MARSHALL DAY Acoustics

MMRP PANEL RMIT UNIVERSITY

NOISE AND VIBRATION ASSESSMENT REVIEW

Rp No. 001 03 2016332ML | 12 August 2016

6 Gipps Street
Collingwood VIC 3066
Australia
T: +613 9416 1855
ABN: 53 470 077 191
www.marshallday.com

Project: **MMRP PANEL RMIT UNIVERSITY**

NOISE AND VIBRATION IMPACT ASSESSMENT REVIEW

Prepared for: **RMIT University**
GPO Box 2476V
MELBOURNE VIC 3001

Report No.: **Rp 001 03 2016332ML**

Disclaimer

Reports produced by Marshall Day Acoustics Pty Ltd are based on a specific scope, conditions and limitations, as agreed between Marshall Day Acoustics and the Client. Information and/or report(s) prepared by Marshall Day Acoustics may not be suitable for uses other than the specific project. No parties other than the Client should use any information and/or report(s) without first conferring with Marshall Day Acoustics.

The advice given herein is for acoustic purposes only. Relevant authorities and experts should be consulted with regard to compliance with regulations or requirements governing areas other than acoustics.

Copyright

The concepts and information contained in this document are the property of Marshall Day Acoustics Pty Ltd.
Use or copying of this document in whole or in part without the written permission of Marshall Day Acoustics constitutes an infringement of copyright. Information shall not be assigned to a third party without prior consent.

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	01	First draft	11/8/16	TMar	JAdc/PFea
Draft	02	Second draft	12/8/16	TMar	JAdc/PFea
Final	03	Final	12/8/16	TMar	JAdc/PFea

Certified System ISO 9001

EXECUTIVE SUMMARY

This report provides a summary of a peer review of the noise and vibration impact assessment (NVIA) prepared for the Melbourne Metro Rail Authority (MMRA) by the Aurecon Jacobs Mott MacDonald Joint Venture (AJM) in relation to the proposed Melbourne Metro Rail Project.

The peer review has been conducted by Marshal Day Acoustics (MDA) on behalf of the RMIT University. Key site wide issues identified by MDA in the review are discussed in Section 3.0 of the report. Specific issues relevant to RMIT University are discussed in Section 4.0 of the report and summarised below.

Construction noise

Air borne noise generated by the works in Franklin street East of Swanston Street will impact upon the northern façade of RMIT Building 9 and 14. Unless significant noise mitigation measures are implemented on all rooms on the northern facade of RMIT Buildings 9 and 14, these potentially could be unusable for lectures, tutorials, offices or laboratory use for a period of up to 3 years.

We recommend changes to the EPR that will establish construction noise limits for RMIT buildings in accordance with MCC Guideline for Zone 2 and a method for monitoring noise during the construction period.

We recommend that the Acoustic Construction Shed proposed for use during construction scenarios C and D is installed at the onset of construction Scenario A providing protection for all levels of RMIT Building 9 and 14

Construction and operation vibration

Of greatest concern is construction vibration and its possible affect on the micro and nano scale electron-microscopes on L2, 4, 5 and L7 RMIT Building 14. These items of particularly sensitive equipment are required to operate continuously in some cases for periods of years at a time.

We strongly recommend that secondary or enhanced vibration isolation is applied to all items of equipment prior to any demolition or construction work being undertaken in Precinct 5.

Given the uncertainty associated with the ground borne vibration from the Metro we also recommend that floated track bed be used throughout this precinct.

Technical review of NVIA

A detailed review of the NVIA including technical considerations is provided in Appendixes A-D. These Appendixes discuss construction noise, construction vibration, operational noise and operational vibration issues respectively

Changes to Environment Protection Requirements

Section 5.0 of the report includes recommendations to protect the amenity of the RMIT University close to the CBD North Station. These are suggested additional controls (Environmental Performance Requirements, EPR's) that should be considered at the EES Inquiry and Advisory Committee Panel Hearing for inclusion with the EPR's.

Appendix E includes a list of the EPR's proposed by AJM as part of the NVIA with commentary by MDA.

TABLE OF CONTENTS

1.0 INTRODUCTION

This document presents the findings of Marshall Day Acoustics review of the Noise and Vibration Impact Assessment (NVIA) of the Melbourne Metro Rail Project (MMRP) Environmental Effects Statement (EES), prepared by the Aurecon Jacobs Mott McDonald Joint Venture (AJM) on behalf of the Melbourne Metro Rail Authority (MMRA).

The review documented in this report was commissioned by the RMIT University to:

- Assist RMIT University to reach an informed view of the findings of the l noise and vibration studies carried out for the MMRP
- Prepare information which may form the basis for submissions to the joint Inquiry / Advisory Committee for the MMRP on behalf of the RMIT University.

This review provides comment on the suitability of the criteria adopted for the assessment of noise and vibration impacts of the project, the adequacy of the noise and vibration assessment methodology and reviews the adequacy of the proposed mitigation measures. This information is separately provided within this report for:

- Airborne noise generated by the project construction
- Vibration and ground-borne noise generated by the project construction
- Airborne noise generated by completed operations
- Vibration and ground-borne noise generated completed operations.

Specific issues of relevance to the RMIT University are provided in Section 4.0. These relate primarily to the issue of construction noise and vibration and operational noise.

The report includes recommendations from the peer review, including matters that are considered to warrant further technical assessment and environmental controls that should be included in the EPR's of the Environmental Management Framework for the MMRP.

2.0 SCOPE OF STUDY

The scope of the study instructed by RMIT University was to conduct a peer review of the following documentation presented in the EES for the MMRP:

- EES Chapter 13: *Noise and Vibration* (subsequently referred to herein as the *noise and vibration chapter*)
- EES Chapter 23: Environmental Management Framework (subsequently referred to herein as the *environmental management chapter*)
- EES Appendix I: *Melbourne Metro Rail Project Noise and Vibration Impact Assessment Report* (AJM document ID MMR-AJM-PWAA-RP-NN-000820) revision C1 dated 20 April 2016 (subsequently referred to herein as the *technical report*)
- EES Appendix I: Technical Appendices A-G (subsequently referred to herein as the *technical appendices*)

The above documents are collectively referred to as the *EES noise and vibration documents Noise and Vibration Impact Assessment or NVIA* within this review.

The peer review considers general matters relating to the noise and vibration impact assessment, which are discussed in Section 3.0 and Appendices A-D. In addition, matters that are specific to the project's potential noise and vibration impacts within the RMIT University and particularly the Eastern Portal, are included in Section 4.0. The scope of the study was primarily a desktop review of the information presented in the above documents, and therefore did not involve site investigations, measurements or verification modelling.

3.0 PEER REVIEW OF NOISE IMPACT ASSESSMENT

The peer review has been undertaken to assess the methodology used for the MMRP as a whole. Only certain aspects of the peer review are relevant to RMIT University but comments on all wider aspects of noise and vibration assessment have been included for completeness.

As detailed in the EES noise and vibration documents, controls over noise and vibration for the construction and operation of the MMRP are to be defined within a set of Environmental Performance Requirements (EPRs). The EPRs effectively form the criteria that are intended to provide suitable protection of amenity and thereby minimise project noise and vibration impacts.

Appendices A through D of this peer review provide a detailed technical review of the EES noise and vibration documents. The discussion within these appendices indicates the following:

- Controls over construction noise, particularly during daytime and weekend periods and also during 'Unavoidable' works are inadequate. The nominated guidance document, EPA 1254, does not include criteria for duration or level of exposure during normal working hours. Consideration should be given to alternative guidance and criteria to address the specific requirements of a construction noise impact assessment for major transportation infrastructure. In this respect, it is noted that no consideration was given to the Melbourne City Council (MCC) *Noise and Vibration Management Guidelines* which provide more detailed advice on construction noise criteria and mitigation. Another example is the NSW Transport for NSW (TfNSW) Construction Noise Strategy 7TP-ST-157/2.0 which is used in part, but not for impact assessment considerations, such as defining mitigation action thresholds for minimising adverse impacts at night.
- The assessment of construction vibration is incomplete and does not adequately consider sensitive buildings, residences and critical equipment and risk. Uncertainties associated with the source strength, vibration propagation and the site geology could have a significant impact on the vibration experienced at affected receivers
- Operational noise is less critical, other than at the portals, because as the trains are underground airborne train noise will be adequately controlled. Further, control of noise from ventilation equipment and mechanical plant to meet the requirements of SEPP N -1 is relatively straightforward to achieve at reasonable cost and should result in a satisfactory amenity for affected sensitive receivers and research facilities or laboratories.
- In our view, operational vibration has not been satisfactorily assessed. Further investigations are required to establish the expected vibration levels at affected sensitive buildings. Uncertainties over the train source vibration, ground coupling effects and vibration propagation rates indicate a high degree of risk and potential exceedance. Given the difficulty of rectifying operational vibration in situ and the particularly high sensitivity of many sites especially RMIT and Melbourne University along the alignment, the use of floated track slab along the majority of the alignment is recommended
- Given the above concerns, consideration should be given to alternative guidance and criteria to address the specific requirements of comprehensive noise and vibration impact associated with this major transport infrastructure on RMIT University.

Details of suggested amendments to the EPRs are provided in Section 5.0 of this report. Our further comments on the proposed EPR's are provided in Appendix E.

4.0 KEY RECOMMENDATIONS RELEVANT TO RMIT UNIVERSITY

We consider that construction noise is the main issue for RMIT University along with vibration impacts to sensitive facilities and equipment.

4.1 Introduction

The findings of the MDA peer review indicate that in general terms, the Metro EES Noise & Vibration Impact Assessment provides information consistent with demonstrating the project could be viably constructed and operated while achieving suitable criteria for noise and vibration. This finding is however subject to recommendations for further detailed assessments, and in some instances changes to the criteria. These recommendations have been documented generally in the peer review and in a detailed review of the proposed noise and vibration related Environmental Performance Requirements, as presented in Appendix E of this Peer Review.

4.2 Construction noise criteria

Considerable above ground demolition and above and below ground construction are proposed to take place within the City of Melbourne. Works at CBD North Station will occur over a 3 year period and require activities to be undertaken during normal working hours (7am to 6pm Monday to Friday and 7am to 1pm Sundays) but unavoidable work would also be required during the evening and through the night at times.

The NVIA recommends EPA Noise Control Guidelines Publication 1254 Section 2 *Construction and Demolition Site Noise* be used to establish construction noise criteria however it does not include criteria for duration or level of exposure during normal working hours. By comparison, the City of Melbourne "*Noise and Vibration Management Guidelines"* provides more detailed advice on construction noise criteria and mitigation including limits for standard hours (7am to 7pm Monday to Friday and 8am to 3pm Sundays) as well as the evening and night period.

Section 4.3 of the City of Melbourne's *Noise and Vibration Management Guidelines* provides a table of Noise Sensitive Zones which are to be used to help noise assessments and determination of Designated Sound Levels (DSLs) for construction. The definition of Noise Sensitive Zones is replicated in Table 1.

Table 1: City of Melbourne Noise& Vibration Management Guidelines Noise Sensitive Zones

Zone	Land uses	Typical sensitive periods	Likely area for consideration
Sensitive Zone 1:	Residential buildings, homes, hotels and motels.	7am–9am Mon-Fri 8am–10am Sat-Sun	Within 200 m from site boundary.
Sensitive Zone 2:	Crèches, schools, hospital wards, nursing homes and other noise sensitive areas identified by Council.	Case specific, will require consultation with the affected premises.	Within 100 m from site boundary.
Sensitive Zone 3:	Office buildings	Will generally be equally sensitive during all hours	Within 50 m from site boundary
Sensitive Zone 4:	Restaurants or cafes	12pm–2pm for lunchtime trade	Within 50 m from site boundary.

The City of Melbourne's *Noise and Vibration Management Guidelines* DSLs and related actions for high impact projects are outlined in Table 2. RMIT University is classed as Zone 2 for the purposes of this assessment, noting that the MCC guidelines do not define the relevant sensitive periods for this Zone.

