Regional Rail Link

Technical Assessment Report Section 1

RRL-1000-EAC-REP-0003

Revision B

13 July 2011

KBR ARUP

Regional Rail Link Authority

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KBR Arup Joint Venture ABN 85 807 465 350
Kellogg Brown & Root Pty Ltd ABN 91 007 660 317
Arup Pty Ltd ABN 18 000 966 165

KBR Arup Joint Venture
Level 34, 80 Collins Street
Melbourne, VIC 3000, Australia
Tel +61 3 8629 4100 Fax +61 3 9654 8715

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1 Introduction

The Regional Rail Link Authority (RRLA) requested that the KBR Arup Joint Venture (KAJV) prepare this report to assist RRLA in responding to Condition 1 of the Minister for Planning's decision that an Environmental Effects Statement is not required for Section 1 of the Regional Rail Link (RRL1). In particular, KAJV was requested to provide a technical acoustic assessment of the operational noise related to RRL1 including:

- Assessment and reporting on the likely noise levels in the vicinity of the RRL1 that will be associated with expected changes in rail operations;
- Documentation of the likely changes in overall noise levels in adjoining residential areas and sensitive receivers from current levels;
- Provision of a comparison of predicted noise levels with relevant standards or guidelines for operational rail noise from other Australian jurisdictions; and
- Evaluation of the effectiveness of options for noise mitigation.

Chapter 2 of this report identifies that there is no numerical noise standard for rail noise in force in Victoria that will apply to the emission of operational noise from passenger trains on RRL1. Chapter 2 therefore considers, in relation to operational noise:

- Policy guidance available in Victoria, for operational rail noise from trains and in relation to fixed infrastructure sites; and

- Interstate guidelines and standards, as required by the Minister's conditions.

Acoustic terminology used in this report is defined in Appendix A.

2 Victorian and Interstate Railway Noise Guidance

There are no numerical noise standards for railway noise in Victoria that apply to the emission of noise from passenger trains on RRL1. Some limited guidance can be found in previous Victorian decisions relating to operational noise from railways, as discussed in Section 2.1.1 below.

KAJV is advised that the Department of Transport has recently commenced a process to develop policy for assessing noise from future passenger rail infrastructure projects and developed a set of policy Principles that are discussed by RRLA in its Noise Impact Assessment Report. However the Principles and policy development process have not been used in this technical assessment of RRL1.

Further, the Victorian State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1) regulates operational noise associated with fixed infrastructure sites, including stations, maintenance facilities and stabling, as discussed in Section 2.2 below.

The Minister's referral conditions also require a comparison of predicted noise levels with relevant standards or guidelines for operational rail noise from other Australian jurisdictions. Various railway noise limits are commonly used in New South Wales, Queensland, South Australia and Tasmania (the latter two states primarily adopt established NSW guidance). Both the NSW and Queensland limits can be used to provide guidance regarding reasonable assessment limits and are reviewed in detail below.

2.1.1 Victorian Guidance

While Victoria does not currently have any specific legislative requirements or numeric guidance for railway noise, limits were established for the Melbourne Airport Rail Link Project, and in various Victorian Civil and Administrative Tribunal (VCAT) decisions.

In the Melbourne Airport Rail Link *Noise and Vibration Impact Assessment*[1] the following external noise limits were used in the assessment for 'new sections of rail line built on new rail reserves':

- 55 dB$L_{Aeq,24hr}$
- 80 dBL_{Amax}

Here, $L_{Aeq,24hr}$ refers to the equivalent continuous 24-hour noise level, averaged over an entire 24 hour (day/night) period. The L_{Amax} refers the to the instantaneous maximum noise level from any single train passage.

For existing sections of line affected by the project the following limit was adopted

- 60 dB$L_{Aeq,24hr.}$

In recent VCAT decisions, *internal* noise limits of both 50 dBL_{Amax}[2], and 55 dBL_{Amax} (bedrooms) and 60 dBL_{Amax}[3] (living room areas) have been adopted as requirements for the developer for residential buildings near to existing railways.

2.1.2 New South Wales Guidance

In NSW, guidelines were first established in 1985 in Ch. 163 of the NSW EPA's Environmental Noise Control Manual[4]. These are expressed as a 24-hour average noise level limit ($L_{Aeq,24hr}$), and a maximum pass by level (L_{Amax}) from individual events, measured *externally* at the building façade. The limits are:

1 Melbourne Airport Rail Link Noise and Vibration Impact Assessment, Marshall Day Acoustics Report 00025a, January 2001
2 Lazzcorp Brunswick Pty Ltd v Stonnington CC, VCAT ref. P771/2002.
3 Kilker v Stonnington CC, VCAT ref. P2470/2003.
4 Environmental Noise Control Manual, NSW EPA, 1985.

Planning Levels

- $L_{Aeq,24hr}$ = 55 dB(A)
- L_{Amax} = 80 dB(A)

Maximum Levels

- $L_{Aeq,24hr}$ = 60 dB(A)
- L_{Amax} = 85 dB(A)

These limits were also incorporated in the CityRail's planning guidance[5] for building applications.

The definitions of when the *planning* and *maximum* levels should be applied is not specified. Usually, *planning* levels are adopted when considering new railway corridors or new developments near to existing railways. *Maximum* levels are adopted where the railway and residential development are existing, or it is not reasonable or feasible to meet the *planning* limits. The planning levels are more onerous than the maximum levels, since they are considered to be less constrained in applying noise mitigation.

For RRL1, which is a well-established existing railway corridor, the *maximum* levels would be relevant if the NSW policy were applied.

In 2003, NSW's Rail Infrastructure Corporation (now RailCorp) updated the guidance for the consideration of rail noise and vibration in the planning process and adopted *internal* noise level limits in living and sleeping areas of:

- 40 $dBL_{Aeq,1hr}$ (Daytime) and
- 35 $dBL_{Aeq,1hr}$ (Night-time)

More recently, Section 87 of the NSW Infrastructure SEPP[6] refined these limits as follows;

- 35 dB(A) in any bedroom between 2200hrs–0700hrs (night-time)
- 40 dB(A) elsewhere at any time

In terms of ongoing operational noise limits for the railway, RailCorp operates under an Environmental Protection Licence (Lic. No. 12208[7]) from the NSW Department of Environment and Climate Change. This licence incorporates the following noise goals;

- progressively reduce noise levels to the goals of 60 $dBL_{Aeq,(24hr)}$ and 85 dBL_{Amax} pass by noise (external)
- In the development of new works, work towards the planning goals of 55 $dBL_{Aeq\ (24hr)}$ and 80 dBL_{Amax} pass by noise (external).

These limits are consistent with those first established in the Environmental Noise Control Manual in 1985.

The most recent NSW guidance on the assessment of noise from *new* rail infrastructure projects, known as IGANRIP[8], was published in 2007 by the NSW Department of Environment & Climate Change (formerly EPA) and Department of Planning. This guidance introduces separate assessment trigger levels for daytime and night-time periods, recognising that noise is generally accepted to be more disturbing at night-time due to the larger number of residents that are home and the increased intrusiveness of noise due to

5 *Rail Related Noise and Vibration, Issues to consider in local environmental planning-development applications and building applications*, State Rail Authority of NSW, October 1995.
6 NSW State Environment Planning Policy (Infrastructure) 2007.
7 Available at http://www.environment.nsw.gov.au/prpoeo/licences/l12208.pdf
8 *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (IGANRIP), Department of Environment and Climate Change NSW and Department of Planning, April 2007.

lower background levels. This also brings the assessment criteria more in line with the separate day/night limits adopted for the assessment of road traffic noise.

The noise trigger levels in IGANRIP are not intended to be applied to noise and vibration impacts from *existing operations*. Furthermore, the noise levels are presented as *trigger levels* which trigger the need for an assessment of potential noise impacts, and are not intended to be applied as, or replace development or licence conditions.

The IGANRIP noise trigger levels for residential land uses are as follows:

Table 1 Airborne rail traffic noise trigger levels for residential land uses, after IGANRIP (2007)

Type of Development	Noise trigger levels, dB(A)		
	Day (7am – 10pm)	Night (10pm – 7am)	Comment
New rail line development	Development increases existing rail noise levels and resulting rail noise level exceed:		These numbers represent external levels of noise that trigger the need for an assessment of the potential noise impacts from a rail infrastructure project. An ‘increase’ in existing rail noise levels is taken to be an increase of 2 dB(A) or more in L_{Aeq} in any hour or an increase of 3 dB(A) or more in L_{Amax}.
	60 $L_{Aeq,15hr}$ 80 L_{Amax}	55 $L_{Aeq,9hr}$ 80 L_{Amax}	
Redevelopment of existing rail line	Development increases existing rail noise levels and resulting rail noise level exceed:		
	65 $L_{Aeq,15hr}$ 85 L_{Amax}	60 $L_{Aeq,15hr}$ 85 L_{Amax}	

Specific airborne rail traffic noise trigger levels for sensitive land uses other than residential, such as schools, places of worship, hospitals and recreation areas are given in Table 2 of IGANRIP, as follows:

Table 2 Airborne rail traffic noise trigger levels for sensitive land uses other than residential, after IGANRIP (2007)

Sensitive land use	Noise trigger levels, dB(A)	
	New rail line development	Redevelopment of existing rail line
	Development increases existing rail noise levels by 2 dB(A) or more in L_{Aeq} in any hour and resulting rail noise levels exceed:	
Schools, educational institutions - internal	40 $L_{Aeq,1hr}$	45 $L_{Aeq,1hr}$
Places of worship - internal	40 $L_{Aeq,1hr}$	45 $L_{Aeq,1hr}$
Hospitals	60 $L_{Aeq,1hr}$	60 $L_{Aeq,1hr}$
Hospitals - internal	35 $L_{Aeq,1hr}$	35 $L_{Aeq,1hr}$
Passive recreation	L_{Aeq} as per residential noise level values in Table 1 (does not include maximum noise level component)	
Active recreation (eg. golf course)	65 $L_{Aeq,24hr}$	65 $L_{Aeq,24hr}$

Since the RRL1 corridor has well established railway use, it would be most reasonable to consider it as a ‘redevelopment of existing rail line’ if the IGANRIP policy was applied.

It is important to understand that these guidance levels are noise level targets that are considered desirable to achieve where it is reasonable or feasible to do so. However, there are many areas on the NSW railway network where these noise levels are not being achieved in practice.

2.1.2.1 Queensland Guidance

Queensland Rail's Code of Practice for Railway Noise Management[9] sets the following assessment levels, measured *externally* as façade noise levels;

Interim Levels

- $L_{Aeq,24hr} \leq$ 70 dB(A)
- $L_{Amax} \leq$ 95 dB(A)

Planning Levels

- $L_{Aeq,24hr} \leq$ 65 dB(A)
- $L_{Amax} \leq$ 87 dB(A)

These limits are less onerous than those used in NSW.

The *interim* levels are used for the prioritisation of areas for action in Queensland Rail's noise management planning. The *Planning* levels are envisaged to be used as a guide in deciding a reasonable noise level for its use or operation, and to be only reasonably applied in the long-term.

2.2 Fixed Infrastructure Sites

Operational noise associated with fixed infrastructure sites, including stations, maintenance facilities and stabling, is required to comply with the State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1).

The goal of SEPP N-1 is to protect people from commercial, industrial or trade noise that may affect the beneficial uses made of noise sensitive areas while recognising the reality of the existing land use structure in the metropolitan region.

A SEPP N-1 assessment includes the following:

- Determination of the 'effective noise level' based upon the noise level measured with adjustments for noise character, duration and measurement position (for each time period, day, evening, night)
- Determination of the noise limit based upon the background noise level measured and the land use structure (for each time period)
- A comparison between the 'effective noise level' and the noise limit; the effective noise level is not to exceed the noise limit (for each time period).

Where two or more premises contribute to the effective noise level in a noise sensitive area, each is to be controlled so that the contribution from each of the premises, when combined, will meet the noise limit at the noise sensitive receiver.

Industrial noise emissions from RRL stations, eg from ventilation systems, will be required to meet these requirements.

[9] *Code of Practice – Railway Noise Management*, Queensland Rail, Version 2, November 2007.

3 Noise Mitigation Options

Noise mitigation elements are an important part of railway design, and must be carefully integrated with other key design constraints to ensure a safe, reliable and maintainable railway. While construction noise and noise from fixed infrastructure such as switchyards and level crossings can be mitigated to some extent by siting considerations and management techniques, the linear nature of the RRL1 railway within an established rail corridor means that other options must be considered for mitigation of operational noise from the RRL1 project.

RRLA requested that KAJV provide advice in relation to the options available for mitigation of operational noise from RRL1, and the relative effectiveness of each option in the specific circumstances of RRL1. This Chapter identifies:

- the key sources of operational railway noise, and
- a range of operational noise mitigation measures.

The mitigation measures discussed include:

- adopting a design alignment that assists to minimise noise emission from the railway,
- track and rail roughness control,
- track and wheel maintenance,
- conventional noise barriers,
- low-level trackside noise barriers,
- resilient rail fixings,
- rail dampers,
- Noise Differentiated Track Access Charges (NDTAC), and
- architectural acoustic treatments.

These are discussed in more detail in the following sections.

3.1 Key Sources of Operational Railway Noise

Noise from operation of railway vehicles generally comes from the following sources:

- engine and motor noise (sometimes called ‘traction noise’). This varies between engine types
- aerodynamic noise; typically only at higher speeds (>160 km/h), and
- rolling noise from the wheel–rail interface. This is dependent on the combined wheel–rail roughness amplitude and speed of the rail vehicle.

Noise from brake squeal can be problematic on some networks and is usually due to the choice of brake pad compound and disk material (which are selected for pad life and stopping efficiency, rather than noise), and the condition of the braking surfaces. Brake squeal is not known to be a major issue on the Victorian passenger fleet, and is reasonably controlled by regular ongoing maintenance.

The primary source of railway noise is from the wheel–rail interface due to:

- roughness of the rail and wheel (including wheel flats),
- rail corrugation,

- curving noise (including wheel squeal on track curves and/or flanging on tight slow curves), and
- impact on rail imperfections (spalls, rail burns), joints and special trackwork, e.g. switches and crossings.

3.2 Options to Assist in Mitigation of Operational Rail Noise

3.2.1 Design alignment to minimise noise emission from the railway

Within the physical constraints inherent in the design of linear transport infrastructure, it can be possible to locate some rail elements to minimise noise impacts from the railway corridor to sensitive receptors. In particular, this can be a relevant consideration in determining the optimal location of fixed infrastructure such as stations and switchyards.

3.2.2 Track and wheel discontinuities

Track and wheel surface roughness significantly influences noise levels adjacent to the railway. Aside from the general surface roughness, local wheel and track discontinuities (eg switches and crossings, welds and local wheel and rail defects such as spalling, wheel burns and wheel flats) also contribute to higher wayside noise levels.

Design of a contemporary track system with a minimum number of rail joints is important in reducing noise impacts. In particular, construction of railway tracks using continuous welded rail (CWR) minimises the number of rail joints and thereby reduces the level of impact noise.

The use of concrete sleepers and large-radius curves with super-elevation (cant) are also track design measures which can assist in reducing operational noise impacts.

3.2.3 Track and wheel maintenance

Poor wheel and track maintenance can result in noise increases of up to 20 dB[10], depending on the type and condition of the wheel and rails. Good wheel and rail maintenance to ensure smooth operating conditions can therefore contribute to significant system-wide railway noise reductions.

Regular maintenance of the track profile (including track grinding, where relevant) and the wheels can assist in minimising noise impacts from operational railways by removing wear and track defects such as corrugation, wheel burns, and uneven welds. This maintenance would be undertaken by the accredited rail operator (ARO) for the RRL project.

Recently, automated wayside noise and vibration measurement systems have been installed on the NSW railway network to allow for the proactive management of the wheel and rail conditions and maintenance programme.

Further innovations which help reduce track discontinuities and maintain wheel condition, such as the use of swing-nose crossings or the introduction of anti-lock braking systems on rolling stock, could also contribute to lower railway noise emission.

3.2.4 Conventional noise barriers

Noise barriers within railway reserves are sometimes used to control airborne noise. Noise barriers usually consist of solid fences or walls designed to interrupt the line of sight between the noise source and the receiver, and obstruct the noise propagation. In Australia, noise barriers are commonly constructed using timber, textured precast concrete or GRC, lightweight concrete panels (Hebel), steel (including recycled steel) and transparent materials, such as glass, Perspex or acrylic panels. A typical railway noise barrier arrangement, showing the barrier located adjacent to the track is shown in Figure 1.

[10] Railway Noise in Europe, A 2010 report on the state of the art, International Union of Railways, September 2010.

Figure 1: Typical timber wayside noise barriers adjacent to railway.

As an alternative to traditional 'fence' type barriers, noise barriers can also be formed using earthworks (ie earth bunds) and embankments.

The amount of noise attenuation provided by the barrier depends on the height, length and location of the barrier relative to both the noise source and receiver.

3.2.5 Low-level noise barriers

Novel 'low-level' trackside noise barriers have recently been used for the Channel Tunnel Rail Link (CTRL) in the UK. These are lower noise barriers (up to 1.4 m above the rail) placed close to the railway - around 2.3 m from the nearest track centreline, which are particularly suited to use on bridges and viaducts as shown in Figure 2. Low-level trackside barriers are less effective for sections of the alignment that have a large number of adjacent tracks as each track would require a separate low-level barrier.

Figure 2 Low-level trackside noise barriers on Medway Viaduct, UK.

3.2.6 Resilient rail fixings

Highly resilient rail fixings, such as Cologne Eggs, are sometimes specified for railways to control ground borne noise and vibration emissions by the track support and substructure or structure radiated noise from viaducts. However, these types of fixing do not reduce the extent of *airborne* noise emission from the railway, and can sometimes increase noise emissions through increased rail mobility.

