise objectives of other noise sensitive receivers, and subject to approval under the OOHW Protocol (OOHWP)
- out of hours work identified and assessed in the EIA or the approved out of hours work protocol (OOHWP)
- the delivery of plant, equipment and materials which is required outside these hours as requested by police or other authorities for safety reasons and with suitable notification to stakeholders as agreed by the Senior Manager Environment (SME) or Associate Director Environmental Management (ADEM)/Department of Planning & Environment (whichever is applicable)[9]
- emergency work to avoid loss of life, damage to external property, damage to utilities and infrastructure, prevent immediate harm to the environment, prevent contamination of land or damage to a heritage (indigenous or non-indigenous) item[10]
- any other work as agreed by the SME/Department of Planning & Environment and considered essential to the Project, or as approved by EPA (where an EPL is in effect) subject to:
    - works which include works with special audible characteristics including sheet piling, pile driving, rock hammering/breaking must be agreed to by the Associate Director Environmental Management/Department of Planning & Environment (whichever is applicable) or as approved by EPA (where relevant to the issuing of an EPL).
    - notification of stakeholders no less than 7 days prior to such activities being undertaken or other period as agreed to by the Director Community Engagement (or nominated delegate) or as approved by EPA (where relevant to the issuing of an EPL). The notification shall include likely times and duration of works.
    - Implementation of the Additional Management Measure: Duration Reduction for extended hours requested for the sole purpose of reducing the duration of construction on public infrastructure projects (see Table 8).

[9] Depending on whether the project is determined by TfNSW – Infrastructure and Place or approved by the Minister for Planning & Environment.

[10] Works that have continued beyond the approved hours as a result of poor planning or scheduling, delays or unforeseen circumstances are not considered emergency works unless they also satisfy the criteria for emergency works. Any emergency OOHW must be recorded as an incident in compliance with IP procedures.

6.1.1. Preferred Working Hours

6.1.1.1. Standard Construction Hours

As a general principle, work shall be completed during standard construction hours wherever reasonable and feasible. However there may be instances where the community may consider work during standard hours as unreasonable, for example, examination periods at educational institutions or during services at places of worship. In these cases it is recommended that Delivery Partners negotiate suitable working times with Other Sensitive Receivers (see Section 8.3.1).

It is also a requirement of this strategy that Construction activities with special audible characteristics (high noise impact, impulsive or tonal noise emissions) should be limited to standard hours, starting no earlier than 8am; and to continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block, unless otherwise approved by TfNSW. Approval may be in the form of Request for Information (RFI) correspondence or OOHW Approvals.

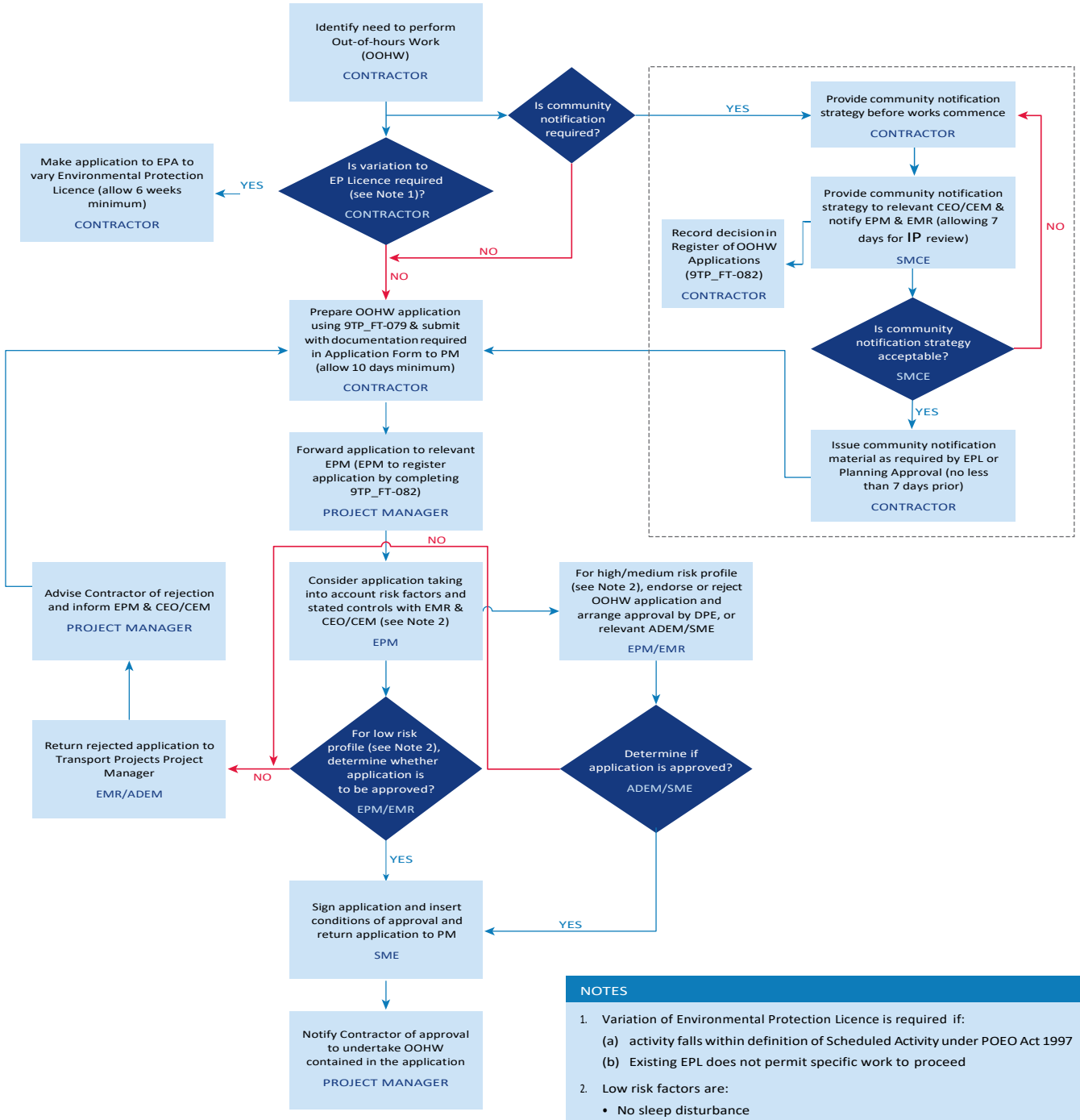
6.1.1.2. OOHW hierarchy

Where OOHW is required, the following hierarchy of working hours must be considered to minimise impacts. The hierarchy does not prohibit work where there is reasonable justification to complete OOHW during restricted timeframes such as Rail Possessions. However, impact of all OOHW activities may be reduced by scheduling work and activities with greater impact during preferred periods when receivers are less sensitive to noise and vibration.

1. Saturday afternoon periods between 1pm and 6pm (Period 1 Day)
2. Sunday and public holiday day periods between 8am and 6pm (Period 1 Day)
3. Weekday evening periods between 6pm and 10pm (Period 1 Evening)
4. Weekend evening periods between 6pm and 10pm (Saturdays Period 1 Evening/Sundays Period 2)
5. Weekend night periods between 10pm and 8am (Period 2)
6. Work during the weekday evening and night and scheduling the noisiest work first (between 6pm and 10pm) to minimise sleep disturbance impacts in the night period between 10pm and 7am) (Period 1 Evening & Period 2)
7. All other times outside recommended standard hours

Note: The hierarchy listed above shall be subject to feedback from affected sensitive receivers and be revised on a case-by-case basis, as required.

Figure 3: Out-of-hours work assessment and approval procedure



LEGEND	
ADEM	Associate Director Environmental Management
CEM	Community Engagement Manager
CEO	Community Engagement Officer
DPE	Department of Planning and Environment
EMR	Environmental Management Representative
EPA	Environment Protection Authority
EPM	Environment & Planning Manager
OOHW	Out-of-hours Work
PM	Infrastructure and Place Project Manager
POEO	Protection of Environment Operations Act
SME	Senior Manager Environment
SMCE	Senior Manager Community Engagement

NOTES

1. Variation of Environmental Protection Licence is required if:
   (a) activity falls within definition of Scheduled Activity under POEO Act 1997
   (b) Existing EPL does not permit specific work to proceed
2. Low risk factors are:
   - No sleep disturbance
   - 1800 – 2200 weekdays
   - 1300 – 2200 Saturdays
   - 0800 – 1800 Sunday & Public Holiday
   - 1 or 2 occurrences
   - No impulsive or tonal noise vibration

   Medium risk factors are:
   - Sleep disturbance risk
   - 2200 – 0700 weekday nights
   - 2200 – 0800 Saturday nights
   - 1800 – 0700 Sunday & Public Holidays nights

   High risk factors are:
   - Prolonged work (ie > 1 week)
   - Sleep disturbance possible
   - Impulsive noise or vibration likely (eg vibratory rolling or rock breaking)

   Contractor to allow extra time with second level of approval.
   (NOTE: for low & medium risk factors, complete Noise Estimator.
   For high risk factors, acoustic assessments are required.)

7. Assessing construction noise and vibration impact

Construction noise and vibration impact should be assessed for all construction works. The assessment identifies the potential impact of airborne noise, ground-borne noise and/or ground-borne vibration on nearby receivers. Appropriate mitigation measures can then be determined depending on the level of impact, the duration of the works and the time at which the noise or vibration activity occurs.

The assessment aims to minimise the inconvenience to affected receivers by limiting the level of construction noise and vibration. The assessment reviews whether identified noise and vibration mitigation measures are reasonable and feasible, and provides alternative management measures whenever this is not the case.

