INLAND RAIL - TOTTENHAM TO ALBURY

Operational Railway Noise and Vibration Memorandum
0-0021-110-EMN-00-ME-0001

Prepared for:

Australian Rail Track Corporation Limited
Inland Rail
Level 16, 180 Ann Street
Brisbane, QLD 4000

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004 Australia)
T: +61 7 3858 4800
E: brisbane@slrconsulting.com   www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Australian Rail Track Corporation Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

CONTENTS

DOCUMENT REFERENCES

TABLES

CONTENTS

1 Introduction

The Inland Rail Program (Program) is a once-in-a-generation Program of infrastructure works which, when completed, will connect regional Australia to domestic and international markets, transforming the way freight is transported around the country. It will complete the 'spine' of the national freight network with a new freight line linking Melbourne and Brisbane via regional Victoria, New South Wales and Queensland. Construction of Inland Rail commenced in late 2018 and it is expected to be fully operational in 2025.

The Tottenham to Albury project on Inland Rail (T2A – Stage 1) (the Project) proposes works to individual assets to provide horizontal and vertical clearance for double stacked freight trains to operate along the North East Rail Line from Beveridge to Albury in Victoria.

The movement of rail freight on the Project is a potential source of noise and vibration that could impact sensitive receptors and the surrounding environment. This report provides assessment of potential noise and vibration emissions associated with the railway operations on the Project. The study considered the level and characteristic of noise and vibration from:

- The operation of freight and passenger rail services within the Project sections where existing track is being enhanced to accommodate the proposed Inland Rail double stacked freight trains.
- Road traffic on the road bridges that are proposed to be replaced, and other significant road realignments required as part of the Project.

This report is based on the current reference design and forecast railway operations for the Project. The report is a preliminary assessment of noise and vibration from railway operations and local road traffic. The assessment and outcomes presented may be subject to change as part of the on-going development of the reference design and preparation of the detailed environmental assessments.

2 Assessment methodology

2.1 Background

The T2A Inland Program in Victoria is an enhancement to 305 km of existing rail corridor from metropolitan Melbourne to the Victoria-NSW border at Albury-Wodonga. This will see the enhancement of existing transport infrastructure and increased clearances for rail freight at several discrete works areas along the rail corridor.

This assessment includes the sections of the Project north of Beveridge, which include; Highway Tallarook Precinct, Hume Highway Seymour Precinct, Wangaratta Station Precinct, and Murray Valley Highway Overbridge. These assessed Project sections are discussed in **Table 1**.

Table 1 Rail noise and vibration assessment areas

T2A Stage 1 Project Section	Location	Chainage	Key factors
Hume Highway Tallarook Precinct	Project alignment under the Hume Highway in Tallarook, Victoria.	88.080 to 88.940	Redeveloped alignment passing under the Hume Highway. The planned works include track slewing and lowering. The Hume Highway is comprised of separate north and south bound overbridges.
Hume Highway Seymour Precinct	Project alignment under the Hume Highway in Seymour, Victoria.	103.470 to 104.110	Redeveloped alignment passing under the Hume Highway. The planned works include track slewing and lowering. The Hume Highway is comprised of separate north and south bound overbridges.
Wangaratta Station Precinct	Project alignment under the Green Street Overbridge in Wangaratta, Victoria.	233.480 to 234.520	Redeveloped alignment passing under the Green Street Overbridge. The planned works include track slewing, lowering, and raising the road bridge. There is an existing level crossing at Sisely Avenue approximately 350 m past the extent of the works area of the Tottenham side. There is an existing bridge over One Mile Creek immediately past the extent of the works area to the Tottenham side. There is an existing bridge over Rowan Street immediately past the extent of the works area to the Albury side.
Murray Valley Highway Overbridge	Project alignment under the Murray Valley Highway Overbridge in Barnawartha North, Victoria.	284.940 to 285.340	Redeveloped alignment passing under the Murray Valley Highway Overbridge. The planned works involve track lowering.

2.2 Noise and vibration guidelines

Based on the environmental assessment requirements for the Project, the assessment of noise and vibration from railway operations was undertaken with consideration to the guidelines listed in **Table 2**.

Table 2 Referenced noise and vibration guidelines

Document	Application in the assessment
Victorian Passenger Rail Infrastructure Noise Policy (PRINP), State Government Victoria, April 2013	Operational noise from passenger train movements and guidance on the assessment of noise from rail freight operations: - Noise and vibration assessment scenarios. - Noise and vibration impact assessment and reporting requirements.
Assessing Vibration: a technical guideline, NSW DEC, 2006	- Assessment methodology and criteria for ground vibration.
Development near rail corridor and busy roads – Interim guideline, NSW DoP, 2008	Whilst included in the SEARs, this guideline does not apply to proponents of new or redeveloped rail infrastructure.

2.3 Consideration of double-stacked container freight

The Inland Rail Program would operate some trains with the containers on wagons in a double-stacked configuration. The weight of the containers can directly influence the mass on the axles of the wagons which may result in different noise emissions between trains with single-stacked and double-stacked containers.

There is limited reliable information available to address how noise emission levels vary with axle load. International Standard ISO 3095[1] provides general guidance on the difference in noise level resulting from changes in axle loads and notes that an approximate doubling of axle loads may result in a reduction in noise levels of around 1 dB in L_{Aeq}.

This variance is considered negligible in the context of other factors which can affect rolling contact noise and vibration emission levels, such as wheel and track roughness / condition, speed and unsprung mass.