Table 2: Designated Sound Levels (DSLs) and related actions for high-impact projects requiring acoustic assessment

Works and hours	Action Level	Basis and Actions
Baseline DSL **Standard Hours under Activities Local Law section 8.5** 7am to 7pm Monday to Fri; 8am to 3pm Saturday	L_{90} + 10dB(A) L_{eq} (Zone 1,2) L_{90} + 15dB(A) L_{eq} (Zone 3, 4) (Measured at the façade of the affected building)	Works generating noise below these levels would generally not require additional noise management and community consultation. General notification and noise sensitive work practices are still expected, including informing the community of work periods and a contact point for complaints. When the predicted or measured noise level is above this point, the builder/contractor should implement additional measures to minimise noise. They should demonstrate to Council that all feasible and reasonable measures have been put in place to minimise impacts and should exercise additional community consultation during these periods of works.
Baseline DSL **Non-standard hours** 7pm to 10pm Monday to Friday; 3pm to 10pm Saturdays 9am to 6pm Sundays & public holidays Requires permit from Council, including operational conditions. Issued with consideration for history of complaints and site conduct.	L_{90} + 10dB(A) L_{eq} (Zone 1,2) Shorter duration[+] L_{90} + 5dB(A) L_{eq} (Zone 1,2) Longer duration[+] L_{90} + 15dB(A) L_{eq} (Zone 4) (Measured at the façade of the affected building)	Works generating noise below these levels would generally not require additional noise management and community consultation. General notification and noise sensitive work practices are still expected, including informing the community of work periods and a contact point for complaints. When the predicted or measured noise level is above this point, the builder/contractor should implement additional measures to minimise noise. They should demonstrate to Council that all feasible and reasonable measures have been put in place to minimise impacts and should exercise additional community consultation during these periods of works
Baseline DSL **Night period** 10pm to 7am Monday to Friday; 10pm to 8am Friday/Saturday; 6pm to 9am Saturday/Sunday & around public holidays Requires a permit from Council, including operation conditions. Issued with consideration for history of complaints.	L_{90} + 5dB(A) L_{eq} (Zone 1,2) (Measured at the façade of the affected building)	Works during these hours are generally discouraged. When a project demonstrates a need to work during these hours for extended periods, all feasible and reasonable measures should be implemented to reduce noise to this level. More substantial expectations apply to what is reasonable for noise management during night periods. Other than special circumstances, Council is unlikely to approve ongoing works that exceed this level. If approved due to special circumstances, the builder/contractor should communicate closely with affected people. Direct negotiation may be required if works will exceed the DSL. Council may facilitate this process.

Based on the above Table the action levels at RMIT University based on the background levels for Franklin Street in the NVIA Table 11-2 would be 79 dB LAeq daytime, 74 dB LAeq evening and 65 dB LAeq at night.

4.3 Equipment noise levels

Sound power data and details of equipment numbers will potentially have a significant impact on the construction noise level predictions, highlighting the uncertainty associated with the construction noise contour maps in the technical appendix.

As discussed in Appendix A, many construction source noise levels have been significantly understated which may lead to misrepresentation of impacts especially with respect to teaching and research activities.

As many construction source noise levels have been understated and we recommend that these be reviewed and the NVIA be updated to reflect British Standard 5228:2009 "*Code Of Practice For Noise And Vibration Control On Construction And Open Sites – Part 1 Noise"* (BS 5228:2009) (supplemented by the 2014 amendment accompanying the standard) and Australian Standard 2436:2010 *"Guide to noise and vibration control on construction, maintenance and demolition sites"* (AS 2436:2010).

4.4 Noise modelling

Noise modelling is all based on 1.5 m receiver heights, with no mention of how the modelling has taken account of reflection paths between buildings which can potentially undermine any attempts to use barriers. Additional modelling is recommended at relevant levels above ground for RMIT Building 9 and 14 to enable the noise level in lecture theatres, tutorial rooms and other sensitive areas to be determined and mitigation measures to be accurately developed. Particularly for the stages were construction work is proposed to be performed without an acoustic shed.

4.5 Construction vibration

Construction equipment use at CBD North (per Table B.1) consists of 20t excavators with rock breakers, bored piling rigs, ripper-excavators, other excavator, fixed plant and trucks. Many of these items generate significant levels of vibration.

Given that the predicted PPV from large rock breakers at distances of 5-10 m are up to 5-12 mm/s, the risk of damage to RMIT University sensitive equipment due to construction at CBD North Station at these severities is high

More detail on how the impacts would be modelled and managed is required.

The issue of ground vibration and its effect on geological conditions and ground settlement is complex. It is an issue best considered by a specialist geotechnical consultant who has a full understanding of soil movement around sensitive buildings. However, ground movement is often considered by reference to codes and standards that discuss the damage probability where buildings are subject to high levels of vibration.

Strong vibration can cause settlement of soil, primarily for loose soils, which can lead to foundation settlement, especially where there is frequent vibration or works below the water table. At large distances from the source, foundation settlement can occur even at vibration severities which normally would not be expected to cause structural damage.

In the EES noise and vibration documents, the geological conditions are discussed only in broad terms, and the risk of settlement, except for situations with light sand or gravel, or non-cohesive silt or clay may be high in some areas.

4.6 Operational vibration and structure-borne noise

The assessment of ground borne noise and vibration due to operation has been comprehensively studied in the EES. The results would appear to indicate that compliance with the nominated criteria can be achieved for both vibration and ground borne noise following the application of appropriate mitigation treatments.

We are concerned that the NVIA limits high performance track bed isolation to selected portions of the tunnel. We recommend that very high performance track bed isolation consisting of a floating track slab should be used throughout the entire tunnel length, except through parkland or non sensitive areas.

4.7 Commercial premises

Proposed mitigation measures comprising of site insulation and temporary relocation have not taken into account the affects this work will have on offices, hotels and other commercial buildings within the City of Melbourne.

The greatest risk to RMIT University is the impact upon the sensitive laboratory is such as those in Building 14 Electron Microscopes, Confocal Microscopes and the FIB Ion Beam Tool are particularly susceptible given their location and even though they are isolated from vibration in various ways. Clear concern has been expressed regarding the uncertainty associated with the rail vibration analysis including the analysis procedure. Given the risk s a particularly near this site (CBD North) floated track rail is considered an essential requirement.

5.0 RECOMMENDATIONS

The following summarises our recommendations in relation to noise and vibrational impact of MMRP that affect RMIT University:

- Changes to ERP NV1 to ensure that RMIT University is included as a stakeholder, to be consistent with the MCC guideline
- Changes to ERP NV3 so that the communications plan is developed in consultation with RMIT University, University of Melbourne, City of Melbourne, City of Stonnington and the EPA Victoria
- Changes to ERP NV3 so that the communications plan is developed in consultation with RMIT University, University of Melbourne City of Melbourne, City of Stonnington and the EPA Victoria.
- Changes to ERP NV7 to ensure that condition assessment and construction vibration monitoring is undertaken at Melbourne City Baths and RMIT University
- Changes to ERP NV10 to require that micro and nano scale electron-microscopes and other sensitive equipment at RMIT University are provided, if required, with secondary vibration or enhanced isolation before construction commences.
- An additional EPR, NV19 is recommended that requires a plan to manage the noise impact of trucks and other construction vehicles on public roads. The plan should assess the change in sleep disturbance that will occur in residential apartments and student accommodation due to night movements of spoil trucks and other construction vehicles. The effects of trucks and other construction vehicles on lecture theatres, research facilities and other sensitive areas associated with RMIT University and University of Melbourne should be assessed.
- Use of very high performance track bed isolation, consisting of a floating track slab, throughout the entire tunnel length, except through parkland or non sensitive areas

APPENDIX A PEER REVIEW – CONSTRUCTION AIRBORNE NOISE

This section presents the findings of the peer review with respect to airborne noise generated by construction of the project.

A1 Criteria

Section 3.2 of the technical report provides a discussion of legislation, policy and guidelines, noting that there is no Commonwealth or Victorian legislation that relates to construction noise or vibration, and that a range of alternative guidelines and standards can be used to assess construction noise.

> *"There are, however, other guidelines and standards, some used in other parts of Australia, notably NSW and some that have been applied on similar rail projects internationally […]"*

Section 3.2.1 of the technical report then states that the noise criteria in EPA Noise Control Guidelines Publication 1254 (EPA 1254) are to apply to the proposed MMRP on the basis that it is widely used for construction noise management in Victoria. The subsequent discussion in that section then refers to the Australian and New Zealand Standard *AS/NZS 2017:2000 Acoustics – Recommended Design Sound Level and Reverberation Times of Building Interiors* (AS/NZS 2107)

EPA 1254 is widely used for construction noise management in Victoria. However, there are limitations to the use of this document for construction works associated with a major infrastructure project which may involve prolonged work and high noise activities in close proximity to sensitive receiver locations.

The limitations of EPA 1254 for this application (discussed further below) are sufficient to have warranted consideration of alternative relevant guidance and noise criteria. This would be consistent with the assessment approach for other matters considered in the Technical Report (e.g. ground-borne noise and vibration), which use criteria derived from interstate and international guidance. As an example, for ground-borne noise and vibration, the technical report refers to guidance from NSW, Germany and the UK, citing EPA advice to the project team about the suitability of using criteria from other jurisdictions in instances when there is no criterion directly available in Victoria.

In relation to the limitations of applying EPA 1254 for this application, we note the following:

- The guidance on construction noise in EPA 1254 applies to specific forms of development, noting the following:

  > *This applies to:*
  >
  > *industrial and commercial premises*
  >
  > *large scale residential premises under construction in non-residential zones, as defined in regulation 9 of the Environment Protection (Residential Noise) Regulations 2008.*

  While EPA 1254 does not explicitly preclude application of the guidance to major infrastructure projects, the document does not make reference to these types of projects. Some aspects of construction of an infrastructure project may be similar to the industrial, commercial or residential projects. However there are a number of aspects of an infrastructure project such as the MMRP which differ from the types of projects considered in EPA 1254. These differences include the types of equipment to be used, the amount of equipment to be used, the duration of the works and, most importantly, the potential for regular night-time work. In relation to the latter point, the requirement for night work as part of a commercial, industrial or residential project is likely to be very limited. In contrast, construction of transportation infrastructure can be reasonably expected to involve regular night-time work.

The guidance within EPA 1254 does not include criteria for duration or level of exposure during normal working hours. Statements of compliance with EPA 1254 throughout the EES documentation therefore do not translate to construction noise being restricted to a specified level, nor does it translate to any restriction on the duration of exposure to increased noise. This is one of the key limitations with respect to an assessment which refers to compliance with EPA 1254.

EPA 1254 criteria for night-time works do not include limits for short term noise levels which are particularly important for assessing amenity impacts related to sleep disturbance. As a result, potential sleep disturbance associated with night works is not adequately assessed in the technical report. In this respect, references to sleep disturbance in the EES documentation are limited, for example, on Page 4 (section 1.3), but no assessment of LAmax levels has been undertaken. This is significant given that extended periods of 24/7 works are proposed and the technical report does not address the impact of construction noise on sleep and well being.

Given the above limitations, consideration should be given to alternative guidance and criteria to address the specific requirements of a construction noise impact assessment for major transportation infrastructure. In this respect, it is noted that no consideration was given to the Melbourne City Council (MCC) *Noise and Vibration Management Guidelines* which provides more detailed advice on construction noise criteria and mitigation. Another example is the NSW Transport for NSW (TfNSW) Construction Noise Strategy 7TP-ST-157/2.0 which is used in part, but not for impact assessment considerations, such as defining mitigation action thresholds for minimising adverse impacts at night.