Initially, this should be completed as part of the EIA phase. The assessment should be reviewed prior to the construction phase to confirm if it is still applicable. If elements have changed, a revised assessment is needed.

There are two types of noise and vibration assessment that can be completed under this strategy:

- Simple noise and vibration assessment
- Detailed noise and vibration assessment

A simple assessment should be completed where noise and vibration objectives are unlikely to be exceeded. The assessment can be completed by the construction contractor using the Construction Noise and Vibration Impact Estimator Tool, as outlined in Section 7.1 and APPENDIX E. The only applicable qualitative noise assessment endorsed under this strategy is where it can be demonstrated that no noise generating activities will occur and therefore no quantitative noise assessment can be completed, such as inspections that do not require noise generating equipment or tools.

A detailed assessment is required where noise and vibration objectives will be exceeded, and will follow the quantitative process as outlined in Section 7.2.

Table 2: Simple or detailed assessment?

Is a detailed assessment required?	
Yes	• Go to Section 7.2 Detailed Assessment
No	• Go to Section 7.1 Simple noise and vibration assessment • Complete the assessment using the Construction Noise Estimator Tool

Unsure	• Go to Section 7.1 Simple noise and vibration assessment
	• Use the Construction Noise Estimator Tool to:
	  • Use the Construction Noise Estimator Tool complete the assessment and
	  • confirm if Detailed Assessment is required

7.1. Simple noise and vibration assessment

Simple construction noise and vibration assessments can be completed using the TfNSW Construction Noise Impact Estimator Tool (APPENDIX E). The tool will either:

- Provide an adequate assessment of noise impacts and identify appropriate mitigation measures, or
- Provide a screening test to determine that a more detailed assessment is required (Section 7.2 outlines detailed assessment)

The following sections outline the steps taken to complete the simple noise and vibration assessment procedure.

7.1.1. When will the construction works to be carried out?

Confirm whether works will be completed in:

- Standard construction hours
- OOHW Period 1
- OOHW Period 2

Section 1.4 defines the relevant construction periods.

7.1.2. How long will it take to complete the construction activity?

Less than 6 weeks ➡	use the Construction Noise Estimator Tool
More than 6 weeks ➡	go to Section 7.2 Detailed Assessment

7.1.3. What are the construction works to be assessed?

- Establish a representative range of construction stages/ scenarios to be assessed
- Identify list of plant and equipment for each construction stage/scenario

7.1.4. Confirm the study area by identifying noise and vibration sensitive receivers

- Determine construction noise study area by identifying noise sensitive receivers, including other sensitive receiver types discussed in APPENDIX A
- Determine construction vibration study area by running a further screening test

1. Are there receivers within the minimum working distances for Cosmetic Damage to buildings (see APPENDIX D)?	
YES	Go to Section 7.2 Detailed Assessment
NO	Go to item 2 below

2. Are the works within the minimum working distances for human disturbance?	
YES	Go to Section 7.2 below and assess vibration impact
NO	Simple vibration assessment complete. The risk of vibration impact is assessed as low. A clear statement to this effect should be included in the report

The answers provided to the questions in the Sections 7.1.1 to 7.1.5 above will determine whether the construction noise estimator tool is adequate or a detailed assessment is required.

7.1.5. Determine noise and vibration management objectives

- Determine construction noise objectives

  Noise monitoring is not essential for a simple noise assessment, although it is not excluded. Construction noise objectives may be determined by:

  1. Estimating background noise levels from AS1055[11] – see Section B.1.1 or RBL/s determined from monitoring, where reasonable and feasible
  2. Establishing Noise Management Levels based on ICNG – see Section A.1

[11] Unless otherwise specified by EPA or EPL approval requirements for establishing background noise levels.

3. Identifying sleep disturbance objectives during the 10pm to 7am night period (if applicable) – see Section A.1

- Determine construction vibration objectives

Vibration assessment may be required if construction activities will generate vibration. Will vibration intensive activities be implemented (see APPENDIX D)?

YES	confirm relevant vibration objectives based on receiver types (see Section 7.2.4)
NO	further vibration assessment is not required. The risk of vibration impact is assessed as low to negligible. A clear statement to this effect should be included in the CNVIA/S

Vibration assessment may be required, depending on the proximity of receivers to the work area. Are there vibration sensitive receivers within 100m of work area (see Table 20, APPENDIX D)?

YES	confirm relevant vibration objectives based on receiver types (see Section 7.2.4) The Construction Noise Estimator Tool cannot be used
NO	further vibration assessment is not required. The risk of vibration impact is assessed as low to negligible. A clear statement to this effect should be included in the CNVIA/S

- Determine construction traffic noise objectives (qualitative assessment may be used)

  Will the construction traffic noise exceed the "without construction" scenario noise level by 2 dBA?

YES	confirm construction traffic noise impact (See Section A.4). The Construction Noise Estimator Tool cannot be used
NO	further construction traffic noise assessment is not required. A clear statement to this effect should be included in the CNVIA/S

Will sleep disturbance objectives be triggered (if applicable – only required for construction traffic movement during the 10pm to 7am night period, see Section A.4)

YES	confirm construction traffic sleep disturbance impact. The Construction Noise Estimator Tool cannot be used
NO	further construction traffic noise assessment is not required. A clear statement to this effect should be included in the CNVIA/S

7.1.6. Assess construction impact using the construction noise estimator tool

- Determine construction noise impact:

1. Calculate the noise levels at the worst affected (representative) receiver/s
2. Document the background noise level (RBL), Noise Management Level/s and predicted noise level/s
3. Identify and implement standard mitigation measures (see Section 8.1) and, where appropriate, adjust the predicted noise level to account for the mitigation adopted
4. Review the additional mitigation measures determined by the Construction Noise Estimator Tool and commence notifications as required
5. Confirm suitable noise monitoring locations for verification noise monitoring, as required

7.1.7. Construction noise and vibration impact assessment or statements

The Construction Noise and Vibration Impact Assessment/Statement (CNVIA/S) will need to include the following as a minimum:

- Justification for using a simple assessment including endorsement by Environmental Management Representative
- Duration of the construction works and time periods over which works will be undertaken
- Equipment likely to be used (during noisiest/ vibration significant operations)
- Identification and description of nearest sensitive receivers potentially impacted by the proposed construction works
- Details of mitigation and management measures that will be employed to minimise the potential noise impacts, including:
  - Standard mitigation and management measures (see Section 8.1)
  - Additional mitigation and management measures (see Section 8.2)
- Documented complaints management process including a strategy for identifying any additional mitigation measures that may be required

7.2. Detailed noise and vibration assessment

A detailed assessment should be completed where noise and vibration objectives will be triggered. A detailed assessment shall be prepared by an appropriately qualified and experienced person (such as a qualified acoustic consultant). Detailed assessments are likely to be required where one or more of the following occurs or is predicted to occur:

- Noise impacts with special audible characteristics
- Longer duration work (works that may impact receivers for more than 6 weeks)
- Moderate to large number of impacted receivers including moderate to high-density residential or commercial buildings
- Exceedance of Construction Traffic Noise Objectives
- Exceedance of Sleep Disturbance Objectives

Detailed assessment reports will need to address the same minimum requirements as the simple assessment procedure. More information will need to be provided, including source noise levels, a description of the existing acoustic environment, appropriate noise and vibration management objectives, relevant construction scenarios and predicted noise and vibration to sensitive receivers. The report will need to demonstrate how noise and vibration impact on sensitive receivers will be minimised using feasible and reasonable mitigation and management measures.

Some activities or work stages within a large project may require only a simple assessment, for example utilities investigation works, to identify the location of services prior to the commencement of construction works. Construction Noise and Vibration Management Plans identify the structure for assessing impacts from construction works on larger projects.

The detailed assessment procedure steps are as follows:

7.2.1. What is the purpose of the noise and vibration assessment?

The detailed noise and vibration assessment may be required to support the preparation of:

- EIA documentation (e.g. REF, EIS)
- Detailed construction noise and vibration impact statements during pre-construction or delivery

Table 3: Purpose of supporting documentation

Environmental Impact Statement/ Environmental Assessment	Delivery / Pre-construction Impact Statements
Assessment defined by concept design and construction scenarios for the project, based on potential construction methodologies known at the time. Assessment inputs usually prepared by a technical advisor and/or planning consultant.	Assessment defined by detailed design and actual construction scenario. Assessment inputs usually prepared by the design and/or construction contractors. These are expected to include finalised construction scenarios and equipment lists, itemising the realistic worst-case plant proposed to be used at any one time.
	Where detail about construction activities or timing of works near specific receivers was insufficient or not available during the environmental assessment an additional Construction Noise and Vibration Impact Statement (CNVIS) may be required for each major construction stage or key activity.
	Additional detail will be included or referenced in the Construction Noise and Vibration Management Plan (CNVMP). The CNVIS should be used as the basis on which to develop or implement the CNVMP for that activity.

7.2.2. When will the construction works be carried out?

Confirm whether works will be completed in:

- Standard construction hours
- OOHW Period 1
- OOHW Period 2

Section 1.4 defines the relevant construction periods.

In addition to the above, confirm the total duration of the construction works, including the duration of any OOHW.

7.2.3. What are the construction works to be assessed?

- Establish a representative range of construction stages/ scenarios to be assessed
- Identify list of plant and equipment for each construction stage/scenario
- Determine the source noise levels (SWLs) of each plant item proposed as part of the construction scenario. Note that the noise levels (SWLs) of each plant or equipment item should be less than the maximum allowable levels in APPENDIX C
- If the noise from a particular plant item has special audible characteristics a 5 dBA penalty should be added to the noise source sound power level (SWL), refer to APPENDIX E – Step 2 for further detail.