A noise and vibration monitoring survey was completed to investigate the potential influence of single and double stacked containers (axle-loads) on noise and vibration emissions from freight trains. The study outcomes summarised below:

- Consistent with ISO 3095, individual wagons with double-stacked containers have L_{Aeq} noise levels approximately 1 to 2 dB less than the individual wagons with single-stacked containers.
- However, the overall noise levels for the train passby events are not influenced by the noise from the individual wagons with double-stacked containers.
- The loading of individual trains can substantially vary both in terms of the number of wagons with single-stacked and double-stacked containers but also the weight of each container on the train will vary from empty to fully load (a typical range of 3 to 30 tonnes).
- The overall passby noise levels, particularly, the L_{Amax} noise levels, are significantly influenced by factors others than the configurations of the containers on individual wagons.

On the basis of the above, correction factors to account for the potential configuration of containers on the wagons were not deemed necessary.

2.4 Assessment methodology

The assessment of railway and road traffic noise from the operation of the Project was based on the following strategy.

- A desktop survey was undertaken to identify sensitive receptors and property uses within a 1 km radius of the T2A Stage 1 Project sections. The assessment considered receptors within 1 km from the extent of construction works for Inland Rail.
- The emission level used in the modelling of trains has been referenced from the Transport for NSW (TfNSW) Asset Standards Authority Stage III Rail Noise Database and ARTC's databases of monitored rail noise emission levels.

[1] International Standard 2013. International Standard ISO 3095, Acoustics – Railway applications – Measurement of noise emitted by railbound vehicles.

- A detailed noise prediction model was developed for the calculation of airborne rail noise levels at the noise sensitive receptors for each of the assessment scenarios. The noise model predicts daytime, night-time L_{Aeq} and maximum (L_{max}) noise levels and includes details of each train type and the specific rail infrastructure proposed to be developed for the T2A Stage 1 Project. The model uses the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) algorithms in SoundPLAN software.
- Predictions of road noise were conducted using the UK Calculation of Road Traffic Noise (CoRTN) methodology, as required by VicRoads. For arterial roads and freeways, the CoRTN methodology was implemented using a SoundPLAN model. For other local roads, the CoRTN methodology was implemented using spreadsheet calculations of road traffic noise levels.
- The predicted noise levels were evaluated against the assessment criteria to demonstrate the T2A Stage 1 Project can meet the assessment criteria.
- A review of feasible and reasonable mitigation measures was undertaken where the predicted noise levels were determined to be above the assessment criteria.
- The rail noise levels were assessed at project opening (year 2025) and for a future design year of 2040, which is the year where rail operation would be at the designed freight capacity.Error! Reference source not found.

3 Noise assessment criteria

3.1 Airborne noise from freight train movements

ARTC is implementing a uniform approach for the assessment and management of operational railway noise across the Inland Rail Program to ensure the potential noise related impacts to public health, amenity and disturbance are managed consistently. The rail noise criteria from railway noise guidelines in Victoria and other railway noise guidelines in use in Australia were considered in the development of the airborne railway noise criteria for the Project.

ARTC's operational railway noise criteria apply to the airborne noise from rollingstock operations on the Project's main line track and, as-required, infrastructure such as level crossings and crossing loops. Where the rail noise levels are above the assessment criteria, ARTC will investigate reasonable and practicable mitigation measures to aim to reduce rail noise levels to meet the criteria and minimise the potential noise impacts at sensitive receptors.

The railway noise criteria are specific to the daytime period of 7.00 am to 10.00 pm and the night-time period of 10.00 pm to 7.00 am. The noise assessment criteria are lower for the night-time period due to the greater sensitivity of communities to noise during the night-time.

There are different assessment criteria for new railways and for upgrading existing railway infrastructure. The criteria for new railways are 5 dBA lower (more stringent) based on the assumption that noise mitigation can be more readily implemented on newly constructed sections of railway infrastructure.

On the T2A Stage 1 Project, the assessment criteria for the redevelopment of existing rail lines apply to all of the sections of rail infrastructure. The corresponding airborne noise trigger levels for residential receptors are shown in **Table 3**.

Table 3 Airborne noise trigger levels for residential receptors

Type of development	Noise trigger levels (External)	
	Day (7.00 am to 10.00 pm)	Night-time (10.00 pm to 7.00 am)
Redevelopment of existing rail line[1]	Development increase existing LAeq(period) rail noise levels by 2 dB or more, or existing LAmax rail noise levels by 3 dB or more and predicted rail noise levels exceed:	
	LAeq(15hour) 65 dBA	LAeq(9hour) 60 dBA
	LAFmax 85 dBA	LAFmax 85 dBA

Note 1 A redeveloped line is a development on land that is within an existing operational rail corridor, where a line is or has been operational or is immediately adjacent to an existing operational rail line which may result in the widening of an existing rail corridor.

The ARTC noise management approach also includes rail noise management levels for sensitive receptors other than residential land uses. The noise management levels in **Table 4** shall be adopted at the sensitive land uses identified in the table.

Table 4 Airborne noise trigger levels for other sensitive receptors

Other sensitive land uses	Noise trigger levels (when receptor premises are in use)
	Development increases existing rail noise levels by 2 dB or more in LAeq for the period and resulting rail noise levels exceed:
Schools, educational institutions and child care centres	LAeq,(1 hour) 45 dBA (internal)
Places of worship	LAeq(1hour) 45 dBA (internal)
Hospital wards	LAeq(1hour) 40 dBA (internal)
Hospital other uses	LAeq(1hour) 65 dBA (external)
Open space – passive use (e.g. parkland, bush reserves)	LAeq(1hour) 65 dBA (external)
Open space – active use (e.g. sports field, golf course)	LAeq(15hour) 65 dBA (external)

Note 1 A redeveloped line is a development on land that is within an existing operational rail corridor, where a line is or has been operational or is immediately adjacent to an existing operational rail line which may result in the widening of an existing rail corridor.

