REF: EV001 R01 2016322ML

Date: 12/08/16

IN THE MATTER OF	**Melbourne Metro EES Inquiry and Advisory committee Panel Hearing**
IN RELATION TO	**Melbourne Metro Rail Project**
AND REGARDING	**Noise and Vibration Impact Assessment (NVIA)**

STATEMENT OF EVIDENCE OF SIMON JAMES MCHUGH

1.0 INTRODUCTION

1.1 My name is SIMON JAMES MCHUGH. I am a Senior Consultant of Marshall Day Acoustics (MDA). My curriculum vitae is attached in Attachment 1. A summary of my recent experience and projects is enclosed as Attachment 2.

1.2 I have been engaged by The Domain Owners Corporation to provide a peer review and a corresponding Statement of Evidence and to present evidence at this Panel Hearing in relation to noise and vibration impacts detailed in the Melbourne Metro Rail Project EES.

1.3 I confirm that MDA has produced the attached Report No. 001 2016322 titled *"MMRP Panel, Noise & Vibration Impact Assessment, Peer Review"* dated 12 August 2016 and, as the author, I adopt the findings and contents of this report as evidence for submission to the Panel in support of the submission by The Domain Owners Corporation. This report is enclosed as Attachment 3.

1.4 In preparing this evidence, I have reviewed relevant documentation, performed a site inspection, reviewed acoustic or vibration calculations and relevant documents and directed other staff members to perform reviews and commentary on the acoustic and vibration modelling within the NVIA.

I have made all the enquiries that I believe are desirable and appropriate and confirm that no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Simon McHugh
Senior Consultant

Marshall Day Acoustics
6 Gipps Street
Collingwood Vic 3066

12 August 2016

ATTACHMENT 1 - SUMMARY OF EXPERIENCE AND PROJECT DETAILS

NAME AND ADDRESS

My name is SIMON JAMES MCHUGH. I am a Senior Consultant with the acoustic consulting practice of Marshall Day Acoustics Pty Ltd which is located at 6 Gipps Street, Collingwood, 3066.

QUALIFICATIONS AND EXPERTISE

I am a professionally qualified engineer who has specialised in acoustics since graduation with honours from Salford University, Manchester, United Kingdom in 2006. I have had extensive experience in preparing noise impact reports for residential developments, major industrial facilities, commercial and mixed use industrial developments, and major railway infrastructure developments including Thameslink and Crossrail (UK). My curriculum vitae are attached.

AREA OF EXPERTISE

For the past 10 years I have worked in the field of acoustics, noise and vibration measurement and control as a consultant.

EXPERTISE TO PREPARE THIS REPORT

I have been involved in environmental noise impact assessments for major projects such as new roads, public infrastructure and mixed use commercial developments, music and sports centres and smaller developments such as residential estates, service stations, convenience stores, manual carwash developments, childcare centres, restaurants, wineries, pubs and night clubs.

INSTRUCTIONS WHICH DEFINED THE SCOPE OF THIS REPORT

I have been engaged by The Domain Owners Corporation to provide a peer review of the acoustic report prepared for the MMRP EES, reference MMR-AJM-PWAA-RP NN-00820 dated 20 April, 2016.

I have also been asked to comment on the suitability of the nominated criteria used in the NVIA and issues of concern with the report and in particular impacts upon The Domain residents (Precinct 7).

I confirm that I have no other association with the applicant other than as a professional consultant.

FACTS, MATTERS AND ASSUMPTIONS RELIED UPON

In the course of my investigations I have:

- Reviewed relevant documentation and reports
- Visited the site
- Reviewed acoustic and vibration calculations
- Reviewed proposed modelling or predictive methodologies
- Prepare a peer review with a general overview of the NVIA as an Appendix
- Provided additional comments on the project Environmental Performance Requirement.