3.2.7 Rail dampers

Rail dampers are used to reduce noise emissions from the rail itself, particularly when highly resilient rail fixings are also used (which increase rail mobility). These usually consist of tuned steel and elastomeric dampers glued or clipped to the rail web (see Figure 3 below).

Figure 3 Vossloh rail web damper

3.2.8 Noise Differentiated Track Access Charges

Several European countries are considering or have recently introduced pilot programmes to introduce noise differentiated track access charges (NDTAC). This type of system aims to incentivise vehicle noise reductions by the railway operators, and is particularly suited to European conditions where operators require incentives to upgrade from older, noisier, wagon fleet with cast-iron brake blocks.

3.2.9 Architectural acoustic treatments

Off-reservation treatments, such as architectural acoustic treatments to individual properties (e.g. double glazing, building design), do not result in increased external amenity but may be incorporated into existing residences, or new developments to reduce internal noise.

Depending on the aspect, layout of individual residences in relation to the railway corridor and type of dwelling (eg. weatherboard, brick veneer etc.), architectural acoustic treatments could typically consist of:

- double glazing of exposed openable windows,
- sealing of vents and windows, where possible, or the provision of noise attenuating air-vents, and/or
- provision of additional door seals and/or noise attenuating doorsets.

Architectural treatments only work well while all windows and doors are kept closed. They therefore have the potential to reduce air-flow and ventilation within houses, and it is usual to provide for air-conditioning systems to maintain ventilation and cooling. While the capital cost of air-conditioning would be provided, it is usually up to the individual resident to cover the ongoing operational energy costs of air-conditioning equipment.

The effectiveness of these types of treatments depend on the building structure type, and are generally found to be less effective on older raised weatherboard homes, than on newer, well-insulated brick-veneer dwellings on concrete slab foundations.

3.3 Effectiveness of options in reducing noise impacts

Table 3 sets out the noise mitigation options discussed above, the effectiveness of each option in reducing noise from the RRL1 project and, where relevant, provides an explanation of the suitability and effectiveness of the option in the circumstances of RRL1.

Table 3 Effectiveness of options in reducing noise impacts of RRL1

Option	Typical reduction in noise level	Comments	'Effectiveness' for RRL
Design of railway alignment	Variable	While RRL1 follows the existing rail alignment, where practicable the rail alignment seeks to maximise distances between RRL1 and residential areas, particularly around Tottenham.	Effective in specific locations
Track and rail roughness control	1-3dB(A)	A contemporary track system which minimises the number of rail joints and surface roughness will reduce wayside noise levels, and can be applied along the entire alignment.	Effective
Track and wheel maintenance	1–3 dB(A) (routewide) 5–10 dB(A) (local defects)	Regular maintenance of the track profile and train wheels can deliver significant railway noise reductions along the entire alignment.	Effective
Conventional noise barriers	Up to 12dB(A), depending on barrier height	Noise barriers are generally a proven and robust means of noise control and are widely used for railway noise mitigation in Europe, Asia and Australia. The amount of noise attenuation provided by the barrier (whether traditional 'fence' or earth bunds and embankments) depends on the height, length and location of the barrier relative to the noise source and receiver.	Effective
Low-level track side noise barriers	3-6dB(A)	Low-level track side barriers can be effective at mitigating noise in some circumstances, but are less effective for sections of the alignment that have a large number of adjacent tracks, as each track would require a separate low-level barrier. Trackside noise barriers can restrict inspection and maintenance access and emergency egress. There is also a safety and collision risk.	Effective
Resilient rail fixings	No impact on airborne noise	Highly resilient rail fixings do not reduce the extent of airborne noise emission from the railway, and can sometimes increase noise emissions through increased rail mobility.	Not Effective
Rail dampers	1-3dB(A)	Rail dampers can be used to reduce noise emissions from the rail itself, particularly when highly resilient rail fixings are also used. The use of this type of rail damper in Victoria would require a detailed approval process. As the use of resilient rail fixings is not proposed, and the rail mobility will be relatively low, it is not expected that rail dampers would provide any significant control of airborne noise emissions from RRL1.	Not Effective

Option	Typical reduction in noise level	Comments	'Effectiveness' for RRL
Noise differentiated track access charges (**NDTAC**)	1-3dB(A)	A system of NDTAC is most useful to incentivise railway operators to reduce noise levels produced by their rolling stock where railways are used by a number of operators. This type of system is particularly suited to European conditions, where operators require incentives to upgrade from their older, noisier, wagon fleet with cast-iron brake blocks. NDTAC programmes are logistically difficult and expensive, since it is necessary to install and maintain a costly recording and billing system – for example, using RFID or GPS identification of train passages. An NDTAC system is unlikely to promote significant noise reductions for RRL1, since the typical rolling stock is modern, has reasonable (non-cast iron) braking systems, and wheel conditions.	Not Effective
Off-reservation architectural acoustic treatments	10-20dB(A) (locally)	Can provide effective noise mitigation to the internal areas of treated buildings, provided that the building structure type is appropriate for the available types of treatment and that doors and windows remain closed. Architectural acoustic treatments provide noise mitigation to individual dwellings, and do not reduce noise impacts external to the buildings nor provide an overall improvement to noise amenity along the rail corridor.	Effective for individual dwellings in some circumstances

4 Ambient Noise Measurements

KAJV undertook ambient noise measurements along the RRL1 rail corridor to determine the existing operational noise impacts experienced along the alignment, and to document the existing ambient noise levels.

The purpose of these measurements is to document the existing noise levels adjacent to the corridor and broadly describe the major contributions to the existing noise climate.

Ambient noise measurements were conducted between March and June 2010 at 23 locations along Section 1 of the proposed RRL corridor. Eleven of the measurement locations were within the existing railway corridor, near to the adjacent property boundary (see Table 4).

Supplementary ambient noise measurements were conducted in December 2010 at an additional 6 locations and are denoted S1–S6.

The measurement locations are shown in Figures 4a and 4b below, and are considered to be representative of the various types of locations found in the study area.

Table 4 Noise measurement locations and dates

Location	Description	Start date	End date
1	within corridor	26 Mar 2010	1 April 2010
2	80 Railway Place, West Melbourne	27 May 2010	7 July 2010
3	133 Ormond Street, Kensington	21 May 2010	27 May 2010
4	within corridor	12 Mar 2010	19 Mar 2010
5	32 Cowper Street, Footscray	27 May 2010	7 July 2010
6	92 Victoria Street, West Footscray	21 May 2010	27 May 2010
7	19 Errol Street, West Footscray	21 May 2010	27 May 2010
8	within corridor	12 Mar 2010	19 Mar 2010
9	within corridor	12 Mar 2010	19 Mar 2010
10	94 Cross Street, West Footscray	13 May 2010	21 May 2010
11	61 Rupert Street, West Footscray	13 May 2010	21 May 2010
12	within corridor	12 Mar 2010	19 Mar 2010
13	195 Sunshine Road, West Footscray	13 May 2010	21 May 2010
14	within corridor	12 Mar 2010	19 Mar 2010
15	within corridor	26 Mar 2010	1 April 2010
16	5 Station Place, Sunshine	27 May 2010	7 July 2010
17	within corridor	26 Mar 2010	1 April 2010
18	within corridor	26 Mar 2010	1 April 2010
19	31 Ridgeway Parade, West Sunshine	13 May 2010	21 May 2010
20	163 Ridgeway Parade, West Sunshine	21 May 2010	27 May 2010
21	within corridor	26 Mar 2010	1 April 2010
22	60 Railway Parade, Deer Park	13 May 2010	21 May 2010
23	within corridor	26 Mar 2010	31 Mar 2010

Location	Description	Start date	End date
S1	9 Railway Place, Footscray	14 Dec 2010	21 Dec 2010
S2	45 Railway Place, Footscray	14 Dec 2010	21 Dec 2010
S3	1/5 Short Street, Footscray	14 Dec 2010	21 Dec 2010
S4	10 Raleigh Street, Footscray	14 Dec 2010	21 Dec 2010
S5	61 Windsor Street, Seddon	14 Dec 2010	21 Dec 2010
S6	135 Ridgeway Parade, Sunshine West	14 Dec 2010	21 Dec 2010

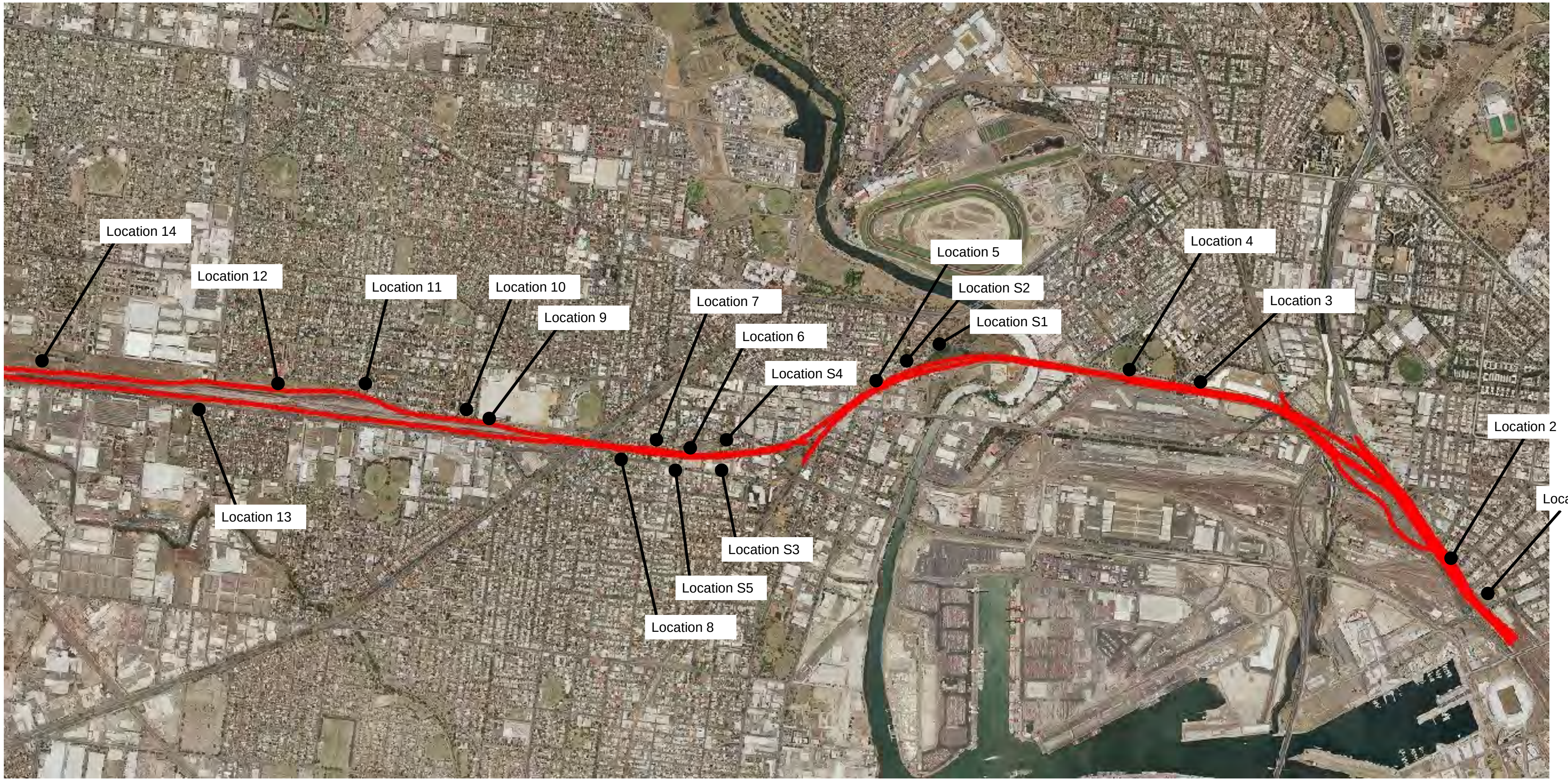

Figure 4a Ambient noise level measurement — Locations 1 to 14 and S1 to S5.

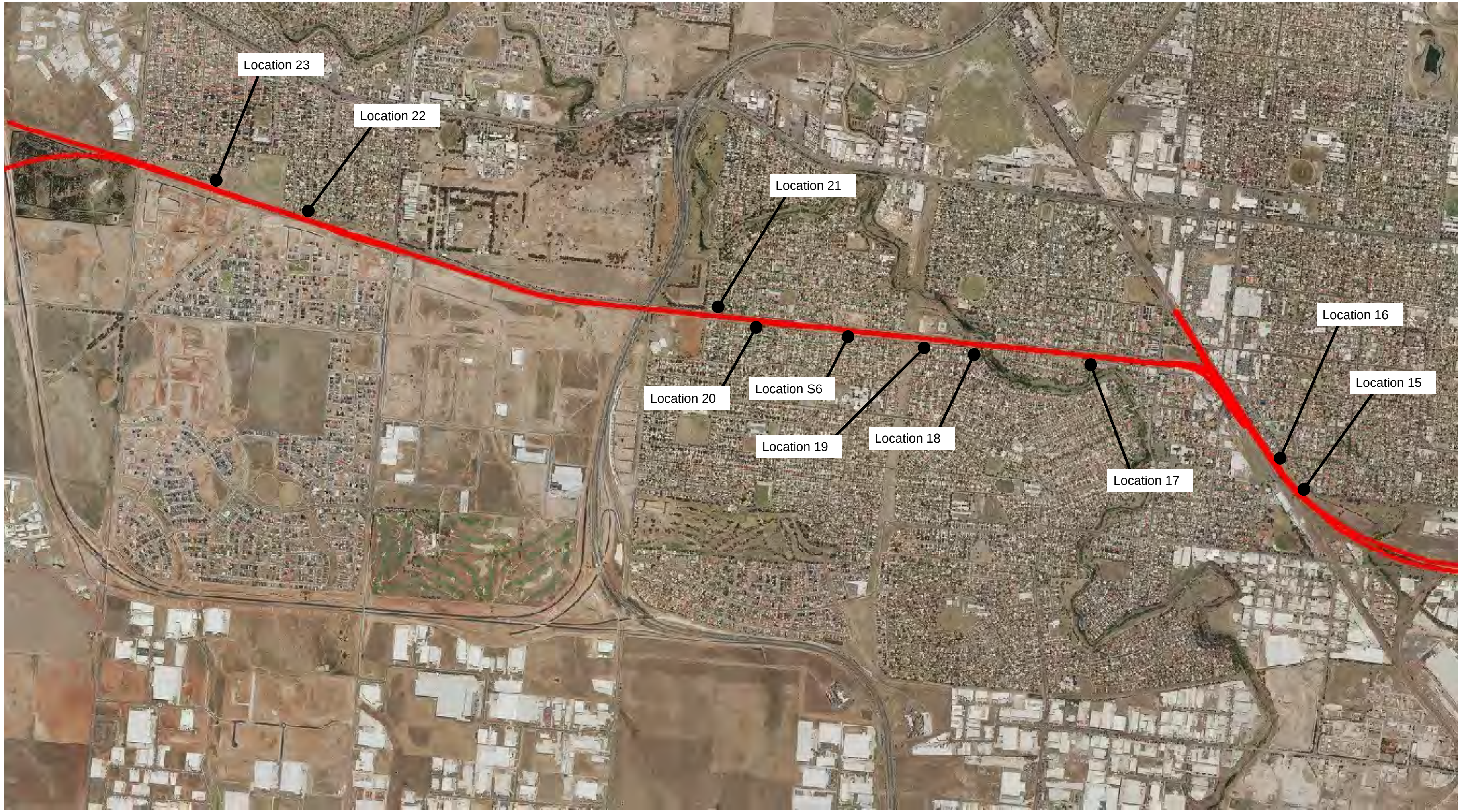

Figure 4b Ambient noise level measurement—Locations 15 to 23 and S6.

4.1 Methodology and Instrumentation

The procedure for the measurement of noise from railways is based on the procedure for measuring road traffic noise in Victoria. Therefore the measurements were conducted 1 m from the centre of the window at the most exposed façade.

The height of the microphone was typically 1.2–1.5 m. Data were recorded at hourly intervals.

Details of the measurement equipment are provided in Table 5. Each item of equipment has current NATA[11] calibration certification. The calibration of equipment was checked before and after each set of measurements.

Table 5 Noise measurement instrumentation

Manufacturer	Name of Instrument	Serial Number
RTA Technology	Noise logger	RTA02-016
RTA Technology	Noise logger	RTA02-029
RTA Technology	Noise logger	RTA02-034
RTA Technology	Noise logger	RTA04-007
RTA Technology	Noise logger	RTA04-008
RTA Technology	Noise logger	RTA04-009
RTA Technology	Noise logger	RTA04-010
Acoustic Research Laboratories	Noise logger	Ngara 878060
Acoustic Research Laboratories	Noise logger	Ngara 878061
Brüel & Kjær	Acoustical calibrator Type 4231	2136569

4.2 Results

The detailed results of these ambient noise measurements are provided in Appendix B.

Generally, within the current railway corridor existing noise levels were:

- average weekday existing noise levels 65–70 $dBL_{Aeq,15h}$ (daytime)
- average week-night existing noise levels 58–63 $dBL_{Aeq,9h}$ (night-time)
- maximum existing noise levels 100–105 dBL_{Amax}.

[11] National Association of Testing Authorities

5 Operational Noise Assessment Methodology

5.1 Overview

KAJV has analysed the impact of operational noise from the RRL1 project in the context of the existing railway noise profile along the RRL1 rail corridor. KAJV have used the RRL1 Reference Design which incorporates the following route-wide noise mitigation measures discussed above;

- Design of railway alignment to include:
  - Trackwork from Moonee Ponds Creek to Footscray Station, including a new bridge over the Maribyrnong River;
  - At-grade track from Footscray Station to Sunshine Station, via Tottenham; and
  - At-grade track from Sunshine Station to Deer Park bypass;
- Track and rail roughness control; and
- Track and wheel maintenance.

