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North West Rail Link
Environmental Assessment
Noise and Vibration

PREPARED FOR

Transport Infrastructure Development Corporation
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Environmental Assessment
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EXECUTIVE SUMMARY

This report has been prepared as part of the Environmental Assessment (EA) of the proposed North West Rail Link (the proposal). The Transport Infrastructure Development Corporation (TIDC) is the proponent of the proposal, and the EA is being prepared by GHD, in accordance with the requirements of Part 3A of the *Environmental Planning and Assessment Act 1979*.

This report assesses the potential impacts of noise and vibration emissions during construction and operation, and discusses potential noise and vibration mitigation measures, where appropriate. It has been prepared to meet the Department of Planning Director General's Requirements for the EA.

The proposed North West Rail Link would be the principal trunk public transport line in Sydney's North West. It would connect with the Main North Line between Beecroft and Cheltenham Stations and terminate at Rouse Hill Town Centre. The rail link would be twin track, approximately 23 kilometres in length and would include:

- A 3 km surface quadruplication of the Main North Line between north of Epping Station and Beecroft Station (including works at Cheltenham Station);
- A 16 km section in tunnel from the Main North Line to north of Norwest Business Park, including four underground stations (Franklin Road Station, Castle Hill Station, Hills Centre Station and Norwest Station);
- A 4 km surface section from north of Norwest Business Park to Rouse Hill, including two underground stations (Burns Road Station and Rouse Hill Station);
- An interim train stabling facility at Rouse Hill;
- Ancillary tunnel support facilities such as tunnel ventilation, transformers and a water treatment plant(s); and
- Construction work sites, including a large site within the Balmoral Road Release Area.

The alignment of the proposed NWRL in this report is referred to as the *Reference Scheme*, as defined in the project Application and Preliminary Environmental Assessment Report (SKM, April 2006).

A preliminary assessment of the potential noise and vibration impacts for the 2002 Alignment was previously undertaken by SKM (*North West Rail Link Working Paper No. 6 - Noise and Vibration Assessment - April 2003)*. This report provides an update to the previous assessment (where required). For additional information in relation to the previous assessment, the reader is directed to the SKM report (2003) attached as **Appendix V**.

Operational Noise

TIDC is seeking a Concept Approval to construct and operate the NWRL proposal. Consequently, at this early stage of the design and the noise and vibration assessment process, it is appropriate to undertake preliminary, rather than detailed noise modelling.

The operational design goals presented in this report should be regarded as indicative only, and may change during the assessment process. The adopted design goals for preliminary assessment are similar to those applied on recent rail infrastructure projects for new works.

A detailed assessment of the potential mitigation measures for operations, such as source controls and the location and height of noise barriers or bund walls will be undertaken at a later stage in the assessment process. For the preliminary assessment, discussion of potential mitigation measures was limited to typical measures that may be required, subject to determining future criteria and the outcome of the feasibility and reasonableness assessment process.

EXECUTIVE SUMMARY

For the preliminary assessment, the predicted future noise levels in 2017 have been with DEC's "Planning Levels" for the sections of new track and with the DEC's "Maximum Levels" for the section of existing track between Epping and Beecroft. The DEC's "Planning Levels" for residential buildings are:

- $L_{Aeq(24hour)}$ 55 dBA
- L_{Amax} 80 dBA

The DEC's "Maximum Levels" are 5 dBA higher than the "Planning Levels".

Main North Line Quadruplication

The section of existing track between Epping and Beecroft would be upgraded to provide two additional tracks - one on each side of the two existing tracks. In this section of the Main North Line, there are existing freight train operations. No freight train operations are proposed on the NWRL.

The results of the computer noise modelling with and without noise barriers are presented in **Appendices D** to **O**. The noise contour plots provide an indication of the noise reductions that may be achieved for various height noise barriers for electric passenger trains and freight trains separately.

In this section of existing track, the current noise levels already exceed the DEC's "Maximum Levels". Without mitigation and with the inclusion of the quadruplication, the future $L_{Aeq(24hour)}$ noise levels would increase by approximately 3 dBA to 4 dBA as a result of the proposal and the L_{Amax} noise levels would increase by approximately 1 dBA to 2 dBA. The preliminary noise modelling identified the highest noise level exceedances can be attributed to freight trains.

For electric passenger trains, most of the potential exceedances could be minimised through the use of noise barriers, however compliance with the noise goals would be more difficult to achieve with noise barriers for diesel locomotives due to the increased source height of the noise emissions.

NWRL - Surface Track

Predicted noise levels for the previous 2002 Alignment between Norwest Business Park and Rouse Hill are provided in **Appendix P** (SKM 2003). The noise contours indicate that for some sections, where the proposed track is located within cutting, noise mitigation in the form of barriers would not be required to achieve compliance with the noise goals at the nearest existing residential receiver locations. At other locations, where the track is at-grade, on embankment or on viaduct, noise mitigation in the form of barriers would be required to achieve compliance with the noise goals at existing and future residential receiver locations.

Groundborne Noise

Groundborne noise is most common in railway tunnel situations where receivers are located in buildings above or in close proximity to the railway tunnels. Groundborne noise results from the transmission of groundborne vibration rather than the direct transmission of noise through the air. If it is of sufficient magnitude to be audible, the noise has a low frequency rumbling character, which progressively increases and then decreases in level as a train approaches and departs the site.

A number of source control options are available to mitigate groundborne noise emissions from underground railway lines. On the basis of the proposed vertical alignments of the various options, it is anticipated that compliance with the groundborne noise design goals would be achieved at all locations through feasible and reasonable mitigation measures. These would be determined at a later stage in the assessment process.

Operational Vibration

The proposed operational vibration criteria used in this report are based on the vibration dose values nominated in British Standard BS 6472, and the DEC's *"Assessing vibration: a technical guideline"*. For this assessment, the operational vibration predictions were conservatively based on the typical maximum train speeds in each section of track.

The preliminary operational vibration modelling results indicate that none of the existing dwellings lie inside the 100 dB human comfort vibration contour. Vibration levels from train passbys may be perceptible at some of the existing and proposed residential locations (within approximately 40 m of the nearest track), however the levels would be well below the 110 dB vibration criterion relating to human comfort.

Train Stabling

The proposed train stabling facility would be located on the western side of Windsor Road within Area 20 of the North West Growth Centre. This area is planned to undergo significant development before the planned opening of the NWRL. Without noise mitigation, the $L_{Aeq(15minute)}$ noise emissions are anticipated to be approximately 10 dBA to 15 dBA lower than the existing road traffic noise levels at the nearest residential receiver locations on the eastern side of Windsor Road. On the western side of the stabling facility, the noise levels exceed the goals for a distance of approximately 100 m at ground floor residential receiver locations. The construction of noise barriers would reduce the area impacted above the goals and reduce the potential noise impacts.

In accordance with the current RailCorp train preparation procedures, the testing of brakes and horns at both ends of the train is required before a train enters service. Additionally, it is necessary to operate the horn as a warning of imminent train movement. Noise from these sources has the potential to cause sleep disturbance to nearby residential receivers during night-time periods. The predicted $L_{A1(60second)}$ noise levels indicate that the typical maximum noise levels from brake testing and horn testing (without mitigation) exceed the DEC's Rating Background Level + 15 dBA sleep disturbance screening criterion at the nearest existing residential receiver locations.

At some locations (on the eastern side of Windsor Road), the noise from brake testing would be less than the existing traffic noise levels on Windsor Road. On the western side of the proposed stabling facility, noise emissions from brake testing would be more noticeable.

Mitigation Options

In addition to noise barriers, RailCorp is investigating the feasibility of a low level horn test mode for trains in order to reduce the potential of sleep disturbance. If a low level horn test mode is not available, other forms of mitigation including an acoustic shed or changes to operational procedures would be required to mitigate the potential noise impacts.

Consideration should also be given to locating commercial and/or industrial receivers adjacent to the proposed stabling facility which are less sensitive to noise than residential developments. Industrial and commercial receivers are also unlikely to be affected by noise emissions during the night-time period when intrusive noise impacts are greatest.

Construction Noise and Vibration

A construction noise and vibration assessment was previously undertaken by SKM (2003) for the works associated with the 2002 Alignment. The analysis undertaken by SKM generally remains consistent with the current design. At locations where the alignment or proposed construction methodologies have changed, an updated assessment has been provided in this report.

At the majority of locations, the predicted L_{A10} construction noise levels would exceed the noise goals when plant and equipment is located in close proximity to residential and commercial receiver locations. This results primarily from the small offset distances involved between construction plant and the nearest receivers.

24 hour construction would be required at the proposed major tunnelling construction site (located within the Balmoral Road Release Area). It is considered likely that substantial noise mitigation measures would be required at the proposed construction site in order to minimise the number of potentially affected receivers. Specific mitigation measures are discussed in **Section 9.4.3**.

The fact that noise criteria exceedances have been identified does not necessarily indicate that the works should not proceed, but rather, highlights the importance of managing the works to minimise both the noise levels and duration of the predicted exceedances.

Vibration monitoring and buffer zones are proposed for all construction sites in order to minimise disruptions to the local community and prevent damage to nearby buildings during vibration-generating construction activities (such as rockbreaking and vibratory rolling).

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

TABLE OF CONTENTS

APPENDICES

1 INTRODUCTION

1.1 Objective

This report has been prepared as part of the environmental assessment associated with the proposed North West Rail Link (NWRL) (the proposal). The Transport Infrastructure Development Corporation (TIDC) is the proponent of the proposal, and the environmental assessment is being prepared by GHD in accordance with the requirements of Part 3A of the *Environmental Planning and Assessment Act 1979*.

This report assesses the potential impacts of noise and vibration emissions during construction and operational phases of the proposal, and discusses the nature of any noise and vibration mitigation measures that may be required. This report has been prepared to meet the Department of Planning Director General's Requirements for the Environmental Assessment.

This report has been structured with a description of the proposal and existing environment, followed by assessment of the operational noise and vibration, an assessment of the train stabling operations and an assessment of construction noise and vibration. The criteria are presented in subsections of the assessment chapter for each of these elements.

1.2 Proposal Outline

The proposal involves the construction of an additional railway line between Epping and Rouse Hill. The following alignment options are referred to in this report:

- 2002 Alignment
- Reference Scheme

This report assesses the potential noise and vibration impacts from the Reference Scheme. Where this option is similar to the 2002 Alignment, the assessment is based on a previous study undertaken by SKM (*North West Rail Link - Assessment of Environmental Issues Report - 2003*) attached as **Appendix V**.

The Reference Scheme alignment considered as part of this Environmental Assessment is described briefly below.

Between Epping and Beecroft, the Main North Line would be quadruplicated by constructing two additional tracks on either side of the existing tracks within the railway corridor. A new rail bridge would be constructed over the M2 and Cheltenham Station would be upgraded to provide easy access facilities. The upgraded section of track spans a distance of approximately 3 km.

The proposed NWRL includes a 16 km dual tunnel section of track from south of Beecroft Station to the proposed Burns Road Station and a 4 km section of surface track between Burns Road Station and Rouse Hill.

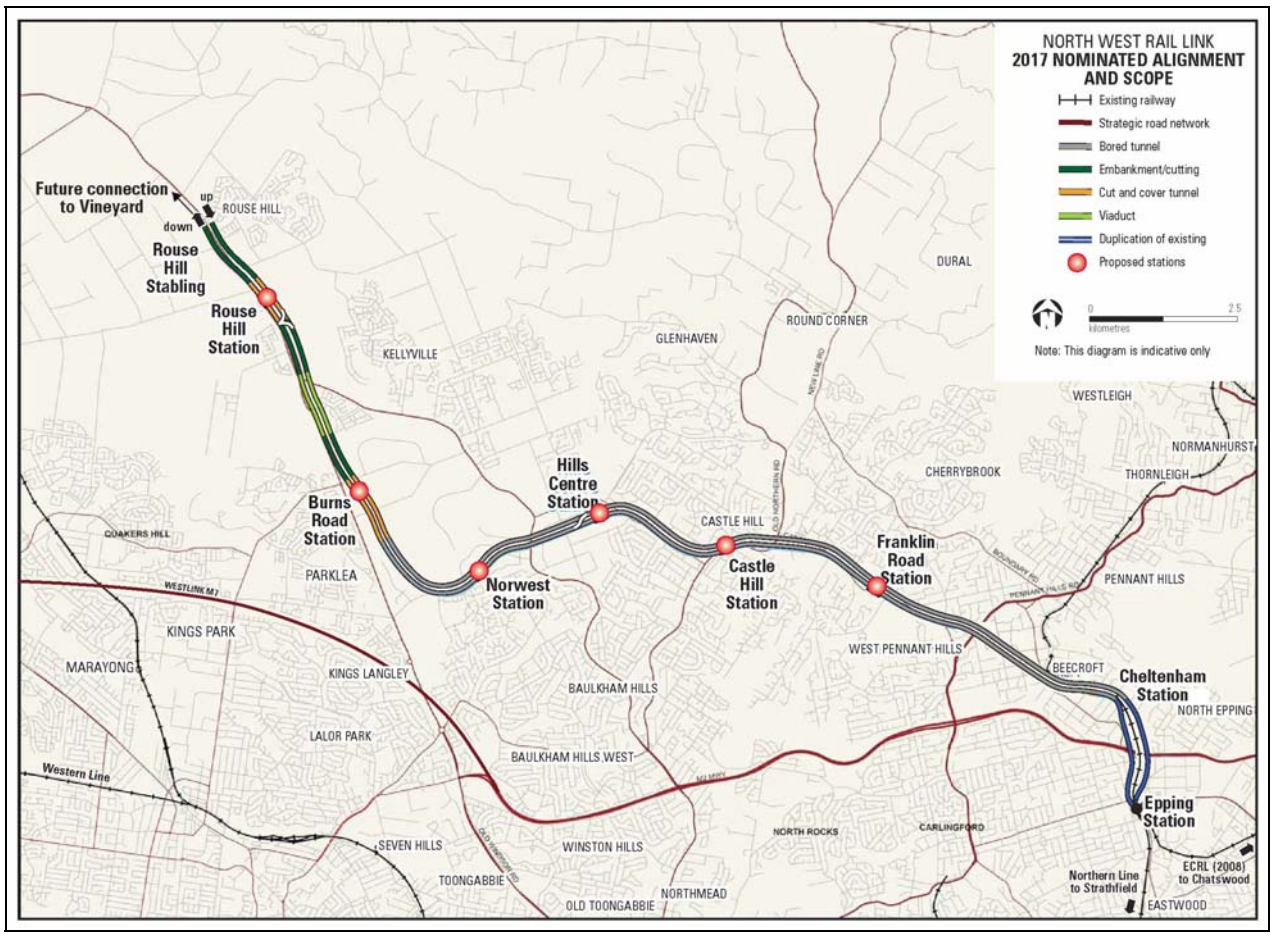
The design of the NWRL comprises six stations, all of which are proposed to be located underground. These are:

- Franklin Road Station
- Castle Hill Station
- Hills Centre Station
- Norwest Station
- Burns Road Station
- Rouse Hill Station

An interim stabling facility is proposed to be located in a cutting to the west of Windsor Road, near the intersection of Rouse Road north of Rouse Hill Station and would service the requirements of the new line.

The number of services along the NWRL at start-up (in 2017) is anticipated to be 86 train movements per day (in each direction), nominally operating at 5 to 10 minute intervals during peak hours and at 15 minute intervals out of peak times. The location of the proposal is shown in **Figure 1**.

Figure 1 Location of the Proposal



Source : Project Application and Preliminary Environmental Assessment (TIDC/SKM, April 2006)

1.3 Terminology

Specific acoustic terminology is used within this report. An explanation of common terms is included as **Appendix A**.

Consistent with normal rail terminology, track chainages are referenced to 0 km at Sydney Terminal Station. Up and Down directions refer to trains travelling to Sydney and from Sydney, respectively. The Up and Down sides of the corridor are the left-hand and right-hand sides, respectively, when facing towards Sydney (ie facing in the direction of decreasing chainage).

2 PROPOSAL DESCRIPTION

2.1 General

The alignment of the proposed NWRL in this report is referred to as the *Reference Scheme*, as defined in the *Project Application and Preliminary Environmental Assessment* report (SKM, April 2006). A brief summary of the Reference Scheme alignment is provided below.

The proposed NWRL would be the principal trunk public transport line in Sydney's North West. It would connect with the Main North Line between Beecroft and Cheltenham Stations and terminate at Rouse Hill Town Centre. The rail link would be twin track, approximately 23 km in length (from the southern point of the Main North Line quadruplication between Epping and Beecroft) and would include:

- A 3 km surface quadruplication of the Main North Line between north of Epping Station and Beecroft Station (including works at Cheltenham Station);
- A 16 km section in tunnel from the Main North Line to north of Norwest Business Park, including four underground stations (Franklin Road Station, Castle Hill Station, Hills Centre Station and Norwest Station);
- A 4 km surface section from north of Norwest Business Park to Rouse Hill, including two underground stations (Burns Road Station and Rouse Hill Station);
- An interim train stabling facility at Rouse Hill;
- Ancillary tunnel support facilities such as tunnel ventilation, transformers and a water treatment plant(s); and
- Construction work sites, including a large site within the Balmoral Road Release Area.

2.2 Alignment of NWRL

The Reference Scheme alignment was developed through a structured route selection process that included the refinement of the previous 2002 alignment to its current proposed position. The following factors were considered in this process:

- Appropriate engineering and operational standards, so that future passengers enjoy a high quality, safe and convenient trip, and efficient and cost-effective services are able to be provided;
- The linkages between existing and planned centres in the North West and selection of a route that maximises its use by people;
- Recognition and minimisation of impacts on existing communities, while taking advantage of the opportunities presented in areas which are currently being planned;
- Maximising appropriate urban development opportunities at key nodes such as Rouse Hill and Norwest Business Park; and
- The environmental impacts likely to arise from the construction and operation of the rail link, such as noise and vibration, ecological impacts (including flora and fauna), water quality and impacts on local character.

2.3 Train Stabling Facility - Rouse Hill

A train stabling facility is proposed to be located west of Windsor Road, north of Rouse Hill Station. The stabling yard would be located within Area 20 (an area that is proposed for future residential development with the North West Growth Centre). The stabling yard would also include facilities for the cleaning of stabled trains, and for the use of crews.

At the planned opening, the stabling facility I proposed to accommodate up to 8 trains and does not preclude possible future expansion of stabling facilities.

2.4 Modifications to the 2002 Alignment

The 2002 alignment on which the North West Rail Link, *Assessment of Environmental Issues Report* (March 2003) was based, has undergone a number of changes which arose from the outcomes of the specialist studies, their recommendations and subsequent consultation with the community and stakeholders.

The key modifications compared with the Reference Scheme are:

- The bored tunnel alignment between the Beecroft dive structure and Franklin Road Station – In some locations, the horizontal alignment has been re-aligned by up to 250 m;
- The bored tunnel and surface sections of the alignment between Norwest Business Park and Burns Road Station – Approximately 5 km of the route has been re-aligned and consequently the western portal has been re-located further west;
- The stabling facility has been moved about 500 m to the east, and is now adjacent to Windsor Road; and
- The NWRL project scope has been expanded to include the quadruplication of the Main North Line from Epping to Beecroft.