In relation to the noise thresholds that have been used in the EES, we note the following:

- The mitigation thresholds for air borne construction noise presented in Table 4-16 are considered to be too lenient and are not accompanied by justifications. It should be noted that construction noise at night could result in significant community disturbance, despite being at levels which would be deemed insufficient to trigger mitigation according to the proposed thresholds.
- The Night Guideline Noise Levels presented in Table A.2 of the technical appendices (Appendix A of Technical Appendix I) equate to relatively high noise levels due to the NVIA's method of deriving baseline referenced targets using ambient (L_{Aeq}) measurement results rather than background noise levels (L_{A90}). While objectively quantifying inaudibility as referenced in EPA 1254 is technically problematic, the use of background noise levels in lieu of ambient noise levels is generally considered the most appropriate method for setting targets corresponding to inaudibility. As a result, construction noise at the levels presented as Night Guildeline Noise Levels is not likely to satisfy the target of inaudibility, and in some instances, would be likely to represent a high risk of disturbance to neighbouring sensitive premises. For example, the Night Guideline Noise Level of 55 dB that has been defined for Fawkner Park would be clearly audible and potentially intrusive.
- The night-time period as defined in Table 4-16 is not reproduced as per the source material. The original text in Table 5 of the NSW Construction Noise Strategy has more restrictive hours for Saturdays, Sundays and Public Holidays. If the NSW Guideline is to be used, then it should be reproduced in its entirety with any changes highlighted and justified
- As stated in the preface of Australian Standard AS 2107 its use is unsuitable for many types of sources associated with construction activity. Care should be taken since AS2107 was intended to be applied to noise sources such as traffic. Further, the recommended noise levels from AS 2107 presented on page 14 of the technical report should be more comprehensive. For example this Section should also present the recommended "satisfactory" and "maximum" levels for schools, offices, and residences. In many instances, construction noise for prolonged periods at the maximum AS 2107 noise levels is likely to be considered intrusive

- Consideration should be given to maximum noise levels (L_{Amax}), particularly given the proximity and concentration of residents and the effects on sleep and amenity.
- Consideration should be given to applying caps to any limits that are based on permissible margins above ambient or background noise levels in order to avoid very high permissible construction levels in high ambient noise locations.

A2 Construction Activities

A2.1 Equipment

The following observations are noted in relation to the types of equipment that have been referenced in the EES:

- Construction equipment noise emission data is presented in the form of sound power levels in Table 4-16, with most of the data coming from the UK Publication "*Update of Noise Database for Prediction of Noise on Construction and Open Sites*" published by The Department of Environment and Rural Affairs (DEFRA) 2008.

  It should be noted that the most up to date UK reference for construction noise emission data is British Standard 5228:2009 "*Code Of Practice For Noise And Vibration Control On Construction And Open Sites – Part 1 Noise"* (supplemented by the 2014 amendment accompanying the standard). While much of the data in BS 5228:2009 is carried over from the 2008 DEFRA publication, there are updated and additional equipment items for some sources. It is therefore recommended that BS 5228:2009 should be used in lieu of the DEFRA when sourcing emission data from the UK. This standard should also be referenced in conjunction with Australian Standard 2436:2010 *"Guide to noise and vibration control on construction, maintenance and demolition sites"*.

- Sound power levels for some of the equipment presented in table 4-6 of the technical report are low when compared with available reference data in BS 5228:2009 and AS 2346:2010. The adoption of low sound power levels has not been justified. Importantly, the selected values are not considered representative of the emissions which may occur in practice. Examples include the spoil trucks, excavator with breaker, jack hammers and the diaphragm wall rig. For example, AJM have taken spoil truck data from the DEFRA database. In Australia, spoil trucks have a sound power level as high at 108 dB L_w (per AS 2436), not 91dB L_w as quoted, a difference of 15 dB, a major discrepancy. Data taken at other comparable rail projects indicates that a typical D-wall rig (Bauer MC64) has a sound power level of 105 dB L_w, which is 14 dB higher than that stated in Table 4-6

  Further, greater clarity on the construction noise level predictions could be obtained by including the duration of activities in the main part of the technical report along with the number of items of each type of plant.

In relation to the construction assumptions that have been used in the EES, we note the following:

- There are no compressors or water pumps in the plant list. This type of equipment is common on construction sites and can represent potentially significant items, particularly if required to run outside of normal working hours. These items should have been included in the schedule of equipment
- Desanding equipment may be required to operate 24/7, however this is not stated in the technical report. If required to operate at night, dedicated attenuation measures are likely to be required for this type of plant
- Water bowsers and related cleaning equipment are also not included in the construction assessment. The technical report notes truck movements will be occurring at night at a number of locations. If vehicles are required to be washed before accessing public roads, truck jet

washes could become a potential additional source of night-time construction noise. This potential for these types of noise sources should be addressed in the assessment

- Anomalies appear to be evident between the schedule of equipment operating at in some precincts and the equipment that has actually been included in the scenario modelling. For example, as part of the assessment of ground-borne noise and vibration, Table 4-7 of the technical report identifies that an excavator with hydraulic breaker will be required for works at the Domain. However, the airborne construction noise assessment presented in the technical appendices (refer to Table A-4 of Appendix A of EES Appendix I) indicates that the excavator with breaker is not included in the scenario modelling for the Domain. The reason for this discrepancy is not evident.

The matters outlined above in relation to noise emission data, and the completeness of the equipment schedule, have the potential to represent a significant source of uncertainty in predicted construction noise levels presented in the in the technical appendices.

In addition to equipment at specific work sites, the EES documentation refers to large numbers of construction vehicles associated with spoil removal and material and equipment deliveries. In particular, Section 5 of the technical report provides a discussion of the potential impacts of construction vehicles, noting the potential for regular night-time construction movements in some precincts. The risks of noise impacts from construction traffic are generally addressed through qualitative discussions of ambient noise levels and the potential for some of the affected receivers to have been insulated to address increased ambient noise levels. However, this approach does not address the potential impact of noise that may be generated as construction vehicles enter and depart work sites at night in the vicinity of sensitive receiver locations. This could represent a potentially significant risk of night-time disturbance at some locations and it is unclear from the EES document whether this risk has been adequately addressed.

A2.2 Unavoidable Works

The EES documentation refers to certain unavoidable works that may result in construction activity occurring outside of normal working hours.

Within the EES, works that are deemed to be unavoidable are not required to adhere to same noise level criteria that apply generally to construction activity occurring at night. Unavoidable works are defined on page 3 of EPA 1254 defines “Unavoidable Works” as follows:

> *“Unavoidable works are works that cannot practicably meet the schedule requirements because the work involves continuous work — such as a concrete pour — or would otherwise pose an unacceptable risk to life or property, or risk a major traffic hazard. Affected premises should be notified of the intended work, its duration and times of occurrence. The relevant authority must be contacted and any necessary approvals sought”*.

The types of activities that the EES considers as unavoidable works includes tasks that may be necessary to avoid construction program delays. The information provided does not provide sufficient justification to support this interpretation. Further clarification should be provided to clearly identify the types of activities which are to be considered unavoidable works, and thus a complete account of all activities that could occur at night, and the regularity of their occurrence. The matter of night construction works and unavoidable works should also be addressed in any subsequent Environmental Performance Requirements for the project

As an example of the types of activities which may be expected to occur at night, reference is made to the Diaphragm walling (D-wall) activities on the Crossrail Project (London) where it was shown that it was not possible to complete a single shaft wall panel within the normal working hours as defined by EPA 1254.

The D-wall process is summarised as follows:

- Excavate panel (Day 1)
- Final grab pass (Day 2)
- Insert and secure rebar (Day 2)
- Concrete pour – continuous (Day 2)
- Remove and process Bentonite – often 24/7

The above activities must be completed within a set time frame, typically 42 hours, due to the structural integrity of the excavation in the first instance (safety) and secondly ensuring the required strength of the finished panel is achieved

It is stated at least twice, at bullet 3 of Section 1.3.1 on page 5 of the technical report and bullet 3 of page 1 of Appendix A of the technical appendices, that:

> *"Concrete pours – this work is proposed to be undertaken during Normal Working Hours, however, if it is not completed then it would extend into other periods. This is anticipated to occur on a regular basis".*

It is therefore known in advance that some construction activities could routinely extend into the evening and night-time periods. Under the definition within the technical report this work would appear to be classified as being "unavoidable" by default in all cases, thus potentially not being required to adhere to the EPA 1254 criteria that apply to work during the night.

In this respect, it is important to emphasise the context within which the EPA 1254 guidance is specified. Specifically, the subject of unavoidable works is addressed in EPA 1254 in relation to residential, commercial and industrial sites for which it can be reasonably expected that works would occur infrequently during the night.

For reference, Page 4 of EPA 1254 states the following with regard to Unavoidable Works:

> *Note: Noise from construction of large-scale residential premises in non-residential zones (see regulation 9 of the Environment Protection (Residential Noise) Regulations 2008) is subject to the unreasonable noise provisions of s48A(3) of the EP Act at all times of day. In all circumstances, the assessment may have regard to this noise control guideline*
>
> *This guideline affirms the minimum expectation that noise from these sites must not be audible within a habitable room of any residential premises between 10 pm and 7 am. This is considered unreasonable noise under the EP Act. However, provision is made for circumstances of unavoidable works or low-noise or managed-impact works*
>
> *This guideline does not limit the general ability of a local government or police officer to assess the unreasonableness of noise at any time. For example, if unavoidable works were done in an unnecessarily noisy way, this may be considered to be unreasonable. General noise at any time during the day might still be considered unreasonable, taking into account the work practices and circumstances of the noise. As specified in s48A(4) of the EP Act, assessment must consider the attributes of the noise and the time, place and circumstances in which it is emitted*

Given that the general construction process information is well known and available in advance, and the project may necessitate regular night working (in contrast to the residential, commercial and industrial projects that EPA 1254 strictly applies to, for which night activity and unavoidable works would be relatively infrequent), it is recommended that this matter is reviewed and assessed in detail to identify all reasonable and practical mitigation measures that are available to reduce the impact of night works. Further, it would be prudent for the EPR to specifically address the subject of night activities, the classification of activities that can be truly considered irregular and unavoidable, and conversely, suitable control measures for foreseeable night works that can practically attenuated.

In addition, Table 3-1 on Page 10 of the technical report presents a summary of the relevant legislation and guidelines. It should be noted that "unavoidable works" are displayed in the table in the column titled "Approvals required". It is acknowledged that Table 3-1 also refers to Section 285A of the Major Transport Projects Facilitation Act 2009 which states that no permits are required from Council. It is therefore recommended that details of the approval process and approval authority is clarified. This would be prudent inclusion in any subsequent Environmental Performance Requirements for the project.

A2.3 Programme & Duration

A key consideration with respect to construction noise impacts and the risks of impacts to sensitive receivers is the duration of exposure to activities and the regularity of exposure to construction noise during sensitive time periods.

The EES noise and vibration documents provide an indication of the periods of working activities, certain types of activities which are likely to occur during the night (but designated as unavoidable – see discussion in preceding section), and the potential for some activities scheduled to occur during normal working hours extending into night periods when required.

However, given the extended time period of the project and the high risk of prolonged periods of elevated night-time noise levels at certain key work areas, the noise assessment would benefit from additional detail to quantify and clarify:

- The locations that are at risk of experiencing regular construction noise during sensitive times of day (evening and night), accounting for all construction activities and vehicle movements for which there is a foreseeable risk of extended operations outside of normal working hours
- The expected timing of key construction activities and the location where they are expected to occur. For example, section 4.7.1 of the Report does not detail which items of equipment or plant will be operating at points along the construction route, unlike the subsequent section 4.7.2 which provides an account of the activities which will occur at certain locations and are relevant to ground vibration (4.7.1 simply notes all equipment assumed to be operating in each scenario, however the concept of scenarios and the equipment operating in each scenario is not evident until reviewing the modelling inputs discussed in the technical appendices)
- The magnitude of the noise levels likely to occur during the evening and night, and the duration for which the elevated noise levels are likely to be experienced. For a project of this nature, it would be reasonable for information to be presented in the form of predicted noise levels for key working stages to illustrate how noise levels at key affected receptor locations will vary over the course of the construction works.

In the absence of this level of information in a readily accessible format, the risks associated with works during sensitive periods are subject to considerable uncertainty. This is compounded by the proposal to designate the majority of construction activities which extend outside of normal working hours as unavoidable works which are subsequently not required to adhere to the night-time targets that have been suggested in the EES documentation

Further, without this level of information, it is not possible to reach an informed view about the importance of identifying and selecting working practices which could provide significant benefits in the form of reducing the amount of time that receivers are exposed to high noise levels (i.e. processes which could result in slight noise increases in noise, but significant benefits in terms of reduced working time).