The proposed alignment is either within or adjacent to the existing metropolitan and regional rail corridors and passes through both industrial and residential areas, and existing railway freight yards. The proposed railway has the potential to create noise impacts at noise sensitive receivers near to the proposed alignment in some locations, and reduce it at others, depending on the configuration of the tracks at any particular location. The locality and alignment for RRL1 are shown in Figure 1 above.

Rolling stock that will use the RRL1 tracks include:

- V/Locity and Sprinter diesel multiple units (DMUs)
- N class locomotives
- P class locomotives

It is expected that newer V/Locity type rolling stock will eventually replace the older N and P class locomotives and carriages that are currently being used. Existing electrified MTM rolling stock on the Upfield, Craigieburn, Werribee, Williamstown, and Sydenham lines will continue to use the corridor.

Freight rail traffic is not proposed to use the RRL1 tracks. However, there are existing freight railway movements along the proposed corridor, particularly near Tottenham Yard and between Sunshine Station and Dynon Yard via the Bunbury Street freight tunnel in Footscray.

The rail operational phases that are considered are based on those documented in the Regional Rail Link Rail Capacity Upgrade Phases report, as follows:

- Phase 0: pre-RRL upgrades ('existing' 2012)
- Phase 1: Day 1, opening of RRL (2014)

In addition, the operation of the railway 10 years after opening (2024) is considered. This scenario is typically used when considering noise mitigation options for transport infrastructure projects.

5.2 Noise Model

The Nordic Rail Prediction Method[12], developed by Kilde, was used to predict operational airborne railway noise levels adjacent to the proposed alignment. The Nordic method is commonly used for railway noise prediction in Australia because it provides both average and maximum noise level predictions. Predictions of the daytime average ($L_{Aeq,15\ hr}$), night-time average ($L_{Aeq,9\ hr}$), 24-hour average ($L_{Aeq,24\ hr}$) and maximum noise level (L_{Amax}) have been conducted.

The Nordic methodology was implemented in SoundPLAN version 7.0, a well-established software package for environmental noise prediction. The computer acoustic model was validated against spot calculations at specific locations.

Only noise from railway operations is considered in the current assessment. Noise from vehicle movements within sidings and wash or maintenance operations are not included, since there are no provisions for these under the current proposal.

5.3 Source Noise Levels

The acoustic analysis is based on the noise levels of specific sources for the following scenarios:

- Phase 0: pre-RRL upgrades (‘existing’ 2012)
- Phase 1: Day 1 RRL (2014)
- 10 years after opening: RRL (2024)

The types and number of RRL (diesel and locomotive) and MTM (electric) rail vehicles assumed to be travelling in the corridor are based on the service plans provided by the Public Transport Division of the Department of Transport in the report on rail capacity upgrade phases. The 10 years after opening scenario represents the currently proposed 2024 flows for the RRL infrastructure[13].

Baseline broad gauge freight movements are based on master timetables for V/Line freight movements[14]. Standard gauge freight movements are based on ARTC’s commitment charts for Victoria[15]. The assumed freight service schedule is shown in Table 6. No increase over current freight schedules is included for any of the future phases.

The metropolitan and RRL schedule for each of the operational scenarios used in the acoustic model is shown in Table 7. The peak and off-peak/counter-peak rail vehicle flow rates are shown visually in Figure 5. Peak services apply from 7-9 am for inbound trains and 4-6 pm for outbound trains.

The railway noise model is relatively insensitive to vehicle flow rate assumptions. For example, a 20% change in vehicle flows would result in a change in predicted noise level of less than 1 dB.

12 Nordic Council of Ministers, *Railway Traffic Noise- The Nordic Prediction Method,* TemaNord 1996:524

13 The *constrained capacity* of the RRL represents the capacity of the RRL infrastructure that is constrained by the provision of rolling stock and adjacent network capacity limitations. The *ultimate capacity* of the infrastructure is higher, but unable to be realised without additional rolling stock or unrelated project works to increase capacity elsewhere on the network.

14 Available at http://www.vline.com.au/rna/rna/information_pack.html#freightschedules

15 Available at http://www.artc.com.au/Content.aspx?p=209

Table 6 Freight services: All phases

Section	Trains per hour, day (no.)	Trains per hour, night (no.)	Average train length, day (m)	Average train length, night (m)	Maximum train length (m)
Rockbank to Sunshine	0.1	0.1	679	679	679
Albion to Sunshine	1.8	0.9	629	629	629
Sunshine to Brooklyn	1.8	0.9	640	640	640
Brooklyn to Dynon	2.5	1.0	688	688	688

Table 7 V/Line and Metro service assumptions

Line	Phase 0 pre-RRL (2012)		Phase 1 RRL (2014)		10 years after opening (2024)	
	Peak direction, services per hour	Off-peak and counter-peak, services per hour	Peak direction, services per hour	Off-peak and counter-peak, services per hour	Peak direction, services per hour	Off-peak and counter-peak, services per hour
V/LINE						
Geelong	2.5 x 6 car V/Locity 1 x 7 car V/Locity 1 x 5 car N-Class loco	3 x 3 car V/Locity	5 x 6 car V/Locity 1 x 5 car N-Class loco	4 x 3 car V/Locity	3 x 6 car V/Locity 3.5 x 8 car V/Locity 1 x 5 car N-Class loco	4 x 3 car V/Locity
Ballarat	1 x 6 car V/Locity 0.5x 5 car V/Locity	1 x 3 car V/Locity	1.5 x 6 car V/Locity 0.5 x 3 car V/Locity	1 x 3 car V/Locity	2 x 6 car V/Locity	1 x 3 car V/Locity
Bacchus Marsh	1 x 6 car P-Class loco 1 x 6 car N-Class loco	1 x 3 car V/Locity	1 x 7 car P-Class loco 1 x 7 car N-Class loco 0.5 x 5 car N-Class loco	1 x 3 car V/Locity	1 x 7 car P-Class loco 1x 7 car N-Class loco 0.5 x 5 car N-Class loco	1 x 3 car V/Locity
Bendigo	1 x 6 car V/Locity 0.5 x 5 car V/Locity 0.5 x 3 car V/Locity 0.5 x 5 car N-Class loco	1 x 3 car V/Locity	1.5 x 6 car V/Locity 1 x 3 car V/Locity 0.5x 5 car N-Class loco	1 x 3 car V/Locity	3 x 6 car V/Locity	1 x 3 car V/Locity
Seymour	2 x 2 car Sprinter	1 x 2 car Sprinter	2 x 2 car Sprinter	1 x 2 car Sprinter	2 x 2 car Sprinter	1 x 2 car Sprinter
Empty Cars (SXS to South Kensington)	2 x 3 car V/Locity 0.5x 2 car Sprinter	1 x 3 car V/Locity 0.5x 2 car Sprinter	2 x 3 car V/Locity 0.5 x 2 car Sprinter	1 x 3 car V/Locity 0.5 x 2 car Sprinter	2 x 3 car V/Locity 0.5 x 2 car Sprinter	1 x 3 car V/Locity 0.5 x 2 car Sprinter
METRO						
Werribee/Williamstown	10.5 x 6 car EMU	6 x 6 car EMU	12.5 x 6 car EMU	6 x 6 car EMU	12.5 x 6 car EMU	6 x 6 car EMU
Sydenham	9 x 6 car EMU	3x 6 car EMU	11 x 6 car EMU	3 x 6 car EMU	11 x 6 car EMU	3 x 6 car EMU
Upfield	7 x 6 car EMU	3 x 6 car EMU	9 x 6 car EMU	4 x 6 car EMU	9 x 6 car EMU	4 x 6 car EMU
Craigieburn	8 x 6 car EMU	5 x 6 car EMU	9 x 6 car EMU	6 x 6 car EMU	9 x 6 car EMU	6 x 6 car EMU

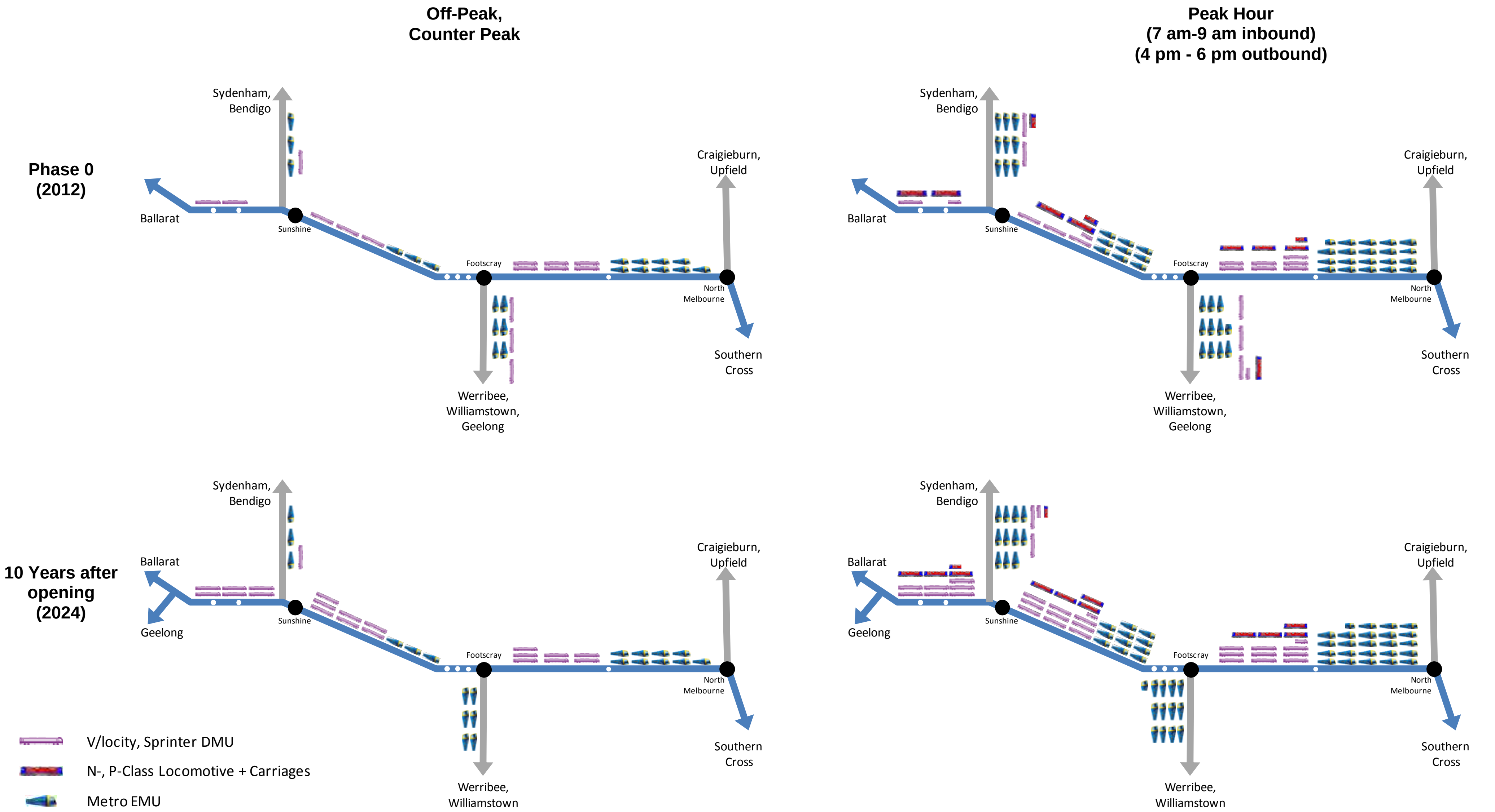

Figure 5 Number of trains per hour, per section of RRL1, (single direction only shown)

The maximum speed for each type of train is shown in Table 8 below. Speed limits for each section of track are shown in Table 9. These track speed limits are based on the maximum recommended vehicle speeds allowable on the particular track geometry (eg. crossing, curve etc.), and are therefore not subject to being increased in the future without significant infrastructure works.

The speed used in the acoustic model is the lower of the train type maximum speed and the track speed limit.

Table 8 Maximum speed for each train type

Train type	Speed Limit, km/h
V'locity	160
Sprinter	130
Locomotive	115
EMU, east of Sunshine	80
EMU, west of Sunshine	115

Table 9 Speed limit for each section of track

Section of Track	Inbound Speed Limit, km/h	Outbound Speed Limit, km/h
PHASE 0 Pre-RRL (2012)		
Rockbank to Ardeer	115	160
Ardeer to ch 14 000	115	130
ch 14000 to ch 12 700	115	115
ch 12 700 to Sunshine	40	40
Albion to Sunshine	70	70
Sunshine to ch 5 900	80	80
ch 5 900 to ch 5 300	50	50
ch 5 300 to ch 2 700	80	80
ch 2 700 to North Melbourne	65	65
PHASE 1 (2014) and 10 years after opening (2024)		
Tarneit to ch 19 800 (Geelong line)	160	160
ch 19800 to ch 18 200 (Geelong line)	65	65
Rockbank to Ardeer	130	160
Ardeer to ch 14 000	130	130
ch 14000 to ch 12 700	115	115
ch 12 700 to Sunshine	40	40
Albion to Sunshine	70	70
Sunshine to ch 11 400	80	80
ch 11400 to ch 7 800 (RRL, Melton, Bendigo lines)	130	130
ch 11400 to ch 7 800 (Sydenham lines)	80	80

Section of Track	Inbound Speed Limit, km/h	Outbound Speed Limit, km/h
ch 7 800 to ch 5 900	80	80
ch 5 600 to 5 300 (RRL, Melton, Bendigo lines)	50	50
ch 5 600 to 5 300 (Sydenham lines)	70	70
ch 5 300 to ch 2 500 (RRL, Melton, Bendigo lines)	80	80
ch 5 300 to ch 2 500 (Sydenham lines)	70	70
ch 2 500 to North Melbourne (RRL, Melton, Bendigo lines)	65	65
ch 2 500 to North Melbourne (Sydenham lines)	70	70
ch 2 700 to North Melbourne (freight flyover)	40	40

5.4 Reference Source Noise Levels

The basic source noise levels for the railway vehicles depend on the type of vehicle (DMU, EMU, freight), car arrangement, vehicle speed and the combined wheel–rail interface roughness.

While there is some variation between individual rail vehicles, it is common to determine a reference source noise spectrum or noise level for various types of vehicle at a reference speed (usually 80 km/h) and distance (usually 10 m).

The reference source noise levels for Victorian rail vehicles are not established. However, source noise levels for similar electric and diesel rail vehicles in NSW were documented by Rail Access Corporation (now RailCorp)[16]. These reference source noise levels are based on a statistical analysis of hundreds of individual rail movements of various vehicle types.

The source noise levels given in Table 10 are adopted for the various classes of trains that will use the corridor. The levels for DMU and locomotive sources are validated against noise level measurements undertaken adjacent to the existing Lilydale, Geelong, Ballarat and Bendigo lines (shown in Chapter 5.5 below).

Sound Exposure Levels (SELs) are used to determine the L_{Aeq} levels (by correcting for the number of events during the time period) and are measured 100 m from the train according to the Nordic Methodology. The reference distance for L_{Amax} levels is 10 m, as specified by Nordic Methodology.

These reference noise levels are also adjusted for the actual speed of the vehicles based on the NSW source level data, as follows:

- $L_{Aeq,\ DMU}\ (S) = L_{A,SEL}(\text{ref}) + 13 \log (S/80)$
- $L_{Amax,\ DMU}\ (S) = L_{Amax}(\text{ref}) + 16.8 \log (S/80)$
- $L_{Aeq,\ Loco}\ (S) = L_{A,SEL}(\text{ref}) + 5.8 \log (S/80)$
- $L_{Amax,\ Loco}\ (S) = L_{Amax}(\text{ref}) + 8 \log (S/80)$

Where *S* is the actual vehicle speed.

16 *Rail Noise Database: State II Noise Measurements and Analysis*, Rail Access Corporation Report 00091 Version A, August 2000.

Table 10 Reference source noise levels of vehicles used for acoustic modelling

Train Type	$L_{A,SEL}$ / L_{Aeq} † (dB)	L_{Amax} (dB)	Reference Speed (km/h)
Diesel multiple unit (DMU) (V/locity, Sprinter)	83	92	80
Electric multiple unit (EMU)	75	87	80
N and P Class Locomotive	83	92	80
Passenger wagon	74†	- *	80

** Since passenger wagons are always hauled by an accompanying locomotive, the maximum noise level is determined by the locomotive.*

5.5 Validation Measurements

Site measurements of noise levels of EMU, DMU and locomotive rail vehicles were undertaken adjacent to the existing Lilydale, Geelong, Ballarat and Bendigo lines. These measurements can be compared with the noise levels predicted using the reference source noise levels in Table 10 to validate the reference source levels used in the modelling.

Comparisons between the SEL at 100 m from the track and the L_{Amax} noise level 10 m from the track for DMUs are presented in Figures 6 and 7 respectively. In each case the noise levels have been normalised to an eight-car DMU, and to the reference distance. Validation comparisons for EMUs are shown in Figures 8 and 9, and for the locomotive source in Figures 10 and 11.

The figures indicate that the source levels used for the predictions are representative of the typical noise level generated by the existing rolling stock.