Between the Beecroft dive structure and Franklin Road Station, the alignment was modified to simplify and straighten the alignment. In the Balmoral Road Release Area, between Norwest Business Park and Burns Road Station, the alignment was modified to minimise impacts on:

- Cumberland Plain Woodland (an endangered ecological community);
- The northern portion of the future Bella Vista Housing Estate by avoiding the requirement for a large cutting through the development;
- Sensitive land uses at the Hillsong Church (including an auditorium and a proposed television and radio studio); and
- Flooding and environmental risks associated with crossing Elizabeth Macarthur Creek in cutting.
- The train stabling facility was re-located to be above the assumed Probable Maximum Flood (PMF) level for Second Ponds Creek and to minimise impacts on Cumberland Plain Woodland.

2.5 Noise and Vibration Assessment for 2002 Alignment

A preliminary noise and vibration assessment was previously undertaken by SKM for the 2002 Alignment (*North West Rail Link - Working Paper No. 6 - Noise and Vibration Assessment - Final - April 2003*). The report was included as an Appendix to the *North West Rail Link - Assessment of Environmental Issues Report* (SKM - March 2003). The full noise and vibration report for the 2002 Alignment option is attached as **Appendix V**.

The SKM noise and vibration report provided an assessment of the potential impacts of the proposal during construction and operations. This included an overview of the proposal, an assessment of the ambient noise environment, identification of sensitive receivers, identification of noise and vibration criteria for construction and operations and an assessment of the potential impacts and mitigation measures that may be required.

Where appropriate, the current Environmental Assessment is based on the previous SKM noise and vibration assessment for the 2002 Alignment. At locations where the proposed alignment deviates from the 2002 Alignment, an updated assessment has been provided.

3 EXISTING NOISE ENVIRONMENT

3.1 Existing Noise Environment

The existing noise environment varies along the length of the proposed NWRL, as would be expected from the wide range of commercial, suburban and rural land uses within the study area and from the proximity of each location to major roads and to the existing rail corridor.

In 2002, SKM undertook an extensive noise survey along the length of the NWRL corridor. Since those surveys were undertaken, there has been a number of road transport initiatives in the proposal area including:

- Opening of the M7 Motorway;
- Local realignment of Windsor Road (at Rouse Hill);
- The current construction of the dedicated bus lanes for the North-West T-way Project; and
- The upgrading of Old Windsor Road project (west of Acres Road).

The combined effects of these various projects would have resulted in some changes in the noise environment since the 2002 noise surveys undertaken by SKM. At this stage however, the SKM noise surveys are considered to be appropriate for this preliminary noise assessment as part of the EA and Concept Plan. However, during the next phase of the proposal (and once all these projects have become operational), it is recommended that the noise environment be revalidated.

Additional noise surveys were undertaken as part of the current assessment to supplement the SKM surveys in the areas around the proposed stabling yard, near the track realignment (at Norwest Business Park) and the section of track quadruplication along the Main North Line, where no or very limited surveys were previously undertaken.

3.2 Supplementary Ambient Noise Surveys

Ambient Noise Monitoring Locations

Ambient noise surveys have been undertaken at a four representative locations between 19 July 2006 and the 28 July 2006 (inclusive) as detailed in **Table 1**:

Table 1 Heggies 2006 Noise Monitoring Locations

Area	Noise Monitoring Location	Reference	UBD Reference
Stabling Yard	18 O'Reilly Way, Rouse Hill	NWBG1	Map SYD 128, P7
Track Realignment	19 Bridgeview CCT., Bella Vista	NWBG2	Map SYD 149, M14
Track Quadruplication	2/23 Derby Street, Epping	NWBG3	Map SYD 173, B12
	5 Sutherland Road, Cheltenham	NWBG4	Map SYD 173, A9

Methodology

The purpose of the ambient noise monitoring is to determine the existing background noise levels, which are used as a basis for assessing the impact of noise emissions during the construction phase of the proposal and also the operational noise emissions from the proposed train stabling yard.

Noise logging was undertaken using ARL noise loggers, type EL215 and EL316, positioned at each of the monitoring locations for a period of approximately one week. These loggers continuously monitored noise levels and stored the results as statistical noise levels every 15 minutes.

All equipment used for the surveys carries current manufacturer's calibration certification. Calibration was checked before and after each measurement and at the downloading of data from the noise loggers. In all cases, the calibration drift was less than the acceptable limit of 0.5 dBA.

Noise Monitoring Results

The noise loggers were set to record ambient noise levels continuously in consecutive 15 minute intervals. These loggers store statistical descriptors which reflect the range of noise levels in the preceding interval.

The full results from the Heggies 2006 unattended noise monitoring are presented graphically in **Appendix B**.

In order to determine the Rating Background Level (RBL) during the daytime, evening and night-time periods, the L_{A90} background noise levels were processed in accordance with the procedure in the Department of Environment and Conservation's (DEC's) Industrial Noise Policy (INP). The RBL is the overall single figure background level representing quiet ambient conditions in each assessment period (daytime, evening and night-time).

The existing L_{Aeq} noise levels for the daytime, evening and night-time periods were also processed in accordance with the procedure in the INP. These values represent the typical "energy-averaged" noise levels during each assessment period.

A summary of the processed noise levels is presented in **Table 2**.

Table 2 Summary of Ambient Noise Levels at Unattended Noise Monitoring Locations

Monitoring Location		Daytime Noise Level* (dBA)		Evening Noise Level* (dBA)		Night-time Noise Level* (dBA)	
		LA90 RBL	LAeq	LA90 RBL	LAeq	LA90 RBL	LAeq
NWBG 1	18 O'Reilly Way, Rouse Hill	42#	46#	39#	42#	35#	40#
NWBG 2	19 Bridgeview CCT., Bella Vista	42	50	40	46	37	44
NWBG 3	2/23 Derby Street, Epping	46	57	46	58	38	57
NWBG 4	5 Sutherland Road, Cheltenham	45	54	43	54	38	52

Note * DEC's preferred definition of daytime, evening and night-time hours. Daytime refers to standard daytime construction hours, namely 7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturday. Evening refers to the period 6.00 pm to 10.00 pm. Night-time refers to the period 10.00 pm to 7.00 am.

Note # At NWBG1, the noise logger periodically stopped during the unattended noise survey. The summary noise levels are based on only limited information and should be considered preliminary only. Additional background noise monitoring would be required in this area as part of any additional assessment.

The summary results in **Table 2** are derived from the entire week of the noise logging. The data has been segregated into the relevant time of day (daytime, evening and night-time) to assist in setting noise criteria for construction and train stabling operations.

3.3 2002 SKM Noise Monitoring

The results of the SKM surveys (undertaken between July 2002 and October 2002 and supplemented by noise surveys extracted from the North-West T-way EIS) are still considered to be a reasonable indication of the prevailing noise environment. An extract from the SKM report which summarises the key noise indices is presented in **Table 3**.

Table 3 Summary of Key Noise Indices – Extracted from 2003 SKM Report

Monitoring Location / Address		Rating Background Level (RBL)			Typical L_{A10} Levels	LAeq(24hr)	LAeq(15hr)	LAeq(9hr)
		7 am to 6 pm	6pm to 10pm	10pm to 7am	7am to 6pm			
1	2 Sutherland Road, Cheltenham	39	38	34	58	59	59	59
2	52 The Crescent, Cheltenham	39	37	31	55	58	58	57
3	30 Sutherland Road Beecroft	43	41	36	63	60	60	59
4	2A The Crescent, Beecroft	44	44	34	59	62	61	62
5	10 Fleur Close, West Pennant Hills	41	36	30	56	51	53	45
6	113 Castle Hill Road, Cherrybrook	43	42	30	52	49	50	45
7	128 Franklin Road, Cherrybrook	49	47	35	64	59	60	56
8	18 Old Castle Hill Road, Cherrybrook	54	49	38	63	59	60	55
9	2 Brisbane Road, Castle Hill	51	46	37	62	58	59	55
10	49 Showground Road, Castle Hill	57	51	39	68	64	65	60
11	112 Showground Road Castle Hill	58	52	33	71	66	67	62
12	20 Carrington Road Castle Hill	48	43	35	65	60	62	53
13	31 Fairway Drive, Castle Hill	41	39	36	52	50	52	46
14	10 Emmanuel Tce, Glenwood - facing Old Windsor Road	48	44	34	65	61	62	58
15	21 Balmoral Road, Kellyville	38	40	35	58	54	55	52
16	27 Burns Road, Kellyville	55	51	38	65	60	61	57
16b	15 Burns Road, Kellyville	47	44	32	64	61	60	55
17	Lot 26, Old Windsor Road, Kellyville	46	46	35	60	57	57	56
18	11 Weynden Avenue, Kellyville	38	41	36	48	49	50	48
19	7 Austin Place, Kellyville	41	41	34	51	49	49	47
20	9 Terry Road, Rouse Hill	41	41	37	53	49	49	46
21	109 Rouse Road, Rouse Hill	37	36	32	53	49	50	47

4 IDENTIFICATION OF SENSITIVE RECEIVERS

Apart from residential properties along the route, the SKM report identified three key noise sensitive buildings along the proposed NWRL route;

- The Hills Entertainment Centre;
- Baulkham Hills Council Chambers; and
- Hillsong Church.

Additionally, a number of commercial buildings within Norwest Business Park have been identified as being potentially sensitive to noise and vibration. A detailed assessment of sensitive equipment located within these buildings will be undertaken at a later stage in the assessment process and mitigation measures incorporated into the track design if required.

At this stage of the design there have been no *special* properties identified in the section of track between Epping and Beecroft. Consistent with the approach detailed in the SKM report, all properties are given equal weighting (from an acoustic perspective).

In the section of proposed track between the Hills Centre Station and Old Windsor Road the alignment has changed compared with the 2002 alignment. At this stage of the design, there have been no *special* properties identified. Consistent with the approach detailed in the SKM report, all properties are given equal weighting (from an acoustic perspective).

The SKM report presented the residential distribution along the NWRL route as it was in 2002/2003, however there has been some subsequent residential subdivision along the eastern and western sides of Windsor Road since that report was prepared.

The Balmoral Road Release Area, which comprises approximately 400 hectares of predominantly rural zoned land within Baulkham Hills Shire, is planned to be re-zoned for residential, commercial and employment development, and for public services and facilities such as open space and schools. It will house approximately 16,000 people and accommodate approximately 6,150 new dwellings. The draft LEP includes a clause relating to development within 60 m of the rail corridor which states that *"consent must not be granted to the carrying out of development unless the consent authority is satisfied that the development incorporates appropriate noise attenuation and vibration minimisation measures, and the design and location of the development is such that it will not interfere with the operation of the rail line and associated facilities"*.

The North West Growth Centre, located that the northern extent of the NWRL will accommodate a further 60,000 new dwellings and over 300 hectares of land for business / employment uses and a further 250 hectares for industrial uses. The proposed train stabling yard for the Reference Scheme would be located within Area 20. This area has been earmarked for future residential development within the North West Growth Centre.

During further stages of the assessment process, a detailed land use assessment study will be required to identify those properties (or developments) that have been granted Council approval and would have considered noise mitigation in their design.

The noise goals discussed in **Section 5.4** apply only to residential receiver locations. Other locations within the community that are sensitive to noise impacts include:

- places of worship
- educational institutions
- cemeteries
- passive recreation areas

For these non-residential land uses, no specific noise criteria currently apply. For this preliminary assessment however, the residential criteria will be adopted for places of worship, educational institutions and cemeteries.

For places of worship and educational facilities, noise goals are normally applied inside the building, rather than one metre from the building facade. Since the typical "outdoor to indoor" noise reduction for a building with windows open is approximately 10 dBA, internal noise goals are usually 10 dBA lower than external levels. Hence, for the purposes of this preliminary assessment, the external noise goals will be adopted, recognising that internal noise levels would be approximately 10 dBA lower with windows open.

While commercial properties are generally less sensitive than the above land uses, it is also important to ensure that occupants are not subjected to excessive noise levels. Commercial properties are generally assumed to be at least 5 dBA to 10 dBA less sensitive than residential properties. In most circumstances, noise mitigation is incorporated into the design of commercial buildings. For commercial buildings located close to railway lines or major roads, mitigation usually includes building facade treatments such as providing fixed glazing or no glazing on exposed facades. In order to maintain adequate air flow to building occupants, mechanical air systems are sometimes provided (where cross ventilation does not occur).

5 OPERATIONAL NOISE ASSESSMENT

5.1 Introduction

The proposed NWRL comprises sections of surface track, sections of track on viaduct and sections of track within tunnels. The assessment in this chapter deals with the airborne noise emissions associated with the sections of surface track and viaduct.

Groundborne noise emissions associated with the section of track within tunnels is discussed in **Chapter 6**.

Section of Upgraded Track - Main North Line between Epping and Beecroft

As part of the Reference Scheme proposal, a 3 km section of existing track between Epping and Beecroft would be upgraded to provide two additional tracks - one on each side of the two existing tracks. The new Down track would be located on the western side of the existing Down Main track, extending from near the ECRL dive to near the proposed NWRL dive. The new Up track would be located on the eastern side of the existing Up Main track, extending from near the proposed NWRL dive to near the ECRL dive.

In this section of the Main North Line, there are existing freight train operations. The current proposal is for the freight trains movements to operate on the outside two lines. No freight train operations are proposed on the NWRL.

A discussion of the predicted noise levels for this section of track and the effectiveness of potential mitigation measures is discussed in **Section 5.9**.

Section of New Track - NWRL between Norwest Business Park and Rouse Hill

As part of the Reference Scheme proposal, a 4 km section of surface track is proposed from west of Norwest Business Park to Rouse Hill, running parallel with, but to the east of Windsor Road. This section of the proposal includes a combination of track in cut and cover tunnels, track at-grade, track within cuttings and track located on viaduct.

The assessment of this section of surface track is largely based on the noise modelling undertaken by SKM for the 2002 Alignment. A summary is provided in **Section 5.10**.

5.2 Operational Noise Metrics

The three primary noise metrics used to describe railway noise emissions in the modelling and assessments are:

L_{Amax} the "Maximum Noise Level" occurring during a train passby noise event.

$L_{Aeq(24hour)}$ the "Equivalent Continuous Noise Level", sometimes also described as the "energy-averaged noise level". The $L_{Aeq(24hour)}$ may be likened to a "noise dose", representing the cumulative effects of all the train noise events occurring in one day.

L_{AE} the "Sound Exposure Level", which is used to indicate the total acoustic energy of an individual noise event. This parameter is used in the calculation of $L_{Aeq(24hour)}$ values from individual noise events.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

5.3 General Approach to Operational Noise

TIDC is seeking a Concept Approval to construct and operate the NWRL. Consequently, at this early stage of the design and the noise and vibration assessment process, it is appropriate to undertake preliminary, rather than detailed noise modelling. The determination of prescriptive noise and vibration mitigation measures is considered to be inappropriate at this early stage.

The design goals presented in this preliminary assessment should be regarded as indicative only, may change during the assessment process. The adopted design goals for this preliminary assessment are similar to those applied on recent rail infrastructure projects for new works.

A detailed assessment of the potential mitigation measures such source controls and the location and height of noise barriers or bund walls will be undertaken at a later stage in the assessment process. For the preliminary assessment, discussion of potential mitigation measures was limited to typical measures that may be required, subject to determining future criteria and the outcome of the feasibility and reasonableness assessment process.

5.4 Operational Noise Goals

Chapter 163 of the DEC's (formerly EPA's) "*Environmental Noise Control Manual"* provides noise criteria for rail traffic, specified as a 24-hour average ($L_{Aeq(24hour)}$) and maximum passby level (L_{Amax}), neither of which should be exceeded.

The noise criteria in Chapter 163 are expressed in terms of "Planning Levels" and "Maximum Levels", evaluated at one metre from the facade of affected residential properties.

Planning Levels

- $L_{Aeq(24hour)}$ 55 dBA
- L_{Amax} 80 dBA

Maximum Levels

- LAeq(24hour) 60 dBA
- LAmax 85 dBA

The DEC "Planning Levels" have generally been applied for new railway lines in areas without existing rail operations and the "Maximum Levels" have been applied when upgrading existing railway lines.

More recently however, for major upgrades to existing railway lines, noise mitigation is only considered at locations where the future noise levels (after opening) exceed the "Maximum Levels". At qualifying locations, the "Planning Levels" have been adopted as environmental objectives and then been applied as design goals for optimising noise mitigation.

For the preliminary assessment, the predicted future noise levels will conservatively be compared with the "Planning Levels" for the new sections of railway corridor and the "Maximum Levels" for the existing railway corridor between Epping and Beecroft. It should be noted however, that higher noise goals may be applied in further assessments.

In the section of track along the Main North Line (ie between Epping and Beecroft), there are existing and proposed freight operations. It is considered likely that any future noise mitigation in this area would need to consider the noise emissions from **all** operations within the railway corridor, (including diesel freight and electric passenger train movements). For the preliminary assessment, noise emissions from freight and passenger trains are modelled separately as the noise mitigation requirements for these sources usually differs (see **Appendix C**).

For the previous operational noise assessment undertaken by SKM for the section of proposed surface track between the NWRL Portal and Rouse Hill, reference is made to both the "Planning Levels" and "Maximum Levels". Potential noise impacts in this assessment are discussed in relation to the "Planning Levels".

5.5 Noise Modelling

Operational noise modelling has been undertaken in this report for the section of upgraded existing track along the Main North Line between Epping and Beecroft.

The section of existing track between Epping and Beecroft was not included in the SKM (2003) assessment. The section of proposed surface track from west of Norwest Business Park to Rouse Hill (Reference Scheme) was previously modelled by SKM (2003) and has been used in this assessment.

SoundPLAN Version 6.3 has been used to calculate railway noise emission levels for this study. Of the train noise prediction models available within SoundPLAN, the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) has been used, since it is capable of efficiently and reliably calculating both the L_{Amax} and L_{Aeq} noise levels.

The calculation procedure involves a 360° scan from each receiver point (using fixed angular steps), with the contributions from each angular increment summed to determine the total received noise level. The calculation procedure takes into account the direct noise, the noise diffracting over obstacles or barriers and the noise reflected off buildings.

A separate model run was also carried out using a fixed calculation grid with a spacing of 20 m to produce noise contours. The resultant contours were interpolated between the grid points.

Passenger Rail Services

Noise emissions from suburban electric passenger trains are predominantly caused by the rolling contact of steel wheels on steel rails. Even under ideal conditions, noise would occur as a result of the rolling contact deflections due to the finite roughness and elasticity of typical wheel and rail running surfaces. Other noise sources on electric passenger trains, (such as air-conditioning plant and air compressors) are generally insignificant when compared with the wheel-rail interaction, unless the train is travelling at very low speed or is stationary.

Impact noise from rail discontinuities such as turnouts and mechanical joints or uneven welded joints also has an effect on the level of wheel-rail noise emission, as impulsive noise is emitted as each wheel of the train impacts the discontinuity. Noise radiated from the structures of some types of rail bridges may also increase the level of noise emission.