DOCUMENTS TAKEN INTO ACCOUNT

The following documents have been taken into account:

1. The Domain MMRP, EES and related matters submission dated 28 June 2016
2. EES Chapter 13: *Noise and Vibration* (the *noise and vibration chapter*)
3. 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 (the NVIA *report*)
4. EES Appendix I: Technical Appendices A-G (the *technical appendices*)
5. Victorian Passenger Rail Infrastructure Noise Policy (PRING)
6. *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1)*
7. *EPA publication 1254 - Noise Control Guidelines*
8. Melbourne City Council: "*Noise and Vibration Management Guidelines*"
9. NSW Transport for NSW (TfNSW) Construction Noise Strategy 7TP-ST-157/2.0
10. NSW Guideline "*Assessing Vibration*" (2006)
11. NSW Rail Infrastructure Noise Guidelines (RING)
12. BS 6472.1:2008 "*Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*"
13. FTA Handbook "*Transit Noise and Vibration Impact Assessment"*
14. ISO 10137: 2007 "*Basis for design of Structures: Serviceability of buildings and walkways against vibration*

IDENTITY OF PERSONS UNDERTAKING THIS WORK

I prepared this report with the assistance of the following staff at Marshall Day Acoustics:

Staff member	Title	Tasks
Tim Marks	Associate Director	Data analysis, report review and vibration assessment
Peter Fearnside	Principal	Strategic review
Ross Leo	Associate	Discussion, review and commentary

SUMMARY OF OPINIONS

A summary of opinions is provided in Section 5.0 of the MDA report attached to this statement.

ATTACHMENT 2 - CURRICULUM VITAE – SIMON JAMES MCHUGH

SIMON JAMES MCHUGH
Senior Consultant, Marshall Day Acoustics, Melbourne, Australia

Bachelor of Science (Honours) Acoustics, Salford University, Manchester, UK

Membership

Member of the Institute of Acoustics, UK (MIOA)

Recent Work

- Exxon Mobil, Longford gas plant extension, noise modelling
- American Hotel, Echuca, music and patron noise modelling and mitigation
- 699 Bourke Street, mechanical services
- Kangaroo Flat Leisure Centre, internal finishes design
- Crossrail, London, environmental statement and construction noise monitoring
- Thameslink Programme, London, acoustic design advice

Project Experience

Simon is a professionally qualified acoustician who has worked continuously in acoustic consulting since 2006. Simon has extensive experience in acoustics for major infrastructure projects having provided detailed acoustic advice on both Crossrail, as consultant to the design and construction team at Whitechapel Station and Thameslink Programme, as a full time employee.

These two projects represent the largest railway infrastructure developments currently underway in Europe.

Since arriving in Melbourne in mid-2012, Simon has been involved in a range of projects including noise modelling for major industrial facilities and acoustics for large mixed use developments.

Employment

2014 - Current	Senior Consultant, Marshall Day Acoustics, Melbourne, Australia
2013 - 2014	Consultant, Marshall Day Acoustics, Melbourne, Australia
2012 - 2013	Consultant, Vipac Engineers and Scientists, Melbourne, Australia
2008 - 2012	Consultant, Anderson Acoustics, Brighton, UK
2006 - 2008	Acoustic Design Engineer, Network Rail, Thameslink Programme, London, UK

ATTACHMENT 3 - REPORT NO RP001 2016322ML

MARSHALL DAY Acoustics

MMRP PRECINCT 7: THE DOMAIN NOISE AND VIBRATION IMPACT ASSESSMENT PEER REVIEW

Rp 001 01Draft 05Di 2016322ML | 12 August 2016

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Project: **MMRP PRECINCT 7 : THE DOMAIN BUILDING**

Prepared for: **The Domain Owners Corporation**
1 Albert Road
Melbourne VIC 3004
AUSTRALIA

Attention: **Mr Fraser Read Smith**

Report No.: **Rp 001 01 2016322ML**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
	01	DRAFT FOR REVIEW	09/8/16	S McHugh	T Marks
	00	Final issue	11/8/16	T Marks	P Fearnside

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 Domain Owners Corporation. Key site wide issues identified by MDA in the review are discussed in Section 3.0 of the report. Specific issues relevant to The Domain apartment building at the corner of St Kida Road and Albert Road, Melbourne are discussed in Section 4.0 of the report.

The report includes recommendations to protect the amenity of residents in The Domain apartments close to The Domain Station construction site. It also provides suggested additional controls (Environmental Performance Requirements, EPR's) that should be considered at the EES Inquiry and Advisory Committee Panel Hearing.

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.

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 peer review of the noise and vibration elements 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 peer review documented in this report was commissioned by The Domain Owners Corporation in order to:

- Assist The Domain Owners Corporation to reach an informed view on the findings of the technical 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 Corporation.

This peer 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 provided separately within this report as Appendices covering:

- 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 by completed operations.