A3 Prediction Method

The construction noise predictions have been prepared using ISO 9613 Acoustics - Attenuation of sound during propagation outdoors.

This is considered an appropriate choice of calculation method, subject to the following technical notes:

- The technical report incorrectly notes that the predictions have been calculated for neutral weather conditions. The ISO 9613 method only provides calculated noise levels for atmospheric conditions which favour the propagation of sound (i.e. increase sound levels at the receptor location) and does not provide a method for assessing neutral conditions. This is solely a reporting matter and is of no consequent to the calculated outcomes. The technical report also correctly notes that atmospheric effects are likely to be negligible over the limited separating distances between construction activities and receiver locations.
- The calculated benefit of mitigation measures such as local screens and barriers can be highly dependent on the presence of sound reflecting objects and the manner in which they are accounted for in the noise model. Given the construction works will occur in urban locations with building structures which act as reflection paths, and the presence of receivers at elevated locations, the modelling should be configured to allow for multiple reflection paths. While this is not explicitly addressed in the EES noise and vibration documentation, this is expected to represent a minor point of detail when compared to greater sources of uncertainty related to input sound power levels.

A4 Receiver Locations

The following general matters are noted regarding the receiver locations assessed in the report:

- The technical report notes night-time work is expected to cause the highest impact. In most cases, this is likely to be a reasonable assumption, however there is no discussion of whether or not there are affected locations which primarily comprise non-residential land uses which may be more sensitive to construction occurring during day time hours, such as schools and offices
- The noise modelling and mitigation assessment has been carried out for receiver heights of 1.5 m above ground level. However, there are instances along the route where the key sensitive receptor locations comprise multi-story structures, meaning that a 1.5 m calculation height is not representative and will overstate the potential benefit of noise mitigation measures. As a result, some receptor locations would experience no benefit from the proposed mitigation, contrary to the calculated benefits demonstrated by the noise contour maps presented for the 1.5 m calculation height.

  For example, there is an office building on Osborne Street and dwellings in William Street that would remain directly exposed to construction noise even after mitigation. For this reason it is misleading to present noise level contour maps at a 1.5m elevation.
- The investigation of construction noise and vibration around the Precinct appears rather selective, and has not identified the worst affected dwellings
- These observations tend to suggest that the details of identified receivers may not be exhaustive. Accordingly, clarification of the source of receiver data should be provided, and the likelihood/risk of any potential additional receivers should be flagged if relevant.

A5 Mitigation Measures

The following general observations are noted with respect to mitigation measures:

- A reactive approach to the use of noise mitigation in the event of complaints is regularly referred to throughout technical report (i.e. action only in response to adverse comment from residents). Construction noise management inevitably involves the use of responsive management measures to deal with unexpected high levels of community disturbance. However, reliance on a reactive approach for situations which can be reasonably predicted to have a high impact is likely to result in unreasonable disturbance of sensitive receptors, and has the potential to introduce delays into the construction program if works must be restricted or suspended until suitable management measures are put in place.
- Noise insulation in the form of upgraded glazing is mentioned throughout the technical report. Section 4.9 deals with construction noise mitigation and Section 4.9.1 states "the following work measures would also apply to Melbourne Metro" and further that "improving sound insulation at the receiver e.g. upgrading glazing" would be optional. However, the technical report does not provide a definition or indication as to the criterion that would trigger eligibility for noise insulation. Further, the assessment does not present sufficient information to understand the viability of retrospectively implementing insulation measures to existing structures, nor is there an indication of the framework which would enable this type of mitigation measure to be implemented in practice. In the absence of this type of detail, off-site mitigation of sensitive receptor locations cannot be considered an assured or reliable means of addressing the impacts identified in the study
- Restriction of working hours is generally a key mitigation measure for addressing construction noise impacts. There are recurring statements throughout the Report with regard to 24 hour works and the impact that any changes to this arrangement could have on the project timeline and construction costs. While certain activities would be expected to legitimately require concession to occur at night, insufficient justification has been put forward to demonstrate that the costs of mitigating night works, or limiting certain activities to normal working hours only are not practical or reasonable in the context of this project. Given the potential scale and duration of impacts from works during sensitive periods, further assessments and cost/benefit analysis of this subject is warranted
- The mitigation measures factored in the assessment include tall barriers to address locations where high predicted noise levels have been determined at ground floor locations. These represent significant measures which introduce practice constraints relating to structure and pedestrian access. It is acknowledged that the barrier specifications would be developed during the during the detailed design stages of the project. However, if these measures are to be relied upon for demonstrating that construction noise impacts can be reasonably and practically mitigated, it is necessary to include to some discussion of the practical viability of implementing the mitigation measures. This information has not been provided in the assessment and therefore the viability of these mitigation measures is unknown
- The Executive Summary to the technical report discusses benefits and opportunities, including a discussion of measures which could reduce construction noise impacts. It is however unclear if treatment options have been considered or not.
- Section 4.9.2.1 outlines additional mitigation measures for airborne and ground-borne construction noise. The report is unclear of the origin of the choices of additional measures to address exceedances warrant further explanation. It is also unclear when these additional measures would apply e.g. if the measures would apply or be considered based on predictions, or only after monitoring and complaints during the construction process.

A6 Environment Effects Assessment

The EES documentation does not provide an introductory discussion on the impacts of noise and its effect on health at work or during recreation, communication or sleep. A full understanding of the health impacts of noise can only be gained following a detailed explanation and understanding of noise impacts on the wider community. This is particularly relevant given the Scoping Requirement outlined in Section 2.1 of the Report and the emphasis on protection of amenity

This may initially appear to be inconsequential to the findings of the assessment. However, this omission becomes relevant in light of the limitations of the criteria that are subsequently adopted within the assessment. Specifically, the adopted assessment criteria do not address key matters relating to the potential health and amenity impacts of noise, such as duration of exposure to the noise, potential sleep disturbance effects and impacts to normal functions within commercial, education and health facilities.

The following points are noted:

- Table 6.1 presents a risk assessment with respect to impacts at the Eastern Portal due to the Project. Risk No. NV001 concerning airborne construction noise and states that the Initial risk of "noise events exceeding the relevant criteria" is medium. The nominated Likelihood rating is "Almost certain" (this being defined in Table 4-1) whilst the Consequence of such risk is given as being "Minor" (defined in Table 4-3). The Residual risk is nominated as being "Low". These conclusions are at variance with the stated predictions for construction noise in Appendix A of the NVIA.

  All construction operations have been stated in the EES as being "Normal hours" works or "Unavoidable" works and have therefore not been assessed against any criteria. Comparison has been made in Section A.5.8 against pre-construction ambient noise levels. However, the construction methodology may effectively result in the closure of local roads to traffic and pedestrians resulting in lower background levels. MDA assert that the conclusion of the assessment in Table 6.1 is misleading with respect to risk from airborne construction noise.

  The risk matrix presented in Section 4.4.1 Table 4-3, is not correct with respect to airborne operational noise compliance with *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1* (SEPP N-1). The matrix suggests that a 2-5 dB exceedance of SEPP N-1 equates to a "moderate" impact. Whilst there are ambiguities and misrepresentations evident when attempting to use risk matrices to categories noise or vibration impacts regulated by legislated mandatory requirements, the references to SEPP N-1 here should be revised

- Table 4-3 indicates exceedances of operational criteria are rated as moderate to severe – understandable but this warrants further comment . There may be severe exceedances of SEPP N-1 but these are more likely to have moderate consequence impact not minor, and hence the initial risk will be medium

- Council should be aware that compliance with SEPP N-1 is a mandatory requirement in Victoria and for the Report to imply otherwise is misleading

APPENDIX B PEER REVIEW – CONSTRUCTION VIBRATION & GROUND-BORNE NOISE

This section presents the findings of the peer review with respect to vibration and ground borne noise generated during construction of the project.

B1 Criteria

- A range of criteria are used in the NVIA for assessment of vibration, which depend on the nature of the receiver. For the assessment of the likelihood of damage to buildings including sensitive and heritage structures, the technical report has nominated the German Standard DIN 4150 Part 3, which is well known and a widely accepted standard. The use of this standard is a reasonable approach.
- For human comfort the technical report refers to the now withdrawn AS 2670.2:1990 and to the replacement standard ISO 2631.2:2003 which does not provide criteria for assessment of human comfort. However Appendix C of another Standard ISO 10137: 2007 "*Basis for design of Structures: Serviceability of buildings and walkways against vibration*" (ISO 10137) does provide suitable criteria for assessment human response to vibration. Given that ISO 10137 includes well defined spectrum based criteria, we consider this standard should have been used for assessment of human comfort in the NVIA.
- As the human comfort criteria in AS 2670.2:1990 were no longer valid, the NVIA uses the NSW Guideline "Assessing Vibration" (2006), which in turn is based on BS 6472.1:1992 also now superseded. Notwithstanding this, the NVIA ultimately refers to the updated version of the standard British Standard BS 6472.1:2008 "*Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting."* This is generally considered the appropriate version when referring to BS 6472.

  However, while BS 6472.1:2008 is relevant to certain types of construction activities (e.g. relatively steady sources of construction vibration), caution must be exercised when attempting to apply the standard to highly variable sources of construction vibration. Specifically, BS 6472.1: 2008 states "Use of the estimated Vibration Dose Value (eVDV) is not recommended for vibration with time varying characteristics or shocks." Annex D of BS 6472 also indicates VDV is best suited to road traffic, particularly heavy vehicles; and railway traffic; and internal sources such as machinery and human activity, but does not discuss construction activities which can involve activities time varying and impulsive vibrations that the standard cautions against eVDV.
- This is particularly relevant since the NVIA makes various assumptions regarding vibration crest factors of the construction equipment to be used to determeine the eVDV. These assumptions introduce a significant risk as the VDV estimates will change significantly with any changes in this factor potentially affecting assessment outcomes. As examples, Section 4.7.2 pages 46 and 47 nominate various crest factors chosen without any justification or valid basis for doing so. In addition, a derivation of the eVDV requires detailed knowledge of the event type, vibration spectra, duration and number events, which cannot be reliably accounted for in a prediction, thus introducing additional sources of uncertaintyBased on the vibration dose values being unsuitable for important types of construction activity, the assessment should be based on alternative vibration metrics such as the peak particle velocity (PPV). In support of the use of PPV in lieu of VDV we note the following:
  - The NSW Guidelines acknowledge the use of VDV for variable sources of vibration, but notes that for short term piling, demolition and construction works (Section 2.3, Table 2.2 "Impulsive Vibration") the PPV is best for assessment purposes.
  - Both the Sydney Southwest and Northwest Metro EIS studies (Refer to Sydney Metro CNVS, 2014) used peak vibration velocity for construction impact assessment of construction vibration impacts

- The FTA Handbook "Transit Noise and Vibration Impact Assessment" discussed in the NVIA for operational vibration assessment also has a large section related to construction noise and vibration. The FTA Handbook nominates annoyance (human comfort) criteria based on velocity amplitudes, such as RMS vibration level or PPV, rather than eVDV.
- British Standard BS 5228-2:2009 *"Code of practice for noise and vibration control on construction and open sites. Vibration" states the following in relation VDV and BS 6472*:

> *BS 6472, as stated, provides guidance on human response to vibration in buildings. Whilst the assessment of the response to vibration in BS 6472 is based on the VDV and weighted acceleration, for construction it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance. Some guidance is given in Table B.1 (of BS 6472)*

- The threshold criteria nominated for construction related ground borne noise of 35 dB $L_{Aeq,15m}$ at night and 40 dB $L_{Aeq,\ 15m}$ in the evening for residential dwellings, hotels hospital wards and student accommodation and based on the NSW Interim Construction Noise Guidelines (ICNG) is consistent with other authoritative guidelines and also considered to be reasonable.