In areas where there are tight radius curves, flanging noise or curve squeal may also increase the level of noise emission.

The SoundPLAN input data used in the modelling for this proposal were adapted to ensure that the calculated noise levels accurately reflect local conditions (i.e. CityRail trains, etc). The reference noise levels used for the noise modelling (**Table 4**) were based on measurements undertaken by Heggies on recent projects, including the Cronulla Line Duplication Project (CLDP) and measurements undertaken adjacent to the Main North Line.

Table 4 Reference Noise Levels used for Electric Passenger Train Modelling

Train Types	Reference Conditions	LAmax	LAE
Tangara / Millennium	15 m, 80 km/h	87	89
Double Deck Suburban	15 m, 80 km/h	89	92
Intercity	15 m, 80 km/h	92	93

Freight Rail Services

The dominant noise sources on diesel-electric locomotives are usually the diesel engine exhaust, dynamic brake fans and the wheel-rail interaction.

The noise emission from the diesel engine is dependent on power requirements (notch setting) and may be at a maximum at any speed. Noise levels also vary significantly between classes of locomotive.

For the section of track between Epping and Beecroft with an uphill grade, it has been assumed that freight locomotives in the Down (northerly) direction would use a high notch setting, resulting in a modelled L_{Amax} noise level of 94 dBA at 15 m and L_{AE} level of 92 dBA (for two locomotives at 60 km/h). The wheel-rail noise component of the noise emissions, assuming 1000 m long freight trains at 60 km/h are L_{Amax} 89 dBA and L_{AE} 98 dBA.

For freight trains in the Up (southerly) direction, it has been assumed that freight trains would use the dynamic brake north of the M2 (L_{Amax} 93 dBA and L_{AE} 91 dBA) and a medium notch setting south of the M2 (L_{Amax} 88 dBA and L_{AE} 86 dBA).

The reference noise levels are based on Heggies' analysis of the *Rail Noise Database* (see **Appendix C**).

Track Features

Bridges and Viaducts

When trains operate on elevated structures, including bridges and viaducts, vibration from the rails is transmitted into the structure, resulting in noise radiation from the surfaces of the bridge or viaduct.

Noise emissions from elevated structures are partially dependent on the damping properties and resonant behaviour of the structural elements. Unballasted steel bridges typically generate the highest noise emissions, whereas noise emissions from concrete bridges with ballasted or resiliently fixed track may be almost as low as "at grade" noise emission levels. Some bridge designs incorporating parapets may actually reduce noise emissions to below "at grade" levels by virtue of the noise barrier effect, however even these bridges may produce some annoying low frequency noise.

For this assessment, it has been assumed that the viaducts near Epping station and the rail over-bridge at the M2 motorway are ballasted concrete spans with no side screens. When modelling these types of bridges, no correction is required.

The use of low (approximately 1 m high) concrete parapets on the M2 over-bridges and viaducts near Epping Station would reduce the wheel-rail emission from the associated tracks by at least 5 dBA. As discussed elsewhere, it is recommended that low level parapets be used as a noise mitigation measure where feasible and reasonable.

Rail Surface Discontinuities

Discontinuities in the rail running surface occur at turnouts, crossings, track defects, etc. For an eight-car train, a single rail discontinuity would result in 32 impulsive noise emissions. For this assessment, the modelled location of turnouts and crossovers was based on:

- The existing and proposed track layout in the vicinity of Epping Station and the ECRL.
- Sketches of the concept design provided by TIDC.

Within SoundPLAN, these are modelled over a track length of 10 m. The correction is applied to both the L_{Amax} and L_{AE}.

Conventional Turnout = +6 dBA (L_{Amax} and L_{AE})

5.6 Assumptions for Main North Line Noise Modelling Assessment

For this assessment, a series of assumptions have been made:

Passenger Services

- Train speed profiles obtained from TIDC were used as the basis for the modelled train speeds. This is a slightly conservative measure as trains not using maximum acceleration would have slower speeds and hence marginally lower noise levels.
- The number of modelled train services on the Main North Line and additional tracks provided by the quadruplication were based the peak and core hourly frequencies discussed in the *Metropolitan Rail Expansion Program – Operating and Stabling Strategy* (RailCorp, Feb 2006) and also the existing rail operations (assuming that there would be no decrease in passenger services on the existing Main North Line).
- The electric passenger services on the NWRL were assumed to consist of 75% Tangara/Millennium car sets, and 25% Suburban car sets. This ratio was also maintained for the Main North Line, however it was also assumed that there are 46 Intercity trains in each direction.

Freight Services

- On the basis of site observations, track grades and curves in the vicinity of the proposal assessment area, freight train speeds are assumed to be typically 60 km/h.
- High notch setting has been assumed for freight trains in the Down direction on the basis of the steep grade and a previous assessment in which a freight driver assisted Heggies in determining typical notch settings. The dynamic brake and medium notch settings are typically used in the Up direction.
- The number of freight train services on the Main North Line was based on the Year 2021 predictions contained in the *North Strathfield to Hornsby Rail Upgrade Assessment* (Heggies 2003). Freight traffic in 2017 is assumed to be 25 trains per day in each direction with trains typically having two locomotives and a trailing length of 1000 m.
- It is understood that freight trains are not currently held up at signals within the study area on a regular basis. On this basis, potential noise sources such as ‘bunching’ and ‘stretching’ (due to coupling slack) of wagons, and ‘idling’ of locomotives have not been included in this assessment.

A more detailed description of the various noise sources, typical noise levels and how these have been represented within the SoundPLAN computer noise modelling is provided in **Appendix C**.

Noise Modelling Inputs

Ground Terrain

The ground terrain data for the current modelling was provided by TIDC in the form of 3D contours in AutoCAD format.

Track Alignment Strings and Ground Terrain within Railway Corridor

Sketches of the track alignments for the proposed lines were provided by TIDC in the form of 2D horizontal alignment drawings. These sketches, in conjunction with the supplied ground contour information were used by Heggies to form the required 3D track strings.

Rail Traffic Data

Table 5 provides a summary of the total passenger train numbers adopted for the modelling scenarios. Generally, it has been assumed that freight trains and express trains would operate on the outside two tracks and stopping trains would operate on the inside two tracks. This provides a conservative assessment of the future noise levels.

Table 5 Summary of Train Movements for Modelling Scenarios

Section of Track	Train Type	Year 2006		Year 2017	
		Down Direction	Up Direction	Down Direction	Up Direction
Between Epping Dives (ECRL) and NWRL Dives	Electric Passenger	113	113	254	254
	XPT	3	3	3	3
	Freight	13	13	25	25
ECRL	Electric Passenger	Nil	Nil	141	141
NWRL	Electric Passenger	Nil	Nil	86	86

Buildings and Receiver Locations

The location of buildings and their representation within the noise model was derived from aerial photography, provided by TIDC. For the Environmental Assessment, a detailed survey of building characteristics was not undertaken on the basis that a high degree of accuracy would not be necessary until the noise mitigation measures (such as noise barriers) were studied in more detail.

Proposed land uses were determined from the following documents:

- Previous SKM Reports (various); and
- Review of the 2006 UBD

5.7 Validation of the Computer Model - Main North Line

Attended noise measurements were undertaken as part of this preliminary assessment at two locations adjacent to the Main North Line. A summary of the noise measurement locations, results and the dates when the noise measurements were undertaken is provided in **Table 6**, together with the modelling outputs for the same locations.

Table 6 Attended Noise Measurement Locations and Results (Passenger Trains)

Measurement Location	Date	Number of Train Events	Measured Noise Levels (dBA)			Modelled[3] Noise Levels (dBA)	
			Highest LAmax[6]	Average LAmax	Calculated LAeq(24hour)	LAmax[4]	LAeq(24hour)
North of Cheltenham Station[1]	21/6/06	37	87	77	60	86 (-1)	59 (-1)
South of Cheltenham Station[2]	25/7/06	20	81	74	56	80 (-1)	57 (+1)

Note 1 Measurements undertaken on Down Side of railway corridor at track chainage 25.85 km and approximately 23 m from the nearest track.

Note 2 Measurements undertaken on Down Side of railway corridor at track chainage 25.20 km and approximately 39 m from the nearest track.

Note 3 Modelled noise levels based on reference levels in **Table 4** and the number of existing electric passenger trains on the Main North Line.

Note 4 Representing the notional 95th percentile of L_{Amax} train noise levels.

Note 5 The numbers in brackets represent the difference between the modelled noise levels and the measured noise levels. A positive number indicates that the modelled noise levels are higher than the measured noise levels.

Note 6 The 95th percentile L_{Amax} noise levels north of Cheltenham were 84 dBA and south of Cheltenham were 80 dBA.

On the basis of the measured and predicted noise levels, it is concluded that the noise model is providing satisfactory predictions of both the L_{Amax} and $L_{Aeq(24hour)}$ noise levels.

5.8 Noise Modelling Scenarios

5.8.1 Main North Line

The following noise modelling scenarios been evaluated for the upgraded section of track between Epping and Beecroft:

Scenario 1

Noise contour plots have been developed for Year 2017 at calculation heights of 1.5 m and 4.2 m above ground level, representing 1st and 2nd floor receivers. Separate noise contour plots have been provided for both the L_{Amax} and $L_{Aeq(24hour)}$ noise parameter, for freight and electric passenger trains separately.

Scenarios 2 to 4

As per Scenario 1, except that notional noise barriers (2.0 m, 3.0 m and 4.0 m) have been included in the noise model at an offset distance of 4.3 m from the outermost track centreline.

5.9 Noise Modelling Results - Main North Line

The results of the computer noise modelling with and without noise barriers (Scenarios 1 to 4) have been presented in the form of L_{Amax} and $L_{Aeq(24hour)}$ noise contour plots as detailed in **Table 7**.

Table 7 Noise Contours – Operational Phase - Main North Line (Reference Scheme)

Train Type	Contour Height	With 2m Barriers	With 3m Barriers	With 4m Barriers
Electric Passenger	1.5 m above ground	Appendix D	Appendix E	Appendix F
	4.2 m above ground	Appendix G	Appendix H	Appendix I
Diesel Freight	1.5 m above ground	Appendix J	Appendix K	Appendix L
	4.2 m above ground	Appendix M	Appendix N	Appendix O

Each of the Appendices shows the predicted noise level contours with varying height barriers together with the "no barrier" noise levels contours for direct comparison. The noise contours are calculated at fixed heights of 1.5 m and 4.2 m above ground which is indicative of the 1st floor and 2nd floor receivers respectively.

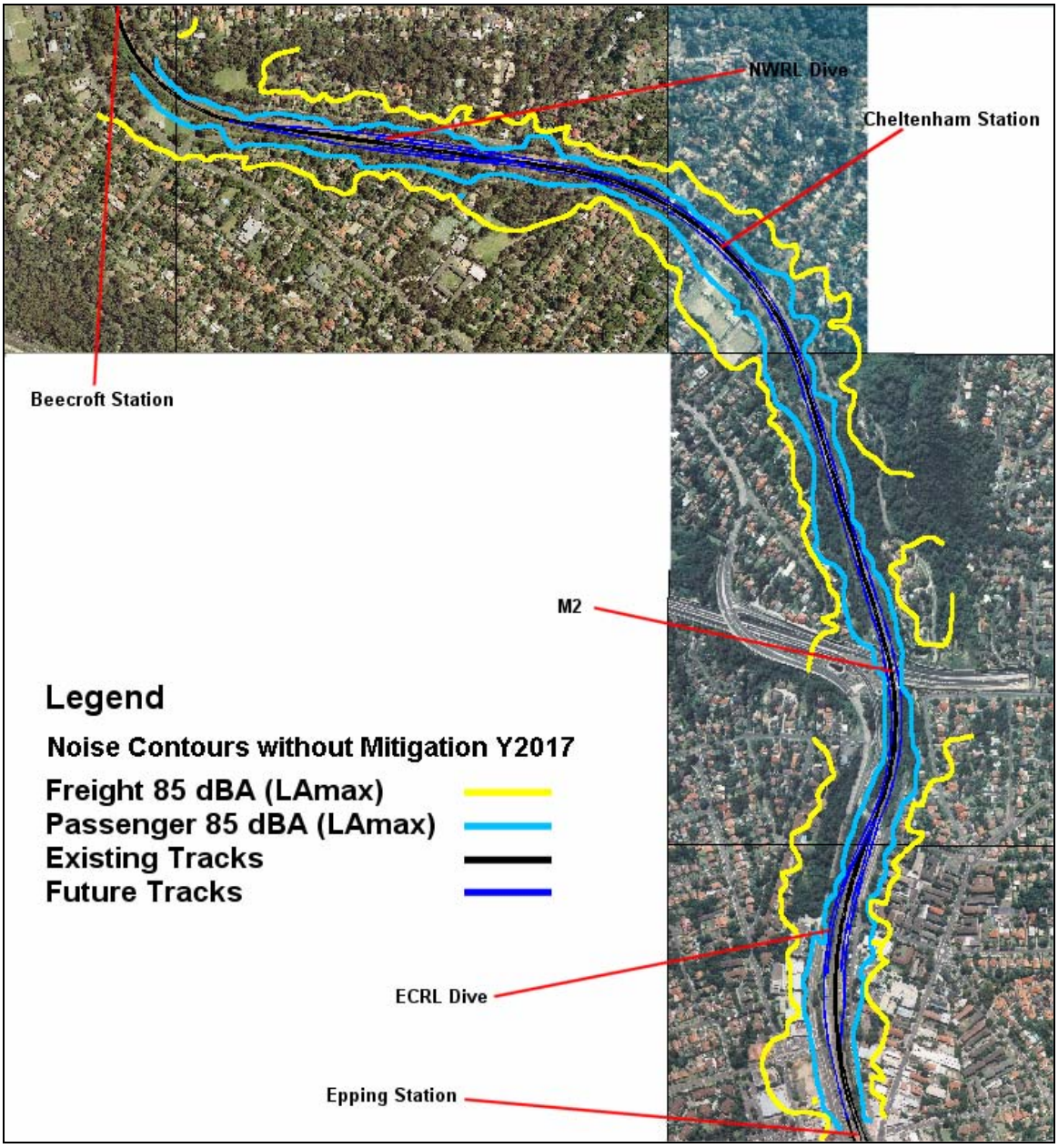
Discussion of Noise Modelling Results

In this section of existing track, the current noise levels already exceed the DEC's "Maximum Levels". On the basis of the proposed increase in rail traffic as a result of the quadruplication, and given that freight and express passenger trains are expected to operate on the new outermost tracks (closer to the nearest residential receiver locations), it is anticipated that the future $L_{Aeq(24hour)}$ noise levels would increase by approximately 3 dBA to 4 dBA as a result of the proposal. Similarly, L_{Amax} noise levels would increase by approximately 1 dBA to 2 dBA as a result of the reduced offset distances.

As discussed in **Section 5.3**, the determination of prescriptive noise mitigation measures is considered to be inappropriate at this early stage of the assessment process. Typical noise mitigation measures that may be applied as part of the proposal are discussed in **Section 5.11**. Feasible and Reasonable mitigation measures will be determined as part of the detailed design.

The predicted noise levels for the year 2017 situation are provided in **Appendices D** to **O**. **Figure 2** shows a summary of the predicted L_{Amax} 85 dBA noise contours without mitigation for electric passenger and diesel freight trains. A discussion of the predicted future noise levels from both of these sources with and without potential noise barriers is provided after the figure.

Figure 2 Predicted LAmax 85 dBA Noise Contours for Main North Line Quadruplication (Passenger and Freight)



Electric Passenger Trains

Without mitigation, the LAmax and LAeq(24hour) noise levels from electric passenger trains are predicted to exceed the DEC's "Maximum Levels" at the following locations:

- Chester Street, Epping to end of Cambridge Street Epping - Up Side
- The Crescent, between the M2 and Lyne Road Cheltenham - Down Side
- Sutherland Road, between the M2 and Day Road Cheltenham (receivers on upper levels) - Up Side
- Between Chorley Avenue and Kethel Road, Cheltenham - Up Side

- The Crescent, between Cheltenham Girls High School and Kirkham Street, Cheltenham - Down Side

The noise contour plots show that at most locations, noise barriers are potentially an effective noise mitigation option for reducing noise emissions from electric passenger trains, with 2.0 m high barriers providing a typical noise reduction of 5 dBA at the lower floors. At some locations, however, 2.0 m barriers or higher would not be an effective measure (eg at the upper floors of unit blocks in Cambridge Street, Epping), as residential receivers would still have a clear line-of-sight to the tracks.

Diesel Freight Trains

Potential exceedances of the DEC's "Maximum Levels" are greater for diesel freight train operations compared with the electric passenger trains, resulting from the high notch settings and hence higher source levels. Additional locations predicted to exceed the DEC's "Maximum Levels" without mitigation are:

- Edensor Street and Kandy Avenue, Epping - Down Side
- Sutherland Road, between the M2 and Day Road Cheltenham (receivers on upper and lower levels) - Up Side
- The Crescent, between Lyne Road and Cheltenham Girls High School, Cheltenham - Down Side
- Sutherland Road, between Day Road, Cheltenham and Copeland Road East, Beecroft

The noise contour plots show that at most locations, 2.0 m and 3.0 m high noise barriers have almost no effect on the predicted L_{Amax} and $L_{Aeq(24hour)}$ noise levels from diesel freight trains, except for locations where the tracks are located within a cutting. This results from the source height of the diesel locomotive noise emissions (approximately 4.0 m above rail) being higher than the barriers. At most ground floor locations, 4.0 m barriers would be required to achieve a noise reduction of approximately 5 dBA. 4.0 m high barriers, however, would not provide any significant benefit to residential receivers located on upper floors of unit blocks (eg Cambridge Street and Edensor Street).

5.10 Noise Modelling Results - North West Rail Link between Norwest Business Park and Rouse Hill

Predicted noise levels for the 2002 alignment between Norwest Business Park and Rouse Hill are provided in **Appendix P** (SKM 2003).

For the 2002 alignment, L_{Amax} noise contours were provided (as this was determined to be to dominant criterion) for the following scenarios:

- No noise controls;
- Erection of a 1.8 m barrier;
- Erection of a 2.4 m barrier;
- Erection of a 3.0 m barrier;
- Erection of a 3 m barrier together with speed restriction on the viaduct.

The noise contours (see **Appendix P**) indicate that for some sections, where the proposed track is located within cutting, noise mitigation in the form of barriers is not required to achieve compliance with the noise goals at the nearest existing residential receiver locations. At other locations, where the track is at-grade, on embankment or on viaduct, noise mitigation in the form of barriers would be required to achieve compliance with the noise goals at existing and future residential receiver locations.