Specific issues of relevance to The Domain building are provided in Section 4.0. These relate primarily to the impact of construction noise.

This 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 Environmental Performance Requirements (EPRs) of the Environmental Management Plan for the MMRP.

2.0 SCOPE OF STUDY

MDA were given the following scope of work:

The Domain Owners Corporation is seeking to commission an expert consultant to review the EES documentation and to establish, whether:

- *The noise and vibration guidelines proposed for the project (and The Domain Station in particular) in respect of both its construction and operation are soundly based and are consistent with achieving acceptable levels of community amenity – given the close proximity of The Domain to this site;*
- *The proposed mitigation measures to be adopted are likely to keep noise levels both during the construction and operational phases of the project to reasonably tolerable levels and to make recommendations on how any deficiencies in the EES in these respects should be overcome.*

MDA has conducted 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 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 NVIA)
- 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* within this peer review.

The peer review considers general matters relating to the noise and vibration impact assessment, which are discussed in Section 3.0 and in Appendices A-D. In addition, matters that are specific to the potential noise and vibration impacts on The Domain Building, located at 1 Albert Road 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 did not involve any site investigations, measurements or verification modelling.

3.0 PEER REVIEW OF NOISE IMPACT ASSESMENT

The controls over noise and vibration for the construction and operation of the MMRP will be defined within the EPRs that will form the criteria that nominate the amenity and objectives to minimise the project impacts.

The discussion within the Appendices attached to this report indicates the following:

- Controls over construction noise, particularly during daytime, weekend and during so called 'Unavoidable' works are inadequate. 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
- The assessment of construction vibration is incomplete and does not adequately consider sensitive buildings, residences and critical equipment and risk. Uncertainty 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 and other than at the portals, because 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 can result in a satisfactory amenity for affected residents.
- In our view, operational vibration has not been satisfactorily assessed. Further investigations are required to establish the expected vibration levels with affected residences. Uncertainty over the train source vibration, ground coupling effects and vibration propagation 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 and receivers 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.

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 ISSUES RELEVANT TO DOMAIN

4.1 Airborne construction noise criteria

The guidance within EPA 1254 does not include any consideration of duration or level of exposure during normal working hours. Statements of compliance with EPA 1254 throughout the EES documentation therefore do not equate to noise being restricted to particular levels, or the duration of noise exposure being restricted to defined periods. This is one of the key limitations with respect to an assessment which refers to compliance with EPA 1254 alone, hence our stated preference for the MCC or NSW guidelines to be used.

4.2 Construction noise and vibration

The construction noise assessment has only been carried out at 1.5 m above ground, or at ground floor level; yet there are several multi storey dwellings including Domain with direct line of sight to the works which, like Domain, will not benefit significantly from the proposed barrier mitigation measures.

As The Domain is a multi-storey residential building, any noise barriers even at 6m high will have limited effect in terms of noise exposure to the majority of the building, i.e. those on the third floor and above.

The investigation of construction noise and vibration around the Precinct appears rather selective, and appears to have not identified the worst affected residential buildings.

We consider the construction noise impact at dwellings in the vicinity of The Domain Station are potentially severe and for the reasons detailed in Appendix A have been significantly understated.

These observations also suggest that the details of all identified receivers are incomplete. 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.

4.3 Road traffic noise

Daytime traffic flows on St Kilda Road, a major arterial road (6 lanes at present and 2 lanes during project construction), could be significantly reduced during construction. The same could be true for Albert Road and Domain Road which will both be closed at The Domain Interchange. It follows therefore that ambient noise levels, immediately prior to the commencement of works (i.e. after the work site has been established but before work commences), could also be lower and therefore an assessment using noise measurements performed at this interim stage would provide a more robust basis for assessment than has been undertaken in the EES.

Truck routes are proposed on Page 69 of the NVIA which states:

"Construction vehicles servicing The Domain station precinct are proposed to use Park Street, Albert Road, Domain Road and Birdwood Avenue before accessing an arterial road. […] The roads are heavily used so the impact of the construction vehicles is not expected to be significant during the day, although impacts are expected to be increased at night when ambient noise levels are lower"

Clarification with respect to truck stabling locations should be provided as previous experience has shown that trucks parked outside residences with engines idling are likely to cause adverse reactions. It is recommended that a statement to the effect that this should be included in the EPRs.