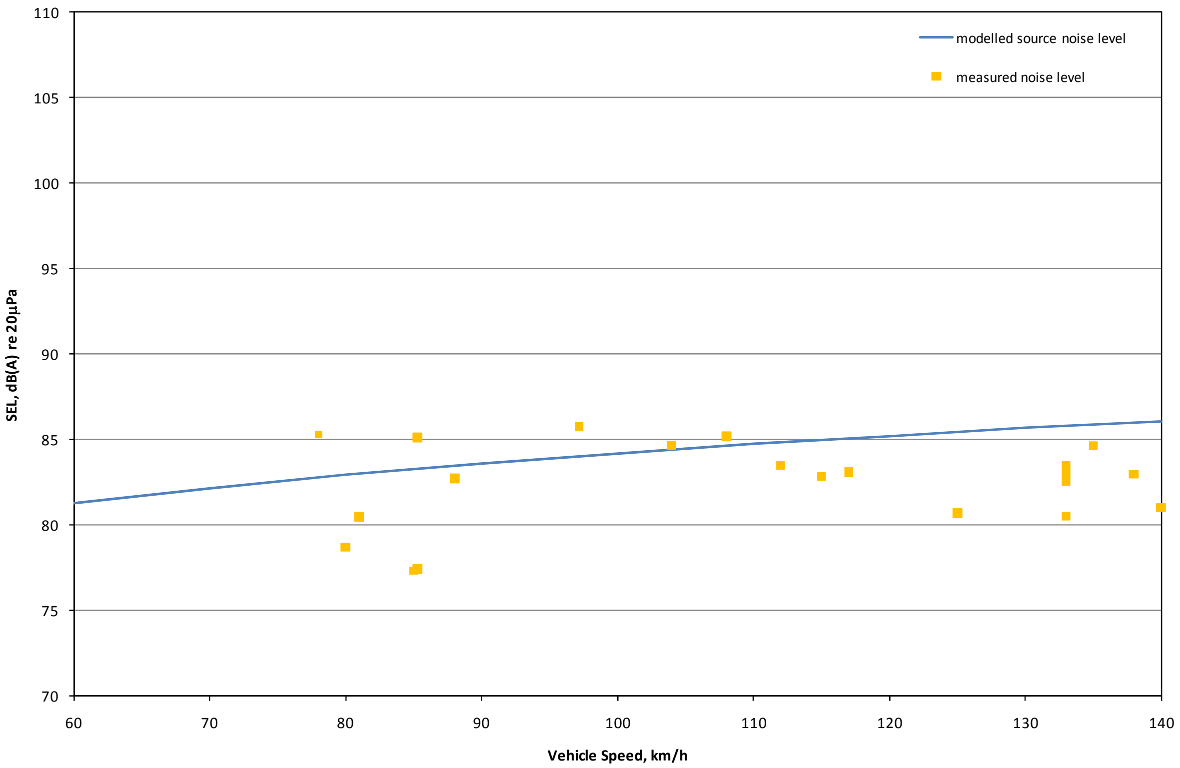

Figure 6 Comparison between V/Locity and Sprinter prediction and measured sound exposure levels, SEL (dB(A) re 20 μPa), normalised to eight-car DMU at 100 m

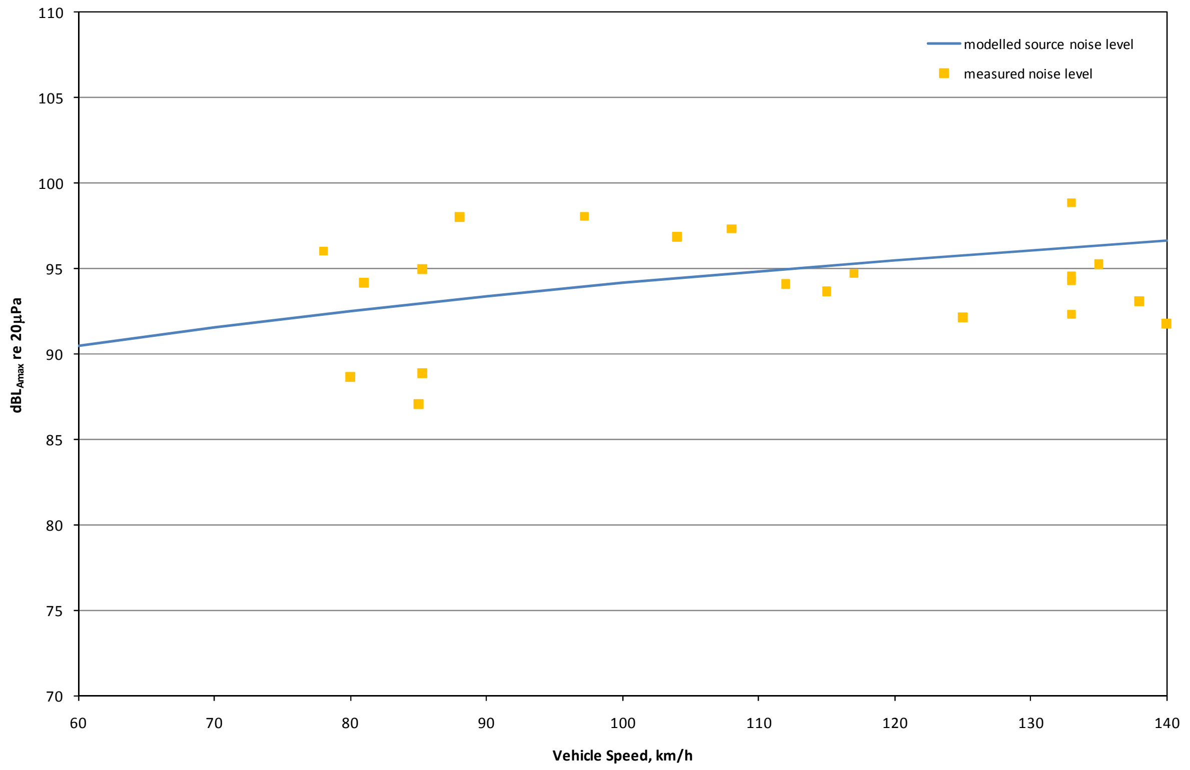

Figure 7 **Comparison between V/Locity and Sprinter prediction and measured maximum noise level, L_{Amax} (dB re 20 µPa), normalised to eight-car DMU at 10 m**

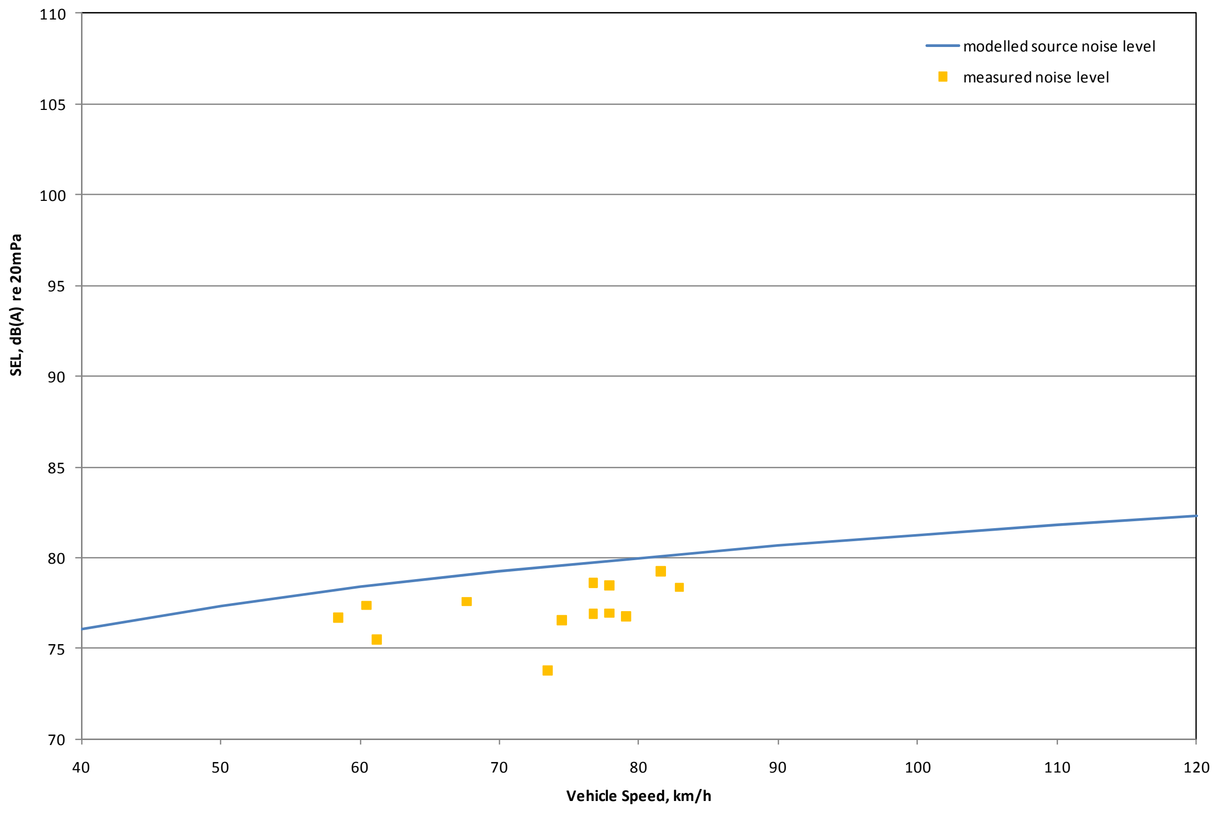

Figure 8 **Comparison between EMU prediction and measured sound exposure levels, SEL (dB(A) re 20 µPa), normalised to eight-car EMU at 100 m**

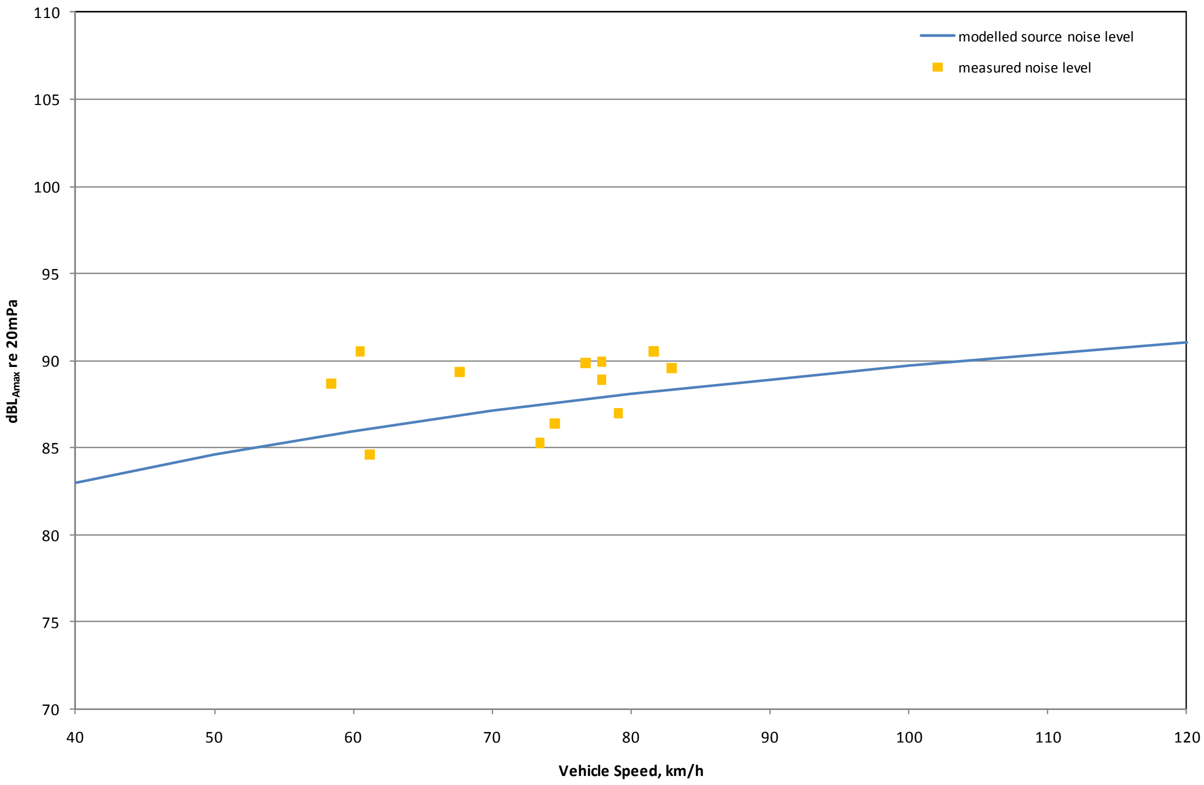

Figure 9 **Comparison between EMU prediction and measured maximum noise level, L_{Amax} (dB re 20 μPa), normalised to eight-car EMU at 10 m**

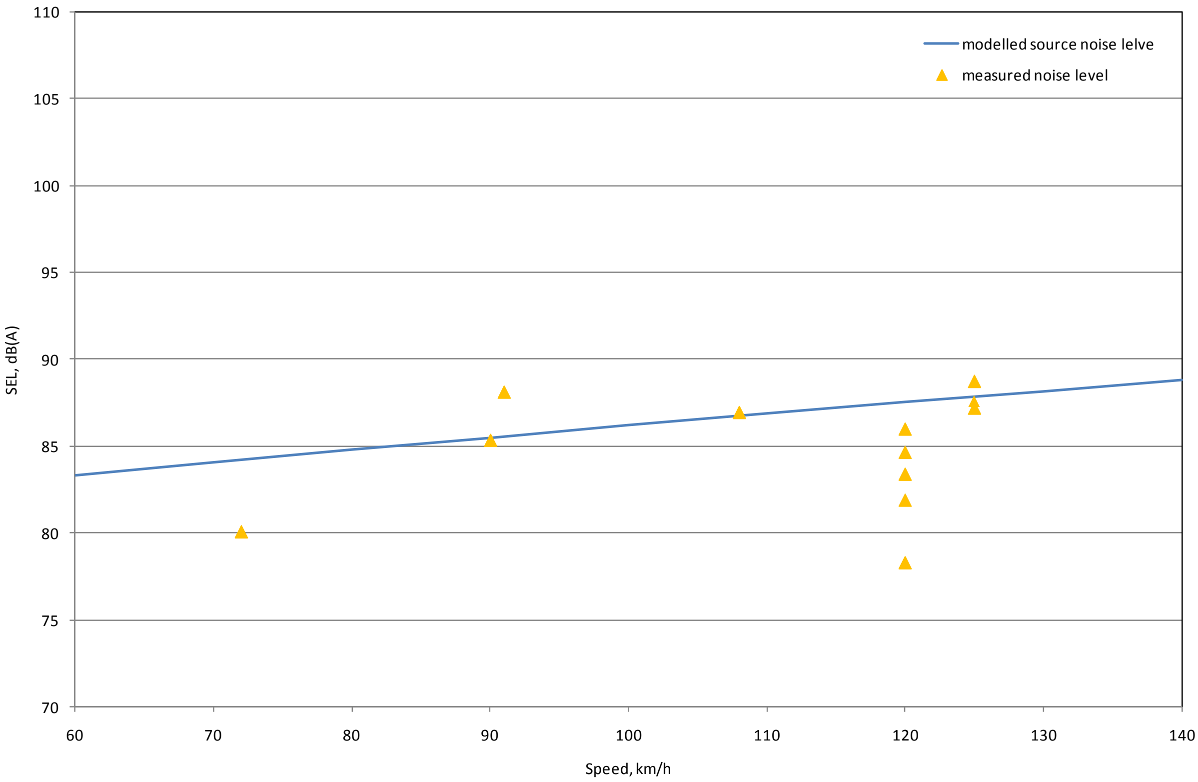

Figure 10 **Comparison between locomotive prediction and measured sound exposure levels, SEL (dB(A) re 20 μPa), at 100 m**

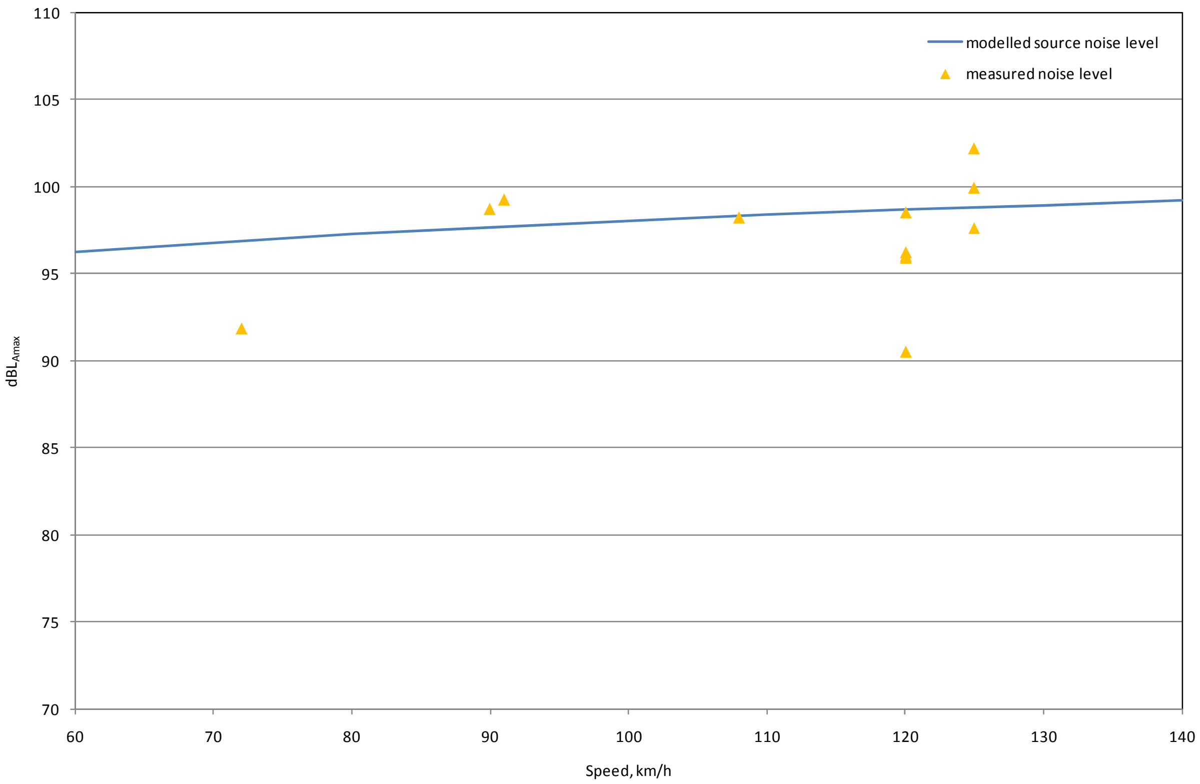

Figure 11 **Comparison between locomotive prediction and measured maximum noise level, L_{Amax} (dB re 20 μPa), at 10 m**

The noise model was also validated by comparing predictions for the existing average 15 hour and maximum noise levels directly with measurements of noise levels undertaken at locations near to the existing railway. The $L_{Aeq,15hr}$ validation results are shown in Figure 12, and the L_{Amax} results in Figure 13. The graphs show the arithmetic average of the daily average and maximum noise levels as '•', as well as the range of measured daily average and maximum noise level across all days measured as '–––'.

