REF: EV001 2016325ML

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 ROSS CAMERON LEO

1.0 INTRODUCTION

1.1 My name is ROSS CAMERON LEO. I am an Associate 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 Melbourne Anglican Trust 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 2016325 titled *"MMRP Panel, Noise & Vibration Impact Assessment, Peer Review"* dated 11 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 Melbourne Anglican Trust 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.

Ross Leo
Associate

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 ROSS CAMERON LEO. I am an Associate 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 scientist who has specialised in acoustics since graduation from Royal Melbourne Institute of Technology in 2000. I have had extensive experience in preparing noise impact reports for residential developments, major industrial facilities, commercial and mixed use industrial developments, and major infrastructure developments. My curriculum vitae is attached.

AREA OF EXPERTISE

I am a professionally qualified scientist who has specialised in acoustics since graduation from Royal Melbourne Institute of Technology in 2000. I have had extensive experience in preparing noise impact reports for residential developments, major industrial facilities, commercial and mixed use industrial developments, and major infrastructure developments. My curriculum vitae is attached.

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, sporting venues, convenience stores, carwash developments, childcare centres, restaurants, pubs and night clubs.

INSTRUCTIONS WHICH DEFINED THE SCOPE OF THIS REPORT

I have been engaged by the Melbourne Anglican Trust Corporation to provide a peer review of the acoustic report prepared for the MMRP EES, reference MMR-AJM-PWAA-RP NN-000820 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 St Paul's Cathedral.

FACTS, MATTERS AND ASSUMPTIONS RELIED UPON

In the course of my investigations I have:

- Reviewed relevant documentation and reports
- Visited the site
- 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. MMRP EES St Paul's Cathedral Submission dated July 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	Discussion, review and commentary
Justin Adcock	Associate	Discussion, review and commentary
Simon McHugh	Senior Consultant	Data analysis and report review
Peter Fearnside	Principal	Strategic review

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 – ROSS CAMERON LEO

ROSS CAMERON LEO
Associate, Marshall Day Acoustics, Melbourne, Australia

Bachelor of Science (Applied Physics), Royal Melbourne Institute of Technology

Membership

Member of the Australian Acoustical Society, (MAAS)

Recent Work

- East West Link – Comprehensive Impact Statement
- Dandenong Road, Carnegie – Rail noise and vibration assessment
- 72-76 Serrel St, Malvern East – Master Planning Assessment
- Morwell West Development Plan – Reverse Amenity Noise Assessment.

Project Experience

Ross graduated from the Royal Melbourne Institute of Technology with a Bachelor of Applied Science (Applied Physics) in 2000. Upon graduation Ross joined the MDA Melbourne team where he has developed extensive experience in room acoustics as well as all aspects of building acoustics, noise control and environmental noise assessment and control. In 2004 Ross moved to the Sydney office, which he successfully managed for three years before heading to Bahrain in 2009 to establish MDA's office in the Middle-East.

Ross returned to the Melbourne office in 2011 and works primarily in environmental acoustics, including preparation of expert evidence.

Employment

2012 - Present	Associate, Marshall Day Acoustics, Melbourne
2009 - 2012	Middle East Manager, Marshall Day Acoustics, Kingdom of Bahrain
2007 - 2009	NSW Manager, Marshall Day Acoustics, Sydney
2004 - 2007	Senior Consultant, Marshall Day Acoustics, Sydney
2001 – 2004	Consultant, Marshall Day Acoustics, Melbourne

ATTACHMENT 3 - REPORT NO RP001 R01 2016325ML

MARSHALL DAY Acoustics

MMRP PANEL ST PAUL'S CATHEDRAL
NOISE AND VIBRATION ASSESSMENT REVIEW

Rp 001 R01 2016325ML | 12 August 2016

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Project: **MMRP PANEL ST PAUL'S CATHEDRAL**

NOISE AND VIBRATION ASSESSMENT REVIEW

Prepared for: **Melbourne Anglican Trust Corporation**
209 Flinders Lane
Melbourne 3000

Attention: **Reverend Doctor Andreas Loewe**

Report No.: **Rp 001 R01 2016325ML**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft			10 Aug 2016	R. Leo	J. Adcock
Final	00		11 Aug 2016	R. Leo	T. Marks
Final	01	With change	12 Aug 2016	T. Marks	D. Griffin

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 Melbourne Anglican Trust Corporation in order to:

- Assist the Melbourne Anglican Trust Corporation 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 Melbourne Anglican Trust Corporation.