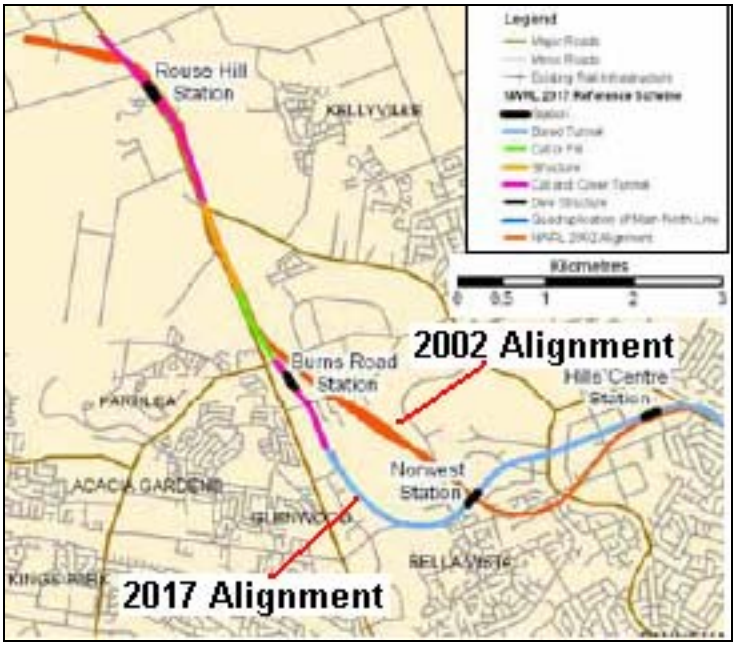
For additional information in relation to the previous assessment in this section of surface track, the reader is directed to the *North West Rail Link Working Paper No. 6 - Noise and Vibration Assessment* (SKM April 2003) attached as **Appendix V**.

The proposed location of the NWRL portal near Norwest Business Park for the Reference Scheme has changed compared with the 2002 alignment (see **Figure 3**).

South of Burns Road (just north of Burns Road Station), the proposed tracks would be in located within a cut and cover tunnel and hence there would be no operational airborne noise impact as part of the proposal to the south of Buns Road. This represents an improvement over the 2002 alignment, in which the tunnel portal was located near Hillsong Church in Norwest Business Park.

For a distance of approximately 500 m north of Burns Road, the Reference Scheme alignment is located marginally closer to residential receiver locations on the western side of Old Windsor Road, compared with the alignment considered by SKM. This represents only a marginal change compared to the previous assessment undertaken by SKM (2003).

Figure 3 Revised NWRL Portal Location (near Norwest Business Park)



Source : Project Application and Preliminary Environmental Assessment (TIDC/SKM, April 2006)

5.11 Operational Noise Mitigation

As discussed in **Section 5.3**, the determination of prescriptive noise mitigation measures is considered to be inappropriate at the Concept Approval stage of the assessment process. The following discussion provides an overview of the potential mitigation measures that may be applied. Specific noise mitigation measures will be considered in more detail after the Concept Approval has been obtained and the detailed design has progressed.

For the purposes of this preliminary assessment, the DEC "Maximum Levels" of L_{Amax} 85 dBA and $L_{Aeq(24hour)}$ 60 dBA have been used to identify receiver locations on the Main North Line that may potentially be noise affected (noting that the proposal's design goals may be higher or lower than these levels). Similarly, the DEC "Planning Levels" of L_{Amax} 80 dBA and $L_{Aeq(24hour)}$ 55 dBA have been used to identify receiver locations adjacent to the proposed NWRL that may potentially be noise affected.

As discussed in **Section 5.9**, the predicted future noise levels in year 2017 exceed the DEC's noise goals at a number of existing receiver locations.

The potential mitigation options include:

- Modifying existing rolling stock to have lower noise emissions.
- Designing viaducts to incorporate noise mitigation measures.
- Modifying the design of cuttings and consideration of other at-source mitigation.
- Lowering operating speeds.
- Stipulating a minimum setback distance for sensitive receivers (where possible).
- Providing acoustic shielding (through the use of noise walls/mounds and cuttings).
- Working with local government to set acoustic standards in the consent conditions for new residential buildings.
- Work with relevant authorities regarding land use decisions.

The hierarchy of noise control is to give first preference to source control measures, then to physical mitigation measures between the source/receiver and as a final measure, receiver controls. These are described briefly below.

Source Control Measures

Source control measures include route selection to maximise the offset distance between the railway line and residential areas, regular track maintenance (to remove track defects), improved wheel condition, speed restrictions and the introduction of quieter rollingstock. At specific locations, source noise levels can be reduced by installing "quiet" bridges and applying lubrication or top-of-rail friction modifiers to mitigate noise on tight-radius curves.

For the Main North Line and NWRL, it is understood that the existing RailCorp fleet would be utilising the new infrastructure, rather than providing a dedicated fleet. On this basis, there is little opportunity to reduce the source noise levels of the rollingstock significantly. The noise modelling does assume, however, that 75% of the electric passenger fleet would be Tangara or Millennium, which are approximately 2 dBA to 3 dBA quieter on average compared with the noisier double deck suburban trains. On this basis, it is considered reasonable to assume that the frequency of noisier train events would reduce over time as older rollingstock is retired.

RailCorp's DEC licence also requires the preparation of a "Whole of Network Strategy", aimed at reducing train noise on the Metropolitan Rail network over time. It is reasonable to expect that this strategy would benefit residents adjacent to the Main North Line and NWRL.

Lowering the train speeds is not desirable from an operational perspective as this would provide an adverse long-term constraint on the rail line.

On the Main North Line, diesel freight trains are responsible for the highest L_{Amax} noise levels. This results from the steep grades in this section of track. There may be opportunities to reduce the source levels of diesel locomotives over time by retrofitting quieter mufflers or by regulation of the maximum allowable noise levels.

Source/Receiver Measures

This includes the construction of noise barriers, enclosures or other structures (which shield some of the direct airborne noise that propagates between the source and receiver locations), and land use planning measures (which increase the distance between the source and sensitive receivers).

Noise barriers can provide significant noise reductions in areas where source control measures are not adequate to mitigate noise levels completely. Noise levels on the ground floor (including back yards and living areas) can usually be significantly reduced through the use of noise barriers. Noise barriers are not as effective, however, for upper floor receivers and are usually ineffective above the second level. As discussed previously, noise barriers can be affective in reducing the wheel-rail noise levels from electric passenger trains and freight wagons, but are usually ineffective at mitigating noise emissions from freight locomotives, as the exhausts and braking fans are located approximately 4.0 m above the rail.

In terms of noise reduction, noise barriers (walls) and earth mounds can be regarded as providing similar acoustic performance if the top of the barrier and mound are at the same height and distance from the track. In practice, earth mounds may be preferred because they can be visually less intrusive and are less likely to be vandalised. The disadvantage, however, is that they require a larger land area (due to the batter) and this may result in the top of an earth mound being located further from the track than an equivalent noise barrier. Earth mounds are generally not suitable for use where track is on embankment, as the resultant widening of the embankment can require substantial amounts of fill. In the section of track adjacent to the Main North Line between Epping and Beecroft, noise barriers are likely to be the only feasible option for this type of mitigation due to the restricted land area.

The use of planned setbacks can reduce or remove the need for noise barriers (which can have detrimental visual, cost and social impacts). Large setback distances are often required, however, in order to achieve compliance with the noise goals for new railway lines and hence it is often necessary to strike a balance between physical noise mitigation measures at the source and building treatments for new dwellings. In some situations, it may be possible to flank the railway corridor with roads to increase setback distances or locate less sensitive land use areas (such as commercial or industrial) adjacent to the railway line.

The draft LEP for the Balmoral Road Release Area acknowledges the need to design buildings in recognition to their proximity to a rail line. As such, developers are required to consider noise and vibration attenuation measures for any development within 60 m of the NWRL. It is recommended that LEP's for other land release areas adjacent to the proposed NWRL also incorporate similar conditions.

In town centres, large setbacks would not be practical from an urban planning perspective, therefore alternative planning regulations for building treatments may be more appropriate as determined by the relevant authorities.

Receiver Controls

This generally involves the inclusion of specific acoustical measures as part of the design of individual dwellings in order to reduce noise levels inside buildings.

Treatments to buildings usually involve higher performance windows, doors and seals to keep noise out. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate air flow. An obvious disadvantage is that building treatments would not have any effect on the noise levels outside the dwelling in their front or back yards. Building treatments are normally more costly than source control and source/receiver control measures. Building treatments are generally applied as a last resort after all other options have been explored.

For the NWRL proposal, the preliminary noise modelling indicated that there are potentially large offset distances (greater than 200 m) from the railway corridor where noise levels may exceed the DEC "Planning Levels". Whilst the provision of noise barriers would significantly reduce the offset distances for "compliance", future residential development may still occur with the DEC's "Planning Levels" exceedance zone. In these situations, it is anticipated that a combination of source/receiver measures (eg noise barriers or earth mounds) would be required in conjunction with receiver controls for new buildings (eg building treatments) to arrive at the most cost effective mitigation option.

Incorporating acoustic standards into consent conditions for new residential buildings adjacent to the corridor could be an effective mitigation measure if Councils agree to the concept. A potential basis for this option is the Rail Infrastructure Corporation (RIC) and State Rail Authority (SRA) (both now part of RailCorp) jointly issued *"Interim Guideline for Councils – Consideration of Rail Noise and Vibration in the Planning Process"*. This document provides guidance in relation to when acoustic assessments should be undertaken, and provides internal noise goals for buildings. A consequence of setting internal noise goals is that noise can mitigated at the building facades (eg door and window materials and seals), rather than with noise barriers (which may be inappropriate or not feasible at that particular location).

The Draft LEP for the Balmoral Road Release Area already includes a clause relating to development within 60 m of the rail corridor which states that *"consent must not be granted to the carrying out of development unless the consent authority is satisfied that the development incorporates appropriate noise attenuation and vibration minimisation measures, and the design and location of the development is such that it will not interfere with the operation of the rail line and associated facilities"*.

For the Main North Line, where there are a large number of existing residential receiver locations that are currently exposed to noise emissions from freight operations, building treatments may represent the only feasible mitigation measure. The reasonableness of providing building treatments at such locations will be determined at a later stage in the assessment process.

5.12 Public Address System Noise at Platforms

Public address (PA) systems at railway stations are not directly covered by RailCorp's Environment Protection Licence because they are viewed as being part of a fixed facility, rather than train operations.

In order to avoid unnecessary noise emission, the station PA system at Burns Road and Rouse Hill Stations should be designed to incorporate the following features:

- Automatic volume control to reduce PA levels in the absence of train noise and to limit the maximum level in the event that station staff speak into the microphone with a raised voice.
- Distributed array of speakers each emitting lower sound levels, rather than a few centrally located loudspeakers.

In addition, the RailCorp document *"Guidelines for Operation of PA Systems"*, prepared by State Rail Authority in 2001 provides guidance on appropriate use of PA systems, which should be adhered to by all staff.

6 GROUNDBORNE NOISE ASSESSMENT

Groundborne noise is most common in railway tunnel situations where receivers are located in buildings above or in close proximity to the railway tunnels. Groundborne noise results from the transmission of groundborne vibration rather than the direct transmission of noise through the air. The vibration is generated by wheel/rail interaction and is transmitted from the trackbed, via the ground and into the building structure.

The vibration entering the building then causes the walls and floors to vibrate faintly and hence to radiate noise (commonly termed “groundborne noise” or “regenerated noise”).

If it is of sufficient magnitude to be audible, the noise has a low frequency rumbling character, which progressively increases and then decreases in level as a train approaches and departs the site, with a total duration of typically 10 seconds or so per train passby. This type of noise can be experienced in many buildings adjacent to most urban underground rail systems.

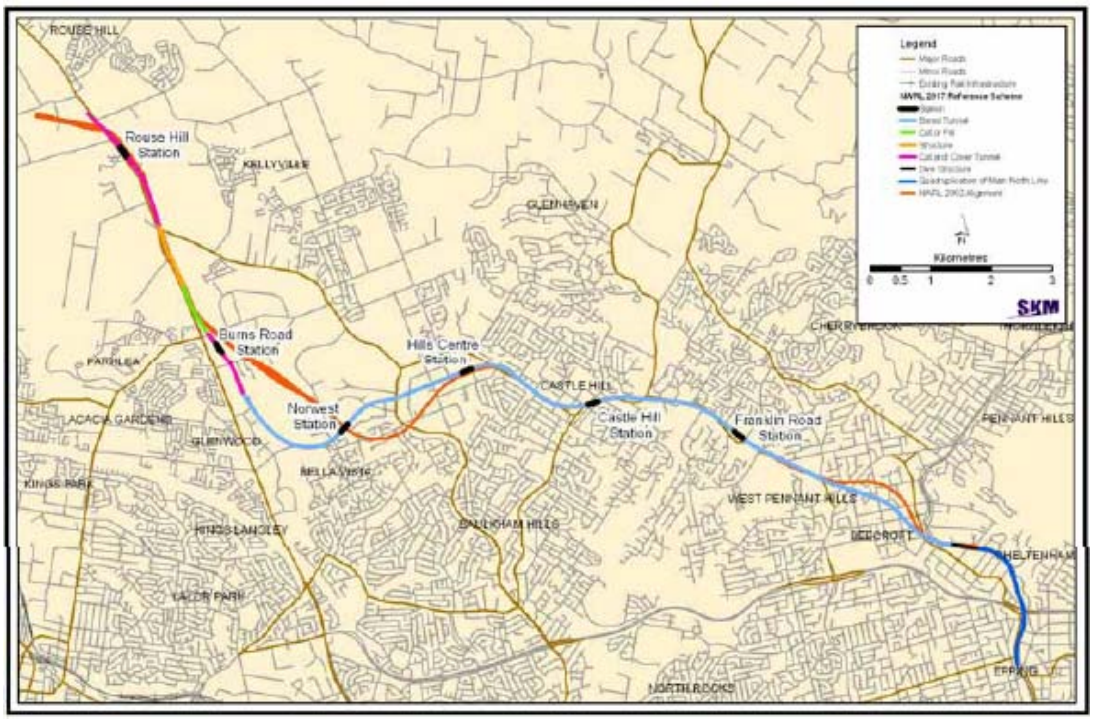
An assessment of the groundborne noise associated with the construction and operation of the NWRL tunnels between Beecroft and Norwest Business Park was previously undertaken by SKM (2003) for the 2002 alignment.

The assessment criteria were based on the approval conditions for the Parramatta Rail Link (now known as the Epping to Chatswood Rail Line).

Compared with the 2002 alignment, two modifications have been proposed as part of the Reference Scheme which affect these previous predictions. These are:

- **Tunnel Construction** - The noise and vibration assessment undertaken by SKM (2003) was based on a tunnel design which included ballasted track. The Reference Scheme design is based on a slab track design.
- **Proposed Alignment** - The proposed horizontal alignment of the tunnels has been modified at two locations as indicated in **Figure 4**. These are between Beecroft and West Pennant Hills, where the proposed alignment has been shifted towards the south. The other change in alignment is to the west of the proposed Hills Centre Station.

Figure 4 Changes to Proposed Horizontal Tunnel Alignment - Reference Scheme



Source : Project Application and Preliminary Environmental Assessment (TIDC/SKM, April 2006)

Whilst the detailed groundborne noise assessment does not form part of the scope of work for the current environmental assessment, some brief comments in relation to the proposed changes are provided below. A more detailed assessment of the potential groundborne noise and vibration from the tunnel section will be undertaken at a later stage in the assessment process.

6.1 Tunnel Construction and Mitigation Options

For ballasted track in railway tunnels, three types of track treatments were recommended in order to comply with the proposal's design goals:

- Standard Ballasted Track - No specific treatment
- Ballast Mat - High and Low performance
- Floating Slab - High and Low performance

The extent of each of the above track types was determined by SKM on the basis of the source vibration levels, tunnel depth, train speeds and ground type. At locations where the predicted noise levels exceeded the design goals using standard ballasted track, higher performance track treatments (which reduce the source vibration levels) were applied to achieve compliance with the design goals.

For slab track (in which the rail is fixed to a concrete base, rather than to sleepers sitting on ballast), different types of track treatments are required in order to mitigate noise and vibration emissions. These include:

- Standard Slab Track - Rail directly fixed onto a concrete slab using steel plates and standard rail pads and clips
- Resilient Track Fixings - Rail sits on composite steel and rubber acoustic rail fixings which are bolted to the concrete slab.

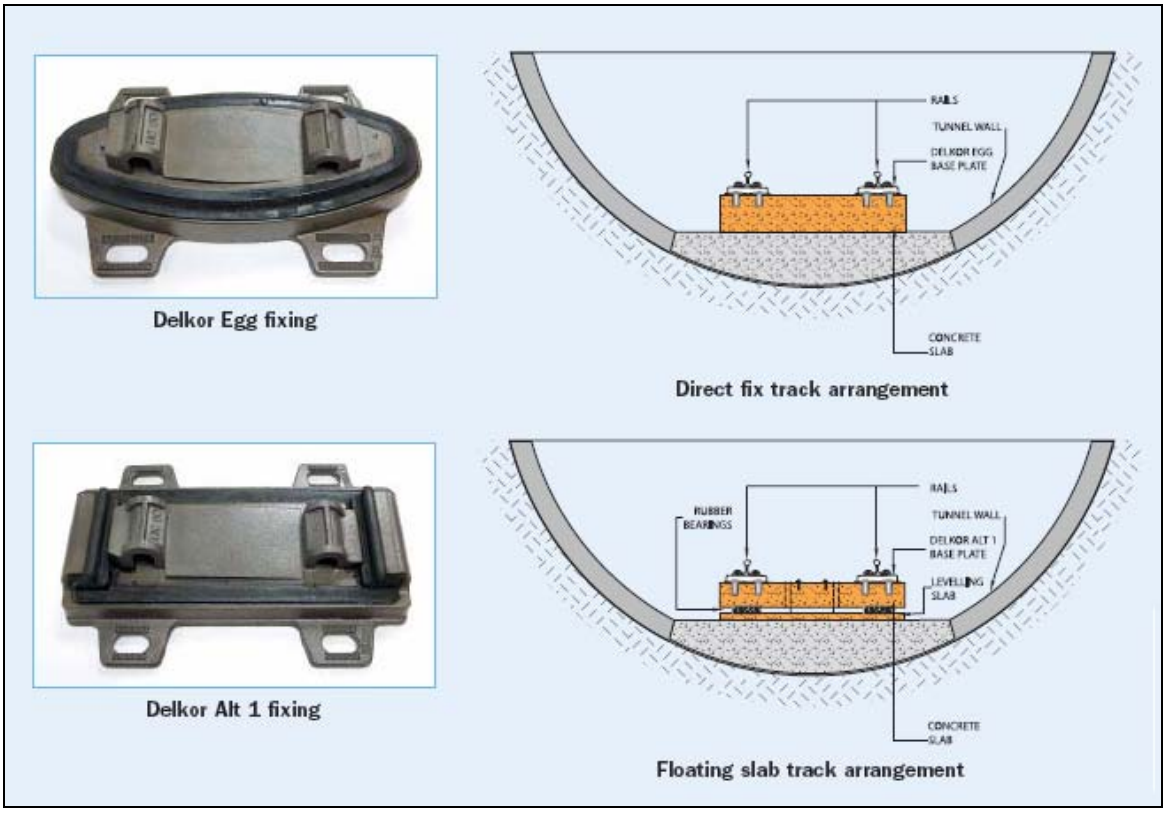
- Floating Slab Track - Rails are fixed to separate concrete slabs which sit or "float" on top of rubber bearings which sit on the concrete slab. The rails can either be fixed to the floating slab using standard rail pads or if a higher degree of attenuation is required, resilient track fixings can be provided.