The $L_{Aeq,15hr}$ validation is based on measurements at Locations 3, 5, 6, 7, 9, 10, 11, 12, 13 and 14, as shown in Figure 4. The L_{Amax} validation is based on measurements at Locations 3, 6, 7, 9, 12, 13 and 14. These locations were selected because they are relatively close to the railway alignment, and therefore less likely to be affected by extraneous noise from other sources. Nevertheless, the variances shown are likely to be due to local influences, such as the condition of the railway track, nearby construction sites, road traffic on local roads or use of alternate (non-worst case) freight alignments (near Tottenham yards).

Overall, the validation shows reasonable agreement between the predicted and measured noise levels at most locations.

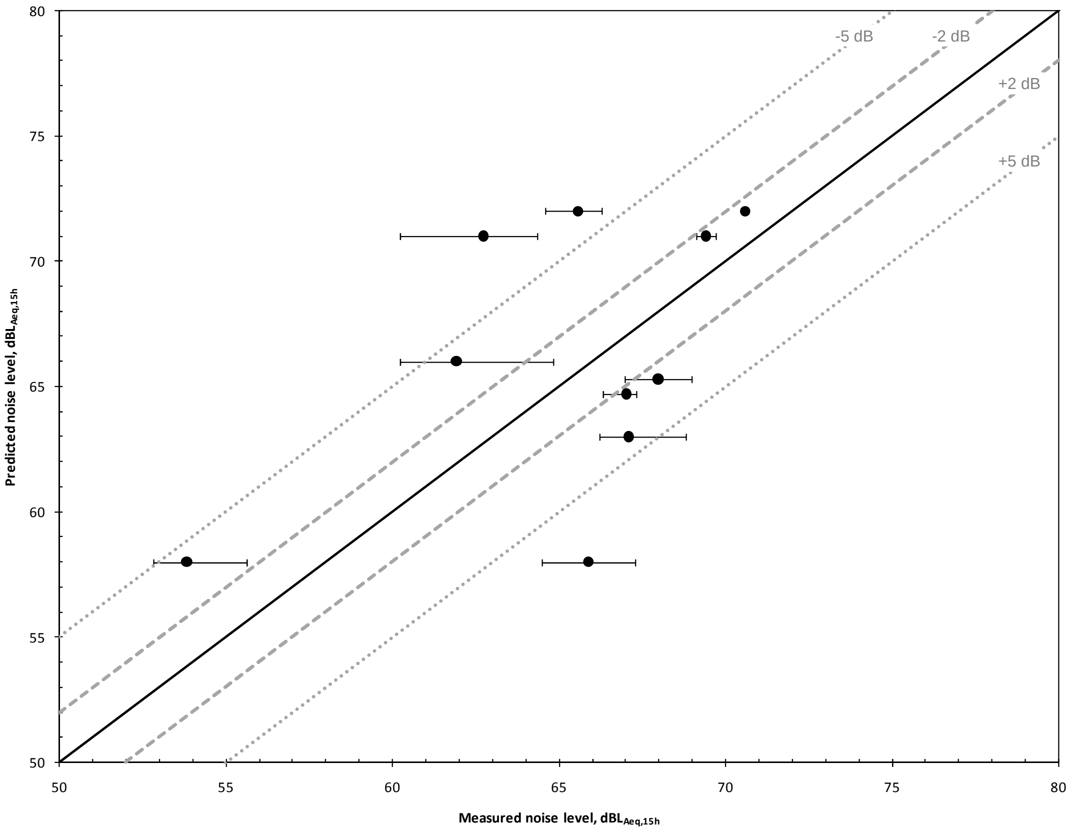

Figure 12 $L_{Aeq,15hr}$ validation measurements

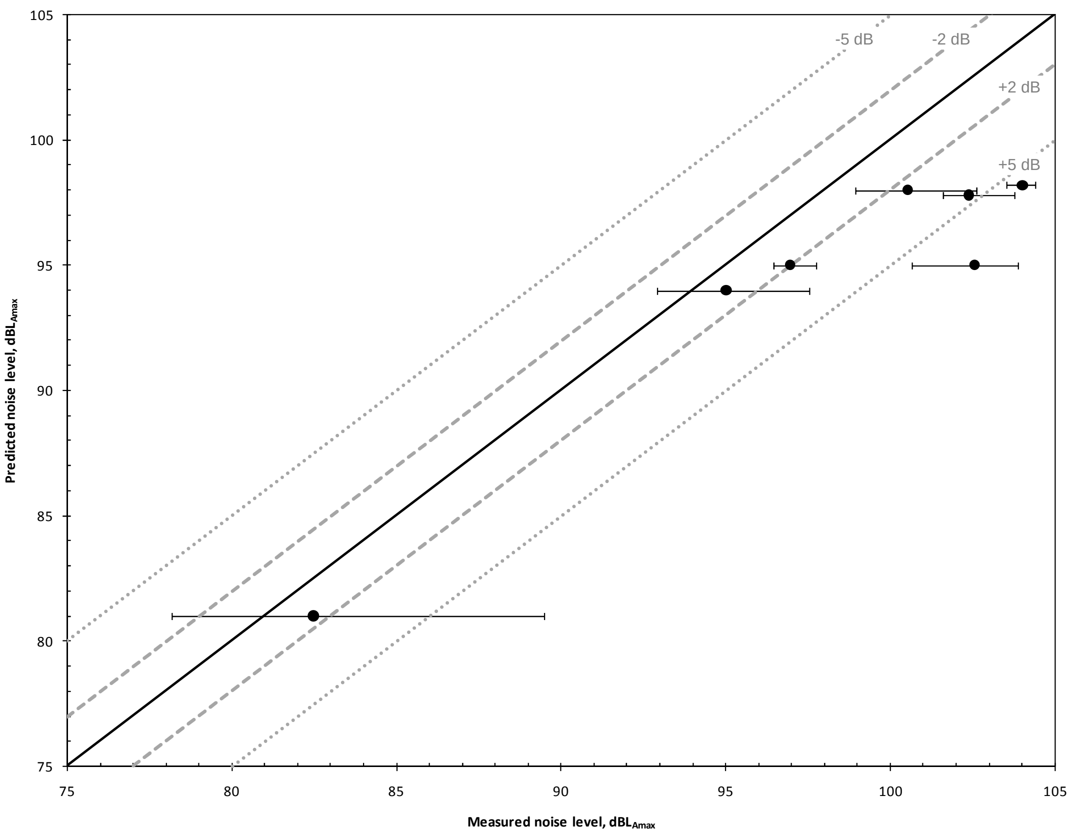

Figure 13 L_{Amax} validation measurements

5.6 Topography

Terrain features were modelled using 1 m terrain survey contours. A ground absorption factor of 0.6 was used since this is representative of ground absorption experienced in similar suburban locations. Shielding from existing terrain and the typical earthworks is included in the model.

The railway alignment design is based on the reference design. Details of the input data used to construct the acoustic model are provided in Appendix C.

5.7 Noise Sensitive Receivers

5.7.1 Definition of 'Noise Sensitive Receiver' in this Report

As discussed in Chapter 2, there is no rail noise policy guideline for Victoria and the Victorian Planning Policy includes only a general observation that noise can affect adjacent land uses and amenity. Other Australian jurisdictions use a range of definitions depending on the nature and purpose of the policy statement or guideline.

In this report, for consistency with Victorian planning policy, it is considered appropriate to use the definition of a 'sensitive use' broadly as defined in Clause 45.03 'Environmental Audit Overlay' of the VPP, *Ministerial Direction No. 1 (Potentially Contaminated Land), the General Practice Note on Potentially Contaminated Land and the State Environmental Planning Policy (Prevention and Management of Contamination of Land)*.

In this report, noise sensitive receivers are therefore defined to include;

- Residential use,
- Child care centre / pre-school centre and
- Primary school.

Noise sensitive receivers are broadly identified based on the aerial photography. The maps in Appendices D and E distinguish between 'residential' buildings, being noise sensitive receivers, and 'other' commercial buildings. However, note that at this stage it has not been practical to undertake a detailed ground-survey of all the properties included in the model, and their actual land uses are not confirmed. Therefore, it is possible that there may be minor inaccuracies in the identification of sensitive receivers. More detailed identification of actual land uses would be undertaken during the detailed design phase of the project.

5.7.2 Modelled Noise Sensitive Receivers

All buildings representing potential noise sensitive receivers within approximately 500 m each side of the railway corridor are included in the noise model. Where photogrammetric data were available, existing building locations and heights were imported into the acoustic model. Where photogrammetric data were not available for a particular building, the building location was traced off the aerial photography and a height of 3.5 m was assumed.

The noise receiver height has been assumed to be at 1.5 m above ground level for all buildings. This is consistent with the approach adopted by VicRoads for the assessment of road traffic noise, where only the lowest habitable rooms of buildings are considered in the noise assessment. It is usually not considered feasible to provide additional noise mitigation for upper floors of multi-storey residential developments, since noise barriers, if they are used, would need to be unfeasibly high. Noise levels for multi-storey residential developments, where these occur, are therefore not specifically considered in this assessment.

The modelled receivers include all residential properties directly adjacent to the alignment. Properties that are expected to be subject to land acquisition in future have been excluded from the models for Phase 1 (2014) and 10 years after opening (2024).

6 Operational Noise Predictions

6.1 Results

Generally, noise levels are expected to increase due to the RRL owing to increased traffic density and vehicle length. The transfer of existing services from shared metropolitan lines to dedicated RRL tracks does result in reduction in noise level at some noise sensitive receivers due to the increased distance between the residences and the new RRL railway line, for example, around Middle Footscray and Sunshine.

Noise levels between Moonee Ponds Creek and Tottenham are expected to increase only marginally (between 1–2 dB(A)) due to the RRL because this part of the alignment is already heavily trafficked with regional, metropolitan and freight movements, and the relative increase in overall railway movements is small.

The greatest noise level increases are expected between Sunshine and Deer Park due to a larger intensification of vehicle movements compared to the corridor between Footscray and Sunshine.

6.2 Assessment

Both the daytime and night-time average noise level and maximum noise level from single train passbys are relevant for assessing the environmental impact of railway noise. The average noise level takes into account the number and duration of train passby events. These noise level parameters are commonly used as assessment criteria in the most recent NSW guidance. In addition, the Queensland (and earlier NSW) guidance uses the 24 hour average noise level ($L_{Aeq,24hr}$) as an assessment limit.

Therefore, the daytime and night-time average ($L_{Aeq,15hr}$, $L_{Aeq,9hr}$ respectively), 24-hour average ($L_{Aeq,24hr}$) and maximum (L_{Amax}) airborne noise levels are predicted at individual residential properties along the alignment for Phases 0, 1 and the '10 years after opening' scenario. The prediction results are summarised in Figures 14 to 25 below.

The noise level predictions are estimates of the day, night and 24-hour average, and maximum noise levels predicted to be experienced external to properties adjacent to the alignment based on the input assumptions described in Chapter 5. Internal noise levels within properties would be expected to be between 10–15 dB lower than the external noise levels shown with windows open, or up to 30 dB lower with windows closed, depending on the level of sound insulation provided by the building structure.

The predicted noise levels may change if the input variables, particularly the horizontal and vertical alignment or number and type of rail vehicles change during detailed design or operation of the railway.

Figures 14 to 25 provide a summary of the predicted daytime, night-time and 24-hour average, and maximum railway noise levels at all of the potentially affected existing residences located within approximately 500 m of the proposed railway.

The results are compared to the relevant guidelines for operational rail noise from NSW and Queensland, which are overlayed on the relevant graphs.

Detailed noise level contours overlaid on aerial photography of the corridor, for each of the noise indices and phases, are presented in Appendix D. For reference, the noise level contours are presented in the following sections:

- Section D1.2, Phase 0, pre-RRL upgrades (2012), $L_{Aeq,15hr}$
- Section D1.3, Phase 0, pre-RRL upgrades (2012), $L_{Aeq,9hr}$
- Section D1.4, Phase 0, pre-RRL upgrades (2012), $L_{Aeq,24hr}$
- Section D1.5, Phase 0, pre-RRL upgrades (2012), L_{Amax}
- Section D1.6, Phase 1, day 1 RRL (2014), $L_{Aeq,15hr}$

- Section D1.7, Phase 1, day 1 RRL (2014), $L_{Aeq,9hr}$
- Section D1.8, Phase 1, day 1 RRL (2014), $L_{Aeq,24hr}$
- Section D1.9, Phase 1, day 1 RRL (2014), L_{Amax}
- Section D1.10, 10 years after opening, RRL (2024), $L_{Aeq,15hr}$
- Section D1.11, 10 years after opening, RRL (2024), $L_{Aeq,9hr}$
- Section D1.12, 10 years after opening, RRL (2024), $L_{Aeq,24hr}$
- Section D1.13, 10 years after opening, RRL (2024), L_{Amax}

The relevant New South Wales and Queensland rail noise guidance levels are shown as a black contour as follows:

- $L_{Aeq,15hr}$ 65 dB (NSW)
- $L_{Aeq,9hr}$ 60 dB (NSW)
- $L_{Aeq,24hr}$ 65 dB (QLD)
- L_{Amax} 85 dB (NSW)

The predictions indicate that both the New South Wales and Queensland rail noise criteria will be exceeded at Phase 0 (2012) (ie before RRL1) due to existing railway movements. The highest noise level exceedances are around 15 dB near to Footscray for both the average and maximum noise levels.

Table 11 provides a summary of the number of properties that would exceed the various interstate railway noise guidelines in both Phase 0, Pre-RRL (2012) and 10 years after opening (2024). (Phase 1, 2014 noise levels are not shown, since they are not significantly different to 2024).

Table 11 Number of properties with noise levels exceeding interstate guidelines

	NSW Guidelines				Queensland Guidelines		
	Daytime Avg. 65 $dBL_{Aeq,15hr}$	Night-time Avg. 60 $dBL_{Aeq,9hr}$	Maximum 85 dBL_{Amax}	Any†	24-hr Avg. 65 $dBL_{Aeq,24hr}$	Maximum 95 dBL_{Amax}	Any†
Phase 0, Pre-RRL (2012)	154	223	701	733	140	515	519
10 years after opening (2024)	430	411	738	764	232	572	593

† 'any' refers to the exceedance of the average daytime or night-time or maximum guideline (NSW), or exceedance of the 24-hour average or maximum guideline (QLD). Depending on property location, topography, vehicle flow rates etc. some properties may exceed both the average and maximum guidelines, while others may exceed one, but not the other.

Prior to the opening of the RRL (2012) the NSW noise limits are predicted to be exceeded at 733 properties adjacent to the alignment. At 10 years after opening (2024), this would rise to 764 properties (although only about two-thirds of these (522) are subject to a L_{Aeq} noise level increase of 2 dB(A) or greater, or L_{Amax} increase of 3 dB(A) or greater, and therefore would not trigger an assessment under the NSW IGANRIP guidance). Under the Queensland planning limits, 593 properties are predicted to have noise levels exceeding the limits in 2024, up from 519 prior to the opening of the RRL.

The highest average and maximum noise levels are predicted around Footscray and West Footscray, where existing properties are located nearest to the existing railway corridor. The corridor between Sunshine and Deer Park currently only has 2 trains per hour (each way, off-peak) and 3.5 trains per hour (peak). This is expected to increase to 6 trains per hour (each way, off peak) and 17 trains per hour (peak). This section will therefore experience the greatest increase in railway noise levels due to the relatively higher intensification of vehicle movements (see Chapter 5.3).

Typical noise levels 10 years after opening (2024) range up to 5–10 dB above the NSW assessment criteria, with areas around Footscray exceeding by between 10–15 dB. The highest exceedance is 17 dB over the maximum noise level criteria in West Footscray.

For 10 years after opening (2024), the highest noise levels are predicted between Footscray and West Footscray, where properties are located nearest to the existing railway corridor. Average daytime noise levels are up to 78 $dBL_{Aeq,15hr}$, and night-time, around 75 $dBL_{Aeq,9hr}$. However, it should be noted that this is only marginally higher than existing noise levels measured in the area.

West of Sunshine, average daytime noise levels of 55–65 $dBL_{Aeq,15hr}$ are generally predicted, with night-time levels of 55–60 $dBL_{Aeq,9hr}$.

10 years after opening (2024), typical event maximum noise levels of 90–95 dBL_{Amax} are predicted generally across the alignment, with maximum noise levels up to around 100 dBL_{Amax} around Middle Footscray where properties are nearest to the corridor. These predicted noise levels compare reasonably well with actual noise levels measured during the attended and long-term monitoring from existing railway movements.