Note 2 The criteria is specified as an internal noise level for this receptor category. As the noise model predicts external noise levels, it has been conservatively assumed that these receptors have openable windows and external noise levels are therefore 10 dB higher than the corresponding internal level, which is generally considered representative of windows being partially open for ventilation.

3.2 Airborne noise from passenger train movements

The railway operations on the Project include both passenger and freight services. In some locations the Project will require the existing passenger tracks to be slewed to accommodate the future rail freight track. Noise from new and upgraded passenger rail infrastructure in Victoria is assessed according to the *Passenger Rail Infrastructure Noise Policy* (PRINP).

The PRINP does not apply to rail freight and it is understood to not apply to changes in railway noise from passenger trains caused by freight rail upgrade projects. Nonetheless, to inform the potential for noise impacts, ARTC has chosen to assess noise from the proposed slewing of passenger tracks using the PRINP assessment criteria, even though this is not strictly required.

The PRINP provides rail noise levels for redevelopment projects based on the overall rail noise level and the change in rail noise level. The policy uses 'Investigation Thresholds' as trigger levels for the further investigation of reasonable and feasible noise mitigation.

The relevant PRINP investigation thresholds are shown in **Table 5** and only apply to the noise from passenger services. Noise from freight trains will be managed as per the noise criteria detailed in **Section 3.1**.

Table 5 PRINP investigation thresholds for redevelopment of an existing rail corridor

Time	Type of receptor	Investigation threshold(s), dB(A) external
Day (6.00 am – 10.00 pm)	• Residential dwellings and other buildings where people sleep including aged person homes, hospitals, motels and caravan parks • Noise sensitive community buildings including schools, kindergartens, libraries	65 LAeq **and** change in LAeq of 3 dB(A) or more or; 85 LAmax **and** change in LAeq of 3 dB(A) or more
Night (10.00 pm – 6.00 am)	• Residential dwellings and other buildings where people sleep including aged person homes, hospitals, motels and caravan parks	60 LAeq **and** change in LAeq of 3 dB(A) or more Or; 85 LAmax **and** change in LAeq of 3 dB(A) or more

3.3 Ground-borne noise and vibration

3.3.1 Ground-borne noise

Ground-borne vibration from passing trains can result in audible impacts inside buildings in the form of a low frequency rumble if the vibration is sufficient to cause floors or walls of the structure to vibrate.

There is applicable guidelines or policy in Victoria for the management of ground-borne noise from railways. To provide suitable assessment criteria and a consistent approach to managing ground-borne noise across the Inland Rail Program, the ARTC is applying the ground-borne noise assessment criteria in **Table 6** which were determined from a review of ground-borne noise criteria commonly applied on railway project in Australia.

Table 6 Ground-borne noise trigger levels

Sensitive Land Use	Time of Day	Internal Noise Trigger Level (dBA)
Development increases existing rail noise levels by 3 dBA or more ***and*** resulting rail noise levels exceed:		
Residential	Day (7am to 10pm)	40 LASmax
	Night (10pm to 7am)	35 LASmax
Schools, educational institutions, places of worship	When in use	40 - 45 LASmax

Based on assessment of ground-borne noise on other rail infrastructure projects, the ground-borne noise design objectives in **Table 7** have been used to assess the potential impacts at sensitive receptors other than those listed in **Table 6**.

Table 7 Ground-borne noise objectives for other sensitive receptors

Receptor type	Time of day	Noise trigger level
Medical institutions	When in use	$L_{Amax(slow)}$ 40 to 45 dBA
Retail areas	When in use	$L_{Amax(slow)}$ 50 dBA
General office areas	When in use	$L_{Amax(slow)}$ 45 dBA
Private offices and conference rooms	When in use	$L_{Amax(slow)}$ 40 dBA
Cinemas, public halls and lecture theatres	When in use	$L_{Amax(slow)}$ 35 dBA

Note The above criteria have been adopted by SLR as a guide to identifying potential impacts based on the sensitive of the receptor type.

3.3.2 Ground-borne vibration

People can perceive floor vibration at levels well below those likely to cause damage to buildings or their contents. For most receptors, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

The exception can be some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) which can require more stringent design goals than those applicable to human comfort. A desktop survey of land-uses within 2 km of the T2A project alignment did not identify premises expected to have these types of scientific equipment.

There is no Victorian policy for ground-borne vibration from railways. In order to provide a consistent approach across the Inland Rail project, the ARTC management approach is to use the ground-borne noise assessment criteria in **Table 8** which have been referenced from vibration guidelines applied on other railway projects.

The ground-borne vibration criteria adopt preferred and maximum values where, the Project shall be designed to meet the preferred values where reasonable and practicable to do so. Where all feasible and reasonable measures have been applied, values up to the maximum range may be applied to manage vibration impacts.

Table 8 Vibration dose values for intermittent vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods and is dependent on the level of vibration as well as the duration.

3.4 Road noise

The road upgrades on the Project are classified by the TNRP as existing arterial roads or freeways which are not being widened by two or more lanes; accordingly, the $L_{A10(18hour)}$ 68 dBA road traffic noise criterion for the "Noise Abatement Program- Retrofitting" applies to freeways and arterial roads which are being realigned as part of the T2A Stage 1 Project.