7.2.4. Determine noise and vibration management objectives

- Identify all noise and/or vibration sensitive receivers which may be affected by the project
- Determine construction noise management levels

  Noise monitoring at representative locations to determine the rating background level should be conducted for a detailed noise assessment, unless there is a suitable justification to not complete it (endorsed by the EMR). Construction noise management levels are determined by:

  1. Estimating background noise levels from noise monitoring – see Section B.1.2
  2. Establishing Noise Management Levels based on ICNG – see Section A.1
  3. Identifying sleep disturbance objectives (if applicable) – see Section A.1
- Determine construction vibration management levels

  Vibration assessment may be required, depending on the proximity of receivers to the work area. Are there vibration sensitive receivers within 100m of work area (see Table 20, APPENDIX D)?

YES	confirm relevant vibration objectives based on receiver types (see Section A.3)
NO	further vibration assessment is not required. The risk of vibration impact is assessed as low to negligible. A clear statement to this effect should be included in the report

- Determine construction traffic noise objectives
  - Confirm the road type used by construction vehicles and establish relevant noise objectives – see Section A.4
  - Identify sleep disturbance objectives (if applicable – only required for construction traffic movement during the 10pm to 7am night period)

7.2.5. Assess construction noise and vibration impact

Table 4: Impact assessment procedures

Impact to assess	Assessment procedure

Airborne noise	• Determine the location of each plant or equipment item in relation to each receiver
	• Develop a construction noise model and include:
	  • All relevant standard mitigation measures (Section 8.1)
	  • Noise shielding provided by site offices, noise barriers or natural topographic features
	  • Noise reflections and ground attenuation
	• Determine whether a 5dBA SWL correction factor is required for activities with special audible characteristics
	• Calculate the $L_{Aeq\ (15minute)}$ noise levels from the proposed construction activities at each receiver and compare these with the airborne construction noise management levels
	• For night-time activities, calculate the maximum (L_{Amax}) noise levels and compare with the sleep disturbance screening objectives. Other factors to consider when assessing the extent of impact on sleep include
	  • How often noisy events occur at night
	  • Predicted maximum noise levels at night

Airborne noise *continued*	• Whether there are times when there is a clear change in the noise environment (such as during early morning shoulder periods) and • The degree of maximum noise levels above the background noise level at night Notes The number of receivers would be dependent on the size of the construction site, the time at which the construction noise occurs and the level of potential noise impact. Calculations would normally be undertaken at locations considered to be representative of a group of receivers with a similar level of exposure to the construction works. For night-time construction works or large construction sites with many nearby receivers, it may be more appropriate to provide noise contour plots in order to illustrate the degree to which each receiver or group of receivers are impacted by the construction works.
Ground-borne noise	• Determine the location of each plant or equipment item in relation to each receiver • Determine the level of ground-borne noise at each building location. For highly sensitive building occupancies, the assessment may need to incorporate the acoustic properties of the building space and the structural response of the building Include the effect of all relevant standard mitigation measures as part of the construction scenario. Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction activities at each receiver and compare these with the ground-borne construction noise objectives.
Vibration	• Determine the location of each plant or equipment item in relation to each receiver • Determine the likely of ground-borne vibration at each building location. For highly sensitive equipment, the assessment may need to incorporate the structural response of the building and sensitivities of the equipment • Incorporate all relevant standard mitigation measures as part of the construction scenario • Calculate the continuous, intermittent and impulsive vibration levels from the proposed construction activities at each receiver and compare these with the ground-borne construction vibration objectives
Traffic noise	• On roads immediately adjacent to IP construction sites, stakeholders may be impacted by heavy vehicle movements associated with the project works Construction traffic movements on public roads shall aim to minimise any sleep disturbance impacts for example by minimising use of any engine brake noise. All feasible and reasonable noise mitigation and management measures shall be implemented
Blasting	Potential vibration and air blast overpressure impacts generated through blasting will be managed primarily through a Blast Management Strategy prepared specifically for the blast activity associated with the IP project. The Blast Management Strategy will address: • Blasting noise and vibration objectives • Details of blasting to be performed, including location, method and justification of the need to blast • Identification of any potentially affected noise and vibration sensitive sites including heritage buildings and utilities

Blasting *continued*	• Establishment of appropriate management levels for blast overpressure and ground vibration levels at each category of noise sensitive site • Details of the storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site • Identification of hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives • Determination of potential noise and vibration and risk impacts from blasting and appropriate monitoring and best management practices to minimise and manage any blasting impacts and assess compliance with the blasting noise and vibration management levels and • Stakeholder consultation procedures A series of initial test blasts at reduced scale will be carried out prior to the commencement of full scale blasting. Air blast overpressure and vibration will be measured from test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions. This information will be used to define allowable blast sizes to meet the air blast overpressure and ground vibration management levels

7.2.6. Determining additional management measures required

Additional Management Measures outlined in Section 8.2 apply when predicted noise and vibration levels exceed the management objectives. Refer to Section 8.2 to determine if Additional Management Measures apply.

7.3. Cumulative noise & vibration impact

When assessing construction noise and vibration, it may be necessary to consider cumulative construction impacts, for example where construction projects occur/will occur in the same Noise Catchment Area (NCA). Key stakeholders from the adjacent construction project/s may be engaged to determine cumulative noise and vibration impact and agree to revised management measures, where reasonable and feasible. It may be beneficial for projects working in the same NCA to coordinate their activities including the management of work with special audible characteristics and community engagement methods.

This approach will be assessed on a case-by-case basis, and may not be appropriate for all IP projects. However, it is recommended that all applicable mitigation and management measures within this strategy be implemented on I&S projects with cumulative noise and vibration impacts.

8. Mitigation and management of construction noise and vibration

This section provides guidance in relation to standard monitoring and survey requirements that are expected for construction projects, in addition to a range of mitigation measures to be applied.

Additional information is provided in relation to satisfactory operating distances to ensure that construction related vibration levels are acceptable. The TfNSW Community Engagement team shall be involved in the process and consulted with in terms of intended mitigation measures to be applied.

8.1. Standard mitigation and management measures

This section sets out the standard measures for mitigating and managing construction noise and vibration to be implemented on all IP projects and delivered via relevant procedures, systems, EIA, construction environmental management and all relevant contract documentation.

For all IP construction projects, the standard mitigation measures shall be applied to mitigate noise and vibration impacts of the project where reasonable and feasible.

Table 5 below outlines actions that can be applied to manage the potential for noise and vibration to impact on sensitive receivers near the works.

Table 5: Standard management measures to reduce construction noise and vibration

Action required	Applies to	Details
Implementation of any project specific mitigation measures required	Airborne noise Ground-borne noise & vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the EIA documentation (e.g. REF, submissions or representations report) or approval or licence conditions must be implemented.
Implement stakeholder consultation measures (refer to Sections 8.2.1 and 8.3 for further details of community consultation measures)	Airborne noise Ground-borne noise & vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions).

Action required	Applies to	Details
Register of noise and vibration sensitive receivers	Airborne noise Ground-borne noise & vibration	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.
Construction hours and scheduling	Airborne noise Ground-borne noise & vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating noise with special audible characteristics and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	Ground-borne noise & vibration Airborne noise	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site inductions	Airborne noise Ground-borne noise & vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics

Action required	Applies to	Details
Site inductions *continued*		• Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.
Monitoring	Airborne noise Ground-borne noise & vibration	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Attended vibration measurements shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise Ground-borne noise & vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage.

8.11. Standard source mitigation measures

Table 6 below outlines the standard mitigation measures that should be applied "at the source" i.e. directly applied to plant and equipment to reduce noise and/or vibration from the work site.

Table 6: Standard source mitigation measures to reduce construction noise and vibration

Action required	Applies to	Details
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Equipment selection	Airborne noise Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable, see APPENDIX C. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels in APPENDIX C.
Rental plant and equipment	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the allowable noise levels in APPENDIX C.
Use and siting of plant	Airborne-noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work, including delivery vehicles.
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise	Loading and unloading of materials/deliveries is to occur *as far as possible* from sensitive receivers.

Action required	Applies to	Details
Minimise disturbance arising from delivery of goods to construction sites *continued*		Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Construction Related Traffic	Airborne noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on Mobile Plant	Airborne noise	Where possible reduce noise from mobile plant through additional fittings including: Residential grade mufflers Damped hammers such as “City” Model Rammer Hammers Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.

8.12. Standard path mitigation measures

Table 7 below outlines the standard mitigation measures that should be in the path between the source and the receiver to reduce noise and/or vibration from the work site.

Table 7: Standard path mitigation measures to reduce construction noise and vibration

Action required	Applies to	Details
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne noise	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

8.2. Managing residual impacts

8.2.1. Applying additional management measures

As part of the EIA process and preparation of the CNVMP (refer Section 4 and 5), it is necessary to identify feasible and reasonable mitigation measures to minimise noise and vibration levels at the nearest receivers. In accordance with Section 4 of this strategy, these measures are to be implemented as part of the standard mitigation measures (in Section 8.1).

The implementation of the standard mitigation measures, compliance with maximum sound power levels for plant and equipment, construction hour management and standard stakeholder consultation measures in this strategy should significantly reduce the noise and vibration impacts on nearby sensitive receivers.