An example of the two track types that are currently being provided for the Epping to Chatswood Rail Line (ECRL) is provided in **Figure 5**.

Whilst different engineering options are applied to mitigate noise and vibration emissions for ballasted and slab track, the same level of attenuation can be provided for both sets of options.

On this basis, it is concluded that although the proposed trackform is different for the Reference Scheme, feasible noise and vibration mitigation options are available for slab track to mitigate any potential exceedances of the design goals. Further assessment would include a more detailed study of the proposed vertical and horizontal alignments, calculations of groundborne noise levels at nearby buildings and an assessment of mitigation measures that will need to be incorporated into the detailed track design.

Figure 5 Example Track Types used for ECRL Tunnels



Source : Epping to Chatswood Rail Line Track Design Update (TIDC, June 2006)

6.2 Tunnel Alignment

The proposed dive structure for the NWRL Reference Scheme commences between Cheltenham and Beecroft Stations in the vicinity of track chainage 25.8 km and continues below ground until approximately track chainage 41.0 km near Burns Road Station. **Figure 6** provides a summary of the surface level, proposed track level and calculated tunnel depths for the Reference Scheme.

Figure 6 Proposed Tunnel Depth for Reference Scheme

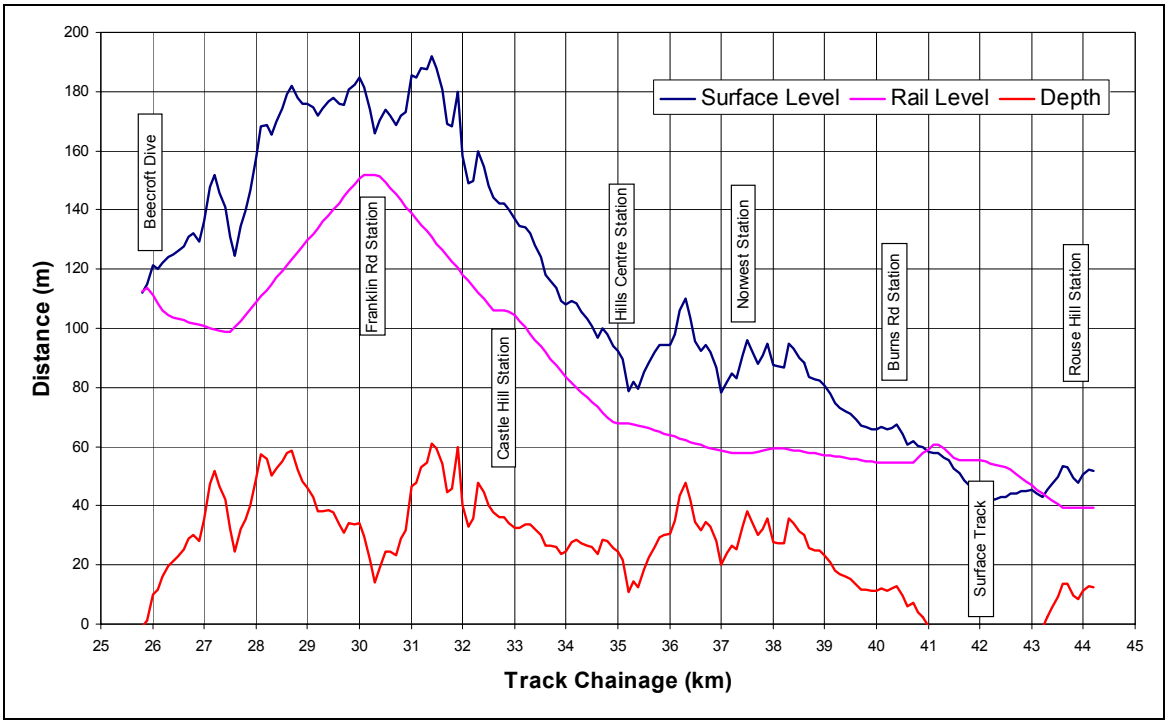
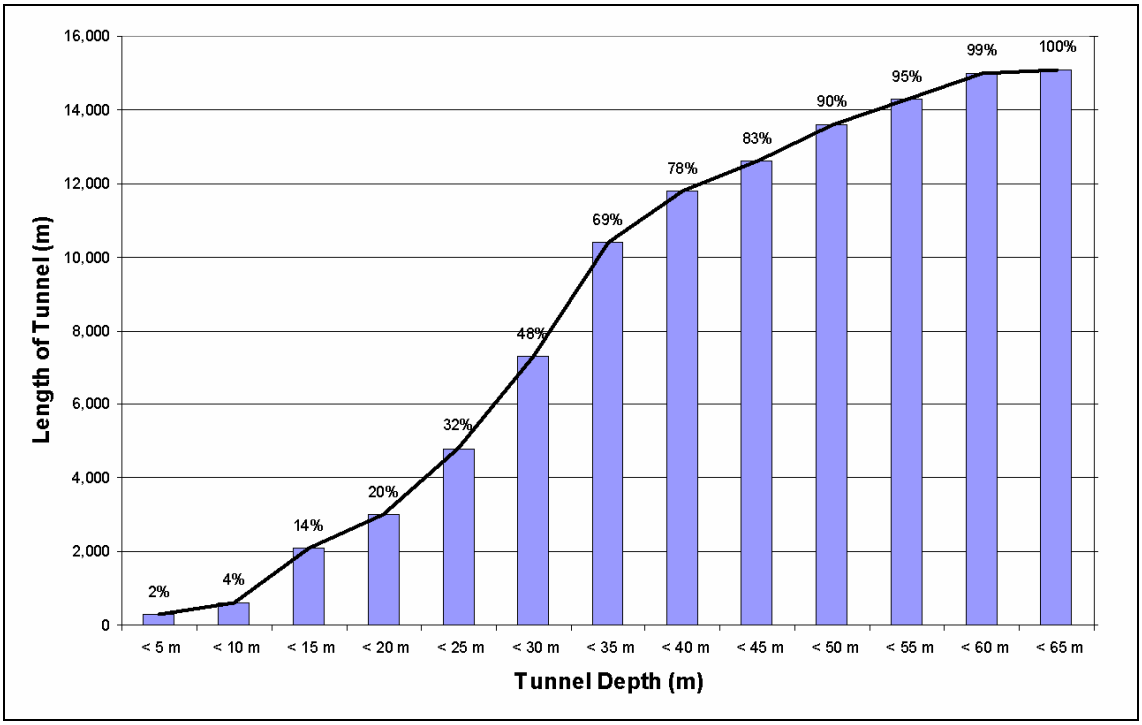


Figure 7 provides an alternative representation of the tunnel depth, expressed as a percentage of track below a certain depth. For the 15.2 km section of tunnel between Beecroft and Burns Road, **Figure 7** illustrates that approximately 20% of the track has a tunnel depth of less than 20 m and approximately 52% of the track has a tunnel depth greater than 30 m.

Figure 7 Percentage of Track Vs Tunnel Depth for Reference Scheme



6.3 Extent of Potential Mitigation Measures

At this early stage of the design and the noise and vibration assessment process, it is appropriate to undertake preliminary, rather than detailed modelling. The determination of prescriptive mitigation measures is therefore considered to be inappropriate at this early stage of the assessment process.

At this stage of the assessment, however, it is noted that the tunnel depth is greater 20 m for a large percentage of the proposed alignments.

On the basis of the preliminary information that has been made available, it is anticipated that the track within the tunnels could be designed to comply with the proposal's design goals for groundborne noise and vibration via implementation of the track types illustrated in **Figure 5** or other similar designs.

The proposed track type at specific locations will be determined as part of the detailed design of the preferred horizontal and vertical alignment, and would be dependent upon factors such as train speed, tunnel depth, ground conditions, building occupancy and building type.

7 OPERATIONAL VIBRATION

7.1 Introduction

Overview

Railway vibration is generated by dynamic forces at the wheel-rail interface and will occur to some degree, even with continuously welded rail and smooth wheel and rail surfaces (due to the moving loads, finite roughness of the surfaces and elastic deformation). Significantly higher vibration levels can occur due to rail and wheel surface irregularities, including some irregularities that do not cause significant levels of airborne noise.

This vibration propagates via the sleepers or rail mounts into the ground or track support structure. It then propagates through the ground or structure, and may sometimes be felt as tactile vibration by the occupants of buildings.

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

Human Perception of Vibration

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling. Industrial environments are clearly less sensitive than say, commercial buildings, where the usual expectation is that there should be little perceptible vibration.

Although people are able to perceive relatively low vibration levels, it is not appropriate to set vibration emission limits requiring “no vibration”, since there will always be some vibration in any environment. It is necessary therefore to set realistic design criteria which minimise disturbance and adverse impacts on amenity. The recommended approach is discussed in **Section 7.3**.

Effects on Building Contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. As such, the controlling vibration criterion will be the human comfort criterion, and it is therefore not necessary to set separate criteria for this proposal in relation to the effect of railway vibration on most building contents.

Effects of Vibration on Structures

The levels of vibration required to cause damage to buildings tend to be at least an order of magnitude (10 times) higher than those at which people consider the vibration acceptable. Hence, the controlling criterion will still be the human comfort criterion, and it is therefore not necessary to set separate criteria for this proposal in relation to building damage from railway vibration.

7.2 Vibration Propagation

The propagation of vibration through the ground is a complex phenomenon. Even for a simple source, the received vibration at any point may include the arrival of several different wave types, plus other effects such as damping, reflection, and impedance mismatch caused by changes in ground conditions along the propagation path.

It is useful to note that predictions of vibration normally involve a combination of empirical and analytical methods as the various characteristics are normally not sufficiently defined to enable full analytical modelling.

7.3 Vibration Criteria

As discussed in **Section 7**, the human comfort criteria for vibration tend to be more stringent than other possible criteria relating to building contents or building damage.

There are several sources from which vibration criteria may be drawn. These include:

- Australian Standard AS 2670.2 1990 *"Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)"*.
- The United States Department of Transportation guideline *"Transit Noise and Vibration Impact Assessment"*, 1995.
- British Standard BS 6472-1992 *"Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)"*.
- The NSW Department of Environment and Conservation document *"Assessing Vibration : a technical guideline"*, 2006

The following discussion expresses vibration levels in terms of decibels (dB re 10^{-9} m/s). A level of 100 dB corresponds to 0.1 mm/s (rms) and a level of 120 dB corresponds to 1 mm/s (rms).

AS 2670 provides criteria corresponding to 106 dB to 112 dB for residential buildings during the daytime, and reducing to 103 dB during the night-time. These criteria apply to both continuous and intermittent vibration. For office and industrial buildings, the criteria are 112 dB and 118 dB, respectively.

For residential buildings, the US guideline recommends a criterion of 100 dB for frequent trains, or 108 dB for infrequent trains (ie less than 70 per day). These are understood to apply to the average train vibration levels. For schools, churches, quiet offices, etc, the recommended criteria are 3 dB higher than the residential criteria.

BS 6472 has similar criteria for continuous vibration, but also includes a dose relationship for intermittent events such as trains, which for a "low probability of adverse comment" would permit vibration levels of up to 110 dB, assuming 300 events of 15 second duration within a 16 hour day and/or 100 events of 15 second duration within a 8 hour night.

The DEC's *"Assessing vibration: a technical guideline"* is based on the guidelines contained in BS 6472–1992, and the acceptable values for intermittent vibration are the same as calculated above (namely 110 dB).

Proposed Vibration Criteria

The proposed criteria have therefore been based on the vibration dose values nominated in BS 6472, and the DEC's *"Assessing vibration: a technical guideline"* (110 dB), recognising that vibration levels above the continuous vibration levels nominated in AS 2670 (106 dB day, 103 dB night) may be perceptible and could potentially result in adverse comment from sensitive receivers.

7.4 Source Vibration Levels

The US Federal Transit Administration's (FTA's) *"Transit Noise and Vibration Impact Assessment"* report provides indicative vibration levels versus distance for a variety of transport systems, including rapid transit rail systems. The base curve, shown in **Figure 8** shows the typical ground-surface vibration levels assuming rollingstock and rail in good condition and a train speed of 80 km/h. At other speeds, the vibration level is approximately proportional to 20 x log(speed/80 km/h), with a note that sometimes the speed has been observed to be as low as 10 to 15 x log(speed/80 km/h).

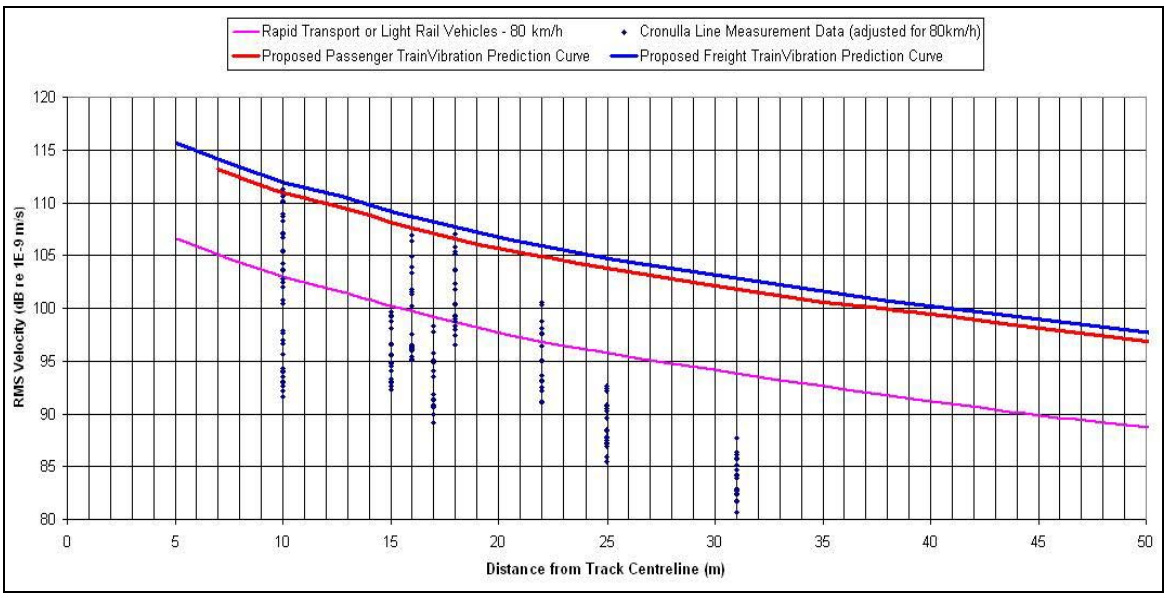
Vibration measurements undertaken by Heggies for the Cronulla Line Upgrade and Duplication Project are also presented in **Figure 8**, for comparison, adjusted for speed to represent the 80 km/h reference.

From the measurement results at four locations adjacent to the Cronulla Line (2 measurement distances per location), it is evident that approximately 50% of the measurement results are above the reference (rapid transport or light rail vehicles) line and 50% are below the reference line. The measurement results therefore appear to correlate well with the FTA reference levels for typical trains.

The red line in **Figure 8**, labelled "Proposed Vibration Prediction Curve", represents the typical maximum vibration level from passenger trains and is 7.5 dB higher than the reference curve. On the basis of the measurement results at Cronulla and similar vibration measurements undertaken by Heggies on other projects, the difference between the 95th percentile (highest 1 in 20 trains) event and the median event is approximately 8 dB. This vibration curve, in conjunction with the typical 20 x log(speed/80 km/h) relationship has been used to predict the future vibration levels from electric passenger trains in the section of track between Epping and Beecroft.

Freight train vibration measurements were previously undertaken by Heggies as part of a proposed rail upgrade project. The measurement data was analysed in a similar manner to the Cronulla Line data in order to provide a direct comparison between the freight and passenger train measurement data. It was determined that the difference between the 95th percentile event for freight trains and the median event for passenger trains was 9 dB. This vibration curve, shown as the upper blue line in **Figure 8** has been used to predict the vibration levels from freight trains on the section of track between Epping and Beecroft.

Figure 8 Ground Surface Vibration Levels Versus Distance



Source : Adapted from Figure 10-1 in FTA' s Transit Noise and Vibration Impact Assessment Report

7.5 Assessment of Ground-Surface Vibration Levels

7.5.1 General

As discussed in **Section 7.4**, the ground vibration levels from trains increases with operating speed. For this assessment, predictions are conservatively based on the typical maximum speeds in each section of track and the actual vibration dose values would be lower than predicted.

The vibration contours are only presented for the section of quadruplicated track between Epping and Beecroft (Reference Scheme). For the tunnel sections, preliminary guidance is provided on the typical offset distances required to comply with the design goals.

The results of the vibration modelling have been presented in the form of vibration velocity (dB re 10^{-9} m/s) contour plots in **Appendix Q.**

7.5.2 Vibration along the Main North Line

In this section of track, the highest electric passenger train speed is assumed to be 100 km/h and the highest freight train speed is assumed to be 80 km/h.

Adjacent to the Main North Line, there is generally a substantial offset distance between the railway corridor and the nearest residential receiver locations such that Cambridge Street, Beecroft Road, Sutherland Street and The Crescent are all located between the corridor and the nearest residential buildings.

The only exception to this is the residential buildings in Sutherland Crescent to the south of Cobran Road. At this location, however, the track is located on a substantial embankment and the nearest residential buildings are approximately 30 m from the nearest future track centreline.

For passenger trains, the 103 dB night-time vibration contour (for perception) lies approximately 35 m from the nearest track centreline. The 106 dB daytime vibration contour (for perception) lies approximately 25 m from the nearest track centreline. The 110 dB criterion vibration contour lies approximately 15 m from the nearest track centreline. As discussed in **Section 7.4**, these levels are based on the 95th percentile (or highest 1 in 20 trains). The vibration levels from the average train would be approximately 8 dB lower.

For Freight trains, the source vibration levels are higher, but the operating speeds are lower. As such, the predicted vibration levels from freight trains are expected to lie within the 95th percentile vibration level range for electric passenger trains.

Since the nearest residential receiver locations are approximately 30 m from the nearest track, it is concluded that vibration from passenger and freight trains would comply with the 110 dB criterion by significant margins. During the night-time period, vibration from freight trains and the occasional high-speed passenger train may be perceptible.

7.5.3 Vibration along the New Tunnel Section

In the section of new tunnel between Beecroft and Burns Road Station, the maximum track speed is assumed to be 110 km/h. In tunnels, however, it is normally the groundborne noise criteria that dictate the requirements for track mitigation rather perceptible vibration levels. On this basis, compliance with the groundborne noise levels (see **Section 6**) would ensure compliance with the proposal's criteria for vibration.

7.5.4 Vibration adjacent to the proposed At-Grade Section - NWRL

In the section of proposed surface track between Burns Road Station and Rouse Hill Station, the maximum track speed is assumed to be 115 km/h.