For roads other than freeways and arterial roads, the TNRP does not apply and potential noise impacts from bridge replacements and tie-ins to local roads have been assessed based on the expected change in noise due to the road realignment.

Where the road traffic noise is predicted to increase by 2 dBA or less, investigation of measures to mitigate road traffic noise impacts is not recommended. This is based on VicRoads guidance for limiting the increases in noise for locations impacted by existing road noise. Subjectively, a change in noise level of 2 dBA is often considered a just noticeable difference.

4 Rail noise assessment

4.1 Operational noise modelling

A noise model utilising the SoundPLAN (Version 7.4) noise prediction software has been used to predict railway noise levels from the operation of the Project at sensitive receptors within a 2 km radius of the rail corridor. The model uses the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) algorithms in SoundPLAN software.

Local terrain, receptor buildings and structures were digitised in the noise model to develop a three-dimensional representation of the rail corridor and surrounding areas. Building heights were determined from geospatial datasets. Where building heights were unavailable a default 5 m building height was used for all buildings in the noise model; this is representative of the single storey residences common in rural regions. The adopted height is conservative for non-sensitive buildings and structures, such as grain hoppers, sheds and warehouses which could shield rail noise.

The source noise levels used in the modelling of trains have been referenced from the Transport for NSW (TfNSW) Asset Standards Authority Stage III Rail Noise Database and ARTC's databases of monitored rail noise emission levels. The source noise levels include noise emissions for locomotives operating under low, medium and high notch settings and under dynamic braking for downhill section of track.

The noise emissions assume track in good condition and that the running surface of the rail head is free of defects. Wheel tread condition is also assumed to be in good to fair condition.

Impact noise from rail discontinuities such as turnouts, expansion joints or rail defects can increase noise levels from trains and are heard as impulsive noise as each train wheel passes over the discontinuity.

In areas where the track has tight radius curves, flanging noise and/or curve squeal is often heard and can also increase noise levels. Noise level corrections have been applied to all segments of the Project rail sections that include these features to account for the potential increase in operational noise.

4.2 Daily rail movements

The daytime and night-time train movements on the T2A Stage 1 Project sections were supplied by ARTC and are shown in **Table 9 Table 9** and **Table 10**. The train volumes are based on operational modelling which factors in the increased carrying capacity of double-stacked freight trains versus single stacked and expected demand for the different time horizons.

Table 9 Train volumes – Existing

Project Section	Train service	Train movements		
		Daytime	Night-time	Total 24-hour
Existing – No Project				
Hume Highway Tallarook	Intermodal	3	3	6
	Steel	1	1	2
	General freight	1	1	2
	Grain	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	10	2	12
	V/line – DMU	21	3	24
	Total	**45**	**13**	**58**
Hume Highway Seymour	Intermodal	3	3	6
	Steel	1	1	2
	General freight	1	1	2
	Grain	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	9	1	10
	Total	**23**	**9**	**32**
Green Street Murray Valley Highway	Intermodal	3	3	6
	Steel	1	1	2
	General freight	1	1	2
	Grain	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	Total	**14**	**8**	**22**

Table 10 Train volumes – Year 2025 with Inland Rail

Project Section	Train service	Train movements		
		Daytime	Night-time	Total 24-hour
2025 – Project Commencement				
Hume Highway Tallarook	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	4	2	6
	Central NSW Grain	0	1	1
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	10	2	12
	V/line – DMU	21	3	24
	Total	**49**	**12**	**61**
	Increase from existing	**4**	**-1**	**3**
Hume Highway Seymour	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	4	2	6
	Central NSW Grain	0	1	1
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	9	1	10
	Total	**27**	**8**	**35**
	Increase from existing	**4**	**-1**	**3**
Green Street Murray Valley Highway	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	4	2	6
	Central NSW Grain	0	1	1
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	Total	**18**	**7**	**25**
	Increase from existing	**4**	**-1**	**3**

Table 11 Train volumes – Year 2040 with Inland Rail

Project Section	Train service	Train movements		
		Daytime	Night-time	Total 24-hour
2040 – Design Year				
Hume Highway Tallarook	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	5	2	7
	Central NSW Grain	0	2	2
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	10	2	12
	V/line – DMU	21	3	24
	Stopping Trains			
	Inland Rail Intermodal	1	0	1
	Total	**51**	**13**	**64**
	Increase from existing	**6**	**0**	**6**
Hume Highway Seymour	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	5	2	7
	Central NSW Grain	0	2	2
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	V/Line – Loco Hauled	9	1	10
	Stopping Trains			
	Inland Rail Intermodal	1	0	1
	Total	**29**	**9**	**38**
	Increase from existing	**6**	**0**	**6**
Green Street Murray Valley Highway	**Express Trains**			
	Inland Rail Intermodal	2	0	2
	Inland Rail Express	3	1	4
	Inland Rail Superfreighter	5	2	7
	Central NSW Grain	0	2	2
	Griffith Export Containers	1	1	2
	Passenger – Melbourne to Albury	6	0	6
	XPT – Melbourne to Sydney	2	2	4
	Stopping Trains			
	Inland Rail Intermodal	1	0	1
	Total	**20**	**8**	**28**
	Increase from existing	**6**	**0**	**6**

4.3 Train speeds

The trains on the T2A Stage 1 Project sections will operate at varying speeds based on train type and direction of travel. The track speed profiles for the main line train movements are shown in **Table 12**, for both existing and 'with project' scenarios. The speed profile accounts expected operational requirements, speed changes, notch settings and anticipated driver behaviour.