Nevertheless, due to the highly variable nature of construction activities and the likelihood of work needing to be undertaken outside the standard construction hours on IP projects, exceedances of a project's construction noise and vibration objectives are likely to occur.

Where construction noise and vibration levels are still predicted to exceed the noise or vibration objectives after the application of the standard mitigation measures the Additional Mitigation Measures Matrices (AMMM) shall be used to determine the additional measures and implementation where reasonable and feasible, and in consultation with TfNSW communications representatives.

Using the relevant AMMM, the following steps need to be carried out to determine the additional mitigation measures:

1. Determine the time period when the work will be undertaken
2. Determine the level of exceedance
3. From the relevant additional mitigation measures matrix, identify the additional mitigation measures to be implemented. Provide justification for mitigation measures determined not to be feasible or reasonable

The additional management measures to be applied are outlined in the table below.

Table 8: Additional management measures

Measure	Description	Abbreviation
Periodic Notification	For each IP project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template.	PN

Measure	Description	Abbreviation
Periodic Notification *continued*	In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the IP Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the IP Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended. Refer to Section 8.4 for more details.	V
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project	SN

Measure	Description	Abbreviation
Specific Notification *continued*	Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all IP projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days (See Table 1).	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all IP projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with IP Community Engagement Representatives.	DR

8.2.2. Additional Mitigation Measure Matrices

8.2.2.1. Additional airborne noise management measures

Table 9 on the following page shows additional measures to be implemented for each receiver depending on how far the predicted airborne noise level is above the background noise level (RBL) or airborne noise management level (ANML). These measures are most appropriate for shorter term works.

Table 9: How to implement additional airborne noise management measures

Construction hours	Receiver perception	dB(A) above RBL*	dB(A) above ANML	Additional management measures
Standard Hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Noticeable	5 to 10	0	–
	Clearly Audible	> 10 to 20	< 10	–
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 20	PN, V
	75dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday-Friday 6pm-10pm Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Noticeable	5 to 10	< 5	–
	Clearly Audible	> 10 to 20	5 to 15	PN
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP#, DR#
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Noticeable	0 to 10	< 5	PN
	Clearly Audible	> 10 to 20	5 to 15	PN, V
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RP, DR
	Highly intrusive	> 30	> 25	PN, V, SN, AA, RP, DR

Notes: PN = Project notification; SN = Specific notification, individual briefings, or phone call; V = Verification monitoring; DR = Duration Reduction; RP = Respite Period; RO = Project specific respite offer; AA = Alternative accommodation

* SWLs used for the purpose of estimating noise impact shall be increased by 5dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics. It is noted that this correction factor is automatically calculated under Step 2 of the Construction Noise Estimator Tool (see APPENDIX E).

Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

The additional management measures in Table 9 may become less effective over time. At-receiver noise mitigation may be considered where feasible and reasonable, where all options for at-source noise

mitigation and management measures have been exhausted. At-receiver mitigation may include temporary window and door screens, temporary localised shielding or permanent forms of mitigation.

Feasible and reasonable considerations for providing at-receiver treatments should include:

- Time of day where construction noise exceeds the ANML
- Time of use of affected receivers
- Amount construction noise exceeds the ANML
- How long the mitigation will provide benefit to the receiver during the project
- Optimal design of acoustic sheds and noise barriers/hoardings

8.2.2.2. Additional ground-borne noise management measures

Table 10 below shows additional measures to be implemented for each receiver depending on how far the predicted ground-borne noise level is above the ground-borne noise management level (GNML).

Table 10: How to implement additional ground-borne noise management measures

Construction hours	Receiver perception	dB(A) above GNML	Additional management measures
Standard Hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Clearly Audible	< 10	PN
	Moderately intrusive	> 10 to 20	PN
	Highly intrusive	> 20	PN, V, SN
OOHW Period 1 Monday-Friday 6pm-10pm Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Clearly Audible	< 10	PN
	Moderately intrusive	> 10 to 20	PN, V, RO, SN
	Highly intrusive	> 20	PN, V, SN, RO, RP#, DR#
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Clearly Audible	< 10	PN, V, SN
	Moderately intrusive	> 10 to 20	PN, V, SN, AA, RP, DR
	Highly intrusive	> 20	PN, V, SN, AA, RP, DR

Notes: PN = Project notification
V = Verification of monitoring
RP = Respite Period
DR = Duration Reduction
AA = Alternative accommodation
SN = Specific notification, individual briefings, or phone call
RO = Project specific respite offer

Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

8.2.2.3. Additional vibration management measures

Table 11 on the following page shows additional measures to be implemented for each receiver depending on whether the predicted vibration is above the vibration management level for human disturbance (HVML), or the vibration management level for cosmetic damage to buildings or structures (DVML).

Where the VML for human disturbance is exceeded, the management measures reflect the need to manage the extent of disturbance. If the VML for building damage is exceeded, vibration monitoring should be conducted to determine site specific minimum working distances. Alternative construction methodologies may need to be considered where it is not possible to complete the works within the DVML.

Table 11: How to implement additional vibration management measures

Construction hours	Receiver perception	above VML	Additional management measures
Standard Hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Human disturbance	> HVML	PN, V, RO
	Building damage	> DVML	V, AC
OOHW Period 1 Monday-Friday (6pm-10pm) Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Human disturbance	> HVML	PN, V, SN, RO, RP, DR
	Building damage	> DVML	V, AC
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am	Human disturbance	> HVML	PN, V, SN, RO, AA, RP, DR
	Building damage	> DVML	V, AC

Notes: PN = Project notification; SN = Specific notification, individual briefings, or phone call; V = Verification of monitoring; AA = Alternative accommodation; DR = Duration Reduction; RO = Project specific respite offer; RP = Respite Period; AC = Alternative construction methodology

8.2.3. Duration of OOHW impact

All reasonable and feasible mitigation must be explored for a work activity prior to commencing a negotiated agreement. Reasonable measures to ameliorate noise and/ or vibration impact will need to be considered based on the level of impact and duration of the works, including:

- Short term residual impacts where a specific phase of the construction work generates noise or vibration that exceeds the management levels, but are not in highly sensitive night period and occur over a shorter timeframe (e.g. 1 to 2 weeks). Consideration should be given to offering respite in the form of movie tickets, coffee/meal vouchers or similar
- Short term residual impacts where a specific phase of the construction work generates noise or vibration that exceeds the management levels inside the highly sensitive night period, consideration should be given to offering alternative accommodation for the duration of the noise or vibration impact

8.3. Further community engagement strategies

8.3.1. Other sensitive receiver types

The management of residual impacts as noted in Section 8.2 may not be reasonable or feasible for sensitive receivers other than residential receivers, such as: educational or medical facilities, places of worship, recreation areas, community centres, and commercial or industrial premises. In these cases, Delivery Partners shall consult with the Community Engagement Representative to define and implement suitable management measures appropriate to the receiver type, including but not limited to the strategies listed in Section 8.3.2.

Community consultation will be required during the assessment and planning phase of a project (prior to construction) to confirm the location of other sensitive receivers including collecting information on specialised requirements for each receiver (for example education or community facilities that provide Autism-specific services or identifying to location of vibration sensitive equipment in medical facilities). This may be achieved by completing a door-knock exercise or completing specific notifications prior to construction.

In areas where there are few residential sensitive receivers it may be the expectation of the local community that works are completed after operating hours of other sensitive receiver types to minimise noise and vibration impacts on staff, students, patients or clients/customers. In these instances the Delivery Partner shall consult with IP including the Associate Director Community Engagement and Associate Director Environmental Management (or delegate).

8.3.2. Additional community engagement strategies

8.3.2.1. Website

The TfNSW website (www.transport.nsw.gov.au/projects) is a key resource for stakeholders to seek further information on projects, noise and vibration management plans, current and upcoming construction activities. It serves to inform on a 24-hour basis and provides a constant and additional layer of information over-and-above the periodic notifications.

The website is reviewed and updated monthly or in line with construction works.

As the website is a public forum, all information to be uploaded is approved by IP Associate Director Community Engagement. The aim is to provide a visually appealing, easy-to-navigate tool for members of the public. Information is provided in plain English with use of illustrative graphics and photos and a minimum of jargon.

8.3.2.2. Project Infoline and 24-hour Construction Response Line

The 24-hour Construction Response Line and Project Infoline are mandatory on all IP projects to provide a contact point for interested stakeholders. IP has established two 24 hour free-call telephone numbers:

- Construction Response Line, 1800 775 465 – providing a dedicated 24-hour contact point for any complaints regarding construction works
- Project Infoline, 1800 684 490 – providing a dedicated contact point for any project enquiries

These lines are managed via a professional answering service and are the key mechanism for the receipt of enquiries/complaints to IP Community Engagement Team for all projects. These numbers are listed with Telstra and are advertised in all project-related communications materials.

Complaints

All complaints require a verbal response within 2 hours. All enquiries require a verbal response within 24 hours during standard construction hours, or on the next working day during out-of-hours work (unless the enquirer agrees otherwise).

The answering service immediately directs any complaints to an on-duty Transport Projects representative via a pager system. Communications team members are scheduled on the pager roster and are on-call 24-hours per day during this period. This ensures that complaints are managed by experienced personnel to facilitate swift resolution.

As a standard response, complaints regarding construction noise shall be responded to by verifying noise levels are within noise predictions as soon as reasonably practical (see Section 8.4).

8.3.2.3. Email distribution list

Email distribution lists are used on all I&S projects to disseminate project information to interested stakeholders and can be used wherever a periodic notification is triggered. Advanced warning of audible activities can assist to reduce the impact of projects experienced by stakeholders.