B2 Construction Activities

B2.1 Tunnelling Equipment

- The NVIA considers 24 hour use of Tunnel Boring Machines (TBMs) citing practical considerations and program constraints. While there may be legitimate reasons for this assertion, the justifications have not been presented in the assessment.
- TBM's are noted to be launched during normal working hours over a period of 4 to 5 weeks, but the NVIA notes that could extend into evening and night periods if it is not completed. There is no indication of how likely this, the extent of night work that could occur, and no justifications provided
- There is limited information on the origin of the TBM noise and vibration emission data to understand the reliability or plausibility of the information. Given the proposed 24 hour operation, this warrants further information and detail, particularly given the reference to 'literature based data'.
- Similar comments apply to the road headers. Specifically, the review has identified that the noise emission data used to represent road headers in the airborne noise assessment is low when compared to empirical standard data. This introduces concerns the vibration levels may also be higher than quoted; particularly since details of the geology in which the machines are working is not provided. Further, vibration from TBM's and road headers are much more dependent on the soil and ground type that the excavation method or machine size and speed, with differences of up to 20 dB between tunnelling in rock and soft ground, e.g. clay
- Owing to the significant uncertainty surrounding the theoretical models used for vibration predictions, particularly the use of the FTA method developed primarily for above or below ground line sources including road and rail, it is essential that field trials be carried out to validate the prediction models used in the NVIA, particularly given the lack of clarity over the TBM and road header vibration emission data.

B2.2 Additional Construction Equipment

- Vibration levels presented in Table 4-8 of the NVIA for additional construction works are not referenced. Whist they may be valid they should be cross checked or validated against known references.
- A review of selected vibration data presented in BS 5228 indicates the levels provided in Table 4-8 lie below that usually experienced for piling operations. Data for other vibration sources are comparable with the 2006 NSW guideline and hence are plausible. However given the dependence of vibration on ground type the validation of the source data proposed to be used in the field is recommended
- The MMRA Technical Note 18 indicates the Scenario A (Rail Occupation) construction works will occur at weekends in addition to weekdays. It is forecast that there will be two occupations of 1.5 weeks and 5 weekends of 24 hour works. The Scenario B (TBM retrieval) works will occur during working hours and, if not completed, then continuously over a period of 4-6 weeks in total.
- Given the likelihood of the weekend and night works described and the risk of extending beyond these periods, the recommendations in Section 17 of the NVIA to conduct site specific detailed and independent assessments to refine outcomes is supported

B3 Prediction Method

The propagation algorithm used for the attenuation models for the additional construction equipment presented in Figures 4-5 are based on an attenuation rate of 4.5 dB per doubling of distance. This scaling factor can vary from 3 to 6dB per doubling of distance depending on the soil type - with high attenuation rates for clay soils, but lower rates for rock and hard materials so more information is required on the actual attenuation rates to be expected at this precinct.

B4 Mitigation Measures

The NVIA correctly identifies that there are limited options when mitigating uncertainty with respect to the validity of these predicted outcomes vibration from tunnelling equipment. Apart from reducing operating speeds and changing to less powerful equipment, both of which should be considered following the detailed independent assessments are performed, the only other option would be to limit operations to day time hours where sensitivity to vibration is lower, due to increased ambient levels(e.g. traffic)

B5 Environmental Effects Assessment

Subject to the technical issues and concerns noted in the preceding sections, the overall methodology for assessing construction vibration is generally appropriate. We would expect that construction vibration can be reasonably managed following proper consideration of source vibration and a better appreciation of ground propagation conditions. However, further assessment work is essential and will need to provide:

- Validation of vibration emission data for the TBM and road header equipment vibration level data
- A detailed account of propagation conditions, in lieu of the simplistic propagation assumptions Relied upon in the NVIA
- An assessment based on PPV vibration levels in lieu of vibration dose values

APPENDIX C PEER REVIEW - OPERATIONAL AIRBORNE NOISE FROM TRAINS AND FIXED INFRASTRUCTURE

C1 Criteria

C1.1 Train Movements

Victorian Passenger Rail Infrastructure Noise Policy (VPRINP) which was released in April 2013, specifies investigation thresholds that apply for new passenger rail infrastructure. Section 5 of the policy sets out conditions under which transport bodies must apply the policy. The policy sets 'investigation thresholds' for the assessment of noise, which if exceeded, indicate that the measurement for noise mitigation should be considered.

For new rail infrastructure the investigation thresholds at 60 dB $L_{Aeq,16h}$ daytime and 55 dB $L_{Aeq,8h}$ night time. The day and night threshold for maximum levels is 80 dB L_{Amax}.

The investigation thresholds are not design criteria. Should the thresholds be exceeded, the following airborne and structure-borne noise criteria are nominated recommended by MDA to further assess the impact of passenger rail noise.

- Maximum noise levels of trains should not exceed 50 dB L_{Amax} in bedrooms.
- Any structure-borne noise component should not exceed 40 - 45 dB L_{Amax}
- Maximum noise levels of trains should not exceed 60 dB L_{Amax} in living areas

MDA has traditionally advocated an internal design target of 55 dB L_{Amax} in bedrooms from train pass-bys, this is based on achieving minimal sleep disturbance during the night, and is an approach that has been adopted on recent MDA projects. However it should be noted that a number of recent VCAT decisions have decided that 50 dB L_{Amax} is the appropriate internal design target for bedrooms of apartments adjacent to railway lines. These decisions have also included VCAT has also nominated 60 dB L_{Amax} as the appropriate design target for living areas. As a result of this decision, MDA have used the lower criterion for design of facades for bedrooms affected by rail noise.

C1.2 Fixed Infrastructure

The applicable policy for the noise of fixed infrastructure is SEPP N-1 *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1* (SEPP N-1). The aim of this policy is to protect people from noise that may affect the beneficial uses made of noise sensitive areas, including domestic and recreational activities and, in particular, sleep at night.

This policy has been discussed appropriately in the NVIA. It is the relevant policy for controlling noise from fixed infrastructure, including station and tunnel ventilation, extract fans and mechanical chillers and other plant including transformers and power supply equipment.

The majority of fixed infrastructure is likely to be required to achieve compliance during the most sensitive period - which is usually night time. Compliance with the night time criteria normally means that compliance is achieved at all other times of day.

In our view SEPP N-1 is the correct policy for control of noise from fixed plant or infrastructure, and this has been appropriately implemented in the NVIA.

C2 Assessment Basis

C2.1 Train Movements

The technical report presents and assessment of airborne noise from train movements primarily for operations occurring outside of the tunnels. This is considered a reasonable approach.

With regard to operational noise predications at the eastern portal, the NVIA has assessed the existing case and the future (2036) operations. The expected increase in rail traffic and the changes

in track alignment have resulted in noise level increases of 4-11 dB as detailed in Table L6 of the technical report.

C2.2 Fixed Infrastructure

At each station there will be ventilation equipment and mechanical plant. As occurred with the Melbourne Underground Rail Loop, fixed infrastructure at stations can be readily incorporated into the design and mitigated to meet SEPP N-1 with conventional noise control techniques such as barriers and attenuators. The issues around each plant are discussed within the EES for each station or precinct and other ears where fixed plant may be required.

The discussions are relatively brief owing to the mandatory requirements of SEPP N-1 and the accepted relativity economical and practical methods of mitigation available.

Accordingly, no further consideration of fixed infrastructure is warranted in this peer review, and the discussions in the following sections are therefore focussed on operation noise associated with train movements only.

C3 Train Noise Prediction Method

The noise predictions have been based on the Nord 2000 methodology as implemented in SoundPLAN proprietary noise modelling software. The following specific notes and observations are provided on the basis for the prediction method described in the technical appendices (Appendix C of Technical Appendix I):

- Nord 2000 is one of the most advanced engineering prediction methods for rail noise, and is routinely used for the prediction of noise associated with railways. This choice of Nord 2000 is therefore considered reasonable and appropriate
- Suitable source heights have been accounted for the in the modelling to represent the location of different elements of the noise generated with rail movements
- Source emission data has been developed from appropriate references including the Transport for New South Wales (TfNSW) train noise database and the Regi onal Rail Link Guideline for Railway Noise Predictions and Assessment
- The technical appendices document the use of measurement and prediction comparisons to provide a basis for investigating the reliability of the train noise model developed for the project. Limited details are provided in relation to the specifics of the measurement and prediction comparison, or the degree to which the reference measurement locations are representative of the propagation conditions for the critical compliance assessment locations. Further, in instances where the comparisons indicate the model slightly under predicted the measured noise levels (approximately 2 dB), no discussion is provided on whether this result warranted adjustment of the model outcomes to account for the difference. This is particularly relevant given subsequent sections indicated predicted noise levels above the investigation thresholds. Notwithstanding these limitations of detail and discussion, information presented is generally supportive of the suitability of the model as a planning assessment tool.
- The technical appendices note the use of adjustment factors to account for curved sections expected to incorporate turn radii less than 300m and between 300 m and 500 m, noting adjustments of +8 dB and +3 dB respectively. Appropriate reference data is sourced for the purpose of conducting a planning stage modelling study, however this aspect of the project represents an operational noise risk and is discussed further in subsequent sections.

Based on the above, appropriate assessment choices and model selections have been made for the purposes of planning stage investigations. It would however be expected that some aspects of the modelling process, including model validation and matters relating to wheal squeal risks with tight curved radii would warrant a greater level of scrutiny and detailed design work (particularly with

respect to the identification of proactive measures for addressing the risk of wheel squeal) during the design development phases of the project.

C4 Modelling Results & Mitigation Measures

The modelling results presented in the technical appendices indicate that the investigation thresholds of the Victorian PRINP are predicted to be exceeded by significant margins at both the Western and Eastern Portals for a number of receptor locations. In the case of the Western Portal, the exceedances are most significant for the concept design; however exceedances are also shown for the variation design.

The exceedances for the Western Portal are primarily noted in relation to the equivalent noise levels L_{Aeq}. No discussion is provided in relation to the maximum noise levels L_{Amax} for the Western Portal, however inspection of the noise contour maps appear to generally support that the receiver locations lie outside of the 85 dB L_{Amax} investigation threshold.

In contrast, the exceedances for the Eastern Portal comprise results relating to both the equivalent and maximum noise levels, notably by up to 11 dB in terms of the maximum noise levels at 4 William Street, South Yarra. Given the investigation threshold of 85 dB L_{Amax}, the exeedence implies very high predicted noise levels of the order of 96 dB L_{Amax}

As per the PRINP, the investigation thresholds do not represent allowable levels. However, consistent with the PRINP, the NVIA has considered mitigation options in the form of noise barriers, summarised as follows:

- Western Portal Concept Design: 4.5 m high barrier between the railway and Childers Street for a length of approximately 150 m
- Western Portal Variation Design: 3 m high barrier between the railway and Childers Street for a length of approximately 75 m
- Eastern Portal: Barrier heights range from 2.5 m to 3 m above the ground height of the adjacent houses and are located at the top of cut. Extents including 2 barriers along the along the northern side of tracks (50 m and 70 m in length) and two barriers along the southern side of the tracks (100 m and 170 m)

Based on revised noise calculations with the above mitigation measures incorporated into the model, the NVIA reports that the investigation thresholds are predicted to be achieved at all sensitive receiver location near the Western Portal. While detailed investigations of the topography and proposed barrier configuration have not been conducted as part of this peer reivew, the modelling result is considered plausible and reasonable given the height of barriers proposed. It is however noted that this result implies that the barriers would achieve reductions in excess of 10 dB. While plausible, this represents performance in the upper range of what can be practically achieved with barriers. Achieving this performance in practice will require detailed design attention to barrier construction, configuration and any potential reflection paths which could limit the effectiveness of the barrier. Notwithstanding these points of detail, the mitigation outcomes are considered reasonable for the purpose of a planning stage model.

In relation to Eastern Portal, the revised calculations incorporating the above mitigation measures indicate that noise levels at 4 of the 10 receiver locations are predicted to remain above the investigation thresholds. In contrast to the Western Portal which considers barrier heights extending to 4 m, the assessment does not present any discussion or assessment of the potential benefit which could be afforded by extending the barriers to greater heights than the nominated 2.5 and 3.5 m investigated for the Eastern Portal. Practical reasons or considerations may be a limiting factor, however this is not discussed or justified through discussion of the relevant considerations. In addition, while tabulated predicted noise level results for the locations predicted to remain above the investigation thresholds are not provided, the results suggest that the upper floors of the most

affected locations could experience similar calculated levels shown for the ground floor locations prior to inclusion of mitigation measures. If this is the case, this would translate to very high noise levels at locations such as 4 Williams Street; as noted above, the calculations indicated unmitigated noise levels of the order of 96 dB L_{Amax}. In recognition of these exceedances, the NVIA refers to the potential to implement offsite mitigation measures in the form of facade treatments to the affected locations.