Table 12 Train speeds

Track Section	Project Scenario	Train Type	Speed (km/h)	
			Inland Rail Speed Profile	
			Northbound	Southbound
Hume Highway – Tallarook	No Project	Intermodal	115	115
		Steel	115	115
		General freight	115	115
		Grain	115	115
		Passenger – Melbourne to Albury	75	75
		XPT – Melbourne to Sydney	120	75
		V/Line – Loco Hauled	130	130
		V/line – DMU	130	130
	With Project	Inland Rail Intermodal	80	75
		Inland Rail Express	105	75
		Inland Rail Superfreighter	105	75
		Central NSW Grain	80	75
		Griffith Export Containers	105	75
		Passenger – Melbourne to Albury	115	75
		XPT – Melbourne to Sydney	120	75
		V/Line – Loco Hauled	130	130
		V/line – DMU	130	130
Hume Highway – Seymour	No Project	Intermodal	115	100
		Steel	115	100
		General freight	115	100
		Grain	115	100
		Passenger – Melbourne to Albury	90	90
		XPT – Melbourne to Sydney	90	95
		V/Line – Loco Hauled	120	100
	With Project	Inland Rail Intermodal	80	80
		Inland Rail Express	75	105
		Inland Rail Superfreighter	75	105
		Central NSW Grain	80	80
		Griffith Export Containers	75	105
		Passenger – Melbourne to Albury	90	90
		XPT – Melbourne to Sydney	90	90
		V/Line – Loco Hauled	120	100

4.4 Summary of findings

The predicted railway noise levels achieve the assessment criteria at the nearest sensitive receptors to the Hume Highway Tallarook Precinct, Hume Highway Seymour Precinct, and Murray Valley Highway Overbridge sections of the Project.

At the Wangaratta Station Precinct, the predicted railway noise levels achieve the noise criteria at the majority of sensitive receptors. The predicted noise levels for the commencement of operations in the year 2025 trigger the daytime noise criteria by up to 2 dBA at a total of five sensitive receptors. For the design year 2040, the additional railway traffic results in railway noise levels being up to 7 dBA above the noise criteria at up to 16 sensitive receptors.

The assessment outcomes are summarised in **Table 13**Error! Reference source not found. shows the level of exceedance above the respective daytime or night criteria at receivers predicted to experience a change in noise level greater than 2 dB.

Table 13 Wangaratta station Precinct airborne rail noise exceedances

Criteria Trigger	Number of sensitive receptors triggering assessment criteria					
	2025			2040		
	Daytime $L_{Aeq(15hr)}$	Night-time $L_{Aeq(9hr)}$	L_{Amax}	Daytime $L_{Aeq(15hr)}$	Night-time $L_{Aeq(9hr)}$	L_{Amax}
0-2 dB	5	0	0	7	0	0
2-5 dB	0	0	0	5	0	0
5-10 dB	0	0	0	4	0	0
10-20 dB	0	0	0	0	0	0
Total	**5**	**0**	**0**	**16**	**0**	**0**

A review of the predicted noise levels and the location of the 16 sensitive receptors determined the anticipated feasible and reasonable noise mitigation option for these receptors will be:

- Architectural acoustic treatments to the building to control rail noise within the internal environment of the building; and/or,
- Upgrades to any existing property boundary fencing to improve screening of rail noise levels.

Whether at-property controls or other alternative mitigation options are required will ultimately be determined through the detail design of the Project. This will include further railway noise modelling, analysis of engineering and environmental constraints, and consultation with directly affected landowners.

To ensure that Project noise and vibration predictions and management have been successful, noise and vibration monitoring will be undertaken once the Project is operational.

5 Ground-borne vibration assessment

5.1 Approach

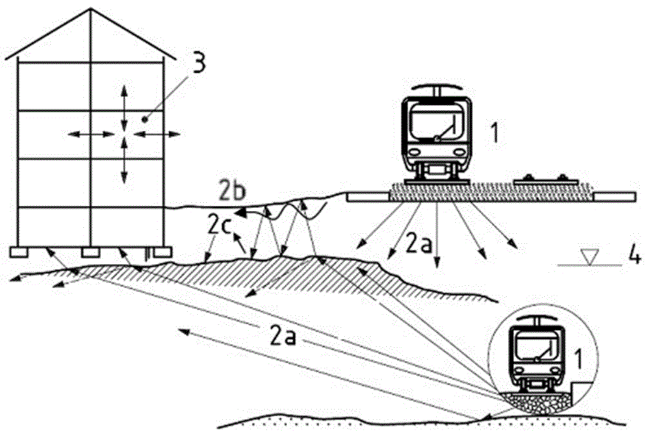
To inform the assessment of potential ground-borne vibration from the railway operations, guidance was referenced from International Standard ISO 14837[2] on the typical assessment requirements for new rail systems, including definitions of:

- **Scoping Model** at the very earliest stages.
- **Environmental Assessment Model** during planning process and preliminary design.
- **Detailed Design Model** to finalise extent and form of mitigation for construction.

For this assessment, a combined Scoping Model with elements of an Environmental Assessment Model was adopted. In accordance with the ISO standard, modelling for ground-borne noise and ground-borne vibration considers key parameters that are critical in determining the likely range levels of ground-borne noise and vibration and the benefits (or otherwise) of different design and mitigation options.

An overview of the modelling approach is illustrated in Error! Reference source not found.. The approach considers the source vibration levels, the vibration propagation between the surrounding environment and nearby building foundations, and the propagation of vibration within the building elements.