Adjacent to this section of track, existing and proposed residential developments are located on both sides of the railway corridor.

For passenger trains, the 103 dB night-time vibration contour (for perception) lies approximately 38 m from the nearest track centreline. The 106 dB daytime vibration contour (for perception) lies approximately 27 m from the nearest track centreline. The 110 dB criterion vibration contour lies approximately 15 m from the nearest track centreline. As discussed in **Section 7.4**, these levels are based on the 95th percentile (or highest 1 in 20 trains). The vibration levels from the average train would be approximately 8 dB lower.

On the Down (western) side of the railway corridor, Windsor Road is located between the railway corridor and the nearest residential receiver locations. These locations are unlikely to be affected by railway vibration.

On the Up (eastern) side of the railway corridor, vibration from train passbys could be perceptible at residential buildings within approximately 40 m from the nearest track, however, compliance with the vibration criterion for human comfort would be achieved at all locations, provided that a minimum setback distance of approximately 15 m or greater is maintained.

8 TRAIN STABLING NOISE

8.1 Operational Noise Goals

RailCorp's Environment Protection Licence covers operations and maintenance activities within the rail corridors, but excludes stations, depots and other fixed facilities. As such, the rail traffic noise goals included in the licence are not applicable to train stabling.

The proposed Stabling Facility would be regarded as a fixed facility, and all operational noise emissions including train movements would need to be assessed in accordance with the DEC's *Industrial Noise Policy* (INP).

The INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. In addition, the DEC normally requires the risk of sleep disturbance to be assessed. Guidance on sleep disturbance is provided in the DEC's *"Environmental Noise Control Manual (ENCM)"* and the *"Environmental Criteria for Road Traffic Noise"* (ECRTN).

Assessing Intrusiveness

In order to assess the intrusiveness of a particular noise source, the background noise needs to be measured. The intrusiveness criterion dictates that the L_{Aeq} noise level, measured over a period of 15 minutes should not be more than 5 dBA above the RBL during the daytime, evening and night-time periods.

Assessing Amenity

The amenity assessment is based on the existing noise environment and noise criteria specific to land use and associated activities. If the noise emissions from the new sources approach the criterion value, the new sources need to be designed so that the cumulative effect does not produce levels that would significantly exceed the criterion.

Project Specific Noise Levels

For a particular project or proposal, the more stringent of the intrusive or amenity criteria sets the project specific noise levels.

8.2 Summary of Background Noise Monitoring and Noise Goals

The SKM report quoted monitoring at rural residential locations, and recent monitoring by Heggies was undertaken at the fringe of the existing residential dwellings along Windsor Road.

For the Reference Scheme, the proposed stabling yard would be located on the western side of Windsor Road, north of Commercial Road and south of the Rouse Hill Regional Park. The stabling yard would be located within Area 20 (an area that is proposed for future residential development with the North West Growth Centre). It is understood that this development is largely to be completed by the time the proposed stabling facility begins operating.

Intrusive Noise Goals

As discussed in the previous section, the intrusiveness criterion dictates that the L_{Aeq} noise level, measured over a period of 15 minutes should not be more than 5 dBA above the Rating Background Level (RBL) during the daytime, evening and night-time periods.

For existing residential areas in the vicinity of the proposed stabling operations, the noise amenity area classification is "Suburban". In this area, however, there is still a significant amount of development to be undertaken prior to the proposed opening date of 2017. On this basis, it is assumed (for this preliminary assessment), that the existing RBL's may be up to 3 dBA higher on the western (undeveloped) side of Windsor Road at the time of opening.

- The SKM location 21 is considered to be representative of the more isolated semi-rural residential receivers that are currently to the west of Windsor Road. At this location, the Rating Background Level (RBL) during the daytime period was 37 dBA, during the evening period was 36 dBA and during the night-time period was 32 dBA.

  On the basis of the measured RBL's (plus a 3 dBA allowance), on the west side of the proposed stabling facility, $L_{Aeq(15\ minute)}$ noise emissions from the proposed stabling operations should not exceed 45 dBA during the daytime period, 44 dBA during the evening period and 40 dBA during the night-time period.

- At the Heggies location NWBG1, considered to be representative of residential receivers on in the suburban area to the east of Windsor Road, the Rating Background Level (RBL) during the daytime period was 42 dBA, during the evening period was 39 dBA and during the night-time period was 35 dBA. As discussed at the foot of **Table 2**, the noise logger periodically stopped during the unattended noise survey and hence the RBL's are based on only limited information and should be considered preliminary only.

  On the basis of the measured RBL's on the east side of the proposed stabling facility, $L_{Aeq(15\ minute)}$ noise emissions from the proposed stabling operations should not exceed 47 dBA during the daytime period, 44 dBA during the evening period and 40 dBA during the night-time period.

Amenity Noise Goals

For residential areas in the vicinity of the proposed stabling operations, the noise amenity area classification is "Suburban". As such, **Table 8** provides a summary of the DEC's acceptable and recommended maximum L_{Aeq} noise levels from industrial sources during the daytime, evening and night-time periods.

Table 8 DEC's Recommended L_{Aeq} Noise Levels from Industrial Noise Sources in Suburban Residential Areas

Time of Day	Recommended L_{Aeq} Noise Level (dBA)	
	Acceptable	Recommended Maximum
Day	55	60
Evening	45	50
Night	40	45

Note: Daytime hours are 7.00 am to 6.00 pm, evening hours are 6.00pm to 10.00pm, and night-time hours are 10.00pm to 7.00am.

At this locality, there are no existing sources of industrial noise. In such circumstances, the appropriate amenity noise goals are the acceptable noise levels in **Table 8**.

Sleep Disturbance

Guidance for assessing potential sleep disturbance is provided in Chapter 19 of the DEC's (previously EPA's) *"Environmental Noise Control Manual"* (ENCM). The guideline recommends a sleep disturbance noise goal based on the $L_{A1(60second)}$ noise parameter, representative of the maximum noise level. According to this guideline, $L_{A1(60second)}$ noise level measured outside a bedroom window during the night-time period should not exceed the background L_{A90} noise level by more than 15 dBA.

It is understood that DEC's current approach is to apply the background plus 15 dBA criterion as an initial screening procedure. If the $L_{A1(60second)}$ noise levels exceed the L_{A90} noise level by more than 15 dBA, more detailed analysis is required to determine the frequency and level of events, the time of day in which they occur and the prevailing background level at the time.

Project Specific Noise Goals

For the proposed stabling operations, the intrusive, amenity and sleep disturbance noise goals would apply. A summary of the operational night-time noise goals are provided in **Table 9**.

Table 9 Summary of Operational Noise Goals for Train Stabling Operations

Location	Period	Rating Background Level (dBA)	Operational Noise Goals (dBA)		
		LA90 Background	LAeq(15 min) Intrusive	LAeq(Period) Amenity	LA1(60 s) Sleep Disturbance
Residential Receivers west of Stabling Facility	Daytime	40[1]	45	55	N/A
	Evening	39[1]	44	45	N/A
	Night-time	35[1]	40	40	50
Residential Receivers east of Stabling Facility	Daytime	42	47	55	N/A
	Evening	39	44	45	N/A
	Night-time	35	40	40	50

Note 1: The RBL's at this location have been increased by 3 dBA on the basis that future background noise levels are likely increase due to the significant amount of development proposed in this area prior to opening of the proposed stabling facility in 2017.

8.3 Noise Modelling Assumptions

Stabled trains often stand for long periods with their electrical systems operating, including alternators, inverters, air compressors and possibly also air-conditioning systems. Some of these systems may need to be left on for the use of train cleaning staff.

There may also be transient sources of noise, including compressed air discharges and train horn operation (either for warning during movements within the yard or for the purposes of testing prior to trains entering service each day).

Attended noise measurements have recently been undertaken by Heggies for the Cronulla Line Upgrade and Duplication Project and Macdonaldtown Train Stabling Project. The purpose of the measurements was to survey the stabling operations and measure typical noise sources. On the basis of the attended measurements, the Sound Power Levels in **Table 10** have been used in the SoundPLAN noise model to predict the L_{Aeq} and $L_{A1(60second)}$ noise levels adjacent to the proposed stabling area.

The L_{Aeq} sound power levels in **Table 10** are representative of the equivalent steady noise level when trains are stabled powered up. The L_{A1} sound power levels are representative of the compressed air discharges and horn operation.

For the compressed air cycle on Tangara and Double Deck Suburban trains, the source of noise emission would occur at two locations for each 4-car set (Cars 1 and 4). The Tangara inverter noise would also be generated at two locations for each 4-car set (Cars 1 and 4).

During the day, air conditioning noise may occur at two locations on each Tangara car, with a typical duty cycle of less than 50% with the cars unoccupied. At night-time temperatures (ie after 10 pm), it is assumed that air conditioning units would not normally operate, other than in air circulation/ventilation mode.

Table 10 Sound Power Levels for Stabling Noise

Train Type	Noise Source	Sound Power Level	Location of Noise Source
Tangara	Full Compressed Air Cycle [1]	90 dBA – LAeq 107 dBA - LA1(60 second)	Under floor
Tangara	Inverter Noise	83 dBA – LAeq	Top of Train
Tangara	Air Conditioner	80 dBA - LAeq 50% duty <62 dBA - LAeq Ventilation only	Top of Train
Tangara	Brake Test	120 dBA - LA1(60second)	End of train, under floor
Double Deck Suburban	Full Compressed Air Cycle [1]	93 dBA – LAeq 107 dBA - LA1(60 second)	Under floor
Double Deck Suburban	Brake Test	120 dBA - LA1(60second)	End of train, under floor
Tangara and Double Deck Suburban	Horn [3]	115 to 145 dBA - LA1(60second)	End of train, under floor

a. The term "Compressed Air Cycle" refers to the air compressor plus the cyclic air discharge noise associated with the air dryers, valves, etc.

b. S Sets and R Sets. It is understood that K Set and C Set trains do not and are not proposed to use this stabling area.

c. Horn noise is dependent on how the drivers operate the horns and the level of noise may also vary depending on whether a horn test was being undertaken as a safety warning.

Brake testing and horn testing are undertaken at both ends of trains prior to trains entering service. This would typically occur in the early hours of the morning as trains start up and prior to the afternoon peak.

Layout of Proposed Stabling Facility

The proposed stabling facility passes beneath Windsor Road and runs parallel to it on the western side in a northerly direction. As part of the current proposal, provision would be made for the overnight stabling of up to eight trains on two tracks.

At the southern end of the facility, the track is located within a deep cutting, having passed beneath Windsor Road. This facilitates the control of noise emissions. At the northern end of the facility, the track is located at-grade.

8.4 Noise Modelling Scenarios

In order to assess the operational noise emissions from the proposed stabling operations, representative 'worst case' noise modelling scenarios have been considered, incorporating the existing ground terrain and proposed stabling operations. The noise model includes eight trains located at the Stabling Facility, 75% of which are assumed to be Tangara or Millennium sets.

Four operating conditions have been assessed. These include:

- The simultaneous day-time operation of the air-conditioning system, ventilation and compressor – termed "Air Conditioning System" in the contour plots;
- The simultaneous night-time operation of the ventilation and compressor – termed "Ventilation System" in the contour plots;
- The night-time operation of the brake – termed "Brake Test" in the contour plots; and
- The night-time operation of the horn – termed "Horn Test" in the contour plots.

Noise emissions during the evening period have not been modelled as a large number of trains would still be operational on the rail network. The night-time period therefore represents a worst-case scenario.

Noise contour plots for receiver heights 1.5 m above ground (representing ground floor receiver locations) are presented in **Table 11** and **Table 12.**

Table 11 Noise Contours – Operational Phase (Reference Scheme)

Contour Height	Air Conditioning System	Ventilation System	Brake Test	Horn Test
1.5 m above the ground				
No Barrier	Appendix R1	Appendix S1	Appendix T1	Appendix U1
3m Perimeter Barrier	Appendix R2	Appendix S2	Appendix T2	Appendix U2
6m Perimeter Barrier	Appendix R3	Appendix S3	Appendix T3	Appendix U3

For the daytime and night-time stabling operations, the $L_{Aeq(15minute)}$ predictions represent the typical maximum noise levels averaged over a 15-minute period. Since the intrusive noise goals are more stringent than the amenity noise goals, compliance with the $L_{Aeq(15minute)}$ intrusive noise goals would also result in compliance with the amenity noise goals.

For the brake and horn tests, the predicted $L_{A1(60second)}$ noise levels represent the typical maximum noise levels that occur during the tests. These tests are usually undertaken prior to the train entering service.

The results of the computer noise modelling are discussed in the following section.

8.5 Predicted Noise Levels

Noise contour plots for the Reference Scheme for receiver heights 1.5 m above ground (representing ground floor receiver locations) are presented in **Appendices R** to **U** for various height noise barriers.

A representative noise plot is provided in **Figure 9** for the night-time scenario (ventilation systems) with 3.0 m high noise barriers.

Figure 9 Night-time $L_{Aeq(15minute)}$ Noise Levels with 3.0 m High Barriers (Reference Scheme)

$L_{Aeq(15minute)}$ Noise Levels

For the proposed daytime and night-time stabling operations, the highest noise levels at existing residential receiver locations would occur at locations to the east of the stabling area adjacent to Windsor Road.

Without noise mitigation measures, existing residences to the east of the proposed stabling are predicted to receive noise levels up to 45 dBA during the daytime period and up to 40 dBA during the night-time period. These levels are equal to the daytime and night-time noise goals. Windsor Road is an arterial road and therefore traffic noise criteria (see DEC's ECRTN) during the daytime and night-time periods would be $L_{Aeq(15hour)}$ 60 dBA and $L_{Aeq(9hour)}$ 55 dBA respectively. The $L_{Aeq(15minute)}$ noise emissions from the night-time stabling operations would therefore be approximately 10 dBA to 15 dBA lower than the existing road traffic noise levels at the nearest residential receiver locations on the eastern side of Windsor Road.

On the western side of the stabling facility, the criteria would by exceeded (without mitigation) at a distance of approximately 100 m from the proposed stabling boundary at ground floor residential receiver locations. With a 3 m noise barrier at the top of the cutting on the western side of the stabling facility, this distance would be reduced to approximately 50 m for the night-time stabling scenario. Providing a higher noise barrier could reduce this exceedance area further.

Night-time $L_{A1(60second)}$ Noise Levels - Brake Testing

Brake and horn testing are currently undertaken as part of the testing procedure before trains are put into service. The predicted $L_{A1(60second)}$ noise levels therefore represent the short-term noise levels that would occur on one occasion at each end of the train before it enters service.

The predicted $L_{A1(60second)}$ noise levels indicate that the typical maximum noise levels from brake testing (without mitigation) exceed the DEC's Rating Background Level (RBL) + 15 dBA screening criterion for sleep disturbance at the nearest existing residential receiver locations on the eastern side of the stabling facility. The typical maximum noise levels are approximately 20 dBA higher than the screening criterion.

The DEC's RBL + 15 dBA screening criterion is considered to be unreasonable at residential receiver locations adjacent to Windsor Road, which are offset approximately 15 m from the nearest lanes.

An L_{Amax} traffic noise study was previously undertaken by Heggies as part of North West T-Way project. One of the assessment locations was adjacent to Old Windsor Road, approximately 15 m from the nearest lane. During the night-time period at this location, there was an average of 36 L_{Amax} noise events between 75 dBA and 80 dBA attributable to road traffic.

Consequently, the noise levels from brake testing (occurring once at each end of the train before entering service) would be approximately 5 dBA to 10 dBA lower than the typical L_{Amax} noise levels from road traffic on Windsor Road during night-time periods. On this basis, noise from brake testing is not considered to be a significant source of noise emission for residential receivers adjacent to Windsor Road.

On the western side of the stabling facility south of Rouse Road, a distance of approximately 200 m from the stabling boundary would be required to achieve compliance with the DEC's screening criterion. This distance would be reduced to approximately 100 m with the provision of a 3.0 m noise barrier. North of Rouse Road, the exceedance area would be larger due to the reduction in depth of the cutting in which the trains are proposed to be stabled.

$L_{A1(60second)}$ Noise Levels - Horn Noise

For the proposed stabling operations without noise mitigation, $L_{A1(60second)}$ noise emission levels due to full horn blasts are predicted to exceed the DEC's sleep disturbance screening criterion of 50 dBA at all existing receiver locations adjacent to the proposed stabling area. As discussed in the footnote of **Table 10**, horn noise is dependent on the purpose for use and can vary from a short "toot" to a louder, longer "blast". This assessment assumes that some horn events would be long enough to develop the full noise level.

In accordance with the current RailCorp train preparation procedures, the testing of horns at both ends of the train is required before a train enters service. Additionally, it is necessary to operate the horn as a warning of imminent train movement. Not all of these horn tests would occur adjacent to the same locations, however, most of these would occur during the early morning night-time period.

The predicted $L_{A1(60second)}$ noise levels from a full horn blast are up to 85 dBA at the nearest residential receiver locations to the east of the stabling facility. Whilst this represents a 35 dBA exceedance of the DEC's sleep disturbance screening criterion (without mitigation), the screening criterion is considered to be unreasonable at locations adjacent to Windsor Road, given that the typical L_{Amax} noise level from road traffic would be approximately 75 dBA to 80 dBA at the nearest residential locations. On this basis, the noise levels of the train horns (without mitigation) would be approximately 5 dBA to 10 dBA higher than the existing traffic noise on Windsor Road.

With a 3 m noise barrier located at the top of the cutting on the northern and eastern site boundaries, the $L_{A1(60second)}$ noise levels from horns can be reduced at the above locations by approximately 5 dBA and would be equivalent to the typical maximum noise levels from road traffic on Windsor Road.

On the western side of the stabling facility further from Windsor Road, the noise from train horns is likely to be more noticeable. The noise goals would be exceeded for distances greater than 200 m between the stabling boundary and residential receiver locations, even with 6.0 m high noise barriers.

RailCorp is currently investigating the feasibility of a low level horn test mode for trains. If this proves to be feasible, the predicted noise levels could be up to 30 dBA quieter than predicted for a full horn blast and hence compliance with the noise goals may be possible at future residential receiver locations on all sides of the stabling facility.

The stabling facility is proposed to be located within the future Precinct Area 20 of the North west Growth Centre. There is an opportunity in the precinct plan for the area surrounding the stabling facility to be zoned for less sensitive land uses such as light industrial or commercial.

8.6 Proposed Mitigation

Train horns represent the greatest potential source of noise impact associated with the operation of the proposed stabling facility. As discussed in the previous sections, RailCorp is currently investigating the feasibility of implementing a low volume horn test. The purpose would be to provide a functional test of the horn to verify that it is working safely, but at a much lower volume so that noise levels are reduced in the surrounding community.

On the basis of the large setback distances required to comply with the intrusive noise goals at residential receiver locations, consideration should be given to the following mitigation strategies:

Land-Use Planning

The area around the stabling yards is planned to undergo extensive redevelopment and rapid growth. Where feasible, the area surrounding the stabling yards should be used (where possible) for accommodating less acoustically sensitive buildings (ie commercial and/or industrial buildings). Industrial and commercial receivers are unlikely to be affected by noise emissions during the night-time period when the more intrusive noise impacts prevail.