This peer review report 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 construction of the project construction
- Vibration and ground-borne noise generated by construction of the project construction
- Airborne noise generated by operation of the completed operation
- Vibration and ground-borne noise generated by operation of the completed operations.

The report includes recommendations from the peer review, including matters that are considered to warrant further technical assessment and environmental controls that should be included in the Environmental Performance Requirements (EPRs) of the Environmental Management Plan for the MMRP.

2.0 SCOPE OF STUDY

The scope of the study instructed by Melbourne Anglican Trust Corporation was to conduct a peer review of the following documentation presented in the EES for the MMRP:

- EES Chapter 13: *Noise and Vibration* (subsequently referred to herein as the *noise and vibration chapter*)
- EES 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 Chapter 23: Environmental Management Framework (subsequently referred to herein as the *environmental management chapter*)
- 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 St Paul's Cathedral 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 ASSESSMENT

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 and weekend 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 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
- The assessment of construction vibration is incomplete and does not adequately consider St Paul's Cathedral. Uncertainty associated with the source strength, vibration propagation and the site geology could have a significant impact on the vibration experienced at St Paul's Cathedral
- In our view, operational vibration has not been satisfactorily assessed. Further investigations are required to establish the expected vibration levels at St Paul's Cathedral. 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 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 THE ST PAUL'S CATHEDRAL

This section presents the key findings of the peer review with respect to noise and vibration generated by construction and operation of the project as it affects St Paul's Cathedral.

4.1 Construction noise

Considerable above ground demolition and construction will take place within close proximity of St Paul's Cathedral.

4.1.1 Criteria

The EES recommends EPA Noise Control Guidelines Publication 1254 Section 2 Construction and Demolition Site Noise. The City of Melbourne *Noise and Vibration Management Guidelines* are considered more appropriate because they detail limits for standard hours (7am to 7pm Monday to Friday and 8am to 3pm Sundays) as well as the evening and night period and also provides construction action levels for non-residential receivers.

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

Table 1: City of Melbourne N&VMG Noise Sensitive Zones

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

The N&VMG do not specifically reference Cathedrals, however, considering that the Australian/New Zealand Standard AS/NZS 2107:2000 *"Acoustics - Recommended design sound levels and reverberation times for building interiors"* (AS2107) recommended design sound levels are lower for Places of Worship than teaching spaces, it could be inferred that St Paul's Cathedral would be considered a Zone 2 land use. It should also be noted that the vibration human comfort criteria is the same for schools and places of worship.

The N&VMG DSLs and related actions for high impact projects are outlined in Table 2.

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

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

Table 3 provides the DSL Zone 2 action levels for construction noise.

Table 3: DSL Zone 2 action levels

Works and hours	Background noise level, L_{A90} [1]	DSL Zone 2 Action Level, L_{Aeq}
7am to 7pm Monday to Fri; 8am to 3pm Saturday	60	70
7pm to 10pm Monday to Friday; 3pm to 10pm Saturdays 9am to 6pm Sundays & public holidays	61	66
10pm to 7am Monday to Friday; 10pm to 8am Friday/Saturday; 6pm to 9am Saturday/Sunday & around public holidays	56	61

[1] based on day, evening and night backgrounds provided in Table 12-1 of the NVIA

It is recommended that the action levels outlined Table 3 be incorporated into the EPRs for construction noise management at CBD South Station.