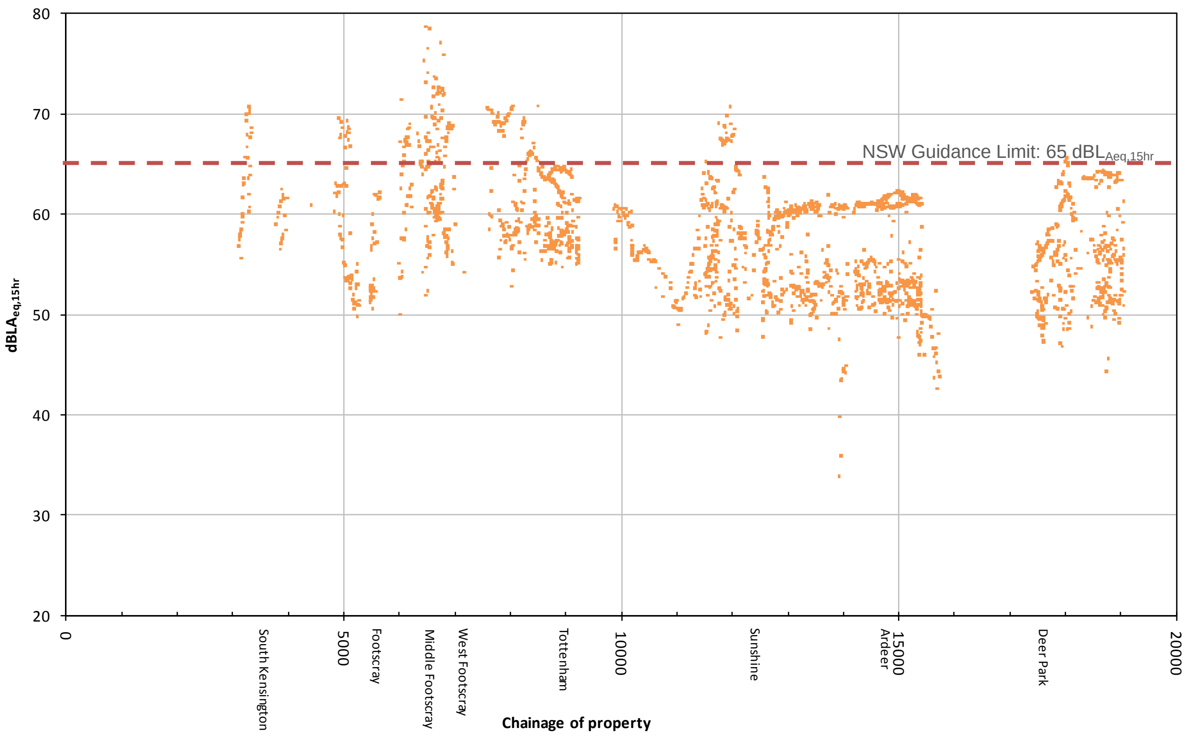

Figure 14 Phase 0, pre-RRL (2012), daytime average noise levels, $dBL_{Aeq,15hr}$ re 20 μPa

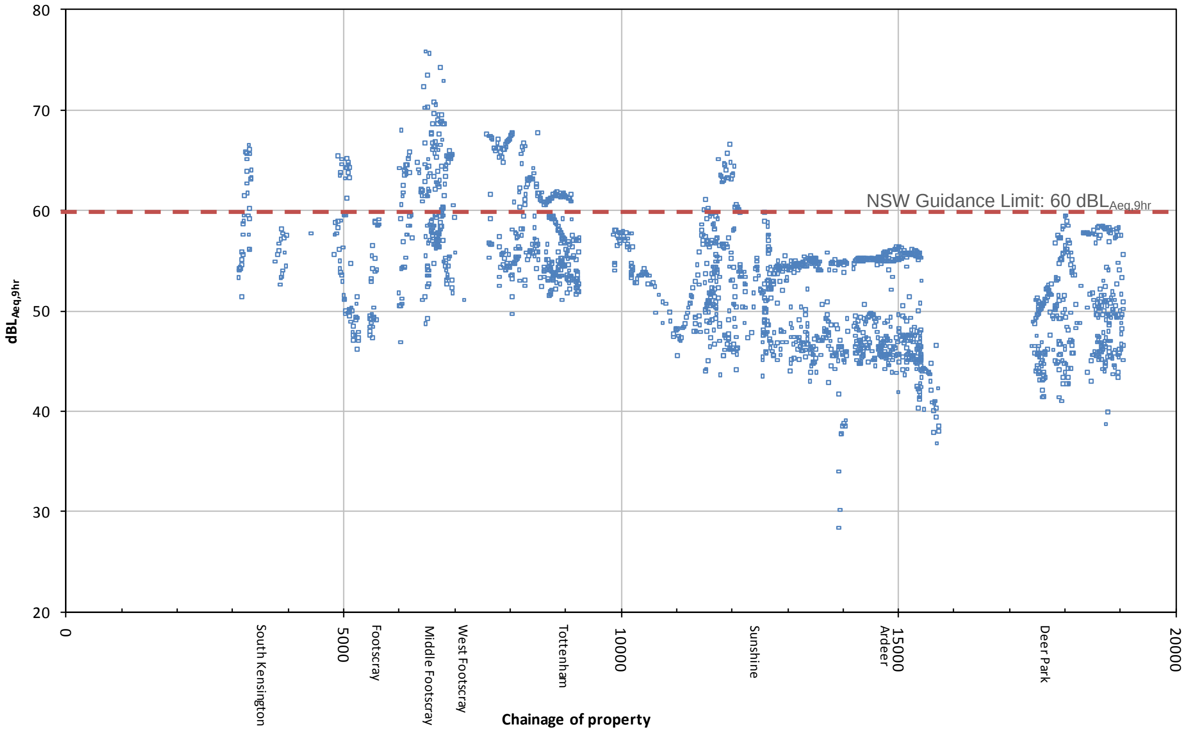

Figure 15 Phase 0, pre-RRL (2012), night-time average noise levels, dBL$_{Aeq,9hr}$ re 20 μPa

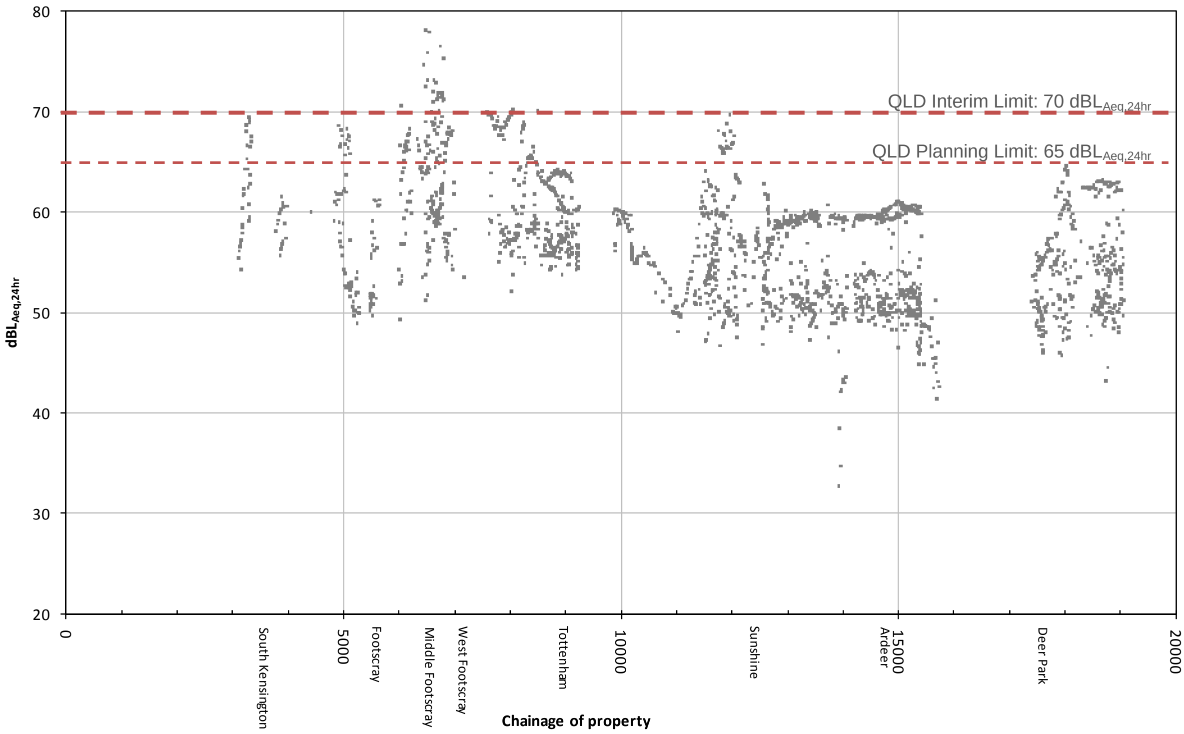

Figure 16 Phase 0, pre-RRL (2012), 24-hour average noise levels, dBL$_{Aeq,24hr}$ re 20 μPa

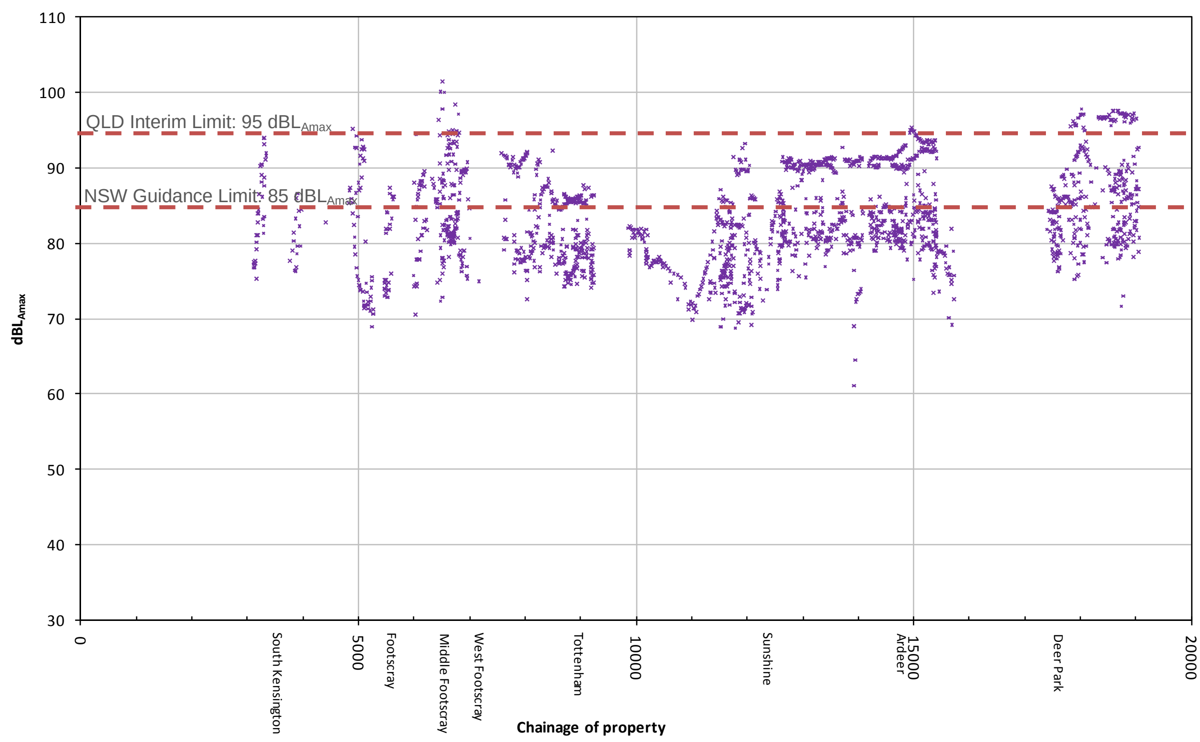

Figure 17 Phase 0, pre-RRL (2012), maximum noise levels, dBL_{Amax} re 20 μPa

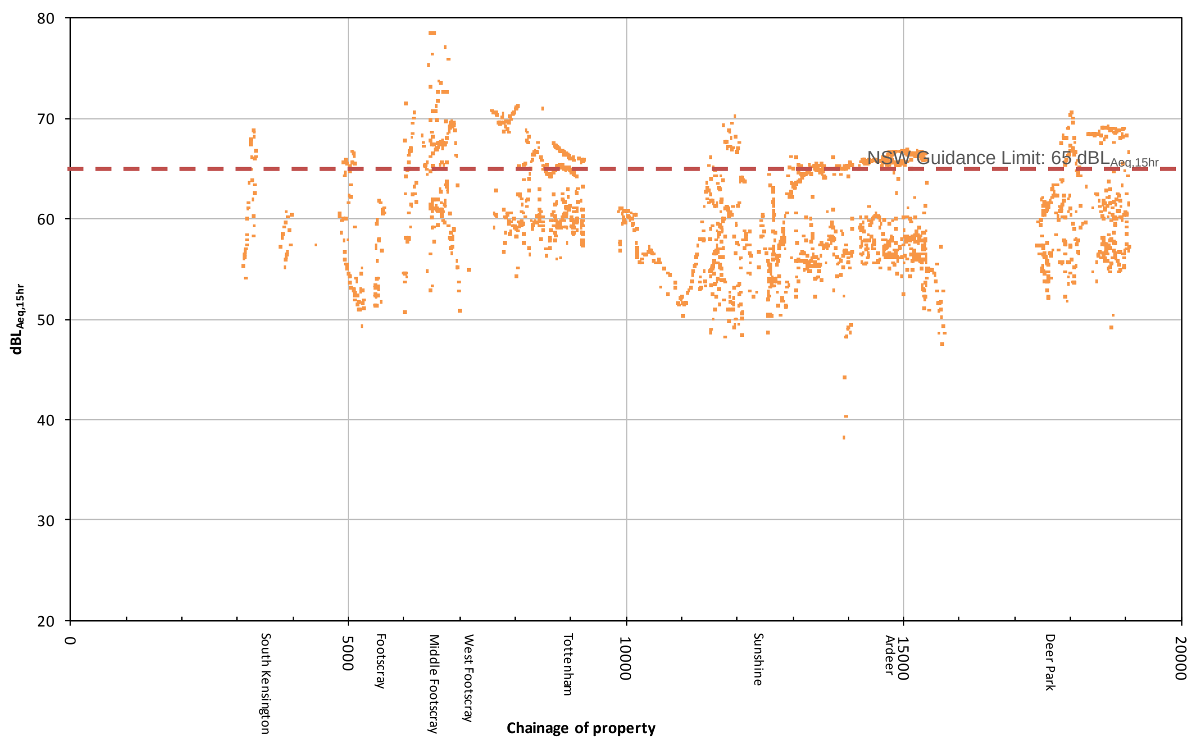

Figure 18 Phase 1, Day 1 (2014), daytime average noise levels, $dBL_{Aeq,15hr}$ re 20 μPa

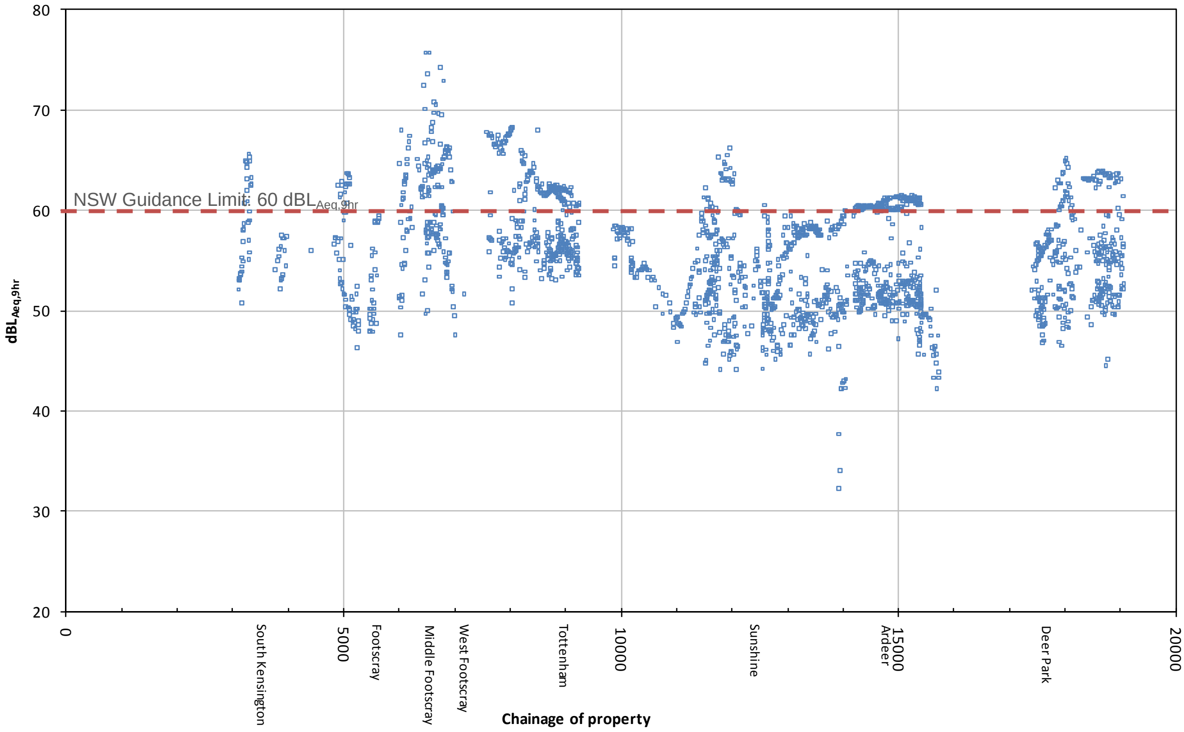

Figure 19 **Phase 1, Day 1 (2014), night-time average noise levels, $dBL_{Aeq,9hr}$ re 20 μPa**