The Rouse Hill Regional Park is located at the northern extent of the Reference Scheme alignment. The provision of commercial or industrial buildings on the northern boundary of the proposed stabling facility is unlikely and hence alternative mitigation options would need to be considered at this location.

Locating less sensitive buildings adjacent to the proposed stabling facility would reduce the setback distances required to comply with the intrusive noise goals at residential receiver locations. If the less sensitive buildings are sufficiently tall and oriented, these buildings can potentially shield noise emissions, blocking noise in a similar manner to noise barriers.

Noise Barriers

If it is not feasible to locate industrial and/or commercial buildings adjacent to the proposed stabling facility or residential exceedance areas are required, other forms of noise mitigation such as noise barriers or acoustic enclosures would be required.

Given that the highest noise emissions from the future stabling operations would occur beneath the carriage (air compressor, horn and air discharge noise), the construction of noise barriers proves to be a reasonably effective form of noise mitigation (except for the horn and brake testing).

8.7 Other Stabling Noise Sources

Train Movements

Train movements within the yard would occur at low speed, such that $L_{Aeq(15minute)}$ noise levels would be controlled by the train auxiliaries, rather than the wheel-rail noise. Train arrivals and departures would include intermittent noise from air brake valves, similar to that included above for brake tests.

Train Cleaning

Train cleaning would not involve external noise sources and would therefore not contribute significantly to noise emission from the site.

Train Maintenance

No regular mechanical train maintenance is planned for the proposed stabling yard. Emergency maintenance could become necessary at any point on the network, but is unlikely to be sufficiently frequent or definable for inclusion in this assessment.

9 CONSTRUCTION NOISE

9.1 Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(60second)}$ the "Typical Maximum Noise Level" for an event, used in the assessment of potential sleep disturbance during night-time periods.

$L_{A10(15\ minute)}$ the "Average Maximum Noise Level" during construction activities. This parameter is used to assess the construction noise impacts.

L_{A90} the "Background Noise Level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{A10(15\ minute)}$ construction noise goals are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

9.2 Construction Noise Goals

The DEC's "*Environmental Noise Control Manual"* provides guidelines for assessing the noise impact from construction sites. The DEC's general approach to the control of noise from construction sites involves the following:

- **Limiting hours of operation for "noisy" construction work** - The DEC normally limits construction works to the following time periods: 7.00 am to 6.00 pm from Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays and Public Holidays.
- **Use of silenced equipment** - All practical measures should be used to silence equipment, particularly in instances where extended hours of operation are required.
- **Compliance with noise emission objectives**:
  - For a construction period of up to 4 weeks duration, the L_{A10} noise level when measured over a period of not less than 15 minutes should not exceed the L_{A90} background noise level by more than 20 dBA.
  - For a construction period of between 4 and 26 weeks, the L_{A10} noise level should not exceed the L_{A90} background noise level by more than 10 dBA.
  - For a construction period of greater than 26 weeks, the L_{A10} noise level should not exceed the L_{A90} background noise level by more than 5 dBA.

As the overall duration of the proposed construction program is greater than 26 weeks, the L_{A90} background + 5 dBA noise goal is applicable to residential and other noise sensitive receiver locations (eg, schools, hospitals, nursing homes, etc.). The $L_{A10(15\ minute)}$ construction noise goal is based on the local L_{A90} background noise level during the relevant time period (day, evening or night).

For retail and commercial buildings, it is generally accepted that receivers are 5 dBA to 10 dBA less sensitive to noise emissions than residential receivers. For these receivers, an L_{A10} noise objective of L_{A90} background + 10 dBA has been conservatively applied. These criteria are only relevant in areas without nearby residential dwellings, otherwise the more stringent residential criteria would apply.

9.3 Typical Sound Pressure Levels

Sound pressure levels for typical items of plant required to carry out the works are listed in **Table 12**. These noise levels are representative of modern plant operating with noise control measures in good condition.

Whilst the 2003 SKM report does not list the sound power levels that were used as the basis for their predictions, it is understood to be reasonably similar to the Heggies recommended levels detailed in **Table 12**.

Table 12 Sound Pressure Levels for Plant Items

Item	Typical Plant Type	Noise Level at 7 m (dBA)	
		Typical Maximum Level (L_{Amax})	Noise Level for Modelling (L_{A10})
Heavy Rockbreaker	On excavator KATO 750	103	98
Excavator KATO	KATO 750	86	83
Boring Rig (Diesel)	-	85	82
Bulldozer	Caterpillar D9	88	83
Skidsteer	-	85	82
Crane	60 t crawler or truck mounted	85	80
Backhoe/FE Loader	Wheeled	86	82
Semi Trailer	25-28 tonne	87	82
Dump Truck	15 tonne	83	82
Product Truck	12-15 tonne	83	82
Vibratory Pile Driver	-	96	90
Impact Piling Rig	-	109	105
Generator	Diesel	79	78
Concrete Saw	-	95	92
Jackhammer	Hand held	88	84
Lighting Tower	Lunar Lighting Tower	55	55
Flood Lights	Daymaker	75	75
Concrete Truck	-	88	85
Concrete Pump	-	84	82
Concrete Vibrator	-	80	78
Ballast Regulator	-	96	93
Ballast Tamper	-	96	93

9.4 Construction Impacts

The analysis undertaken by SKM in Section 5 of their 2003 report generally remains consistent with the current design except for the following:

- Surface track construction between Epping and Beecroft
- Surface track construction north of NWRL Portal
- Major worksite for tunnelling (Balmoral Road)
- Tunnelling Construction
- Stabling Facility
- Council Chambers and Hills Centre
- Construction impacts on the Hillsong Church

A discussion of the change in construction noise impacts for these changes is provided below:

9.4.1 Surface Track Construction between Epping and Beecroft

Since the quadruplication of the Main North Line between Epping and the NWRL portal south of Beecroft did not form part of the 2002 Alignment, an assessment of construction noise has not previously been undertaken.

In this section of track, typical construction activities would include excavation works associated with embankment widening and cuttings, bridge construction over the M2 Motorway, construction of overhead wiring and track construction. For most receiver locations, the duration of noisy work in close proximity to individual receivers would only be a fraction of the overall project duration as the construction works would move progressively along the rail corridor.

Excavation Works

The typical $L_{A10(15minute)}$ noise levels from construction works associated with embankment widening and cuttings would be approximately 60 dBA to 70 dBA at the nearest residential receiver locations and are dependent upon the number and type of plant items operating at the same time in close proximity to individual receiver locations.

On the basis of the L_{A90} RBL's during the daytime period (see **Table 2** and **Table 3**) in the vicinity of the proposal, which vary from 39 dBA to 46 dBA during the daytime period, the predicted $L_{A10(15minute)}$ construction noise levels represent a moderately high (albeit brief) exceedance of the noise goals.

Due to the close proximity of residential receivers to the works, the construction noise objectives would be exceeded at many locations along the corridor. This is relatively common on major infrastructure projects, particularly where there is no opportunity to increase the distance between the construction works an receiver locations

In some cases, particularly when sensitive receiver locations are within close proximity to work sites, the potential exists for exceedances up to 30 dBA of the nominated construction noise goal during intensive activities such as piling works. It is recognised that such exceedances may be of concern to surrounding residents and particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies.

Track possessions would be required as part of the proposal which usually involves night-time works. A track possession is a planned shutdown of a section of the rail network, taking place generally on a weekend between 2 am Saturday to 2 am Monday.

Construction activities requiring track possessions include:

- Connections to existing track.
- Upgrading of existing crossovers.
- Excavation under new bridge spans.
- Modifications to existing overhead wiring structures and signalling.
- Utility relocation works near to or across operating tracks.
- Testing and commissioning.

All other works can take place outside possessions and would not affect train operations as long as the sites are adequately hoarded and the existing infrastructure and operations are not affected. Night-time works may be required at other locations to reduce traffic impacts on existing roads.

Bridge Construction over M2 Motorway

Two new bridges would be required over the M2 motorway. For these works, the typical $L_{A10(15minute)}$ noise levels from construction activities would be approximately 5 dBA quieter than the excavation works at the nearest residential receiver locations, but would occur over a longer period of time.

If vibratory piling or rockbreaking is required at the bridge abutments, $L_{A10(15minute)}$ noise levels would be approximately 70 dBA to 80 dBA at the nearest residential receiver locations. These works would generally be limited to daytime only, including weekend track possessions. However, it is anticipated that night-time works would be required on occasions in order to minimise traffic impacts on the M2. Where possible, bored piling would be used in lieu of vibratory piling to reduce noise emission to the surrounding community.

Overhead Wiring and Track Construction

For the overhead wiring works, the construction noise levels would be similar to excavation works phase, except that the duration of the construction works would be much shorter.

For the track construction works, the construction noise levels would be approximately 5 dBA higher than the excavation phase, except that the duration of the construction works would also be much shorter.

The fact that noise criteria exceedances have been identified does not necessarily indicate that the works should not proceed, but rather, highlights the importance of managing the works to minimise both the noise levels and duration of the predicted exceedances. Mitigation measures are discussed further in **Section 9.5**.

9.4.2 Surface Track Construction North of NWRL Portal

In the section of surface track north of the proposed NWRL bored tunnel portal, the Reference Scheme alignment follows essentially the same alignment as previously assessed by SKM (2003) and hence the previous assessment of construction noise between Burns Road and Rouse Hill remains valid.

For the 2002 Alignment, surface track was proposed between the Norwest Business Park and Burns Road Stations. The adjacent area would no longer be affected by surface construction noise as a result of the proposed alignment changes.

Between Balmoral Road and Burns Road, the proposed tracks for the Reference Scheme are located closer to existing residential receiver locations on the western side of Old Windsor Road. The consequent elevation of construction noise levels in this area would be less than 5 dBA which is not considered to represent a significant change.

9.4.3 Major Worksite for Tunnelling (Balmoral Road Release Area)

It is proposed that the major construction compound for the tunnelling be located in the parcel of land south of Balmoral Road, east of Old Windsor Road and north of the Homemaker Collection Centre in Celebration Drive. This site is located near the NWRL portal and has direct access onto Old Windsor Road. The exact size of the proposed construction site is subject to detailed design, but at this stage is anticipated to cover an area spanning approximately 550 m north to south and 350 m east to west.

Specific details of all the construction activities to be undertaken on site are not currently known, however it is anticipated that operations would be similar to the major construction compound for ECRL, located in North Ryde. The anticipated construction activities at this site include the following:

- Site establishment works
- Excavation works to construct the cut and cover tunnel between Burns Road Station and portals
- Excavation works to establish tunnel portals and launch tunnel boring machines
- Construction of spoil management facility
- On-site plant would include bulldozers, excavators, spoil trucks and water trucks
- Delivery of materials and stockpiling of materials

24 hour construction is proposed at the Balmoral Road construction site and hence it is likely that substantial noise mitigation measures would be required in order to comply with the construction noise goals.

Residential receiver locations potentially impacted by construction works include the residential areas on the western side of Old Windsor Road, located approximately 100 m from the worksite boundary and 300 m from the proposed tunnel portals. Residential receiver locations in Brighton Drive and Craigend Place would also be potentially impacted by construction works, being located approximately 100 m to 150 m from the tunnel portals. Specific information about the timing and location of proposed residential development within the Balmoral Road Release Area is currently unknown and would need to be considered as part of any further assessment.

As part of the ambient noise surveys, background noise levels were measured at three locations in the vicinity of the construction compound (Heggies location NWBG2 and SKM locations 14 and 15). At these locations, the Rating Background Levels (RBL's) were between 34 dBA and 37 dBA during the night-time period.

Detailed construction scenarios have not been developed for the proposed construction activities, however it is considered likely that the following noise mitigation measures would be required in order to achieve acceptable noise levels in the adjacent communities during night-time periods:

- The site offices and amenity buildings should be located in positions that would shield noise emissions to nearby receiver locations.
- At the southern end of the construction compound, near Brighton Drive and Craigend Place, it is anticipated that an earth mound (made from tunnel spoil), approximately 5 m or more high may be required to shield noise emissions to the south and south east of the construction compound.

- Where possible, the site layout should be designed to maximise the offset distance between the noisiest plant items and nearby residential receiver locations.
- Where possible, noise from bulldozers should be shielded by noise barriers or other structures and grades minimised to prevent excessive revving of engines.
- All plant on site would need to be fitted with non-tonal reversing alarms, sized appropriately to avoid excessive noise.
- The design of any tunnel spoil conveyor should incorporate noise control measures on the drive components.
- The tunnel ventilation system and dust collection systems would require silencers and possibly an enclosure or building to reduce noise emissions, particularly at night-time.

On the basis of previous experience with the noise emissions generated at the major construction compound for ECRL, it is anticipated that construction noise can be minimised to avoid excessive noise emissions during night-time periods. The main noise sources are likely to comprise haul trucks, excavators, conveyors, dump truck movements and other diesel operated plant.

A detailed assessment of the proposed construction activities would be undertaken as part of any further design. This would include investigation of the potential need for a building to be erected around the portal to reduce noise from vehicles and spoil removal at night-time. Truck traffic noise assessments on nearby roads would also need to be addressed and impacts would be managed through controls on timing or entry and egress of vehicles - and the provision of adequate on-site holding points and stockpile areas to facilitate these control measures.

9.4.4 Tunnelling Construction

As discussed in **Section 6**, there are two locations where the proposed horizontal alignment of the tunnels has been modified compared with the 2002 Alignment. These are:

- Between Beecroft and West Pennant Hills, where the proposed alignment has been shifted towards the south.
- To the west of the proposed Hills Centre Station.

Review of Groundborne Noise during Construction

The SKM report (2003) nominated that the predicted upper limits of groundborne noise from tunnel boring machines are expected to be below 40 dBA beyond a nominal 40 m offset distance (see Figure 5-3 in **Appendix V**).

On the basis of the proposed vertical alignment (summarised in **Figure 7**) the tunnel depth would be less than 40 m for approximately 70% to 80% of the proposed route. At any particular receiver location, the actual distance between the tunnel and the receiver would be based on the slant distance, which is a function of both the tunnel depth and also the horizontal offset distance from the tunnel centreline.

24-hour construction would be required within the proposed bored tunnels in order to deliver the project in a timely manner. Groundborne noise levels are predicted to exceed the anticipated night-time noise goal of 40 dBA when TBM's are operating in close proximity to nearby residential receiver locations. Depending on the tunnel depth and rate of progression (which is dependent on ground conditions), noise emissions from the TBM's would increase to a maximum over a period of typically 1 week and then subside until past the site. In the shallowest sections, where the tunnel depth is approximately 25 m, groundborne noise levels could be up to 50 dBA (however this would only occur over an approximate period of 2 to 3 days).

Residential receivers would need to be kept informed about the progress of the TBM's in relation to their property and the likely noise levels that can be expected.

9.4.5 Stabling Facility

Compared with the 2002 Alignment, the location of the stabling yard has been relocated such that it is now around 80 m from the existing residences along Windsor Road. This is significantly closer than the 700 m offset distance previously assessed by SKM. It is expected that the daytime construction criteria would be in the order of 47 dBA, (based on the L_{A90} for NWBG1 in **Table 2**).

Given the 'typical' construction plan for the site, it is anticipated that construction noise levels of 65 dBA are anticipated at the nearest existing residential receiver locations and 70 dBA during track installation. This represents a noticeable exceedance of the design goals and consideration of mitigation and management measures would need to be made as a Construction Plan is progressively refined.

It is understood that the proposed development within Area 20 is largely to be completed by the time the proposed stabling facility begins operating. Construction noise levels are likely to be exceeded at the nearest residential receiver locations. Where feasible and reasonable, consideration of mitigation and management measures would need to be made as a Construction Plan is progressively refined.

9.4.6 Council Chambers and Hills Centre

The SKM report predicted marginal impacts of up to 4 dBA above the groundborne construction noise objectives from the in-tunnel construction works. The revised tunnel alignment for the Reference Scheme brings it marginally closer to these buildings, potentially increasing the resulting impacts. The extent of the additional increase however is considered marginal (ie nominally 1 dBA to 2 dBA), and could be minimised through the appropriate planning of construction works and to avoid coincidence with critically sensitive events held at the centre (if required).

9.4.7 Construction Impacts on the Hillsong Church

The SKM report predicted the potential for appreciable impacts from the construction of the tunnel, station and at-grade tracks on the current and proposed future buildings on this site.

The revised track layout results in a significant alignment change at this location, such that the proposed alignment now runs under Norwest Boulevard, rather than dissecting the Hillsong Church property. As a result, the level of groundborne noise during construction would be significantly lower.

On the basis that the Church would be located approximately 100 from the proposed alignment and the *TV, film or drama studio* would be located approximately 200 m from the proposed alignment, it is considered unlikely that airborne or groundborne noise during construction would cause any significant impact on these facilities.

9.4.8 Noise from Construction Traffic on Local Roads

On the local roads immediately adjacent to the proposal, the community may associate truck movements with the construction works. Once the trucks move onto collector and arterial roads the truck noise is likely to be perceived as part of the general road traffic.

Preliminary access routes to the proposed construction sites are detailed in the *North West Rail Link Traffic, Transport, Parking and Access* report (GHD - August 2006). Where possible, construction traffic would utilise major roads such as Old Windsor Road, Windsor Road or the M2 Motorway. Construction vehicles however, may need to travel short distances on local roads to access some worksites.

At the major spoil management site, located within the Balmoral Road Release Area, it is anticipated that trucks would access Old Windsor Road directly without the need to access local roads. At this site, the typical number of truck movements is estimated to be up to 134 per hour (during daytime periods only) during intense spoil removal operations. Preliminary calculations show that the truck noise levels in the busiest anticipated periods would result in traffic $L_{Aeq(1hour)}$ noise level increases of less than 2 dBA on Old Windsor Road.

At other worksites, the typical number of truck movements is estimated to be up to nine per hour during the most intensive earthworks stage. Preliminary calculations show that the truck noise levels in the busiest anticipated periods would result in traffic $L_{Aeq(1hour)}$ noise level increases of less than 2 dBA. Whilst individual truck noise events would be clearly perceptible, the L_{Aeq} assessment indicates that there would be too few movements to have a major impact on the acoustic amenity of residential areas.

Consideration of proposal-related traffic noise from specific worksites would require further consideration as the construction site plans are refined. Where feasible, access to the proposed construction sites should be via major roads.

Noise from idling trucks near construction sites can also impact on amenity in some instances. For this reason, it is recommended that any queuing of trucks awaiting entry to the site outside normal construction hours should be restricted to locations away from residences and that if trucks are required to queue in such locations during construction hours, engines should be shut down.

9.4.9 Corridor Earthworks and Track Works - General

The typical offset distances between the construction works and the nearest receivers to the north of Norwest Boulevard may be significantly closer than predicted in the SKM report, due to the continuing urbanisation along the route. In some cases the offset may be in the range of 20 m to 60 m.