The following points are noted:

- This may be the only practical approach to addressing the excess over the investigation threshold, However, as per the PRINP, noise levels above the investigation threshold indicate noise control should be a primary consideration., Accordingly, further discussion of why alternative barrier configurations cannot be practically implemented should be provided
- Offsite attenuation may be an appropriate method of addressing residual high predicted noise levels. However, if noise levels remain as high as 96 dB L_{Amax}, this introduces questions of whether remedial measures can be practically implemented to meet the internal noise criterion of 50 dB L_{Amax} referred to in both the NVIA and the PRINP. Specifically, a noise reduction in excess of 40 dB (between outside and inside noise levels) equates to a very high level of insulation, particularly for retrospective insulation of an existing dwelling. Given the potential significance of this type of insulation measure, further discussion of both the viability of implementing such measures, and the framework for how such measures could be provided, should have been discussed in the technical appendices. The potential significance of the offsite treatments required, and the magnitude of the predicted noise levels, also provides further reasons why alternative barrier configurations or heights should have been discussed in further detail (even if primarily to demonstrate why it could be reasonably to concluded that such alternatives would be impractical or disproportionate to the benefit achieved).

The above findings indicate that residual queries remain about the adequacy of the mitigation measures that have been investigated. Further, the technical appendices do provide any indication as to whether the barriers that have been investigated are feasible, or whether the general form of the barrier designs will be incorporated into the concept design.

Notwithstanding these points which we expect could be addressed through further information, or as part of the detailed design development, the modelling is generally supportive of the conclusion that the operational impacts of train movements associated with the project can be adequately mitigated, based on the guidance of the PRINP.

APPENDIX D OPERATIONAL VIBRATION AND GROUND-BORNE NOISE FROM TRAINS

D1 Criteria

D1.1 Vibration

Section 3.3.4 of the NVIA details the criteria for vibration from passenger trains. The report proposes the use of the VDV in accordance with the NSW Guideline "Assessing Vibration" (2006). The criteria used for assessment based on VDV are detailed in Table 3-20. Reference should also be made to BS 6472.1:2008 which uses a definition of risk based on the likelihood of adverse comment, being low probability, adverse comment probable and adverse comment possible.

The VDV range for "low probability of adverse comment" is between 0.2 to 0.4 for residential day periods and 0.1 to 0.2 for residential night periods. Hence, the choice of 0.2 as the preferred value during the day and 0.1 for night is considered appropriate.

We are satisfied that VDV is a valid metric for assessment of operational train vibration. In addition, there are other ways to assess rail vibration. It is not uncommon that VDV values can be low yet complaints still arise regarding train vibration. In our view, the NVIA should also have addressed intermittent vibration within occupied buildings in accordance with threshold curves such as those detailed in the superseded AS 2670.2:1990 and ISO 2631.2:2003 but is still included within ISO 10137:2008.

It is also common to assess rail vibration using the criteria in ISO 10137:2008 which considers a range of vibration curves (VC) applicable to assessment for different uses, for example VC 1.4 for residential uses at night, VC2 for daytime residential use and VC4 for commercial uses. This is consistent with the ASHRAE VC criteria used for assessment of sensitive equipment in the NVIA.

The use of this form of assessment can highlight the risk of individual train events exceeding given thresholds and is also a guide as to the likelihood of ground borne noise. In contrast to VDV which considers overall vibration, this method identifies the frequency at which vibration is likely to be detected, noticeable or annoying, usually over the range 10-80Hz.

We recommend that as part of the detailed assessment for this precinct that absolute vibration levels be assessed as well as forecast VDV.

D1.2 Ground-Borne Noise

Noise criteria applicable to ground-borne rail noise has been derived from guidance contained in the NSW EPA publication Rail Infrastructure Noise Guidelines 2013. The criteria is expressed in terms of the maximum A-weighted sound pressure level (slow response) and includes criteria for residential dwellings, schools, educations institutions and places of worship. The selected crtierai are considered reasonable and consistent t with industry practice.

In relation to other types of sensitive spaces that the NSW Guidelines do not provide criteria, the NVIA has included a proposed schedule of internal noise levels which are generally comparable to or lower than the criterion values from the guidelines (the exception being retail spaces which are permitted slightly higher levels). An exhaustive review of the types of spaces that could be impacted by ground-borne vibration has not been conducted as part of this peer review, however the proposed additional criteria detailed in the NVIA are considered reasonably for the spaces referred to. However, lower criteria may be considered suitable for more sensitive rooms within office environments (e.g. meeting or conference rooms).

D2 Operations

The modelling performed for the NVIA has assumed certain speed profiles, train lengths and is based on the expected future time tables for the operation of the trains through the network. Full details of these assumptions have not been reviewed but the assumptions made appear to be reasonable.

D3 Prediction Method

The assessment used the FTA method for the prediction of ground borne vibration. There may be legitimate technical reasons to favour the FTA method, but further justification for the appropriate choice of method should be provided. For example, other sections of the NVIA have documented why particular standards have been chosen when a range of options exist. It would be informative for this procedure to carry over into this section.

Notwithstanding the above, the report is not clear whether the formal detailed method in the FTA manual has been used or whether a frequency based general assessment has been performed. It is not clear whether line source force density and transfer mobility has been used as inferred from Figure 4.3. Either methodology can be appropriate but more clarity is required around the actual methodology employed as it is not possible to validate the predictions without this information. Assumptions that have been made including a 5 dB uncertainty and corrections for existing and new rolling stock, geotechnical conditions and curve squeal indicate the predictions are potentially conservative.

Mention is also made of modelling of track dynamics but there is no evidence of what has been carried out nor is there any evidence other than Figure E8 that provides any validation of the vibration propagation through the grounds. Further assumptions such as taking the 95th percentile and referencing source data based on a reference speed of 80 km/hr is consistent with industry practice.

The use of a calculated vibration reduction for alternative track forms presents a significant risk. Isolation of rail track from vibration using conventional isolation techniques varies significantly in practice from theory. Hence, a measurement of the proposed rail isolation system is recommended prior to finalising isolation systems as part of the design process.

It was not possible to validate the source data but the calculation methodology detailed in the NVIA are broadly consistent with industry practice with appropriate corrections for coupling losses, building amplification and floor to floor transmission. It is not possible to validate the propagation losses through the ground which are taken from theory and from other references. Owing to the sensitive nature of this issue it is recommended that site tests be performed as part of the detailed design phase to gain more confidence in the predictions of these losses and obtain data which is relevant for the particular site. The calculation procedure appears to have determined maximum noise levels but these have not been presented. It is recommended that the maximum noise levels be presented against the ISO 10137 criteria as described previously.

D4 Receiver Locations

The receiver locations used in the technical appendices (Appendix E of Technical Appendix I) for assessment of vibration are the same as used for assessment of air borne noise. Consistent with expectations, vibration related impacts primarily occur close to the rail line and the NVIA appears to have made a reasonable choice of receivers for the assessment. Although numerous receivers were assessed at the eastern portal there may be others who may be considered once the project design commences and the rail alignment is finalised.

It is noted that based on the sites assessed, up to 20 residences are predicted to experience to ground borne in excess of the criteria for the unmitigated assessment scenario. Following the implementation of the high performance track bed isolation system (floating track slab), the NVIA indicates that compliance with the ground borne criteria is predicted to be achieved. These results appear to be reasonable. Since much of the alignment will be non compliant with respect to the limits set for operational vibration and ground borne noise, the NVIA recommends track bed isolation using floating track slab in sensitive areas and in other locations direct fix track with standard and high attenuation properties.

In sensitive areas including the main Swanston Street strip to Domain, and the Eastern Portal, track bed isolation has been proposed with direct fix isolation ("high attenuations track bed") except for the Parkville precinct where very high attenuation track bed is proposed.

D5 Mitigation Measures

The NVIA considers three alternative attenuations for a range of track bed isolation systems. The report highlights that these attenuations are indicative only and that other track forms may provide equivalent performance. Therefore, the detailed design should be specific about the track borne isolation system and provide details of actual performance of such systems and include these results within the prediction methodology. Specifically, measurement data should be obtained to verify the performance of any proposed isolation systems prior to their selection during the detailed design phase.

D6 Environmental Effects Assessment

The assessment of ground borne noise and vibration due to operation has been comprehensively studied in the EES. Apart from the issues described above, the results would appear to indicate that compliance with the nominated criteria can be achieved for both vibration and ground borne noise following the application of appropriate mitigation treatments. For the reasons stated above, we are concerned that the NVIA limits the track bed isolation to only portions of the tunnel and recommends that very high performance track bed isolation (Floating track slab) be used throughout the entire tunnel length, except through parkland or non sensitive areas.

D7 Summary

There is a comprehensive but potentially flawed assessment within the NVIA of ground borne noise and vibrations. The results of the assessment indicate that with commonly available mitigation measures, primarily comprising isolation of the rail tracks from the tunnel structure, the nominated criteria for vibration and ground borne noise can be achieved in most areas.

While the NVIA is generally considered adequate for demonstrating the viability of managing ground and vibration impacts at the planning approval stage of the project, a significantly more detailed assessment will be required during the design stage of the project to address risks of non-compliance in practice. This is particularly important for the control of vibration and ground borne noise as the options for providing mitigation once the track is installed are limited.

The track bed isolation system must be carried out in a way to ensure that the isolation system works as tested.

APPENDIX E RECOMMENDATIONS – ENVIRONMENTAL PERFORMANCE REQUIREMENTS

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
Noise & Vibration				
NV1	Develop and implement a plan to manage construction noise in accordance with EPA Publication 1254 Noise Control Guidelines. The construction plan should be reviewed by all affected parties including but not limited to City of Melbourne , City of Stonnington, RMIT University and University of Melbourne	All	Construction	EPA 1254 does not include criteria for work during normal hours, nor does it establish any obligation to investigate or implement working methods which could significantly shorten the periods of exposure to the highest noise levels. The construction plan should nominate day time noise levels that can be practically adhered to, and that will be referenced as action levels when monitoring of daytime construction noise is required. The selection of day time noise levels for this purpose should consider the City of Melbourne Noise & Vibration Management Guidelines and the NSW Interim Construction Noise Guideline. The construction plan should also define: • the working periods for key activities that will result in high noise exposure, the measures that have been adopted to limit the duration of these periods, and how working periods will be monitored to avoid unnecessary prolongation of exposure to high noise levels • the measures that will be adopted for the control of impacts related to offsite construction vehicle movements, particularly during the night at site access and departure points in the vicinity of sensitive locations • a clear framework for the implementation of any off-site mitigation measures proposed, prior to commencement of the construction activity in question. This shall included details of consultations and investigations with the affected locations, and verification of the feasibility of implementing the measures proposed. • A program of monitoring to confirm adherence to the plan

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
NV2	For construction works conducted between CBD South station and Domain station, comply with the requirements of the Notification of Referral Decision for the Melbourne Metro Rail Project (EPBC 2015/7549, dated 22 September 2015) under the EPBC Act for vibration monitoring and measurement, as follows: • Conduct pre-construction dilapidation surveys of the nearest Commonwealth Heritage listed structures to the construction activity, including the Former Guardhouse (Block B), to record structural condition and structural integrity prior to commencement of tunnelling • Conduct vibration monitoring at the commencement of tunnelling in geological conditions that are similar to those at Victoria Barracks in order to quantify the actual tunnel boring machine vibration characteristics (level and frequency) for comparison to the values derived from the literature and the German DIN (DIN 4150) target • Conduct continuous vibration monitoring at the nearest Victoria Barracks heritage structures to the construction activity, including the Former Guardhouse (B Block), to assess the actual tunnelling vibration for acceptability, taking into account both the vibration frequency and condition of structures, until monitoring of vibration at the Former Guardhouse (B Block) shows measurements equivalent to preconstruction vibration readings at the Former Guardhouse (B Block) • If monitoring conducted according to the above demonstrates the condition of heritage structures may be degraded as a result of vibration, ground vibration must be reduced by adjusting the advance rate of the tunnel boring machine until monitoring of vibration at the Former Guardhouse (B Block) shows consistent measurements equivalent to preconstruction vibration readings at the Former Guardhouse (B Block).	1 – Tunnels (between CBD South station and Domain station)	Construction	Prior to commencement of the construction works, a vibration monitoring plan should be submitted for review and approval by the relevant authority. This should include full details of: • vibration measurement methodologies to be adopted for monitoring both baseline and construction levels. This shall include details of the parameters to be obtained, the measurement equipment, parameters to be recorded and relevant standards that shall be adhered to for the collection and analysis of data • baseline and construction vibration monitoring locations • the most critical periods, whether determined by separating distance or ground conditions, and the duration of the monitoring periods. The requirement of NV2 is also recommended to be extended to apply to Melbourne Town Hall, Melbourne City Baths and St Paul's Cathedral.