I&S and its contractors maintain mailing lists of stakeholders interested in receiving project information via email.

8.3.2.4. Signage

Signage is used on all I&S projects to disseminate project information. Signage is provided at each I&S project to notify stakeholders of project details, and project emergency and enquiry contact information. Where possible and when appropriate, the full stakeholder notification, detailing likely audible construction noise will be on display at the work site.

8.3.2.5. Social media

Social media can be used on all I&S projects to disseminate project information. Social media is not standard practice for communicating noise and vibration impacts, however if it is necessary to highlight potential impacts to a wider audience such as Major Projects in CBD areas or activities requiring closure of major transport corridors, social media may be considered.

Further information regarding social media can be sourced from the I&S Community Engagement Representative.

8.3.2.6. Emergency Works

In the event that emergency works including emergency works requiring OOHW (as described in Box 1) occur, it may be suitable to commence an immediate community notification strategy. The strategy may include door-knock visits to impacted sensitive receivers, distribution of project contact cards and post-emergency specific notifications (as detailed in Table 8). The I&S Community Engagement Team must be consulted regarding the emergency's specific community notification strategy as soon as practicable after becoming aware of the emergency situation.

8.4. Noise and vibration verification

Compliance with the approved construction noise and vibration objectives is to be audited at the commencement of works and least every three months, where reasonable and feasible. This will involve the measurement of equipment noise levels (on site) and noise and vibration monitoring at the nearest sensitive receivers. A summary of the measurement requirements is provided below and in APPENDIX A.

The objective of noise and vibration verification monitoring is to ensure that construction equipment used on I&S sites have low noise emissions at the commencement of construction works. Auditing plant and equipment noise periodically will ensure that they are adequately maintained and will continue to meet expectations with regard to noise and vibration.

The attended measurements shall be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, familiar with applicable standards and procedures.

8.4.1. Noise and vibration measurements

Attended measurements are to be undertaken within a period of 14 days from the commencement of construction activities (or as agreed with the EMR/TfNSW) to confirm that the noise and vibration levels at receiver locations are consistent with the predictions in the CNVIS[13], approval and/or licence conditions.

The attended measurements must be undertaken at the potentially most impacted receivers. Attended noise verification records must be in the format of the template provided in APPENDIX F, to comply with relevant standards, see below.

Noise measurements shall be undertaken consistent with the procedures documented in AS1055.1-1997 *Acoustics – Description and Measurement of Environmental Noise – General Procedures*. Vibration measurements shall be undertaken in accordance with the procedures documented in the EPA's *Assessing Vibration – a technical guideline* (2006) and BS7385 Part 2-1993 *Evaluation and measurement for vibration in buildings*.

For projects with a duration greater than three months, the attended measurements are to be repeated on a three-monthly basis, where reasonable and feasible, as part of the audit cycle to ensure that noise and vibration levels in the receiver locations remain consistent with the predicted levels in the CNVIS, approval and/or licence conditions. Where out of hours works are required, the attended measurements must be undertaken at the time intervals described in the CNVIS, out of hours assessment, approval and/or licence conditions.

Noise monitoring should be implemented on all projects where specified by the Additional Management Measures outlined in this document (Section 8.2) or as an on-going management measure during critical periods, such as when noise emissions are expected to be at their highest including piling and hammering activities.

[13] Or other relevant acoustic assessment

9. Documentation

I&S shall maintain a record of all noise and vibration records including, complaints received and the subsequent action taken, in accordance with the approval and licence conditions.

Contractors are to retain records of the following:

- Complaints records (i.e. time and nature of complaint)
- Complaints responses and close out actions
- Correspondence
- Monitoring/verification results
- Mitigation measures
- Construction Environmental Management Plans and associated sub-plans

10. Related Documents and References

Related Documents and References
Environmental Management System Manual DMS-ST-052
Out-of-Hours Assessment DMS-PR-065
Out-of-Hours Work Application Form (EPL Variation NOT Required) DMS-FT-079
www.transport.nsw.gov.au
NSW Department of Climate Change, *Interim Construction Noise Guideline*, (July 2009)
NSW Department of Climate Change, *Assessing Vibration – a technical guideline*, (OEH, 2006)
NSW Environment Protection Authority, *Rail infrastructure noise guideline*, (NSW EPA, 2013)
NSW Environment Protection Authority, *NSW industrial noise policy*, (NSW EPA, 2000)
NSW Department of Environment, Climate Change and Water, *Road noise policy*, (DECCW, 2011)
Australian Standard, *AS2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites*
Australian Standard, *AS1055:1997 – Acoustics – Description and measurement of environmental noise*
British Standard, *BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites*
British Standard, *BS7385-2:1993 Evaluation and measurement for vibration in buildings*
Department for Environment, Food & Rural Affairs (DEFRA), *Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plan used on quarries* (July, 2006)
German Institute for Standardisation, *DIN4150-3:1999-02 Structural vibration – Effects of vibration on structures*
Government of South Australia – Department of Planning, Transport & Infrastructure, *Underwater Piling Noise Guidelines* (November, 2012)
NSW Roads & Maritime Services, *Construction Noise & Vibration Guideline* (April, 2016)
NSW Roads & Traffic Authority, *Environmental Noise Management Manual* (December, 2001)

Appendices

APPENDIX A
Overview of construction noise and vibration objectives

This appendix provides a brief overview of construction noise and vibration and its potential effects on people, buildings and their contents. It also provides guidance on how to establish construction noise and vibration objectives during the environmental assessment phase.

A.1 Construction airborne noise objectives

A.1.1 Airborne noise management levels

Where a quantitative noise assessment is to be undertaken, the construction airborne noise objectives are based on the EPA's *Interim Construction Noise Guideline* (2009).

The ICNG contains *noise management* levels for sensitive land uses including commercial and industrial receivers. These are provided in Table 12 and Table 13. At locations where the predicted construction noise levels exceed the noise management levels, the proponent should apply all feasible and reasonable work practices, document these within the EIA and implement the proposed work practices as part of the standard mitigation measures (refer to Section 8.1).

Where the predicted construction noise levels remain above the noise management levels after implementation of all feasible and reasonable work practices, the relevant Additional Mitigation Measures Matrix (AMMM) is to be implemented (refer Section 8.2), based on the predicted $L_{Aeq(15minute)}$ noise levels. These are primarily aimed at pro-active engagement with affected sensitive receivers. When communicating with sensitive receivers impacted by the construction works, the guidelines in the "how to apply" column should be followed.

Table 12: Airborne noise objectives at stakeholders using quantitative assessment

Time of Day	Noise Management Level $L_{Aeq\ (15minute)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents and stakeholders of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Recommended standard hours *continued*	Highly noise affected 75 dBA	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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should consult with the community. For guidance on negotiating agreements see Section 7.2.2 of the *Interim Construction Noise Guideline*.

The L_{A90} Rating Background Levels (RBL's) should be determined using the "tenth percentile method" described in the OEH's *NSW Industrial Noise Policy* during the relevant assessment periods (daytime, evening or night-time).

Table 13: Airborne noise objectives at sensitive land uses (other than residential) using quantitative assessment

Land Use	Management Level, L L_{Aeq} (Applies When Land Use is being Utilised)
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of Worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community Centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories. The external noise levels should be assessed at the most-affected occupied point of the premises:

- Industrial premises: external $L_{Aeq\ (15\ minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq\ (15\ minute)}$ 70 dBA
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below

Examples of other noise-sensitive businesses are theatres and child care centres. The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors* may assist in determining relevant noise levels.

The proponent should assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required. During construction, the proponent should regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.

In addition to the above, the proponent should consider the impact of OOHW construction noise on Rough Sleepers that may occupy the area surrounding the project. The proponent should notify Rough Sleepers when OOHW are to be carried out, the duration of the works and the noise levels anticipated during the work. Where appropriate it may be suitable to seek advice from the NSW Department of Family & Community Services when considering the well-being of rough sleepers as sensitive receivers.

Mitigation offered to Rough Sleepers would generally be limited to Project Notifications and Specific Notifications where it has been identified during project planning/development that the project locality provides shelter to rough sleepers on a regular basis.

A1.2 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the Project should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The potential for both sleep disturbance and awakenings should be considered in the assessment.

The NSW EPA's sleep disturbance screening level for industrial noise based on the LAF1, (1 minute) level (equivalent to the L_{Amax}) of a noise event which should not exceed the ambient LA90 noise level by more than 15 dB is not applied to traffic noise.

Where sleep disturbance criteria exceedance for more than 2 consecutive nights cannot be avoided due to reasonable and feasible justification (see Box 1), the Delivery Partner must consult with the community and consider further mitigation prescribed under Table 8: Additional Management Measures such as Duration Reduction or Alternative Accommodation.

A.2 Ground-borne noise objectives

Construction ground-borne noise objectives are based on the EPA's *Interim Construction Noise Guideline* (2009).

Ground-borne construction noise is usually present on tunnelling projects when equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. The ground-borne noise inside buildings initially propagates as ground-borne vibration, before entering the building, which causes floors, walls and ceilings to gently vibrate and hence radiate noise. Sometimes the vibration may be perceptible within the building. For some critical spaces such as recording studios and cinemas, which are designed to reduce airborne noise intrusion, an assessment of ground-borne construction noise for surface construction may also be required.

Ground-borne noise is usually not a significant disturbance to building occupants during daytime periods due to higher ambient levels which mask the audibility of ground-borne noise emissions. During night-time periods however, when ambient noise levels are often much lower, ground-borne noise is more prominent and may result in adverse comment from building occupants. Table 14 provides a summary of the ground-borne construction noise objectives.