Figure 1 Example of rail vibration source, propagation and receptor system



Key
1 source
2 propagation:
 2 a body waves (compression, shear)
 2 b surface waves (e.g. Rayleigh, Love)
 2 c interface waves (e.g. Stoneley)
3 receiver (vibration, re-radiated noise)
4 water table

NOTE The components of the system comprising source, propagation and receiver are interdependent.

The modelling has been carried out using a combination of theoretical and empirical relationships to determine the attenuation and/or amplification of ground-borne vibration levels.

[2] ISO 14837-1 2005 "*Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance*

Previous measurement and assessment of ground-borne vibration from existing rail freight corridors indicates that potential for ground-borne vibration impacts would be limited to sensitive receptors located within 100 m of the proposed rails. Forecast levels at properties beyond this distance are routinely expected to be within assessment criteria and the integrity of building structures is unlikely to be compromised by passing trains.

Notwithstanding, the calculation of ground-borne vibration from rail operations refrained from applying estimated adjustments, such as loss of vibration energy as it is transferred to buildings, where such adjustments could infer there would be no risk of impacts from ground-borne vibration outside of the rail corridor.

5.2 Source vibration levels

To determine a reference ground vibration level, detailed measurement surveys were completed on existing rail corridors between Wagga Wagga and Albury in NSW and Euroa and Wallan in Victoria. The locations are associated with the Inland Rail Program in NSW and Victoria where there are comparable existing rail freight operations, with single-stacked freight wagons, on ballasted track form.

The rail corridor in these regions is mainly used for rail freight and had an average of 20 or more freight train movements per day operating at 60 km/h to 80 km/h. Ground-borne vibration levels were measured at three locations in each region, with measurements made at-grade (ground level) at distances of 15 m to 45 m from the outer rail line.

The train vibration measurements were referenced to calculate the W_b-weighted VDVs at 15 m from the outer rail varied at all sites from 0.01 $m/s^{1.75}$ to 0.04 $m/s^{1.75}$ for a single train passby event. The variation is representative of differences in rollingstock, wheel conditions and consists. The adopted VDV (W_b weighted) of 0.04 $m/s^{1.75}$ at a setback of 15 m for a single train passby was based on the maximum derived VDVs. Accordingly, the assessment inherently assumes that each train is a worst-case vibration generating event and is therefore conservative.

As discussed in **Section 2.3**, recent railway vibration surveys have identified double-stacked freight wagons would not necessarily result in higher ground-borne vibration emissions.

5.3 Ground-borne vibration from ground-level train passbys

The effects of vibration in buildings can be divided into two broad categories which are considered further in the following sections.

- Where the occupants or users of the building are inconvenienced or possibly disturbed either from tactile vibration or audible noise generated from the building vibration ('comfort risk'); and
- Where the building contents or internal linings may be noticeably affected or where the integrity of the building or the structure itself may be prejudiced ('cosmetic damage risk').

5.3.1 Residential and other occupied buildings

The VDV results were estimated based on daily train movements at the project opening in 2025 and the 2040 design year and the forecast train speeds. Estimated VDV levels for trains at 105 km/h were applied to determine the minimum off-set distance from the outer rail of the Project where the ground-borne vibration criteria would be expected to be achieved.

Suggested off-set distances to achieve the daytime and night-time rail vibration criteria are shown in **Table 14**. Based on the estimated off-set distance for the night-time railway operations for the design year 2040, an distance of 16 m from the outer rail would be required to achieve ground-borne vibration criteria.

Table 14 Screening assessment of ground-borne vibration levels

Year of operation	Estimated off-set to meet vibration criteria, subject to detailed review		Receptors within the off-set distance
	Daytime (0.2 m/s$^{1.75}$)	Night-time (0.13 m/s$^{1.75}$)	
2025 opening year	14 m (49 trains)	15 m (19 trains)	None
2040 design year	14 m (51 trains)	16 m (22 trains)	None

Note The estimated off-set distances are based on the VDV reference, actual vibration levels at individual receptors can vary from the calculated levels due to the rail infrastructure and geological conditions.

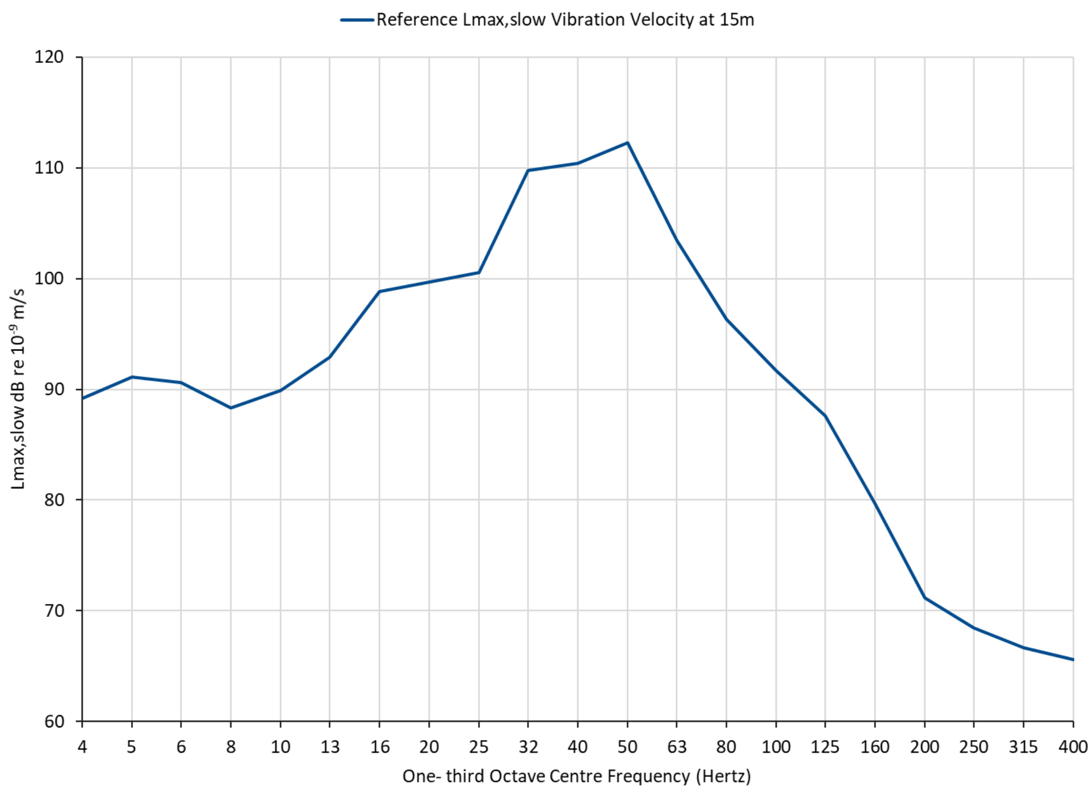
VDV levels calculated applying the W_b-weighted vibration levels as per the 2008 version of BS 6472.