4.4 Construction noise mitigation

For mitigation purposes, 6 m barriers are proposed around the Domain Station site, however their viability and effectiveness have not been addressed in sufficient depth or detail. Issues such as wind loads, pedestrian access and flexibility and all of which affect the practicality of such treatments have not been addressed. Further, reflections and reverberant build-up between barriers can lead to increased levels in urban areas which may require absorptive faced barriers to resolve.

In addition we estimate that engineering and construction issues associated with the barriers, including buildability, will be significant as, based on previous experience, concrete footings, steel supports and barriers built from 100mm concrete wall panels will be required.

4.5 Domain external glazing

A statement in Paragraph 2 on page 70 of the NVIA says The Domain is "a busy urban location and some of the sensitive buildings may have been designed to mitigate noise ingress."

In the process of conversion of BP House into an apartment building, the original facade and glazing at The Domain was retained in response to the building's age and historic status. New apertures were created to allow for sliding doors and casement windows to suit apartment living on all levels.

The façade glazing and framing is typical of the era, consisting of anodised aluminium framing with a split mullion section with a transom within a head and sill assembly. The new apertures for the apartments' sliding doors and casement windows were created by the removal of glazed sections and the fixing of either operable frames within the opening or the fixing of sliding tracks to the frame for the new sliding doors. The original bronze tinted 6 mm plate glass was retained where possible, except for new apertures and or where safety glass was required.

The facade also suffers from a lack of an effective noise isolation barrier above the head section. The adjacent soffit treatment consists solely of a 6mm fibrous cement sheet lining.

As a result, the facade of The Domain is unlikely to provide a high level of noise attenuation, making effective mitigation of construction noise problematical without major upgrades.

4.6 Impact assessment

Floor plans of the building indicate there are numerous apartments on all floors that have bedroom windows directly overlooking The Domain Station work site.

Table 6.1 of the NVIA presents a risk assessment with respect to impacts at Domain due to the Project. Risk No. NV001 is concerned with airborne construction noise and states that the Initial risk of "noise events exceeding the relevant criteria" is medium. The nominated Likelihood rating is nominated as being "Almost Certain" (defined in Table 4-1) whilst the Consequence of such is given as being "Minor" (defined in Table 4-3). The Residual risk is nominated as being "Low".

These comments show a serious disconnect, given the statement made in Section A.5.7 with respect to predicted construction noise levels which says "construction noise levels would generally be similar to baseline average noise levels at sensitive receivers" (64 dB L_{Aeq} from Figure F14) and in Figures A.35 and A.36. In each figure, the unmitigated level, which is indicative of the likely noise level at residences with line of sight over the proposed barriers, is within the <70 dB contour.

The reactive response that is proposed throughout the NVIA (i.e. action only in response to adverse comment from residents) is not acceptable. Following the detailed assessment for each precinct and at least 6 months prior to construction commencing, mitigation should be offered and actioned in advance of the commencement of works to avoid delays in implementation.

4.7 Construction equipment

Sound power data and details of equipment numbers will potentially have a significant impact on the final construction noise level predictions, highlighting the uncertainty associated with the noise contour maps in the technical appendices. In our view and as discussed in Appendix A, the sound level of many construction sources have been significantly understated.

The position of the major construction equipment sources in Figures A.35 and A.36 are not worst case in terms of the impact on The Domain. It is acknowledged that plant and equipment will move around depending upon the area being constructed and as work tasks require. Notwithstanding this, it is possible that noise levels could be significantly higher than the pre-construction ambient level, particularly at mid-levels of The Domain.

Table 4.7 on page 38 of the NVIA details the sound power level for desanding plant (111 dB Lw). The desander is used to process the bentonite removed from the diaphragm wall panel excavation. The process is continuous and could be required to operate 24/7 during some periods. Figures A.35 and A.36 show this equipment located at approximately 30-50m from The Domain building. A high level calculation of noise at the nearest residential dwellings with line of sight over the proposed noise barriers, due to this unit, is of the order of 60-65 dB L_{Aeq}. This compares to the measured night-time background level at the building of 47 dB L_{A90}. It is likely therefore that the desander will be clearly audible at The Domain building and given that the D-wall process is scheduled to take at least 8 months, arguably be defined as 'fixed plant' under the terms of SEPP N-1.