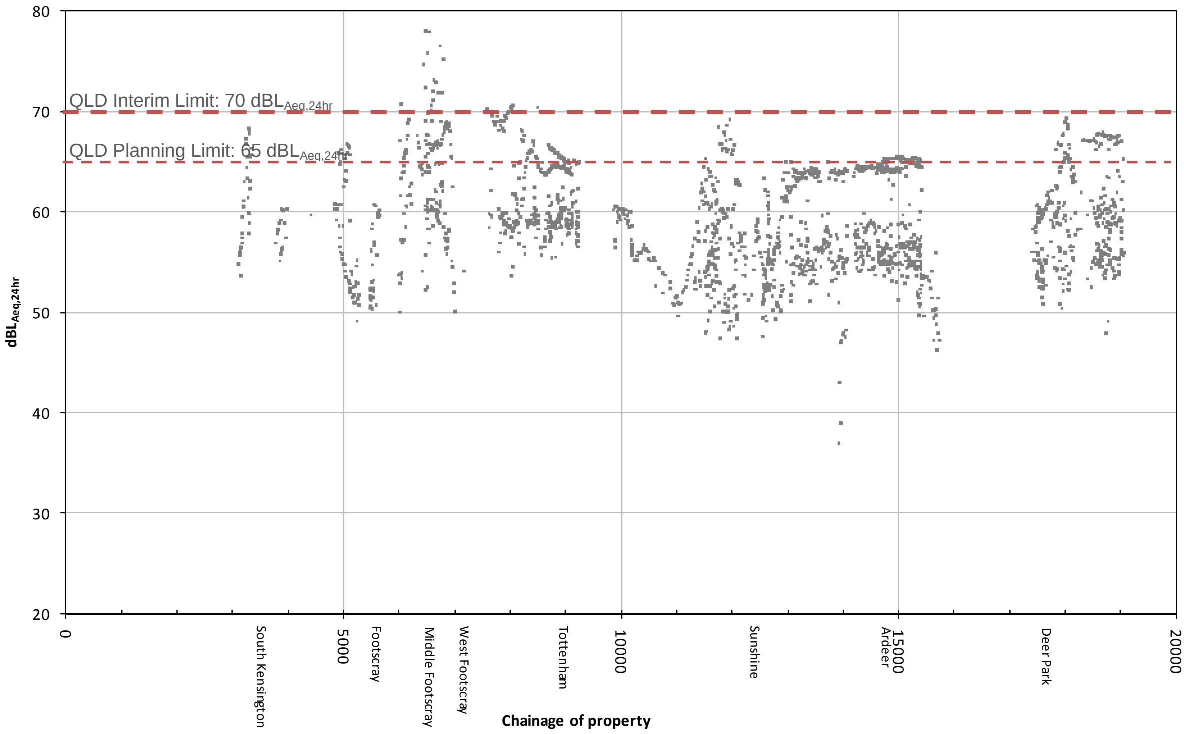

Figure 20 **Phase 1, Day 1 (2014), 24-hour average noise levels, $dBL_{Aeq,24hr}$ re 20 μPa**

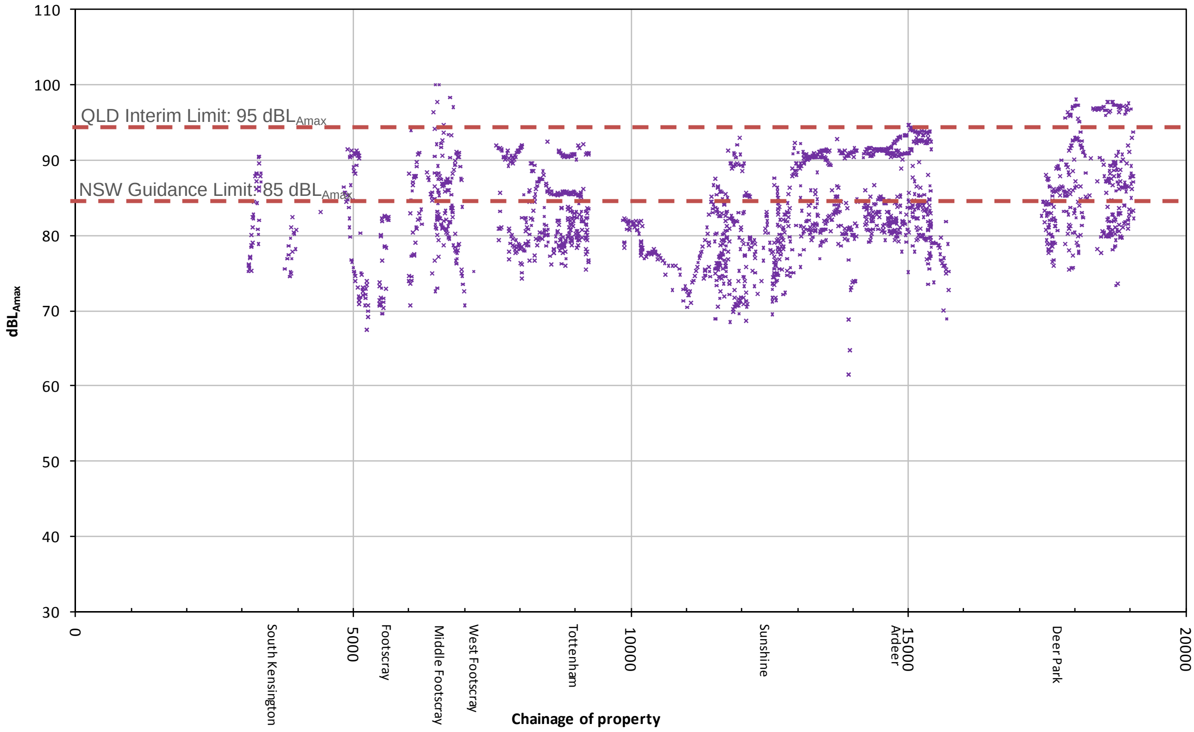

Figure 21 **Phase 1, Day 1 (2014), maximum noise levels, dBL_{Amax} re 20 μPa**

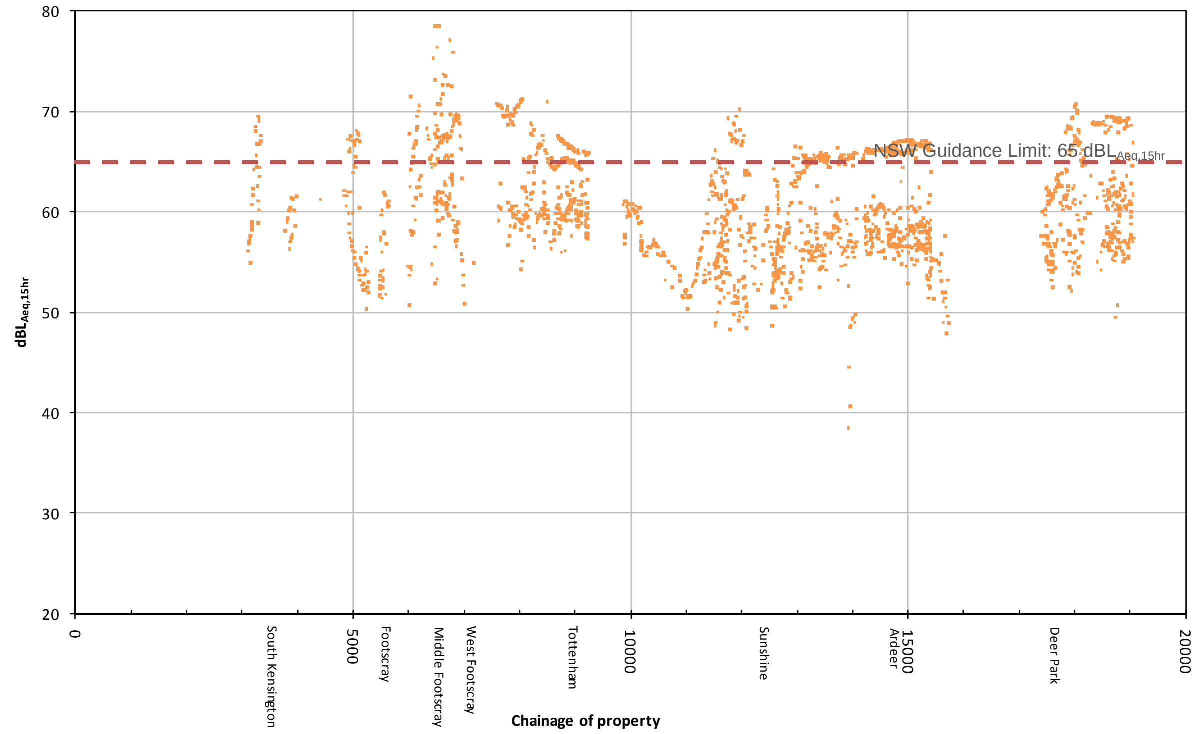

Figure 22 **10 years after opening, RRL (2024), daytime average noise levels, $dBL_{Aeq,15hr}$ re 20 μPa**

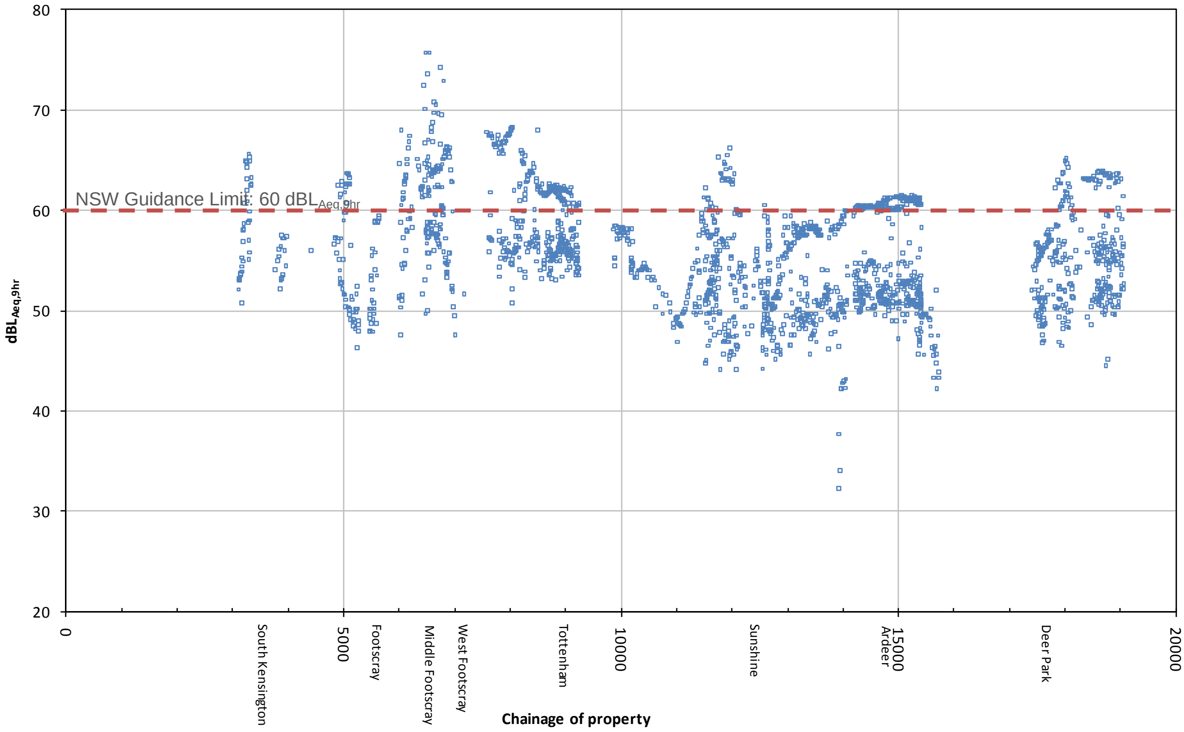

Figure 23 10 years after opening, RRL (2024), night-time average noise levels, dBL$_{Aeq,9hr}$ re 20 μPa

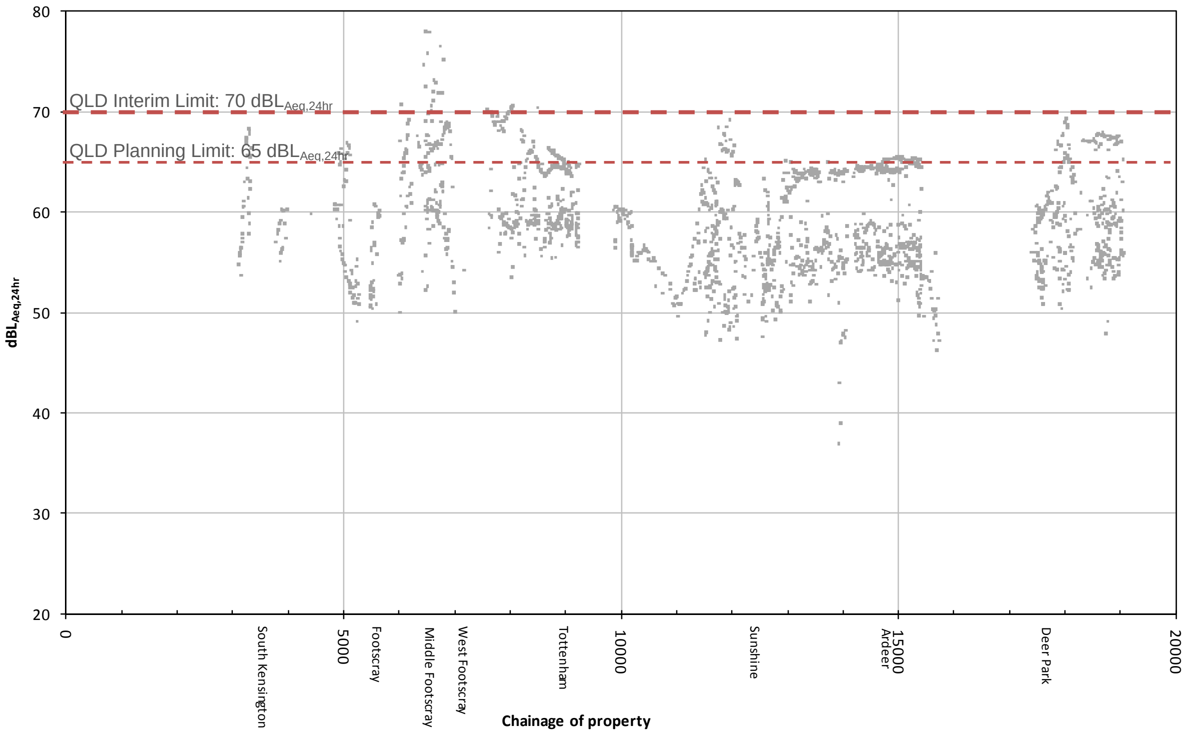

Figure 24 10 years after opening, RRL (2024), 24-hour average noise levels, dBL$_{Aeq,24hr}$ re 20 μPa

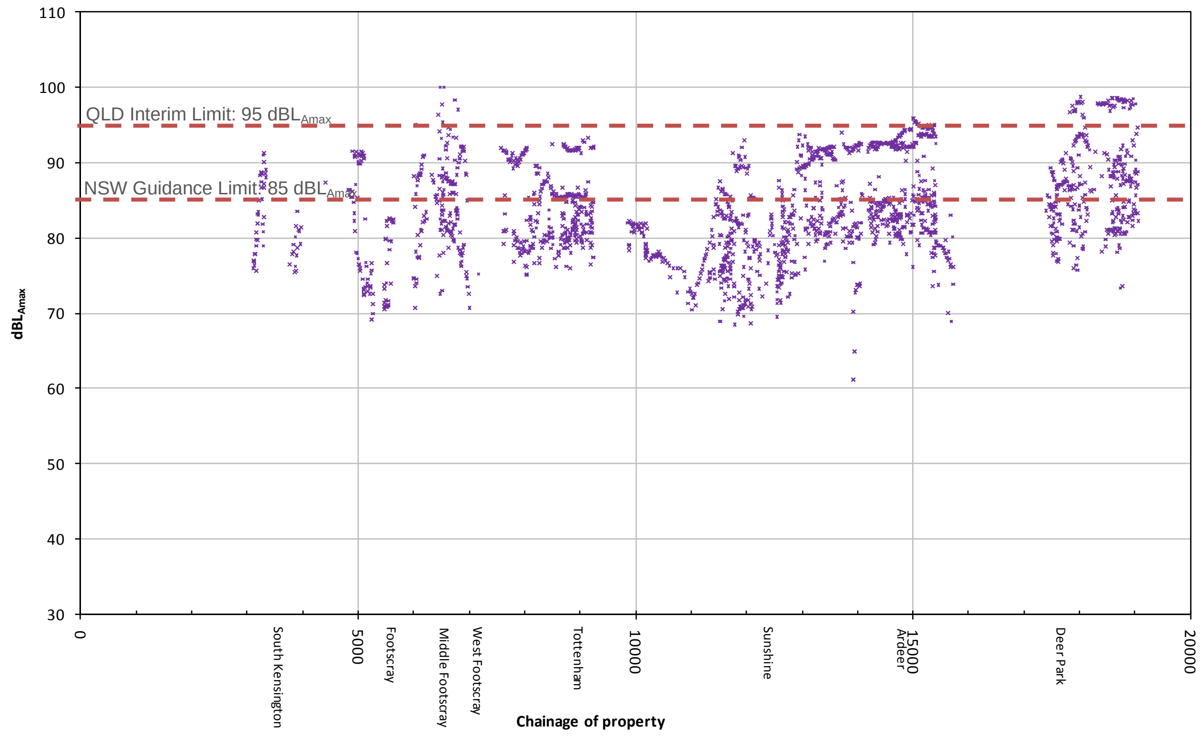

Figure 25 **10 years after opening, RRL (2024), maximum noise levels, dBL$_{Amax}$ re 20 μPa**

6.3 Change in noise level

The predicted change in average and maximum noise level between Phase 0 (pre-RRL) and 10 years after opening (2024) is shown in Figures 26 and 27.