4.1.2 Equipment sound power levels

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, many construction source noise levels have been significantly understated.

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

4.1.3 Truck routes

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

> *"Construction trucks servicing the CBD South station precinct are proposed to use Collins Street, Flinders Lane, Flinders Street, Exhibition Street and Queens Street. These streets mostly have commercial buildings however, there are some sensitive receivers. As they are already heavily used roads, the impact of the construction vehicles would not be expected to be significant during the day period, although increased at night when ambient noise levels are lower. As it is a busy urban location, some sensitive buildings may have been designed to mitigate noise ingress."*

Confirmation is sought with respect to truck stabling locations, as previous project experience has shown that trucks parked outside noise sensitive buildings with engines idling is likely to cause adverse reaction and it is recommended that a statement to the effect that this should be avoided, be included in the EPR.

It should be noted that, as a 125 year old building, St Paul's Cathedral has not been designed to mitigate noise ingress and given the sensitive nature of its uses, special consideration should be made to protect this building.

4.1.4 Response to adverse comment in relation to construction noise

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 of construction noise at St Paul's Cathedral and at least 6 months in advance of construction commencing, mitigation should be offered and actioned to allow for any delays in implementation.

4.1.5 Noise modelling

The NVIA has identified St Paul's Cathedral as a noise sensitive receiver, however, 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, such as St Paul's Cathedral, which may be more sensitive to construction occurring during day time hours, particularly day and evening services
- The noise modelling and mitigation assessment has been carried out for receiver heights of 1.5 m above ground level. However, for St Paul's Cathedral, the 1.5 m calculation height is not representative of the most significant noise ingress path.

4.2 Construction vibration

With regard to constructional vibration damage to heritage building Page 48 of the NVIA states:

> *Vibration and ground settlement affecting the fabric of heritage buildings – There would be potential impacts on the fabric of heritage places as a result of vibration and/or ground settlement in proximity to construction works. These impacts would be modelled and managed throughout the project's construction phase.*

The issue of ground vibration and its effect on geological conditions are best considered by a specialist geotechnical consultant who has a full understanding of soil movement around St Paul's Cathedral.

Given that the predicted PPV from large rock breakers at distances of 5-10 m are up to 5-12 mm/s, the risk of damage to St Paul's Cathedral due to construction at CBD South Station at these severities is high.

The equipment used for the construction of the underground connection between the CBD South Precinct platform and Federation Square does not appear to be considered in the assessment of risk to St Paul's Cathedral.

It is expected that a geotechnical survey and building damage assessment of St Paul's Cathedral should be conducted to investigate risk of building damage from construction vibration and foundation settlement.

The following factors should be considered in the assessment of building damage due to constructional vibration:

- the fact the building is of bluestone and limestone construction and has no slab foundation. The flooring tiles are laid directly on to rammed earth and would be particularly susceptible to settlement or ground borne vibration
- the effect of ground vibration on the stained glass windows
- the effect of ground vibration on the pipe organ.

4.3 Operational vibration and structure-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 criteria are considered reasonable and consistent with industry practice.

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.

5.0 RECOMMENDATIONS

The following summarises our recommendations in relation to noise and vibrational impact on St Paul's Cathedral from MMRP:

- Construction noise action levels for St Paul's Cathedral as outlined Table 3 be incorporated into the environmental performance requirements/ construction noise management plan for the CBD South Station
- A geotechnical survey and building damage assessment of St Paul's Cathedral should be conducted to investigate risk of building damage from construction vibration and foundation settlement. The assessment of building damage risk to St Paul's Cathedral should consider the underground connection between the CBD South Precinct platform and Federation Square. The building damage assessment should consider the stone building construction, the stained glass and the pipe organ
- A truck management plan should be prepared with consideration of truck controls to minimise disturbance especially from stationary idling vehicles
- Based on the NSW Interim Construction Noise Guidelines, threshold criteria for construction related ground borne noise of 45 dB $L_{Aeq,15m}$ be applied at St Paul's Cathedral
- The NVIA construction assessment should be updated to reflect the sound power levels for equipment detailed in BS 5228:2009 and AS 2436:2010.