Table 14: Ground-borne noise objectives at residences

Time of Day	Ground-borne noise objectives $L_{Aeq\ (15minute)}$
Daytime 7.00am to 6.00pm	Human comfort vibration objectives only
Evening 6.00pm to 10.00pm	40 dBA – Internal
Night-time 10.00pm to 7.00am	35 dBA – Internal

A.3 Construction vibration objectives

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

A3.1 Human perception of vibration

Guidance in relation to acceptable vibration levels for human comfort are provided in EPA's *Assessing Vibration: a technical guideline* (February 2006). This document is based on the guidelines contained in BS 6472-1992.

The EPA guideline provides thee assessment methods, depending on whether the vibration is continuous, impulsive or intermittent. The preferred and maximum values are provided in Table 15.

- Continuous vibration would normally be generated by fixed plant items such as generators, fans and the like where the vibration emissions continue uninterrupted (usually throughout the daytime or night-time period)
- Impulsive vibration would normally be generated by short duration (i.e. less than two second) events with no more than three occurrences in an assessment period. A typical example would be ground compaction by dropping a large mass. Higher levels are allowed for impulsive vibration, however if more than three impulsive vibration events occur during the assessment period, the more stringent intermittent objectives are applied
- Intermittent vibration can be defined as interrupted periods of continuous vibration (e.g. vibratory rolling, heavy truck passbys or rock breaking) or continuous periods of impulsive vibration (e.g. impact pile driving). Higher vibration levels are allowed for intermittent vibration compared with continuous vibration on the basis that the higher levels occur over a shorter time period. Hence, for intermittent vibration, human comfort vibration levels are assessed on the basis of the Vibration Dose Value, based on the level and the duration of the vibration events

Table 15: Preferred and maximum vibration levels for human comfort

Location	Assessment period	Preferred values		Maximum values	
Continuous vibration		z axis	x and y axes	z axis	x and y axes
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.010 m/s^2	0.0071 m/s^2	0.020 m/s^2	0.014 m/s^2
	Night-time	0.007 m/s^2	0.005 m/s^2	0.014 m/s^2	0.010 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020 m/s^2	0.014 m/s^2	0.040 m/s^2	0.028 m/s^2
Workshops	Day- or night-time	0.040 m/s^2	0.029 m/s^2	0.080 m/s^2	0.058 m/s^2
Impulsive vibration		z axis	x and y axes	z axis	x and y axes
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.30 m/s^2	0.21 m/s^2	0.60 m/s^2	0.42 m/s^2
	Night-time	0.10 m/s^2	0.071 m/s^2	0.20 m/s^2	0.14 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Workshops	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Intermittent vibration		x, y and z axes		x, y and z axes	
Critical Areas	Day- or night-time	0.10 $m/s^{1.75}$		0.20 $m/s^{1.75}$	
Residences	Daytime	0.20 $m/s^{1.75}$		0.40 $m/s^{1.75}$	
	Night-time	0.13 $m/s^{1.75}$		0.26 $m/s^{1.75}$	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40 $m/s^{1.75}$		0.80 $m/s^{1.75}$	
Workshops	Day- or night-time	0.80 $m/s^{1.75}$		1.60 $m/s^{1.75}$	

Notes: For continuous and intermittent vibration, the preferred and maximum values are weighted acceleration values (Wg for z axis and Wd for x and y axes).

For intermittent vibration, the preferred and maximum values are Vibration Dose Values (VDVs), based on the weighted acceleration values.

A3.2 Effects on building contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect their operation. For most receivers, the controlling vibration criterion is therefore the human comfort criterion and separate objectives are not normally required in relation to the effect of construction vibration on building contents.

Some recording studios, high technology facilities and buildings with scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort. Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives.

A3.3 Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings tend to be at least an order of magnitude (10 times) higher than those at which people may consider the vibration to be intrusive.

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 *Explosives – Storage and Use – Part 2: Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* as they "are applicable to Australian conditions" BS7385.

The British Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

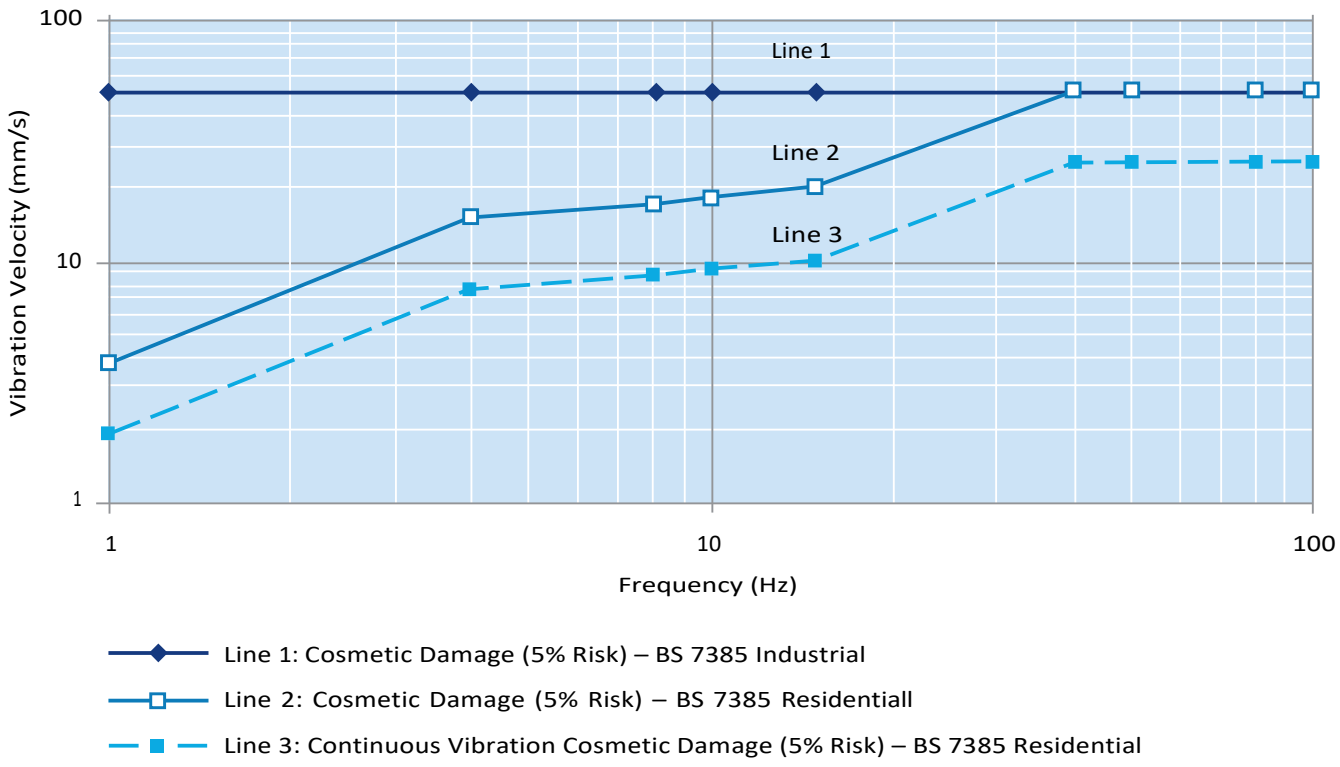
The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 16 and graphically in Figure 4.

Table 16: Transient vibration guide values – minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The standard states that the guide values in Table 16 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 16 may need to be reduced by up to 50% (as shown by Line 3 of Figure 4: Graph of Transient Vibration Guide Values for Cosmetic Damage for Residential Buildings).

Figure 4: Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 16 and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 16 should not be reduced for fatigue considerations.

It is noteworthy that, extra to the guide values nominated in Table 16, the standard states that:

"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."

Also that:

"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."

A.3.4 General vibration screening criterion

The British Standard states that the guide values in Table 16: Transient vibration guide values – minimal risk of cosmetic damage relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 16 may need to be reduced by up to 50%. Note: rock breaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

Therefore, for most construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

A.3.5 Guidelines for vibration sensitive and special structures

Heritage

Heritage buildings and structures would be assessed as per the screening criteria in Section A.3.4 as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered.

Sensitive Scientific and Medical Equipment

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use inside the premises of an identified vibration sensitive receiver, objectives for the satisfactory operation of the instrument would be sourced from manufacturer's data. Where manufacturer's data is not available, generic vibration criterion (VC) curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon – 28 September 1999) may be adopted as vibration objectives. These generic VC curves are presented below in Table 17: and Figure 5.