Noise emissions from the proposed track works, including earthworks, overhead wiring, signalling and tracklaying would progressively move along the railway corridor in stages, such that most residential receivers would not be exposed to high levels of construction noise emissions for periods longer than approximately one month at a time. Depending on the locations of access points, construction traffic may continue to pass individual receivers for a longer duration.

The SKM report presents the long-term construction noise levels along the at-grade section of track, noting that short-term impacts may be 10 dBA to 15 dBA higher than for the long-term construction noise.

The daytime construction noise objectives are based on the “background +5 dBA” design goals. These noise levels are appropriate for long term activities and are well within the range of other normal ambient noise. Although some track construction activities would have only a short duration at any given location, the long term criteria have been applied for assessment, in recognition of the overall duration of the proposal (despite the fact that at some residences along the route, the apparent construction works in their immediate vicinity would be much shorter than the total duration of the proposal).

For short periods of time, moderate exceedances of the noise goals are to be expected at the closest receivers.

The fact that noise criteria exceedances have been identified does not necessarily indicate that the works should not proceed, but rather, highlights the importance of managing the works to minimise both the noise levels and duration of exposure. Mitigation measures are discussed further in **Section 9.5**.

9.5 Noise Mitigation

In view of the predicted noise criteria exceedances, noise mitigation would be required to minimise the impact of bridge, station and track construction noise at nearby residential receivers. The following measures are recommended for consideration as part of the further design and assessment:

- The contractor(s) will prepare and implement site-specific Construction Noise and Vibration Management Plans including the measures listed below and any other initiatives identified to minimise the noise impact.
- Noise intensive construction works will be carried out during normal construction hours. Where works involving the operating line need to be carried out during weekend possessions, noise intensive activities should be scheduled to occur during the daytime, where possible.
- Quietest available plant suitable for the relevant tasks will be used and (at critical locations and times) they will be operated in a manner that reduces their noise emission to the minimum practical level consistent with conducting the work in a reasonably effective manner.
- The duration of noise intensive activities will be minimised insofar as possible. It should be noted that in some cases it may be preferable to employ a larger, slightly noisier machine or operation, if the overall outcome is a reduction in the duration of the noise exposure.
- Where feasible and reasonable, site hoardings or temporary noise barriers will be used to provide acoustic shielding of noise intensive activities. In order to be reasonably effective, these must at least break the line of sight between the receiver and the source of noise emission.
- Rock breakers will be of the “Vibro-silenced” or “City” type, where possible.
- Activities resulting in highly impulsive or tonal noise emission (eg rock breaking and vibratory or impact piling) will be limited to 8 am to 12 pm Monday to Saturday and 2 pm to 5 pm Monday to Friday (except where essential during track possessions).
- Noise awareness training will be included in inductions for site staff and contractors.
- Noise generating plant with a directional noise emission pattern will be orientated away from sensitive receivers, where possible.
- Notification will be provided to residents via newspaper advertising and letterbox drops, advising of the nature and timing of works, contact number and complaint procedures.
- Noise monitoring will be carried out to confirm that noise levels do not significantly exceed the predictions and that noise levels of individual plant items do not significantly exceed the levels shown in **Table 12** - and to provide feedback to plant operators where there is an opportunity to moderate their activities and reduce noise emission levels.
- Deliveries will be carried out within standard construction hours, except as directed by the Police or RTA.
- Non-tonal reversing beepers or equivalent must be fitted and used on all construction vehicles and mobile plant regularly used on site and other vehicles where possible.
- Trucking routes to be via major roads, where possible.
- Trucks will not be permitted to queue near residential dwellings with engines running.

Construction activities requiring track possessions include works on or in very close proximity to the existing track, modifications to existing overhead wiring structures and signalling and installation of new bridge spans.

Where possible, noise intensive construction works during the weekend possessions will be undertaken during the daytime periods, with noise emissions during the night-time period being kept to a minimum, except where activities are critical to meeting programme and restoring rail services.

10 CONSTRUCTION VIBRATION

10.1 Operational Vibration Metrics

The three primary metrics used to describe construction vibration are:

PPV "Peak Particle Velocity" evaluated at the building footings and used to assess the risk of damage to structures.

V_{rms} "Root mean squared vibration velocity", a vibration parameter used to assess human response to continuous or intermittent vibration.

eVDV "Estimated Vibration Dose Value", the overall vibration exposure assessed over the daytime or night-time period to assess human response to intermittent vibration.

10.2 Construction Vibration Goals

The standards normally used as a basis for assessing the risk of vibration damage to structures are German Standard DIN 4150 Part 3 1999 and British Standard BS 7385 Part 2 1993.

For continuous vibration or repetitive vibration with potential to cause fatigue effects, DIN 4150 provides the following PPV values as safe limits, below which even superficial cosmetic damage is not to be expected:

- 10 mm/s for commercial buildings and buildings of similar design.
- 5 mm/s for dwellings and buildings of similar design.
- 2.5 mm/s for buildings of great intrinsic value (eg heritage listed buildings).

For short term vibration events (ie those unlikely to cause resonance or fatigue), DIN 4150 offers the criteria shown in **Table 13**. These are maximum levels measured in any direction at the foundation or in the horizontal axes, in the plane of the uppermost floor.

Table 13 DIN 4150 - Structural Damage - Safe Limits for Short Term Building Vibration

Group	Type of Structure	Peak Particle Velocity (mm/s)			
		At Foundation At a Frequency of		Plane of Floor of Uppermost Storey	
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

These levels are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Human comfort is normally assessed with reference to British Standard BS 6472 1992 or Australian Standard AS 2670.2 1990. For daytime activities, the limiting objective for continuous vibration at residential or commercial receivers is V_{rms} 0.4 mm/s. BS 6472 1992 also contains a formula for the Vibration Dose Value (VDV), which can be used to evaluate intermittent vibration or vibration levels that vary significantly over time. As the vibration approaches continuous, this VDV trends to the continuous vibration criterion.

As noted in **Section 7.3**, the NSW Department of Environment and Conservation document *Assessing vibration: a technical guideline* is based on guidelines contained in BS 6472–1992, and the acceptable values for continuous and intermittent vibration are the same.

10.3 Ground Vibration - Safe Working Distances for Intensive Activities

As a guide, safe working distances for typical items of vibration intensive plant are listed in **Table 14**. Safe working distances are quoted for both "cosmetic" damage (refer DIN 4150) and human comfort (refer BS 6472).

Table 14 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (DIN 4150)	Human Response (BS 6472)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

The safe working distances given in **Table 14** are indicative and would vary depending on the particular item of plant and local geotechnical conditions etc. **Table 14** indicates that exceedances of the structural damage criteria (DIN 4150) may occur if a 13 tonne (or larger) roller or a heavy hydraulic hammer is operated within 20 m to 25 m of a residential building. Therefore, monitoring at the commencement of vibratory compaction or hydraulic hammering within 30 m of residential buildings would confirm compliance or non-compliance. In the event that non-compliance occurs, immediate corrective action should be taken.

The safe working distances apply to typical buildings and typical geotechnical conditions. They do not address heritage structures. Vibration monitoring is recommended to confirm the safe working distances at specific sites.

10.4 Assessment of Construction Vibration Impact

It is reasonable to assume that the construction activities would be managed such as to avoid structural damage due to vibration. In order to achieve this objective, the recommended safe working distances in Column 3 of **Table 14** should be observed. If it is necessary to work within these zones, vibration monitoring should be undertaken.

The potential impact would thus be primarily in relation to human response.

Measured data on recent projects has been used to obtain indicative vibration levels for medium size vibratory rollers (ie 12 to 14 tonnes). PPV values of 2 mm/s to 4 mm/s on the ground surface at 10 m were typical. This would correspond to maximum V_{rms} floor vibration values of approximately 1 mm/s to 2 mm/s at a receiver at this distance.

This vibration would be clearly perceptible but would not be expected to cause damage to buildings.

It is recommended that any roller be selected to minimise vibration, insofar as possible (without compromising the ability to complete the required task) and that monitoring be carried out on commencement of vibratory rolling to determine an acceptable duration consistent with BS 6472.

Ground vibration levels for vibratory sheet piling are typically less than 2 mm/s at 10 m and are likely to comply with the human comfort criteria at distances exceeding 20 m from a piling rig. Vibration levels vary considerably with ground conditions, and vibratory piles are sometimes used at closer distances without significant vibration impact.

If impact piling is required, the vibration impacts would be assessed on a case by case basis.

11 SUMMARY OF MITIGATION MEASURES AND STATEMENT OF COMMITMENTS/FURTHER RECOMMENDATIONS

The following is a summary the outcomes of the preliminary modelling. Where appropriate, this includes recommended mitigation measures; where such details will be determined at a later stage in the assessment process, a statement of commitment is provided.

Operational Noise (refer Sections 5.9 to 5.11)

- Operational noise impacts will be assessed in more detail as part of the further design development.
- Undertake to work with the relevant authorities regarding land use decisions.
- Undertake to work with local government to set acoustic standards in the consent conditions for new residential buildings.
- Provide acoustic mitigation measures (noise barriers/mounds) to meet, where reasonable and feasible, the design goals (in situations where the above land use planning and consent condition measures do not provide adequate protection).
- Low level parapets be used (where feasible and reasonable) on bridges and viaducts to minimise noise.
- Station PA systems (if required) to be designed to avoid excessive noise.

Groundborne Noise (refer Section 6)

- Groundborne noise impacts for the revised alignment and track design will be assessed in more detail as part of the further design development..

Operational Vibration (refer Section 7.5)

- No mitigation measures are required at this stage.
- Operational vibration impacts will be reassessed at a later stage of the design process if proposed buildings are located within the vibration buffer zones descried in this report.

Stabling Noise (refer Section 8.5)

- Physical noise mitigation measures (noise barriers) are recommended in conjunction with land use planning (where possible) to reduce the potential noise impacts upon future residential communities on the western and northern sides of the proposed stabling facility. Consideration may need to be given to fully or partially enclosing the facility in order to reduce the potential noise impacts in the adjacent community.
- RailCorp is currently investigating the feasibility of implementing a low volume horn test. Any new developments in addressing horn noise will be investigated at a later stage in the design process.

Construction Noise (refer Sections 9.4 and 9.5)

- The contractor(s) will prepare and implement a site-specific Construction Noise and Vibration Management Plan including the measures listed below and any other initiatives identified to minimise the noise impact.
- Noise intensive construction works will be carried out during normal construction hours. Where works involving the operating line need to be carried out during weekend possessions, noise intensive activities should be scheduled to occur during the daytime, where possible.
- Quietest available plant suitable for the relevant tasks will be used.

- The duration of noise intensive activities will be minimised insofar as possible.
- Where feasible and reasonable, site hoardings or temporary noise barriers will be used to provide acoustic shielding of noise intensive activities. In order to be effective, these must at least break the line of sight between the receiver and the source of noise emission.
- At major worksites, such as the proposed stations, bridge locations, tunnelling construction compound and stabling facility, it is anticipated that the requirements for noise mitigation will be greater on the basis of the longer duration of the proposed construction works.
- It is not anticipated that impact pile driving will be required. In the event that it is found to be necessary, further assessment would be required.
- Rock breakers will be of the "Vibro-silenced" or "City" type, where feasible and reasonable.
- Activities resulting in highly impulsive or tonal noise emission (eg rock breaking and vibratory or impact pile driving) will be limited to 8 am to 12 pm Monday to Saturday and 2 pm to 5 pm Monday to Friday (except where essential during track possessions).
- Noise awareness training will be included in inductions for site staff and contractors.
- Noise generating plant will be orientated away from sensitive receivers, where possible.
- Notification will be provided to residents via newspaper advertising and letterbox drops, advising of the nature and timing of works, contact number and complaint procedures.
- Noise monitoring will be carried out to confirm that noise levels do not significantly exceed the predictions and that noise levels of individual plant items do not significantly exceed the levels shown in **Table 12**.
- Deliveries will be carried out within standard construction hours, except as directed by the Police or RTA.
- Non-tonal reversing beepers or equivalent must be fitted and used on all construction vehicles and mobile plant regularly used on site and other vehicles where possible.
- Trucking routes to be via major roads, where possible.
- Trucks will not be permitted to queue near residential dwellings with engines running.

At the major worksite for tunnelling (Balmoral Road Release Area), 24-hour construction would be required in order to complete the works in a timely fashion. Specific additional measures likely to be required at these sites are detailed in **Section 9.4.3**.

Construction Vibration (refer Sections 10.3 and 10.4)

- Buffer zones will be established and work within these zones limited to activities that have been assessed as safe or to activities undertaken in conjunction with strict vibration monitoring.
- The smallest suitable size of vibratory roller will be selected when working close to occupy and heritage buildings to minimise vibration impact.

12 CONCLUSIONS

This report assesses the potential impacts of noise and vibration emissions during construction and operation, and discusses potential noise and vibration mitigation measures, where appropriate. It has been prepared to meet the Department of Planning Director General's Requirements for the EA.

The proposal consists of a quadruplication of the Main North Line between Epping and Beecroft, the construction of two underground tunnels between Beecroft and Balmoral Road, Kellyville and the construction of surface track between Balmoral Road and Rouse Hill. The proposal also incorporates an upgraded station at Cheltenham, four new underground stations at Franklin Road, Castle Hill, The Hills centre and Norwest Business Park, two new surface stations at Burns Road and Rouse Hill and a stabling facility north west of the planned Rouse Hill town centre.

TIDC will be seeking a Concept Approval to construct and operate the proposed NWRL. Consequently, at this early stage in the noise and vibration assessment process, it is appropriate to undertake preliminary, rather than detailed modelling.

The design goals presented in this report should be regarded as indicative only, and may change during the assessment process. The adopted design goals for preliminary assessment of operational airborne noise are the DEC's "Maximum Levels" (for existing track) and the DEC's "Planning Levels" (for new track), and are similar to those applied on recent rail infrastructure projects.

The section of existing track between Epping and Beecroft would be upgraded to provide two additional tracks as a part of the proposal. In this section of existing track, the current noise levels already exceed the DEC's "Maximum Levels". The preliminary operational noise modelling indicated that without mitigation measures such as noise barriers or bund walls, there is the potential for a significant number of exceedances of the DEC's "Maximum Levels". For electric passenger trains, most of these exceedances can be minimised through the use of noise barriers. However, compliance with the DEC's "Maximum Levels" would be more difficult to achieve with noise barriers for diesel locomotives due the increased source height of the noise emissions.

For the new sections of proposed track, compliance with the DEC's "Planning Levels" could be achieved at most locations via the construction of noise barriers/mounds. In new land release areas, it may be possible to minimise impacts on residential areas by providing minimum setback distances between the railway corridor and residential development, or locating less sensitive land uses closest to the railway corridor. Potential mitigation measures for operations, such as source controls and the location and height of noise barriers or bund walls would be undertaken as part of further design development.

It is recommended that TIDC continue to work with the relevant authorities regarding land use decisions, and work with local government to set acoustic standards in the consent conditions for new residential buildings.

A number of changes to the tunnelling section have been proposed as part of the Reference Scheme alignment. It is anticipated that compliance with the groundborne noise design goals would be achieved through feasible and reasonable mitigation measures. These would be determined at a later stage in the assessment process.

The preliminary operational vibration modelling results indicate that none of the existing dwellings lie inside the 110 dB human comfort criterion contour. Vibration levels may be perceptible at some of the existing and proposed residential locations (within approximately 40 m of the nearest track), however the levels would be well below the 110 dB criterion relating to human comfort.

For the proposed train stabling facility, without noise mitigation, the continuous noise emissions would comply with the design goals at existing residential receiver locations on the eastern side of Windsor Road. On the northern and western sides of the stabling facility, the construction of noise barriers/mounds would reduce the number of exceedances. In Area 20, which is part of the North West Growth Centre, residential development is planned prior to opening of the NWRL. It may be possible to minimise impacts on residential areas by providing minimum setback distances between the proposed stabling facility and residential development, or locating less sensitive land uses closest to the facility. Industrial and commercial receivers are also unlikely to be affected by noise emissions during the night-time period when intrusive noise impacts are greatest.

Without noise mitigation, the $L_{A1(60second)}$ noise levels from horn testing during night-time periods would exceed the DEC's background + 5 dBA sleep disturbance screening criterion by clear margins. RailCorp is currently investigating the feasibility of implementing a low volume horn test. The purpose of the low volume test would be to provide a functional test of the horn to verify that it is working safely, but at a much lower volume so that noise levels are reduced in the surrounding community. Any new developments in addressing horn noise will be investigated at a later stage in the design process.

At the majority of construction sites, the construction noise modelling identifies exceedances of the noise goals when plant and equipment are located in close proximity to residential receiver locations. Exceedances result primarily from the small offset distances involved between construction plant and the nearest receivers.

It is recognised that such exceedances may be concerning for surrounding residents and particular effort would be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies. For new track sections, construction works would be limited to daytime hours only (unless essential for traffic management or safety reasons) in order to reduce any potential impacts as much as possible.

24 hour construction would be required at the proposed major tunnelling construction site (located within the Balmoral Road Release Area). It is considered likely that substantial noise mitigation measures would be required at the proposed construction site in order to minimise the number of potentially affected receivers. Specific mitigation measures are discussed in **Section 9.4.3**.

The fact that noise criteria exceedances have been identified does not necessarily indicate that the works should not proceed, but rather, highlights the importance of managing the works to minimise both the noise levels and duration of the predicted exceedances.

Vibration monitoring and buffer zones are proposed in order to minimise disruptions to the local community and prevent damage to nearby buildings during vibration-generating construction activities (such as rockbreaking and vibratory rolling).

13 REFERENCES

This assessment has utilised the following references:

Noise and Vibration Guidelines and Standards

- Australian Standard AS 2670.2:1990 *Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*.
- British Standard BS 6472:1992, *Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)*.
- British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration*.
- German Standard DIN 4150-3:1999 *Structural Vibration Part 3: Effects of vibration in structures*.
- New South Wales State Government, Department of Environment and Conservation (2006), *Assessing Vibration : a technical guideline*.
- New South Wales State Government, Environment Protection Authority (2000), *New South Wales Industrial Noise Policy*.
- New South Wales State Government, Environment Protection Authority (1999), *Environmental Criteria for Road Traffic Noise*.
- New South Wales State Government, Environment Protection Authority (1985), *Environmental Noise Control Manual*.

Design Inputs

- Sinclair Knight Merz (SKM) (March 2003), *Proposed North West Rail Link - Volume One - Assessment of Environmental Issues Report*
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- New South Wales State Government, Department of Environment and Conservation, *Environment Protection Licence 12208 (Rail Corporation New South Wales)*.
- RailCorp (2006), *Metropolitan Rail Expansion Program – Operating and Stabling Strategy*.
- RailCorp, *Sydney Metropolitan Area Rail Network Maps*.
- Rail Infrastructure Corporation and State Rail Authority (November 2003*), Interim Guideline for Councils – Consideration of Rail Noise and Vibration in the Planning Process*.
- The United States Department of Transportation (1995), *Transit Noise and Vibration Impact Assessment*.
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