If the desander is to be inaudible within The Domain building at night (per EPA 1254) then MDA asserts, in accordance with the calculation method outlined in Section A2.3, that the maximum allowable noise level from this plant is 37 dB L_{Aeq}. This is because a design target of 10 dB below the ambient level is not a satisfactory definition of inaudibility, and 10 dB below background is more commonly accepted method to define inaudibility.

Maximum noise levels from the desander and other equipment to be used at the Domain Station construction site could be as high as 70-75dB L_{Amax} or more, with the potential to cause significant sleep disturbance for occupants. Sleep disturbance is a major issue with construction at night and has not been adequately addressed in the NVIA.

5.0 RECOMMENDATIONS

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.

The key points in relation to the recommended changes to the EPR's are summarised here for ease of reference:

- Quantitative criteria are required for control of construction noise during daytime hours
- A requirement to consider opportunities to reduce exposure to periods of the highest construction noise levels
- A requirement to nominate and monitor the duration of key construction periods to avoid unnecessary prolongation of exposure to the highest noise levels
- A requirement to prepare detailed Noise and Vibration Assessment Reports for both the construction and operational phases of the project, including details of proposed monitoring arrangements, which must be reviewed by the Independent Auditor
- Changes to ERP NV3 so that the communications plan is developed in consultation with City of Melbourne, City of Stonnington and the EPA Victoria.
- An additional PR NV19 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 due to movements of spoil trucks and other construction vehicles at night and from stationary idling vehicles
- Consideration of double glazing or other suitable forms of façade insulation for affected residents likely to be exposed to construction noise levels above the nominated threshold and duration limit

- Developing a criteria for construction noise impact that triggers compensation for residents in the form of mitigation measures for residences exposed to daytime noise up to 75 dB $L_{Aeq, 1Hr,}$ or night time noise in excess of 65 dB $L_{Aeq,. 1hr}$
- Construction noise criteria and thresholds should also be developed for commercial users including offices, hospitals and research and educational institutions.
- Detailed site testing of vibration generated by construction equipment to be used along with studies of ground vibration propagation in the soils around each construction site
- Conduct a more comprehensive operational rail vibration asesssment using more sophisticated analysis techniques along with studies of line source ground vibration propagation along the alignment
- Provision of 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
- Inclusion of a requirement to establish an Independent Auditor, as referenced in the discussion of the Governance Framework in the EES. However, in contrast to the EES proposal, it is recommended that the Independent Auditor is not jointly appointed by the MMRA and PPP

APPENDIX A 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 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 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 (LAeq) measurement results rather than background noise levels (LA90). 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 Guideline 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 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, owing to their nature an duration, can significantly differ from the types of projects envisaged when preparing the EPA 1254 construction guideline. 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 L_{Amax} 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 Guideline 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 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 17 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 be 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 are clarified. This would be a prudent inclusion in any additional 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 NVIA provides 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 propagation 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 consequence 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 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 other 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.
- The investigation of construction noise and vibration around some Precincts appears rather selective, and has not identified the worst affected dwellings
- These observations 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 acknowledge 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.

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.

B2.3 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 recommendedTiming & Duration

- 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.
- The

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 C.6 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 fo 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 underpredicted 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 mae 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 also.

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 consisten twiht industry practice.

In relation t 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 sesnistive 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.	All	Construction	
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	

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV3</td><td>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 a soon as possible.</td><td>All</td><td>Construction</td><td></td></tr>
<tr><td>NV4</td><td>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.</td><td>All</td><td>Construction</td><td></td></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></table></td><td>All</td><td>Construction</td><td></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 horizontal plane of highest floor at 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 Component 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 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></td><td>Long-term vibration on structures
<table><tr><th>Type of Structure</th><th>Vibration Velocity, mm/s (Peak Component Particle Velocity) in horizontal plane at all frequencies</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></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></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 Room</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></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></td></tr>
<tr><td>NV12</td><td><u>Blasting</u>
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.</td><td>4 – Parkville station</td><td>Construction</td><td></td></tr>
</table>

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA 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	
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	

<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></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></td></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</td><td>All</td><td>Operation</td><td></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>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).</td><td></td><td></td><td></td></tr>
<tr><td></td><td>3 Assessment location is internal near to the centre of the most affected habitable room.
4 L_{ASmax} refers to the maximum noise level not exceeded for 95% of the rail pass-by events.</td><td></td><td></td><td></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>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></td></tr>
</table>