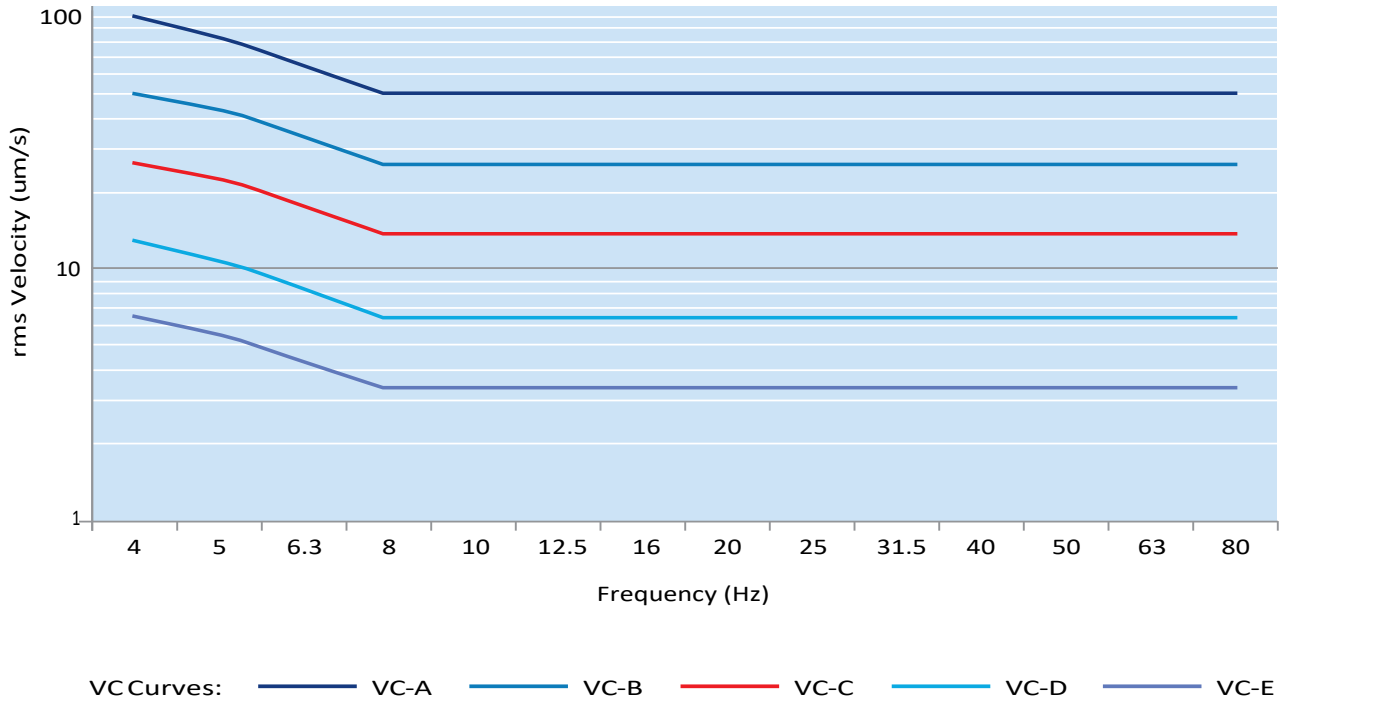
Table 17: Application and interpretation of the generic Vibration Criterion (VC) curves

Criterion Curve	Max Level (µm/sec, rms)[1]	Detail Size (microns)[2]	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
CV-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note 1: As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

Note 2: The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation requirements of many items depend upon the detail size of the process.

Figure 5: Vibration Criterion (VC) Curves



Buried pipework and services

The British Standard BS 7385-2:1993 'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground-borne vibration' notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition (British Standard BS 7385-2:1993, p5).

Further guidance is taken from the German Standard DIN 4150: Part 3-1999.02 'Structural vibration in buildings – Effects on Structures'. Section 5.3 of DIN 4150: Part 3 sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values are reproduced and presented in Table 18, below.

Table 18: DIN 4150-3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe
1	Steel (including welded pipes)	100 mm/s
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80 mm/s
3	Masonry, plastic	50 mm/s

Note: rock breaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures and it may therefore be appropriate to reduce the transient values by 50%.

Other Vibration Sensitive Structures and Utilities

Some structures and utilities located a project may be particularly sensitive to vibration. A vibration goal which is more stringent than structural damage objectives presented in Section A3.5 may need to be adopted. Examples of such structures and utilities include:

- Tunnels
- Gas pipelines
- Fibre optic cables

Specific vibration objectives should be determined on a case-by-case basis. An acoustic consultant should be engaged by the construction contractor to liaise with the structure or utility's owner to determine acceptable vibration levels.

A.4 Construction-related traffic noise objectives

On roads immediately adjacent to construction sites, stakeholders may associate heavy vehicle movements with the project. Once the heavy vehicles move further from construction sites onto major collector or arterial roads however, the noise may be perceived as part of the general road traffic.

In most situations, it may be sufficient to undertake a qualitative assessment of the potential noise impacts associated with heavy vehicle movements. This assessment should take into consideration the number of heavy vehicle movements per hour or shift, the proximity of sensitive receivers, the duration of the construction works and the time of day. Where a qualitative assessment is being undertaken, this will need to be approved by the EMR.

If a quantitative assessment is required, construction-related traffic noise objectives should be based on the guidance contained in the NSW Road Noise Policy (RNP, NSW Department of Environment, Climate Change and Water 2011).

The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. For existing residences and other sensitive land uses affected by *additional traffic on existing roads generated by land use developments* (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario.

If the heavy vehicle movements occur during the 10pm to 7am night-time period, guidance on assessing the potential for sleep disturbance is taken from the RNP, which refers to Practice Note 3 of the 'Environmental Noise Management Manual' (ENMM) (Roads and Traffic Authority of NSW, 2001). The ENMM Practice Note 3 outlines the following protocol for assessing and reporting on existing maximum noise levels and to assist in assessing the potential for sleep disturbance of a road project:

1. Determine the number of L_{Amax} noise levels greater than 65dB(A) where L_{Amax}- L_{Aeq} exceeds 15dB;
2. The number and distribution should be determined on an hourly basis between 10pm and 7am;
3. Evaluate whether the number of maximum noise impacts will reduce or increase as a result of the project; and,
4. Based on this evaluation, take account of maximum noise levels when prioritising, selecting and designing noise control measures.

Whilst this protocol applies specifically to road projects, it is appropriate to use in the assessment of noise from construction traffic on existing roads associated with the project.

A.5 Construction noise and vibration effects on aquatic life

Where projects are in or potentially impact on aquatic areas (for example ferry wharves), the Proponent will need to consider the potential noise and vibration impacts from construction activity on aquatic life. Prior to the commencement of construction, approval from the EMR will be required and to confirm that adequate assessment has been undertaken.

Where impacts to aquatic life are anticipated, such as whenever works will occur in close proximity to marine areas (construction of ferry wharves) or other areas of aquatic life (large commercial aquariums), the noise and vibration impact assessment should include advice from a Marine Ecologist/Biologist to determine if aquatic life is likely to be affected by vibration and how to best manage this impact. Further advice on piling activities can be sourced from the Government of South Australia – Department of Planning, Transport & Infrastructure publication, *Underwater Piling Noise Guidelines* (November, 2012).

A.6 Multi-level receivers

Individual occupancies should be considered and treated the same as 1-2 storey dwellings in terms of assessing, mitigating and managing noise and vibration. Note that it may not be reasonable (cost-effective) to offer respite or alternative accommodation to multiple receivers in multi-storey buildings.

APPENDIX B
Quantifying existing acoustic environment

This appendix provides a brief overview of construction noise and vibration and its potential effects on people, buildings and their contents. It also provides guidance on how to establish construction noise and vibration objectives during the environmental assessment phase.

B.1 Quantifying existing acoustic environment

Prior to commencing the assessment, the existing acoustic environment for receivers surrounding the construction project should be quantified.

B.1.1 Estimated

Assumed background noise levels based on Australian Standard AS1055 may be used as an estimate for simple noise assessments. Note that existing data from other projects or short term attended measurements should be used to assist in establishing noise management levels where possible.

Table A1: Typical background noise levels for different areas surrounding I&S projects

Area type	Description of area surrounding I&S project	RBL Day	RBL Evening	RBL Night
Rural	Areas with negligible transportation	40	35	30
Suburban/Urban	Areas with low density transportation	45	40	35
Urban	Areas with medium density transportation OR some commerce or industry	50	45	40
Urban/Industrial	Areas with dense transportation OR with some commerce or industry	55	50	45

B.1.2 Measured

1. Use of rating background level (RBL) based on measured noise levels. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW *Noise Policy for Industry* (EPA 2017).

APPENDIX C
Maximum noise levels for plant and equipment

All plant and equipment used for construction must have operating Sound Power or Sound Pressure Levels below or equal to the allowable noise levels in Table 19. Equipment not listed in Table 19, shall achieve compliance to the most applicable equipment listed in Australian Standard AS 2436-2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*, British Standard BS 5228-1 *Code of practice for noise and vibration control on construction and open sites* or DEFRA noise database[14] (2006).

The noise levels in Table 19 can also be used as a guide in the prediction of $L_{Aeq\ (15minute)}$ construction noise. In doing so, the predicted $L_{Aeq\ (15minute)}$ noise levels will be dependent on several factors including, but not limited to the duration of the construction activities, the number of plant items and their location on site in relation to the nearest receivers.

Attended measurements shall be undertaken within 14 days of equipment arriving on site to confirm that the operating noise levels of all plant items comply with the maximum levels in Table 19. Measurements are to be repeated on a three-monthly basis to ensure that noise from individual plant items are still within the acceptable noise range.

Table 19: Maximum allowable noise levels for construction equipment

Equipment	Approx. Size/ Weight/ Model	Highest Permissible Sound Power Level (dBA) – L_{Aeq} [1,2,3]	Highest Permissible Sound Pressure Level (dBA) – L_{Aeq} azt 7 m
Asphalt – Truck & Sprayer		106	81
Backhoe		111	86
Chainsaw – petrol[4]	4-5hp	114	89
Compactor		106	81
Compressor		109	84
Crane – Fixed		113	88
Crane – Franna	20 tonne	98	73
Crane – Mobile		113	88
Crane – Truck mounted	20 to 60 tonne	108	83
Crusher – Rock[4]		118	93
Dozer	CAT D9	116	91
Dozer	CAT D10	121	96
Elevated work platform – scissor lift		98	73

[14] DEFRA – Department for Environment Food and Rural Affairs (United Kingdom), Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plant used on quarries, July 2006.