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 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.

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 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-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, places of worship 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 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. 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
- 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.

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 CBD South Station, 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 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 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 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 NVIA and bullet 3 of page 1 of Technical Appendix A, 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 only 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 range of 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 is to specifically address the subject of night activities, a classification 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 NVIA 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 subsequent Environmental Performance Requirements for the project.

A2.3 Programme & Duration

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

Given the extended time period of the project and the high risk of prolonged periods of elevated 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, accounting for all construction activities and vehicle movements for which there is a foreseeable risk of extended operations
- The expected timing of key construction activities and the location where they are expected to occur
- The magnitude of the noise levels likely to occur sensitive times, 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.

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 NVIA has identified St Paul's Cathedral as a noise sensitive receiver, however, 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 St Paul's Cathedral
- The noise modelling and mitigation assessment has been carried out for receiver heights of 1.5 m above ground level. However, for St Paul's Cathedral, the 1.5 m calculation height is not representative of the most significant noise ingress path

A5 Mitigation Measures

The following 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). Following the detailed assessment of construction noise at St Paul's Cathedral and prior to construction commencing, mitigation should be offered and actioned at least 6 months in advance of the commencement of works to allow for any delays in implementation.
- 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
- 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

A6 Environment Effects Assessment

The Executive Summary to the NVIA discusses benefits and opportunities, including measures which could reduce construction noise impacts. It is unclear if treatment options have been considered or not.

The EES documentation does not provide an introductory discussion on the impacts of noise and its effect on health at work or during service or communication. A full understanding of the 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 and impacts to normal functions of the Cathedral and associated offices.

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 mention construction vibration which can involve activities characterised by time varying and impulsive vibrations that the standard cautions against using the eVDV for

  This is particularly relevant since the NVIA makes various assumptions regarding the crest factor of the vibration construction equipment to be used to enable results to be presented in the form of eVDV. These assumptions introduce a risk because the VDV estimates will change significantly with any changes in this factor. 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, derivation of the eVDV requires detailed knowledge of the event type, vibration spectra, duration and number of each event, which cannot be reliably accounted for in a prediction, thus introducing additional sources of uncertainty
- It would be prudent for further analysis to be conducted using RMS metrics for human comfort
- Based 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)*

- It is recommended that a threshold criteria for construction related ground borne noise of 45 dB $L_{Aeq,15m}$ apply at St Paul's Cathedral based on the NSW Interim Construction Noise Guidelines (ICNG) is consistent with other authoritative guidelines and also considered to be reasonable.

B2 Construction Activities

B2.1 Tunnelling Equipment

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

the prediction models used in the NVIA, particularly given the lack of clarity over the TBM and road header vibration emission data.

B2.2 Additional Construction Equipment

- Vibration levels presented in Table 4-8 of the NVIA for additional construction works are not referenced. Whist they may be valid they should be cross checked or validated against known references.
- A review of selected vibration data presented in BS 5228 indicates the levels provided in Table 4-8 lie below that usually experienced for piling operations. Data for other vibration sources are comparable with the 2006 NSW guideline and hence are plausible. However given the dependence of vibration on ground type the validation of the source data proposed to be used in the field is recommended

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 method used to convert from vibration to ground borne noise for the construction and operational scenarios is not consistent. This process is well known and it is considered that the use of rough approximations which are not in agreement is inadequate, and the methodology needs revision

B4 Environmental Effects Assessment

Subject to the technical issues noted in the preceding sections, the overall methodology for assessing construction vibration is generally appropriate and we would expect that construction vibration can be practically managed in most instances. 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 FIXED INFRASTRUCTURE

C1 Criteria

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 to residential receivers.