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
NV3	Appoint an acoustic and vibration consultant to predict construction noise and vibration (through modelling) and update the modelling to reflect current construction methodology, site conditions and specific equipment noise and vibration levels (this will require noise and vibration measurements). The model would be used to determine appropriate mitigation to achieve the Environmental Performance Requirements. The acoustic and vibration consultant will also be required to undertake noise and vibration monitoring to assess levels with respect to Guideline Targets specified in the Environmental Performance Requirements. Where monitoring indicates exceedances of Guideline Targets, apply appropriate management measures as soon as possible.	All	Construction	Acoustics and vibration consultant should be independent and not appointed by MMRP or the PPP contractor. The findings of the modelling and mitigation investigation shall be documented in a Construction Noise and Vibration Assessment Report, which shall provide the basis for the development of the construction management plan required under NV1. The report shall be reviewed by the Independent Auditor (see separate recommended NV concerning the establishment of an Independent Auditor). The report shall implement any recommendations arising from the review prior to being finalised. Consistent with the recommended NV1 modifications, report shall address day time noise levels that can be practically adhered to and that will be referenced as action levels when monitoring of daytime construction noise is required. The selection of day time noise levels for this purpose should consider the City of Melbourne Noise & Vibration Management Guidelines and the NSW Interim Construction Noise Guideline.
NV4	Develop and implement a communications plan to liaise with potentially affected community stakeholders and land owners regarding potential noise and vibration impacts. The plan shall include procedures for complaint management.	All	Construction	The communications plan should be developed in consultation with RMIT University, University of Melbourne City of Melbourne, City of Stonnington and the EPA Victoria. The plan should also specify precinct-specific community consultations that will be conducted as part of developing, and prior to finalising, the Construction Noise and Vibration Management Plan required under NV-1.

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr>
<td>NV5</td>
<td><u>Airborne Construction Noise Guideline Targets (Internal)</u>
Implement management actions if construction noise exceeds the internal noise levels below for Highly Sensitive Areas (based on AS/NZS 2107:2000) and a noise sensitive receptor is adversely impacted.
<table>
<tr><th>Highly Sensitive Area</th><th>Maximum Internal Construction Noise Level $L_{Aeq,\ 15\ mins}$</th></tr>
<tr><td>Intensive Care Wards</td><td>45</td></tr>
<tr><td>Operating Theatres</td><td>45</td></tr>
<tr><td>Surgeries</td><td>45</td></tr>
<tr><td>Wards</td><td>40</td></tr>
<tr><td>Lecture Theatres</td><td>35</td></tr>
<tr><td></td><td></td></tr>
</table>
</td>
<td>All</td>
<td>Construction</td>
<td>This is the only proposed EPR which presently includes proposed Airborne Construction Noise Guideline Targets, However, this EPR does not address external noise levels or residential receiver locations.

This EPR should therefore be modified to include Guideline Targets that will apply in accordance with EPA 1254 (i.e. evening and night periods), and should also include recommended Guideline Targets for work during normal hours which would be referenced as part of any requirement to monitor the noise of day time construction work (see recommended modifications to EPR numbers NV1 and NV3). In relation to the Guideline Targets derived in accordance with EPA 1254, the nominated values must be derived on the basis of the background noise level (L_{A90} as specified in EPA 1254) in lieu of the higher ambient levels (L_{Aeq}) that have been referenced in the EES.

Further to the above, the proposed internal targets are not considered suitable for prolonged periods of exposure. AS 2107 is primarily concerned with less intrusive types of noise sources such as road traffic. Mitigation measures should therefore be directed at achieving the lower values outlined in AS 2107, Any instances where this cannot be met may be permitted to extend to the upper values that have been presently nominated. It is however expected that concessions to work to the upper levels of AS 2107 would be limited to brief/essential working periods and would need to be clearly identified in the Construction Noise and Vibration Assessment Report recommended in relation to EPR number NV3.

The internal targets should also be extended to all other types or relevant non-residential sensitive uses such as offices, schools and hotel accommodation.</td>
</tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV6</td><td><u>Vibration Guideline Targets for Structures</u>
Implement management actions if due to construction activity, the following DIN 4150 Guideline Targets for structural damage to buildings (for short-term vibration or long-term vibration) are not achieved.
Short-term vibration on structures
<table>
<tr><th rowspan="2">Type of structure</th><th colspan="3">Vibration at the foundation, mm/s (Peak Component Particle Velocity)</th><th>Vibration at horizonta plane of highest floor all frequencies</th></tr>
<tr><th>1 to 10 Hz</th><th>10 to 50 Hz</th><th>50 to 100 Hz[1]</th><th>mm/s (Peak Compone Particle Velocity)</th></tr>
<tr><td>Type 1: Buildings used for commercial purposes, industrial buildings and buildings of similar design</td><td>20</td><td>20 to 40</td><td>40 to 50</td><td>40</td></tr>
<tr><td>Type 2: Dwellings and buildings of similar design and/or occupancy</td><td>5</td><td>5 to15</td><td>15 to 20</td><td>15</td></tr>
<tr><td>Type 3: Structures that have a particular sensitivity to vibration e.g. heritage buildings</td><td>3</td><td>3 to 8</td><td>8 to 10</td><td>8</td></tr>
</table>
Notes
1 At frequencies above 100 Hz, the values given in this column may be used as minimum values.
2 Vibration levels marginally exceeding those vibration levels in the table would not necessarily mean that damage would occur and further investigation would be required to determine if higher vibration levels can be accommodated without risk of damage.
3 For civil engineering structures (e.g. with reinforced concrete constructions used as abutments or foundation pads) the values for Type 1 buildings may be increased by a factor of 2.
4 Short-term vibration is defined as vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated.</td><td>All</td><td>Construction</td><td>Measurement of ground propagation characteristics are recommended to improve the confidence of predictions and to ensure that ground settling does not occur particularly in the vicinity of Melbourne Town Hall, Melbourne City Baths, St Paul’s Cathedral, RMIT University and University of Melbourne</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td></td><td>Long-term vibration on structures
<table>
<tr><th>Type of Structure</th><th>Vibration Velocity, mm/s (Pea Component Particle Velocity) horizontal plane at all frequenc</th></tr>
<tr><td>Buildings used for commercial purposes, industrial buildings and similar design</td><td>10</td></tr>
<tr><td>Dwellings and buildings of similar design and/or occupancy</td><td>5</td></tr>
<tr><td>Structures that have a particular sensitivity to vibration, e.g. heritage buildings</td><td>2.5</td></tr>
</table>
Notes
1 Vibration levels marginally exceeding those in the table would not necessarily mean that damage would occur and further investigation is required would be required to determine if higher vibration levels can be accommodated without risk of damage.
2 Long-term vibration means vibration events that may result in a resonant structural response.</td><td></td><td></td><td></td></tr>
<tr><td>NV7</td><td>Undertake condition assessments of above and below ground utility assets and establish construction vibration limits with asset owners.
Monitor vibration during construction to demonstrate compliance with agreed vibration guideline targets. Take remedial action if limits are not met.</td><td>All</td><td>Construction</td><td>Condition assessment and monitoring of vibration during construction should also be undertaken at Arden Street Bridge, Swanston Street brick drain, Flinders Street drains, Princes Bridge, Melbourne Town Hall, Melbourne City Baths and St Paul’s Cathedral.</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV8</td><td><u>Vibration Guideline Targets for Underground Infrastructure</u>
Implement management actions if the following DIN 4150 Guideline Targets for buried pipework/underground infrastructure from construction are not achieved.
<table><tr><th>Pipe material</th><th>Vibration Velocity, mm/s (PPV</th></tr><tr><td>Steel</td><td>100</td></tr><tr><td>Clay, concrete, reinforced concrete, prestressed concrete, metal</td><td>80</td></tr><tr><td>Masonry, plastic</td><td>50</td></tr></table>Notes
1 These values may be reduced by 50% when evaluating the effects of long-term vibration on buried pipework.
2 It is assumed pipes have been manufactured and laid using current technology (however it is noted that this is not the case for the majority of buried pipework potentially affected by Melbourne Metro).
3 Compliance with is to be achieved with asset owner’s Utility Standards.</td><td>All</td><td>Construction</td><td>Specific vibration targets should be developed for Swanston Street brick drain and Flinders Street drains in consultation with the responsible authority.</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV9</td><td><u>Vibration Dose Values (VDVs) (Human Comfort)</u>
Implement management actions if the following Guideline Targets (VDVs) (based Table 1 in BS6472-1:2008) for continuous (as for TBMs and road headers), intermittent, or impulsive vibration are not achieved.
<table><tr><th rowspan="3">Location</th><th colspan="4">VDV (m/s$^{1.75}$)</th></tr><tr><th colspan="2">Day
7:00am to 10:00pm</th><th colspan="2">Night
10:00pm to 7:00am</th></tr><tr><th>Preferred Value</th><th>Maximum Value</th><th>Preferred Value</th><th>Maximum Value</th></tr><tr><td>Residences</td><td>0.20</td><td>0.40</td><td>0.10</td><td>0.20</td></tr><tr><td>Offices, schools, educational institutions, places of worship</td><td>0.40</td><td>0.80</td><td>0.40</td><td>0.80</td></tr><tr><td>Workshops</td><td>0.80</td><td>1.60</td><td>0.80</td><td>1.60</td></tr></table>Notes
1 The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures. If exceeded then management actions would be required.
2 The VDVs may be converted to PPVs within a future noise and vibration construction management plan</td><td>All</td><td>Construction</td><td>Assessment of human comfort should also be assessed against the relevant Victorian Curve (VC) presented in ISO Stand 10137:2007 Basis for design of Structures: Serviceability of buildings and walkways against vibration</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV10</td><td><u>Vibration-sensitive Equipment Guideline Targets</u>
Implement management actions if the following ASHRAE equipment vibration Guideline Targets or measured background levels (whichever is higher) are exceeded for vibration-sensitive equipment during construction and operation at Parkville and CBD North stations.
<table><tr><th>Equipment requirements</th><th>Curve</th></tr><tr><td>Bench microscopes up to 100x magnification; laboratory robots</td><td>Operating Roo</td></tr><tr><td>Bench microscopes up to 400x magnification; optical and other precision balances; co-ordinate measuring machines; metrology laboratories; optical comparators; micro electronics manufacturing equipment; proximity and projection aligners, etc</td><td>VC-A</td></tr><tr><td>Microsurgery, eye surgery, neurosurgery; bench microscope at magnification greater than 400x; optical equipment on isolation tables; microelectronic manufacturing equipment such as inspection and lithography equipment (including steppers) to 3mm line widths</td><td>VC-B</td></tr><tr><td>Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance images; microelectronics manufacturing equipment such as lithography and inspection equipment to 1mm detail size</td><td>VC-C</td></tr><tr><td>Electron microscopes at magnification greater than 30,000x; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for phot-lithography with line widths of ½ micro m; includes electron beam systems</td><td>VC-D</td></tr><tr><td>Unisolated laser and optical research systems; microelectronics manufacturing equipment such as aligners, steppers and other critical equipment for photolithography with line widths of ¼ micro m; includes electron beam systems</td><td>VC-E</td></tr></table>Notes
1 The proponent may undertake consultation with the users and agree alternative Guideline Targets.</td><td>4 – Parkville station
5 – CBD North station</td><td>Construction / Operation</td><td>Micro and nano scale electron-microscopes at Melbourne University and RMIT University are required to operate continuously. We recommend reducing risk of disruption to experiments by providing secondary vibration isolation to the equipment.</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr>
<td>NV11</td>
<td><u>Ground-borne (internal) Noise Guideline Targets for Amenity</u>
Implement management actions as determined in consultation with potentially affected land owners to protect amenity at residences, sleeping areas in hospital wards, student accommodation and hotel rooms where the following ground-borne noise Guideline Targets (from the NSW Interim Construction Noise Guideline) are exceeded during construction.
<table>
<tr><th>Time Period</th><th>Internal $L_{Aeq,15min}$, dB</th></tr>
<tr><td>Evening, 6pm to 10pm</td><td>40</td></tr>
<tr><td>Night, 10pm to 7am</td><td>35</td></tr>
</table>
Notes
1 Levels are only applicable when ground-borne noise levels are higher than airborne noise levels.
2 The noise levels are assessed at the centre of the most affected habitable room.
3 Management actions include extensive community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances.</td>
<td>All</td>
<td>Construction</td>
<td>The proposed EPR conflicts with the NV1 which commits to manage construction noise in accordance with EPA Publication 1254 Noise Control Guidelines.