Elevated work platform		97	77
Excavator – tracked	3 tonne	90	65
Excavator – tracked	6 tonne	95	70
As above + hydraulic hammer[4]		115	90
Excavator – tracked	10 tonne	100	75
As above + hydraulic hammer[4]		118	93
Excavator – tracked	20 tonne	105	80
Excavator – tracked	30 tonne	110	85
As above + hydraulic hammer[4]		122	97
Excavator – tracked	40 tonne	115	90
Grader		113	88
Generator – diesel/ petrol	6kW	103	78
Generator – attenuated	30kW	92	67
Grinder[4]		105	80
Jackhammer		113	88
Lighting Tower		80	55
Lighting – Daymakers		98	73
Light Vehicle – 4WD		103	78
Line Marking Truck		108	83
Loader – Front-end (wheeled)	23 tonne	112	87
Loader – Skidsteer	1/2 tonne	107	82
Loaders – Skidsteer	1 tonne	110	85
Loader – Tracked	0 to 50 kW	115	90
Loaders – Tracked	200 to 300 kW	121	96
Pavement Laying Machine		114	89
Pavement Profiler		117	92
Pile Driver – Vibratory[4]		121	96
Piling Rig – Bored		112	87
Piling Rig – Impact[4]		134	109
Pump – Concrete		109	84
Rattle gun (hand held)		104	79
Roller – smooth drum		107	82
Roller – large pad foot		109	84

Roller – Vibratory[4]	10 tonne	109	84
Saw – Concrete[4]		118	93
Scraper		113	88
Truck – Concrete		109	84
Truck – Dump	15 tonne	110	85
Truck – Medium rigid	20 tonne	103	78
Truck – road truck/ truck & dog	30 tonne	108	83
Truck – Vacuum (NDD or non-destructive digger)		109	84
Tub Grinder/Mulcher	40-50hp	116	91
Vibrator – Concrete[4]		113	88
Water Cart		107	82
Welding equipment		110	85
Wrench – Impact		111	86

Notes:

1. The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7m) from the plant or equipment.
2. The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW, as well as various TfNSW noise & vibration impact assessments and the RMS Construction Noise & Vibration Guideline (August, 2016).
3. Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites.
4. Equipment with special audible characteristics.

APPENDIX D
Minimum working distances for vibration intensive activities

As a guide, minimum working distances for typical items of vibration intensive plant are listed in Table 20. The minimum working distances are quoted for both "cosmetic" damage (refer BS 7385) and human comfort (refer OEH's *Assessing Vibration – a technical guideline*). The minimum working distances for cosmetic damage must be complied with at all times, unless otherwise approved by the relevant authority.

Table 20: Recommended minimum working distances from vibration intensive plant

Plant Item	Approx. Size/ Weight/ Model	Minimum Distance – Cosmetic Damage (BS 7385)	Minimum Distance – Human Response (OE&H Vibration Guideline)
Vibratory Roller	1-2 tonne	5 m	15 m to 20 m
	2-4 tonne	6 m	20 m
	4-6 tonne	12 m	40 m
	7-13 tonne	15 m	100 m
	13-18 tonne	20 m	100 m
	> 18 tonne	25 m	100 m
Small Hydraulic Hammer	300 kg (5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m
Pile Driver – Vibratory	Sheet piles	2 m to 20 m	20 m
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	N/A
Piling Rig – Hammer	12 t down force	15 m	50 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

The minimum working distances presented in Table 20 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions. Vibration monitoring is recommended to confirm the minimum working distances at specific sites.

For highly sensitive receivers (e.g. high technology facilities, recording studios and cinemas), specific assessment is required to ensure satisfactory operation of the facility and determine if any mitigation or management measures are required to minimise the potential impacts.

In relation to human comfort (response), the minimum working distances in Table 20 relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed (see APPENDIX A). Where the predicted vibration levels exceed the human comfort objectives, the procedures in Section 8 are to be followed in order to mitigate the potential impacts at sensitive receivers.

D.1 Works within minimum working distance

If the predicted ground-borne vibration levels exceed the cosmetic damage objectives in APPENDIX A, a different construction method with lower source vibration levels must be used where feasible and reasonable. Otherwise construction works should not proceed unless attended vibration measurements are undertaken at the commencement of the works to determine if there is risk of exceeding of the cosmetic damage objective, a permanent vibration monitoring system should be installed, to warn plant operators (for example via flashing light, audible alarm, SMS) when vibration levels are approaching the cosmetic damage objective.

APPENDIX E
Construction noise estimator tool

The Construction Noise Estimator Tool DMS-FT-412 is available via the TfNSW IP Divisional Management System (DMS) (internal intranet) or the Project Delivery Requirements on the TfNSW website.

APPENDIX F
Noise verification record sheet

Transport for NSW

NOISE VERIFICATION RECORD

DETAILS				
LOCATION OF CONSTRUCTION ACTIVITY:			**MONITORING LOCATION:**	
DATE & TIME OF TEST:			**TEST CONDUCTED BY:**	
CONSTRUCTION ACTIVITY:			**DISTANCE FROM NOISE SOURCE:**	
METEROLOGICAL CONDITIONS[1]:				
WIND SPEED:	**None**	**Light** **Moderate** **Strong**	**WIND DIRECTION:**	
NOISE ENVIRONMENT[2]:				
SOUND METER RECORD				
SOUND LEVEL METER:	**Serial #:**	**Make:**	**Model:**	
FIELD CALIBRATION (external):	**Start:**	**End:**		
TEST PROCEDURE:	AS 1055.1:1997 and AS 2659.2:1983			
NOISE CATCHMENT AREA No:				
NOISE LEVELS				
Day RBL / NML	**Evening RBL / NML**	**Night RBL / NML**		
/	/	/		
PREDICTED NOISE LEVELS				
$L_{Aeq15min}$	**NOISE ESTIMATE REFERENCE:**			
RESULTS				
SUBJECTIVE ASSESSMENT (mark all that apply)				
Construction noise inaudible ☐	Construction noise sometimes audible ☐	Construction noise audible at most times ☐		
Construction noise clearly audible ☐	Construction noise is dominant noise source ☐			
Impulsive Construction noise audible (e.g. rock-breaker) ☐	Tonal Construction noise audible (e.g. cutting steel) ☐			
Estimated noise level[3]:	dBA			
SOUND METER ASSESSMENT				
Start time: (24hr clock)		**End time: (24hr clock)**		
Select time weighting "Fast" not slow		**Select frequency weighting "A" not C or Flat**		
L_{Amax}:	dBA	**$L_{Aeq15min}$:**	dBA	**L_{A90}:** dBA
Exceedance of NML:	$L_{Aeq15min}$	**Difference to prediction:**	$L_{Aeq15min}$	

[1] i.e. temperature, humidity, cloud cover

[2] e.g. hard/soft groundcover, built or natural solid barrier

[3] At the nearest receiver, listen to the ambient and construction noise, without using any noise monitoring equipment take note of how loud you perceive the construction noise to be e.g. breathing 10dBA/freight train passing 80dBA/thunder 120dBA

Exceedance of RBL[4]:	$L_{Aeq15min}$	Difference to prediction:	$L_{Aeq15min}$

SITE ACTIVITIES / MONITORING COMMENTS:
[5]

SITE DIAGRAM
[6]

[4] RBL Exceedance shall be completed for all OOHW activities to confirm compliance with the Construction Noise & Vibration Strategy

[5] Site Activities, monitoring comments, typical L_{Amax} noise levels of construction activities / other sources, recommended changes to construction activities

[6] show monitoring location, buildings, construction activity other noise sources, distances, north

Transport for NSW
18 Lee Street, Chippendale NSW 2008
PO Box K659, Haymarket NSW 1240
T 02 8202 2200
F 02 8202 2209
W transport.nsw.gov.au

Table 8: Additional management measures

Measure	Description	Abbreviation
Periodic Notification	For each IP project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the IP Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the IP Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended. Refer to Section 8.4 for more details.	V

Measure	Description	Abbreviation
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all IP projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC

Measure	Description	Abbreviation
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days (See Table 1).	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all IP projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with IP Community Engagement Representatives.	DR

Construction Noise and Vibration Strategy Addendum – Replacing Tables 8 & 9

Table 9: How to implement additional airborne noise management measures

Construction hours	Receiver perception	dB(A) above RBL*	dB(A) above ANML	Additional management measures
Standard Hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Noticeable	5 to 10	0	–
	Clearly Audible	> 10 to 20	< 10	–
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 20	PN, V
	75dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday-Friday 6pm-10pm Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Noticeable	5 to 10	< 5	–
	Clearly Audible	> 10 to 20	5 to 15	PN, RP#, DR#
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO, RP#, DR#
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP#, DR#
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Noticeable	5 to 10	< 5	PN
	Clearly Audible	> 10 to 20	5 to 15	PN, V, SN, RO^, RP#, DR#
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO^, RP#, DR#
	Highly intrusive	> 30	> 25	PN, V, SN, RO^, RP#, DR#, AA

Notes:
PN = Project notification
V = Verification monitoring
RP = Respite Period
AA = Alternative accommodation
SN = Specific notification, individual briefings, or phone call
DR = Duration Reduction
RO = Project specific respite offer

* SWLs used for the purpose of estimating noise impact shall be increased by 5dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics. It is noted that this correction factor is automatically calculate under Step 2 of the Construction Noise Estimator Tool (see APPENDIX E).

Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

^ Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays / Public Holidays 6pm-10pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.