There is no fixed infrastructure criteria established within the NVIA for noise at St Paul's Cathedral, however, given compliance with SEPP N-1 is mandatory at nearby residential properties we do not consider airborne noise from fixed infrastructure to be a significant risk

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.

When assessing rail vibration using ISO 10137:2008 a range of vibration curves (VC) applicable to assessment for different uses. For example VC 1.4 for residential uses at night, VC 2 for daytime residential use and VC 4 for commercial uses. This is consistent with the ASHRAE VC criteria used for assessment of sensitive equipment at affected sites in the NVIA.

The use of vibration curves 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 of the absolute vibration levels be conducted 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 (RING). The criteria are 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 criteria are considered reasonable and consistent with industry practice.

In relation to other sensitive spaces, where 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 NVIA had 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 provided necessary corrections are implemented but further 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 the 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 field 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 train 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 MMRP alignment. The calculation procedure appears to have determined maximum levels but these have not been presented as discussed. It is recommended that the maximum vibration levels be presented against the ISO 10137 criteria as described previously.

D4 Mitigation Measures

The NVIA considers three alternative grades of attenuation 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 with regard to the proposed track borne isolation system and provide details of actual performance of such systems and include these results within the prediction methodology. Specifically, during the detailed design phase measurement data should be obtained to verify the performance of any proposed isolation systems prior to their selection.

D5 Environmental Effects Assessment

The assessment of ground borne noise and vibration due to Metro operations 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 ultimately 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 grade of track bed isolation to portions of the alignment and recommend that very high performance track bed isolation (Floating track slab) be used throughout the entire tunnel length, except through parkland or non-sensitive areas.

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	EPA 1254 does not include criteria for work during normal hours, nor does it establish any obligation to investigate or implement working methods which could significantly shorten the periods of exposure to the highest noise levels. The construction plan should nominate day time noise levels that can be practically adhered to, and that will be referenced as action levels when monitoring of daytime construction noise is required. The selection of day time noise levels for this purpose should consider the City of Melbourne Noise & Vibration Management Guidelines and the NSW Interim Construction Noise Guideline. The construction plan should also define: • the working periods for key activities that will result in high noise exposure, the measures that have been adopted to limit the duration of these periods, and how working periods will be monitored to avoid unnecessary prolongation of exposure to high noise levels • the measures that will be adopted for the control of impacts related to offsite construction vehicle movements, particularly during the night at site access and departure points in the vicinity of sensitive locations • a clear framework for the implementation of any off-site mitigation measures proposed, prior to commencement of the construction activity in question. This shall included details of consultations and investigations with the affected locations, and verification of the feasibility of implementing the measures proposed. • A program of monitoring to confirm adherence to the plan

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

EPR No.	Environmental Performance Requirement	Precinct	Timing	MDA Comment
NV3	Appoint an acoustic and vibration consultant to predict construction noise and vibration (through modelling) and update the modelling to reflect current construction methodology, site conditions and specific equipment noise and vibration levels (this will require noise and vibration measurements). The model would be used to determine appropriate mitigation to achieve the Environmental Performance Requirements. The acoustic and vibration consultant will also be required to undertake noise and vibration monitoring to assess levels with respect to Guideline Targets specified in the Environmental Performance Requirements. Where monitoring indicates exceedances of Guideline Targets, apply appropriate management measures as soon as possible.	All	Construction	The findings of the modelling and mitigation investigation shall be documented in a Construction Noise and Vibration Assessment Report, which shall provide the basis for the development of the construction management plan required under NV1. The report shall be reviewed by the Independent Auditor (see separate recommended NV concerning the establishment of an Independent Auditor). The report shall implement any recommendations arising from the review prior to being finalised. Consistent with the recommended NV1 modifications, report shall address day time noise levels that can be practically adhered to, and that will be referenced as action levels when monitoring of daytime construction noise is required. The selection of day time noise levels for this purpose should consider the City of Melbourne Noise & Vibration Management Guidelines and the NSW Interim Construction Noise Guideline.
NV4	Develop and implement a communications plan to liaise with potentially affected community stakeholders and land owners regarding potential noise and vibration impacts. The plan shall include procedures for complaint management.	All	Construction	The communications plan should be developed in consultation with City of Melbourne, City of Stonnington and the EPA Victoria. The plan should also specify precinct-specific community consultations that will be conducted as part of developing, and prior to finalising, the Construction Noise and Vibration Management Plan required under NV-1.