While EPA 1254 does not explicitly address ground-borne intrusion paths, the advice it provides in relation to night-time work and airborne intrusion paths is to achieve inaudibility within affected receiver locations. For context, ground-borne noise is generally considered more intrusive then airborne noise; this is evident from the lower targets that have been proposed for operational noise intrusion that is dominated by ground-borne noise. It therefore follows that for consistency with NV1 and EPA 1254, the intrusion targets for ground-borne construction noise at night should also be based on achieving inaudibility. If this cannot be practically achieved, alternative limits must be specified in terms of both the duration of the period of exposure as well as intrusion levels set at significantly lower thresholds than have been presently nominated.

In terms of the evening Guideline Targets, there is no direct advice in EPA 1254 with respect to internal noise levels. However, while the Guideline Targets for the evening are consistent with the alternative reference guidance in the NSW Interim Construction Noise Guidelines, prolonged construction noise exposure at an internal level of 40 dB L_{Aeq} represents a significant risk. Accordingly, ground-borne noise intrusion at the proposed evening level, if permitted, should be specifically restricted to limited periods (e.g. less than 1 week).</td>
</tr>
</table>

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
NV12	**Blasting** Comply with Australian Standard AS2187.2-2006, Explosives – Storage and use Part 2 – Use of explosives for all blasting For Highly Sensitive Areas, hospital wards, operating theatres and Bio-resources and areas with vibration-sensitive equipment which are not covered in AS2187.2-2006, develop a plan in consultation with facilities owners that: • Avoids damage to vibration-sensitive equipment • Minimises adverse impact on Highly Sensitive Areas and Bio-resources.	4 – Parkville station	Construction	No comment
NV13	To protect the amenity of Bio-resources and sensitive research during construction and operation, the following criteria apply: • Background noise should be kept below 50 dB and should be free of distinct tones (internal) • Short exposure should be kept to less than 85 dB (internal). **Notes** 1 The levels above should take into consideration the frequency threshold for the Bio-resource under consideration. 2 Higher levels may be acceptable if it can be shown that the Bio-resource under consideration is exposed to higher levels and is not adversely impacted by them.	4 – Parkville station 5 – CBD North station	Construction / operation	The proposed EPR is generally considered reasonably but should be clarified in terms of the measurement parameters and measurement durations that apply to background noise and short exposures, including citation of the relevant references for the selected thresholds.

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
NV14	Appoint an acoustic and vibration consultant to predict noise and vibration and determine appropriate mitigation to achieve the Environmental Performance Requirements. The acoustic and vibration consultant would also be required to undertake commissioning noise and vibration measurements to assess levels with respect to the Environmental Performance Requirements.	All	Operation	Acoustics and vibration consultant should be independent and not appointed by MMRP or the PPP contractor. The noise and vibration report shall be required to prepare all Construction and Operational Noise and Vibration Reports for review and approval by the Independent Auditor commissioned to review the predictions and proposed design mitigation measures. In contrast to the Governance Framework outlined in Chapter 23, the Independent Auditor should not be appointed jointly by the MMRA and PPP. It is recommended that the Independent Auditor should be selected and engaged by the Department of Economic Development, Jobs, Transport and Resources (DEDJTR), with costs borne by the MMRA and/or PPP contractor. The Independent Auditor should also be granted access to all materials required to conduct a complete review, including where necessary for sample verification work, access to modelling files, measurement data and supporting test documentation relied upon in the development of design mitigation measures.

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV15</td><td><u>Victorian Passenger Rail Infrastructure Noise Policy (PRINP)</u>
Avoid, minimise or mitigate rail noise where the following PRINP (April 2013) Investigation Thresholds are exceeded during operation:
<table>
<tr><th>Time</th><th>Type of Receiver</th><th>Investigation Thresholds</th></tr>
<tr><td>Day
(6am – 10pm)</td><td>• Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks
• Noise sensitive community buildings, including schools, kindergartens, libraries</td><td>65 dBL_{Aeq} and a change in 3 dB(A) or more
or
85 dBL_{Amax} and a change in 3 dB(A) or more</td></tr>
<tr><td>Night
(10pm – 6am)</td><td>• Residential dwellings and other buildings where people sleep including aged persons homes, hospitals, motels and caravan parks</td><td>60 dBL_{Aeq} and a change in 3 dB(A) or more
or
85 dBL_{Amax} and a change in 3 dB(A) or more</td></tr>
</table>
Notes
1 If an investigation shows that the thresholds are not exceeded, then no further action is considered under the PRINP.
2 L_{Amax}, is defined as maximum A-weighted sound pressure level and is the 95 percentile of the highest value of the A-weighed sound pressure level reached within the day or night.
3 For Melbourne Metro the location of assessment is at 1m from the centre of the window of the most exposed external façade.</td><td>All</td><td>Operation</td><td>The proposed performance targets are considered appropriate, based on PRINP, subject to the inclusion of the appropriate internal noise targets to address the locations near the Eastern Portal that the EES proposes would be addressed through offsite mitigation (retrospective facade insulation measures) rather than barriers.
Consistent with the EES proposed NV1, this EPR should also include requirements to document the proposed methods of achieving the targets.
Specifically, the findings of all detailed modelling and mitigation assessments during the design development shall be documented in an Operational Noise and Vibration Assessment Report.
The report shall be reviewed by the Independent Auditor (see separate MDA comments for NV14 concerning the establishment of an Independent Auditor). The report shall implement any recommendations arising from the review prior to being finalised.
An additional report shall be prepared documenting a proposed operational noise compliance monitoring plan, including details of monitoring locations and methodologies.
It is recommended that because of the sensitive nature of RMIT University and University of Melbourne lecture theatres and laboratories are treated as residential dwellings</td></tr>
<tr><td>NV16</td><td>For operation, comply with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1). This does not apply to trains and trams.</td><td>All</td><td>Design/ Operation</td><td>No Comment</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV17</td><td>
<u>Ground-borne Noise Guideline Targets for Operation</u>
Where operational ground-borne noise trigger levels are exceeded for sensitive occupancies as shown in the table below (trigger levels are based on the Rail Infrastructure Noise Guideline, 17 May 2013 (RING(1)), assess feasible and reasonable mitigation to reduce noise towards the relevant ground-borne noise trigger level.
<table>
<tr><th>Sensitive land use</th><th>Time of day</th><th>Internal noise trigger levels</th></tr>
<tr><td rowspan="2">Residential</td><td>Day
(7am-10pm)</td><td>40 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td></tr>
<tr><td>Night
(10pm-7am)</td><td>35 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td></tr>
<tr><td>Schools, educational institutions, places of worship</td><td>When in use</td><td>40-45 dBL_{ASmax} and an increase in existing rail noise level by 3 dB(A) or more</td></tr>
<tr><td>Hospitals(bed wards and operating theatres)</td><td>24 hours</td><td>35 dB(A) L_{ASMax}</td></tr>
<tr><td>Offices</td><td>When in use</td><td>45 dB(A) L_{ASMax}</td></tr>
<tr><td>Cinemas and Public Halls</td><td>When in use</td><td>30 dB(A) L_{ASMax}</td></tr>
<tr><td>Drama Theatres</td><td>When in use</td><td>25 dB(A) L_{ASMax}</td></tr>
<tr><td>Concert halls, Television and Sound Recording Studios</td><td>When in use</td><td>25 dB(A) L_{ASMax}</td></tr>
</table>
Notes
1 RING provides trigger levels for residential and schools, educational institutions and places of worship, but does not provide guidance on acceptable ground-borne noise levels for other types of sensitive receivers. Ground-borne noise trigger levels for other types of sensitive occupancies have been devised based on RING and industry knowledge.
2 Specified noise levels refer to noise from heavy or light rail transportation only (not ambient noise from other sources).
3 Assessment location is internal near to the centre of the most affected habitable room.
</td><td>All</td><td>Operation</td><td>As per MDA comments with respect to NV15, the findings of all detailed modelling and mitigation assessments during the design development shall be documented in an Operational Noise and Vibration Assessment Report. The purpose being to demonstrate how the completed project is proposed to adhere to the targets established in NV17.

The report shall be reviewed by the Independent Auditor (see separate MDA comments for NV14 concerning the establishment of an Independent Auditor). The report shall implement any recommendations arising from the review prior to being finalised.

An additional report shall be prepared documenting a proposed operational noise compliance monitoring plan, including details of monitoring locations and methodologies.</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td></td><td>4 L_{ASmax} refers to the maximum noise level not exceeded for 95% of the rail pass-by events.
5 For schools, educational institutions, places of worship the lower value of the range is most applicable where low internal noise levels is expected.
6 The values for performing arts spaces may need to be reassessed to address the specific requirements of a venue.</td><td></td><td></td><td></td></tr>
<tr><td>NV18</td><td><u>Vibration Guideline Targets for Operation</u>
During operation, achieve the Guideline Targets (based on Table 1 in BS6472-1:2008) or background levels (whichever is higher) for vibration as follows:
<table>
<tr><th rowspan="2">Location</th><th colspan="4">VDV (m/s$^{1.75}$)</th></tr>
<tr><th colspan="2">Day
7:00am to 10:00pm</th><th colspan="2">Night
10:00pm to 7:00am</th></tr>
<tr><th>Preferred Value</th><th>Maximum Value</th><th>Preferred Value</th><th>Maximum Value</th></tr>
<tr><td>Residences</td><td>0.20</td><td>0.40</td><td>0.10</td><td>0.20</td></tr>
<tr><td>Offices, schools, educational institutions, places of worship</td><td>0.40</td><td>0.80</td><td>0.40</td><td>0.80</td></tr>
<tr><td>Workshops</td><td>0.80</td><td>1.60</td><td>0.80</td><td>1.60</td></tr>
</table>
Notes
1 The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures.
2 Compliance with these values implies no structural damage due to operation.</td><td>All</td><td>Operation</td><td>As per MDA comments with respect to EPR numbers NV15 and NV17, the measures to achieve compliance with these targets should be documented in an Operational Noise and Vibration Compliance Report for review by the Independent Auditor.</td></tr>
<tr><td>NV19</td><td>Develop and implement a plan to manage the noise impact of trucks and other construction vehicles on public roads. The plan will assess the change in sleep distortable that will occur within the City of Melbourne and City of Stonnington due to night movements of spoil trucks and other construction vehicles. The effects of trucks and other construction vehicles on lecture theatres, research facilities and other sensitive areas associated with RMIT University and University of Melbourne should also be assessed</td><td>All</td><td>Construction</td><td>Additional EPR to cover noise impact assessment of truck noise impact during construction</td></tr>
</table>