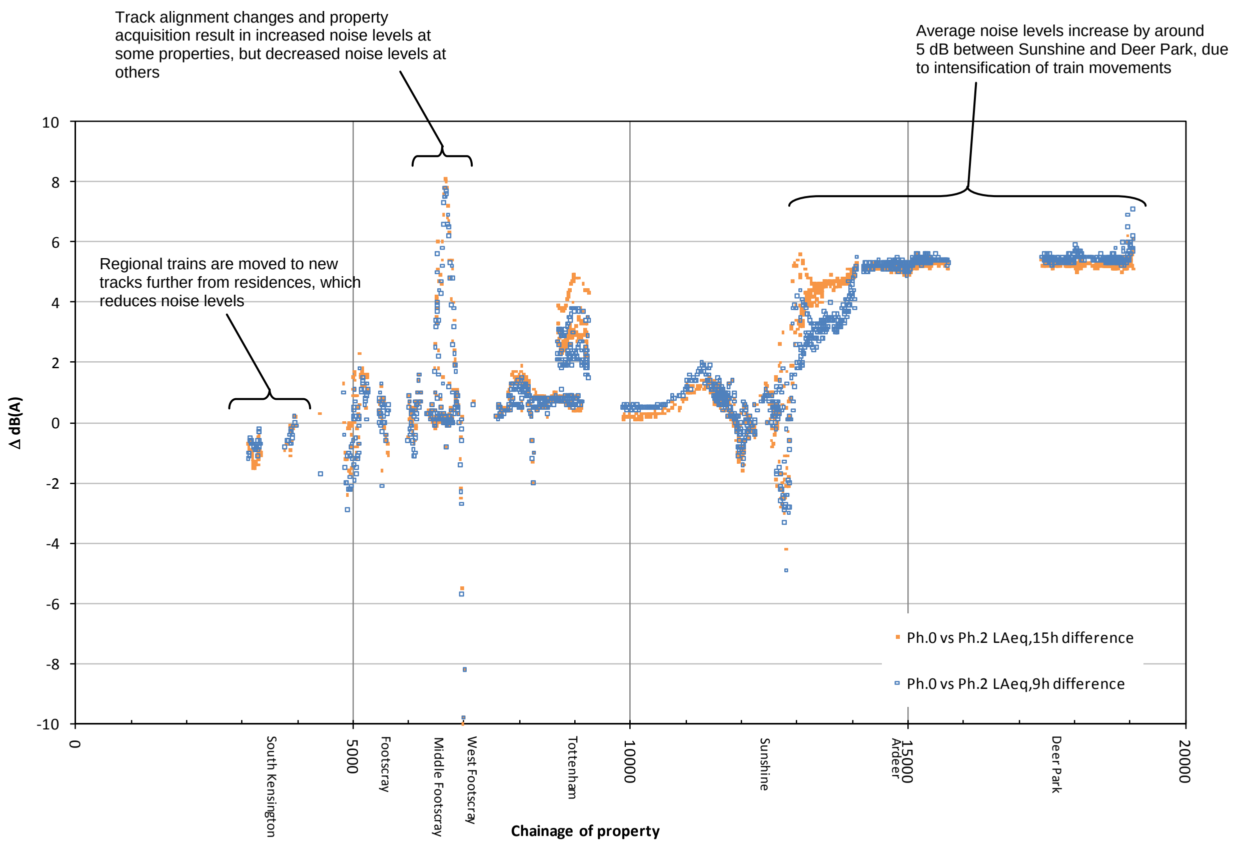

Figure 26 **Phase 0, pre-RRL (2012) to 10 years after opening, RRL (2024), change in noise levels, dBL$_A$ re 20 μPa**

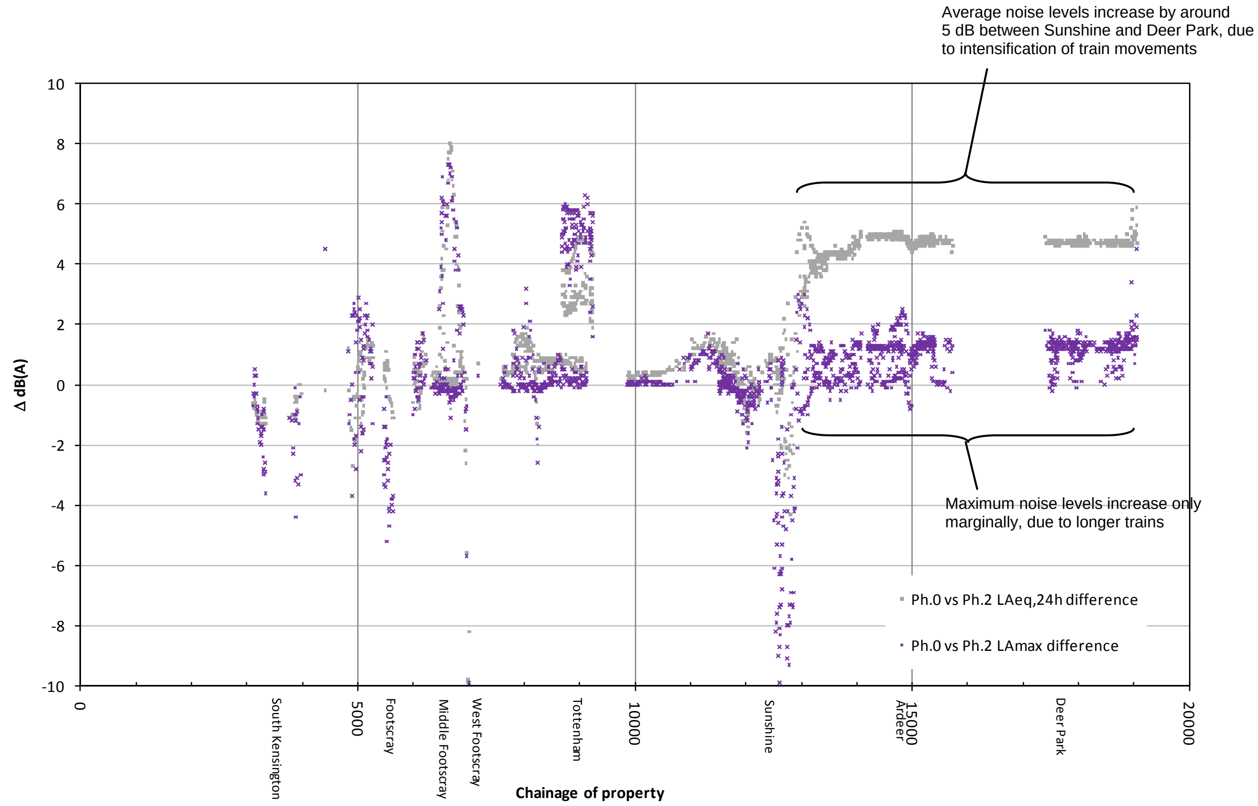

Figure 27 **Phase 0, pre-RRL (2012) to 10 years after opening, RRL (2024), change in noise levels, dBL_A re 20 μPa**

Noise levels are generally expected to increase with the provision of the RRL due to increased traffic density and vehicle length. The transfer of existing services from shared metropolitan lines to dedicated RRL tracks does result in some reduction in noise level due to the increased distance between the residences and the new RRL railway line, for example, around Middle Footscray and Sunshine.

In general, noise levels between Moonee Ponds Creek and Tottenham are expected to increase only marginally (between 1 to 2 dB(A)) with the RRL because this part of the alignment is already heavily trafficked with regional, metropolitan and freight movements, and the relative increase in overall railway movements would be small. In this area, the introduction of the RRL would result in an extra 4 off-peak vehicle movements per hour, each direction, over the existing 3 regional and 8 metropolitan services[17].

The greatest noise level increases are expected between Sunshine and Deer Park due to a larger intensification of vehicle movements compared to the corridor between Footscray and Sunshine. The daytime average noise level west of Sunshine is expected to increase by around 5 dB with the provision of the RRL.

17 Between Moonee Ponds Creek and Footscray, the off-peak increase would be 4 additional vehicle movements per hour, each way, over the pre-RRL schedule of 6 Regional and 14 metropolitan vehicle movements per hour.

7 Noise Barrier Modelling

7.1 Noise Barrier Modelling

As set out above, the noise predictions based on the Reference Design identified that there are some areas along the RRL1 rail corridor that will experience noise impacts, either from the RRL1 project or from RRL1 in conjunction with existing rail noise, at levels that exceed the NSW guidelines.

RRLA have requested that KAJV provide further advice in relation to the potential effectiveness of noise barriers as a mitigation option in addition to the mitigation incorporated in the modelled Reference Design, including an assessment of the cost of various types of noise barrier in the specific circumstances of the RRL1 corridor.

Initially, the broad cost effectiveness of barriers has been assessed by investigating the noise reduction provided by typical noise barrier designs and based on typical RRL alignment scenarios at the following locations where noise levels due to the railway are highest;

- Ardeer
- Sunshine
- Footscray
- South Kensington.

Noise contour plots for both the daytime ($L_{Aeq,15hr}$) and maximum (L_{Amax}) noise levels at each of these locations, with no barrier, a 2-metre barrier and a 4-metre barrier are shown in Appendix E. In addition, for the Ardeer location, these contour plots also show the effects of a 1.4 m high low-level barrier (a low level barrier is likely to be ineffective at Sunshine, Footscray and South Kensington because of the large numbers of tracks at each of these locations).

This broad analysis shows that, typically, 2 m noise barriers can be expected to provide between 3–8 dB(A) noise reduction at the most affected residences. A 4 m high barrier provides between 8–12 dB(A) reduction in railway noise levels. The 1.4 m high low-level trackside barriers provide similar noise reductions as the 2 m high barriers.

A more detailed assessment of the height and location of noise barriers that would be necessary to maintain the status quo noise levels (ie the noise level that would exist immediately at each location prior to the operation of RRL1 (Phase 1, 2014)) has also been undertaken. This is referred to as maintaining the status quo, where there is no noise increase experienced by residents at these locations due to RRL1.

For the 'status quo' analysis, noise barriers have been considered where properties are subject to any increase in average or maximum noise levels from 2014 to 2024, and the 2024 noise levels would exceed 65 $dBL_{Aeq,15hr}$ daytime, or 60 $dBL_{Aeq,9hr}$ night-time or 85 dBL_{Amax} (ie the NSW IGANRIP guidelines). The barriers are designed to mitigate any noise level increase in 2024 so that it is no worse than the higher of the prevailing 2014 noise level, or the NSW IGANRIP guideline.

For the 'status quo' analysis, noise barriers are not considered where there is no increase in average or maximum noise level between 2014 and 2024, even if the 2014 or the 2024 absolute noise levels are predicted to be above than the NSW IGANRIP guidelines.

The height and locations of noise barrier that are feasible (ie in an engineering sense) and would maintain the status quo are shown, along with the mitigated noise level contours, in the following sections in Appendix F:

- Section F1.1, 10 years after opening RRL (2024) - Mitigated, $L_{Aeq,15hr}$
- Section F1.2, 10 years after opening RRL (2024) - Mitigated, $L_{Aeq,9hr}$

- Section F1.3, 10 years after opening RRL (2024) - Mitigated, $L_{Aeq,24hr}$
- Section F1.4, 10 years after opening RRL (2024) - Mitigated, $L_{Amax.}$

7.1.1 Type of noise barrier that would be required for RRL1 to maintain the status quo

Generally, noise barriers between 2–3 m high would be required in affected areas to maintain the status quo.

A summary of the extent of these barriers is provided in Table 12.

Table 12 Extent of predicted noise barriers to maintain the Status Quo

Approx. Chainage	Description	Side of railway	Noise barrier height, m	Noise barrier length, m	Noise barrier area, m^2
4800–5100	Railway Place, Footscray	UP	2.0–4.0	300	800
6000–6050	Short Street/Albert Street, Footscray	DN	2.0	50	100
6050–6200	Raleigh Street/Sullivan Place, Footscray	UP	2.0	150	300
6390	Victoria Street, Footscray	DN	4.0	25	100
6450–6950	Buckley Street, Footscray	DN	2.5–3.0	500	1250
8650–9300	Sunshine Road, West Footscray (Tottenham)	DN	2.0–3.0	650	1450
11450–11600	Drayton Street, Sunshine	UP	2.0	150	300
12900–13650	Forrest Street, Sunshine	UP	2.0	750	1500
13200–13300	Fraser Street, Sunshine	DN	2.0	100	200
13350–13550	Fraser Street, Sunshine	DN	2.0	200	400
13650–14100	Ridgeway Parade, Sunshine West	DN	2.0–3.0	450	920
14200–15450	Ridgeway Parade, Sunshine West (Ardeer)	DN	2.0–3.0	1250	2700
14250–14450	Forrest Street, Sunshine West	UP	2.0	200	400
14600–15500	Forrest Street, Sunshine West (Ardeer)	UP	2.0	900	1800
17400–19100	Hemsley Drive/O'Connor Road, Deer Park	DN	2.5–3.0	1700	4400
17600–18200	Railway Parade, Deer Park	UP	2.0–3.0	650	1430
18500–19050	Bayliss Road/Campbell Avenue, Deer Park	UP	2.0–2.5	550	1180

7.2 Alternative Barrier Scenario to Mitigate 'Night-time Noise'

During RRLA consultations with the EPA, it was suggested that an alternative noise mitigation scenario which specifically addressed night-time noise levels should be considered. The EPA suggested that noise mitigation should be designed to achieve a night-time noise level of 60 $dBL_{Aeq,9hr}$, where the residence was also subject to a noise level increased of more than 2 dB(A) (daytime or night-time) or 3 dBL_{Amax}.

Table 13 provides a summary of the location, height, length and extent of predicted noise barriers that would be necessary to limit night-time noise to 60 $dBL_{Aeq,9hr}$. The locations of the barriers are shown in Figure 28.

Table 13 Extent of predicted noise barriers to limit night-time noise to 60 $dBL_{Aeq,9hr}$

Barrier No.	Approx. Chainage	Description	Adjacent to rail track	Noise barrier height, m	Noise barrier length, m	Noise barrier area, m²
1	6390	Victoria Street, Footscray	DN	4.0	25	100
2	6450–6850	Buckley Street, Footscray	DN	2.0–3.5	390	920
3	8700–9250	Sunshine Road, West Footscray (Tottenham)	DN	2.0	570	1130
4	14250–14500	Ridgeway Parade, Sunshine West (Ardeer)	DN	2.0	250	500
5	14600–15100	Drayton Street, Sunshine	UP	2.0	150	300
6	14600–15400	Ridgeway Parade, Sunshine West (Ardeer)	DN	2.0	800	1600
7	14600–15050	Forrest Street, Sunshine West (Ardeer)	UP	2.0	450	900
8	15100–15400	Forrest Street, Sunshine West (Ardeer)	UP	2.0	300	600
9	17800–181500	Hemsley Drive, Deer Park	DN	2.5–3.0	350	880
10	17800–18150	Railway Parade, Deer Park	UP	2.0–2.5	320	680
11	18300–19050	O'Connor Road, Deer Park	DN	2.0	740	1470

Figure 28 Location of predicted noise barriers to limit night-time noise to 60 $dBL_{Aeq,9hr}$

7.3 Cost of Noise Barriers and Other Noise Mitigation

Table 14 provides a summary of the various noise mitigation options detailed above discussed in Chapter 2 as being potentially effective in relation to RRL1, setting out,

- the effectiveness of each option in the specific circumstances of the RRL1 project;
- the relative effectiveness of the various types of noise barrier based on the modelling discussed above; and
- the approximate cost of each option.

Table 14 Feasibility and effectiveness of noise mitigation treatments.

Mitigation method	Typical reduction in noise level, dB(A)	Potential application for RRL	Approximate costs† ‡
Design of railway alignment	Variable	Effective in specific locations - applied in Reference Design	Variable
Track and rail roughness control	1–3 dB(A)	Effective - applied in Reference Design	
Track and wheel maintenance	1–3 dB(A) (routewide) 5–10 dB(A) (local defects)	Effective - applied in Reference Design	Ongoing operational expenses to ARO
Noise barriers – 2 m	3–8 dB(A)	Potentially effective routewide - reasonable noise reduction to groups of sensitive receptors	$6,200/linear metre $45,000–$75,000 per residence $20,000–$50,000 per dB per residence reduction
Noise barriers – 4 m	8–12 dB(A)	Potentially effective routewide - reasonable noise reduction to groups of sensitive receptors	$12,400/linear metre $85,000–$150,000 per residence $20,000–$25,000 per dB per residence reduction
Earth bunds	3–8 dB(A)	Effective in mitigating noise to groups of sensitive receptors but no application for RRL1 due to requirement for additional land acquisition	$450/linear metre $3,500–$4,000 per residence $1,200–$1,500 per dB per residence reduction
Low-level trackside noise barriers	3–6 dB(A)	Potentially effective noise mitigation in some locations where only 2 tracks, but no application for RRL1 due to operational maintenance requirements	~$650/linear metre ~$5,000 per residence ~$3,500 per dB reduction

Mitigation method	Typical reduction in noise level, dB(A)	Potential application for RRL	Approximate costs† ‡
Off-reservation architectural acoustic treatments	10–20 dB(A) (locally)	Effective for individual dwellings in some circumstances. Isolated residential receivers – Footscray to West Footscray. Significant improvement in internal amenity but does not improve external amenity and applies to individual sensitive receptors rather than groups or communities	$30,000 per property 5–10% of development value

† Does not include likely land acquisition costs.

‡ Costs provided by RRLA and based on VicRoads data for installed barriers plus allowances for inflation and contingency, including installation costs for occupation of the rail corridor. Costs assume that barriers are constructed with concrete and acrylic.