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

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

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

The internal targets should also be extended to all other types or relevant non-residential sensitive uses such as offices, schools places of worship and hotel accommodation.</td>
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<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>Condition assessment and monitoring of vibration during construction should also be undertaken at Arden Street Bridge, Swanston Street brick drain, Flinders Street drains, Princes Bridge, Melbourne Town Hall , Melbourne City Baths and St Paul’s Cathedral.</td></tr>
</table>

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

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV9</td><td><u>Vibration Dose Values (VDVs) (Human Comfort)</u>
Implement management actions if the following Guideline Targets (VDVs) (based Table 1 in BS6472-1:2008) for continuous (as for TBMs and road headers), intermittent, or impulsive vibration are not achieved.
<table><tr><th rowspan="3">Location</th><th colspan="4">VDV (m/s$^{1.75}$)</th></tr><tr><th colspan="2">Day
7:00am to 10:00pm</th><th colspan="2">Night
10:00pm to 7:00am</th></tr><tr><th>Preferred Value</th><th>Maximum Value</th><th>Preferred Value</th><th>Maximum Value</th></tr><tr><td>Residences</td><td>0.20</td><td>0.40</td><td>0.10</td><td>0.20</td></tr><tr><td>Offices, schools, educational institutions, places of worship</td><td>0.40</td><td>0.80</td><td>0.40</td><td>0.80</td></tr><tr><td>Workshops</td><td>0.80</td><td>1.60</td><td>0.80</td><td>1.60</td></tr></table>Notes
1 The Guideline Targets are non-mandatory; they are goals that should be sought to be achieved through the application of feasible and reasonable mitigation measures. If exceeded then management actions would be required.
2 The VDVs may be converted to PPVs within a future noise and vibration construction management plan</td><td>All</td><td>Construction</td><td>Assessment of human comfort should also be assessed against the relevant Vibration Criteria (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>Micro and nano scale electron-microscopes at Melbourne University and RMIT University are required to operate continuously. Consideration should be given to reducing risk of disruption to experiments by providing secondary vibration isolation to the equipment.</td></tr>
</table>