A review of the Project alignment identified that all sensitive receptors not resumed by the Project would be outside of the 16 m off-set distance from the outer rail of the Inland Rail track. On this basis, the railway operations on the Project rail tracks would achieve the ground-borne vibration assessment criteria at all sensitive receptors. Where ground-borne vibration from railway operations are within the assessment criteria, there can still be potential for rail operations to generate perceptible levels of ground-borne vibration at sensitive receptors.

6 Ground-borne noise assessment

The ground vibration during the rail passbys is a potential source of ground-borne noise at the nearby receptors. The statistical 95th percentile $L_{Amax,slow}$ vibration velocity spectra was determined from the measured ground vibration levels at the trackside monitoring sites. All sites had exhibited similar vibration spectra and relationships between the vibration levels and distance from the rail track. The reference spectrum at an off-set distance of 15 m from the outer rail of the track is shown in **Figure 2**.

Figure 2 Vibration velocity spectrum at 15 m from the track

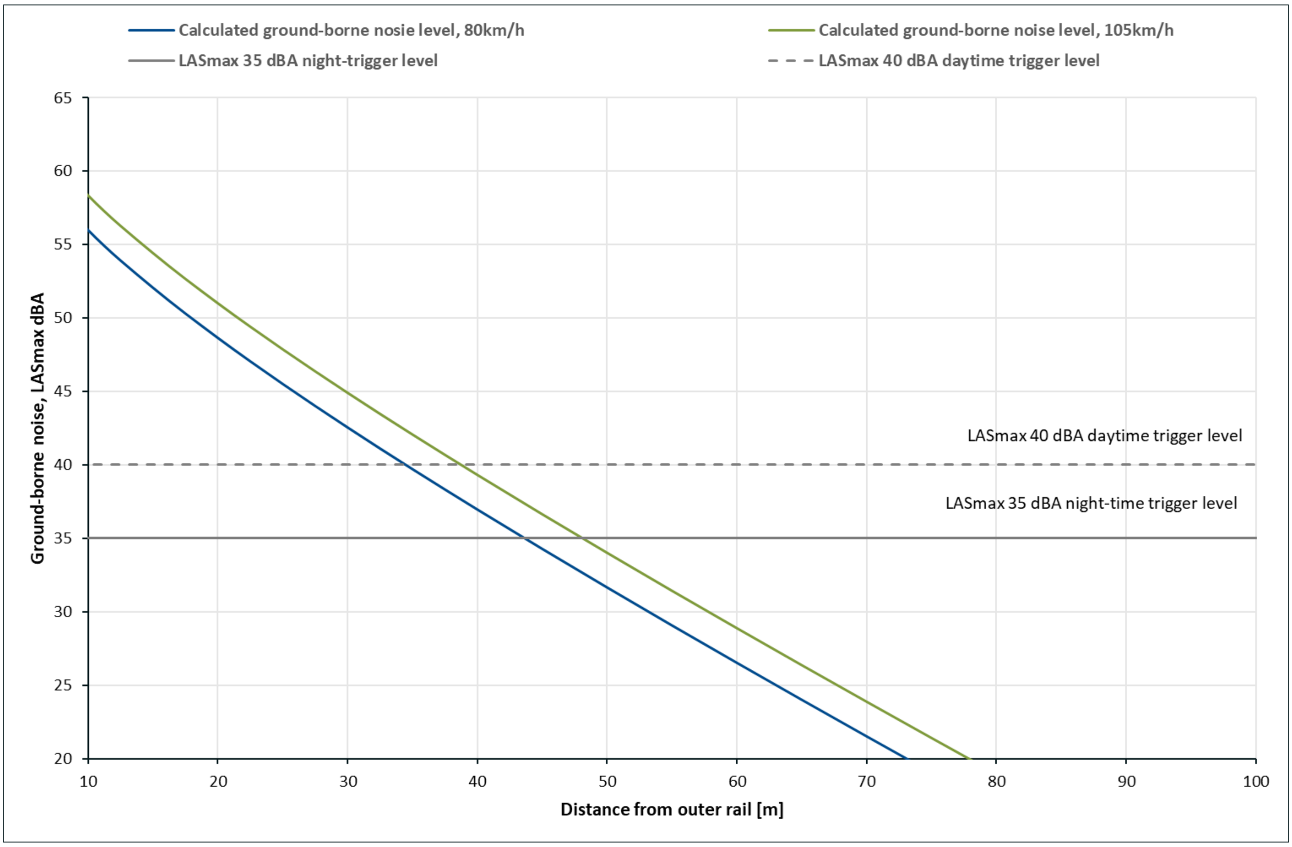


The ground-borne noise has been conservatively estimated using following key assumptions:

- No coupling loss between the ground and the receptor building structures given the specific construction of individual buildings is not currently known.
- No floor amplification within the receptor structures.
- Use of a vibration to sound pressure (noise) conversion factor of -32 dB[3];

The calculated regenerated noise versus distance relationship is presented in **Figure 3**.

Figure 3 Calculated ground-borne noise levels



At a distance of approximately 50 m from the track, the most stringent ground-borne noise criterion of $L_{Amax,slow}$ 35 dBA is expected to be achieved. There are several sensitive receptors within 50 m from the T2A works areas, however at the majority of these locations, the Lmax ground-borne noise level is not predicted to increase due to the Project.

As per assessment methodolog, the assessment of ground borne noise is not required where the airborne noise contribution is dominant. At all residential receptors where the ground-borne rail noise contribution is dominant, the predicted increase is less than 3 dBA criteria.

Based on the above results, the assessment criteria are met at all locations. It is also noted that if coupling losses for the receptor building structure were to be included, the internal ground-borne noise levels would be less than those stated above.

[3] ANC Guideline “Measurement & Assessment of Groundborne Noise & Vibration”, 2nd Edition 2012.

7 Road noise assessment

7.1 Road noise modelling

Changes in noise level due to the proposed road overbridge replacements have been calculated using the CoRTN prediction methodology which is widely applied in Australia for the prediction of road noise levels and is the road noise prediction methodology specified by VicRoads. Applying the SoundPLAN noise model developed for the Project, road noise assessments were conducted for the following bridge upgrades proposed on the Project:

- Broadford-Wandong Road Overbridge
- Hamilton Street Overbridge
- Short Street Overbridge
- Marchbanks Road Overbridge
- Seymour Avenel Road Overbridge
- Anderson Street Overbridge
- Benalla Station Approach Road Overbridge
- Beaconsfield Parade Overbridge

7.2 Summary of findings

The results of the road noise assessment at each project section are summarised in **Table 15**. The road traffic noise assessment criteria are considered to be achieved at all locations. Whilst the change in road traffic noise is up to 6 dBA at Benalla Station approach road overbridge, the overall road traffic noise level of $L_{A10(18hour)}$ 52 dBA is within road traffic noise guidelines.

Table 15 Assessment of road noise

Project Road Section	Proposed Upgrade	Criteria	Prediction
Broadford-Wandong Road Overbridge	Relocate the road bridge by to the south by up to 20 metres and increase its height.	Increase of >2dB	Increase of 0-1 dB
Hamilton Street Overbridge	Raise the road bridge by up to 2.5 metres while retaining the existing horizontal alignment.	Increase of >2dB	Increase of 0-2 dB
Short Street Overbridge	Relocate the road bridge by to the west by up to 15 metres and increase its height.	Increase of >2dB	Increase of 0-2 dB
Marchbanks Road Overbridge	Relocate the road bridge by to the west by up to 15 metres and increase its height.	68 dB $L_{A10(18hour)}$	56 – 68 dBA $L_{A10(18hour)}$ (increase of 1dB)
Seymour Avenel Road Overbridge	Raise the road bridge by up to 2.5 metres while retaining the existing horizontal alignment.	Increase of >2dB	Increase of 0-1 dB
Anderson Street Overbridge	Raise the road bridge by up to 2.5 metres while retaining the existing horizontal alignment.	Increase of >2dB	Increase of 0-1 dB
Benalla Station Approach Road Overbridge	Relocate the road bridge by to the south by up to 10 metres and increase its height.	Increase of >2dB	52 dBA $L_{A10(18hour)}$ Increase of 3 – 6 dB
Beaconsfield Parade Overbridge	Relocate the road bridge by to the west by up to 30 metres and increase its height.	Increase of >2dB	Increase of 0-2 dB

8 Conclusion

This report has been prepared as a preliminary evaluation of potential noise levels, and potential impacts, associated with the operation of the T2A Stage 1 Project (north of Beverage).

The Wangaratta Station Precinct is the only T2A works area with predicted rail noise levels above the criteria. The predicted railway noise levels achieve the assessment criteria at the majority of the sensitive receptors. The noise levels adjacent to the Wangaratta Station Precinct were above the assessment criteria at 5 receptors at commencement of railway operations in 2025 and up to 16 receptors in 2040.

An initial review of noise mitigation options identified that at-property treatments may be the feasible and reasonable railway noise mitigation option for these properties. The final mitigation strategy would be confirmed during detail design.

The assessment of vibration levels from railway operations predicts that the criteria is met at all sensitive receptors. The ground vibration levels would also be well within vibration levels for damage to building contents and structural (cosmetic) damage to buildings.

A conservative assessment of ground borne noise from railway operations predicts compliance with the criteria.

The assessment of road noise from the proposed overbridge replacements and other significant road realignments predicts compliance with VicRoads criteria for the applicable work areas. For local roads, the predicted increases in road noise are below the threshold at which mitigation is required to be considered.

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 404 939 922

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628