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV11</td><td><u>Ground-borne (internal) Noise Guideline Targets for Amenity</u>
Implement management actions as determined in consultation with potentially affected land owners to protect amenity at residences, sleeping areas in hospital wards, student accommodation and hotel rooms where the following ground-borne noise Guideline Targets (from the NSW Interim Construction Noise Guideline) are exceeded during construction.
<table><tr><th>Time Period</th><th>Internal $L_{Aeq,15min}$, dB</th></tr><tr><td>Evening, 6pm to 10pm</td><td>40</td></tr><tr><td>Night, 10pm to 7am</td><td>35</td></tr></table>Notes
1 Levels are only applicable when ground-borne noise levels are higher than airborne noise levels.
2 The noise levels are assessed at the centre of the most affected habitable room.
3 Management actions include extensive community consultation to determine acceptable level of disruption and provision of respite accommodation in some circumstances.</td><td>All</td><td>Construction</td><td>The proposed EPR conflicts with the NV1 which commits to manage construction noise in accordance with EPA Publication 1254 Noise Control Guidelines.
While EPA 1254 does not explicitly address ground-borne intrusion paths, the advice it provides in relation to night-time work and airborne intrusion paths is to achieve inaudibility within affected receiver locations. For context, ground-borne noise is generally considered more intrusive then airborne noise; this is evident from the lower targets that have been proposed for operational noise intrusion that is dominated by ground-borne noise. It therefore follows that for consistency with NV1 and EPA 1254, the intrusion targets for ground-borne construction noise at night should also be based on achieving inaudibility. If this cannot be practically achieved, alternative limits must be specified in terms of both the duration of the period of exposure as well as intrusion levels set at significantly lower thresholds than have been presently nominated.
In terms of the evening Guideline Targets, there is no direct advice in EPA 1254 with respect to internal noise levels. However, while the Guideline Targets for the evening are consistent with the alternative reference guidance in the NSW Interim Construction Noise Guidelines, prolonged construction noise exposure at an internal level of 40 dB L_{Aeq} represents a significant risk. Accordingly, ground-borne noise intrusion at the proposed evening level, if permitted, should be specifically restricted to limited periods (e.g. less than 1 week).</td></tr>
<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>No comment</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	The proposed EPR is generally considered reasonably but should be clarified in terms of the measurement parameters and measurement durations that apply to background noise and short exposures, including citation of the relevant references for the selected thresholds.
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	The noise and vibration consultant shall be required to prepare Construction and Operational Noise and Vibration Reports for review and approval by the Independent Auditor commissioned to review the predictions and proposed design mitigation measures. In contrast to the Governance Framework outlined in Chapter 23, the Independent Auditor should not be appointed jointly by the MMRA and PPP. It is recommended that the Independent Auditor should be selected and engaged by the Department of Transport, Planning and Local Infrastructure, with costs borne by the MMRA and/or PPP contractor. The Independent Auditor should also be granted access to all materials required to conduct a complete review, including where necessary for sample verification work, access to modelling files, measurement data and supporting test documentation relied upon in the development of design mitigation measures.

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

<table>
<tr><th>EPR No.</th><th>Environmental Performance Requirement</th><th>Precinct</th><th>Timing</th><th>MDA Comment</th></tr>
<tr><td>NV17</td><td>
<u>Ground-borne Noise Guideline Targets for Operation</u>
Where operational ground-borne noise trigger levels are exceeded for sensitive occupancies as shown in the table below (trigger levels are based on the Rail Infrastructure Noise Guideline, 17 May 2013 (RING(1)), assess feasible and reasonable mitigation to reduce noise towards the relevant ground-borne noise trigger level.
<table>
<tr><th>Sensitive land use</th><th>Time of day</th><th>Internal noise trigger levels</th></tr>
<tr><td>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></td><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.
</td><td>All</td><td>Operation</td><td>As per MDA comments with respect to NV15, the findings of all detailed modelling and mitigation assessments during the design development shall be documented in an Operational Noise and Vibration Assessment Report. The purpose being to demonstrate how the completed project is proposed to adhere to the targets established in NV17.

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

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

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<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>2 Specified noise levels refer to noise from heavy or light rail transportation only (not ambient noise from other sources).3 Assessment location is internal near to the centre of the most affected habitable room.
4 L_{ASmax} refers to the maximum noise level not exceeded for 95% of the rail pass-by events.
5 For schools, educational institutions, places of worship the lower value of the range is most applicable where low internal noise levels is expected.
6 The values for performing arts spaces may need to be reassessed to address the specific requirements of a venue.</td><td></td><td></td><td></td></tr>
<tr><td>NV18</td><td><u>Vibration Guideline Targets for Operation</u>
During operation, achieve the Guideline Targets (based on Table 1 in BS6472-1:2008) or background levels (whichever is higher) for vibration as follows:
<table>
<tr><th rowspan="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.
2 Compliance with these values implies no structural damage due to operation.</td><td>All</td><td>Operation</td><td>As per MDA comments with respect to EPR numbers NV15 and NV17, the measures to achieve compliance with these targets should be documented in an Operational Noise and Vibration Compliance Report for review by the Independent Auditor.</td></tr>
</table>