REPORT 10-5050-R3

Revision 1

Quakers Hill to Vineyard Duplication
Noise and Vibration Assessment
Construction and Operations

PREPARED FOR

Transport Infrastructure Development Corporation
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Quakers Hill to Vineyard Duplication

Noise and Vibration Assessment

Construction and Operations

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EXECUTIVE SUMMARY

The following report provides an assessment of the potential noise and vibration impacts associated with the construction and operational phases of the Quakers Hill to Vineyard Duplication Project.

The Quakers Hill to Vineyard Duplication Project is one of a number of projects, which together, comprise the Rail Clearways Program, part of RailCorp's overall response to issues of operational reliability and passenger growth on the Sydney metropolitan rail network.

The existing rail line between Quakers Hill and Vineyard is predominantly a single-track line with a short dual track section located at Riverstone Station. The line provides direct suburban services to and from the city. The existing rail line to the south of Quakers Hill is dual track. The proposed duplication will involve the construction of approximately 10 km of new track between Quakers Hill and Vineyard. The project will include the construction of new stations at Schofields and Vineyard, and the upgrading of Riverstone Station.

The Quakers Hill to Vineyard Duplication is currently scheduled to be constructed in two stages. The construction of Stage 1, between Quakers Hill and the new Schofields Station, is scheduled to commence in 2009 and take approximately 24 months to complete. Works associated with Stage 2 of the project will complete the duplication of the line between the new Schofields Station and Vineyard and would similarly take approximately 24 months to complete. The timing of Stage 2 is yet to be determined, however works are unlikely to commence prior to the commissioning of Stage 1.

Operational Noise Modelling

The operational noise impacts from the Quakers Hill to Vineyard Duplication Project have been assessed in accordance with the *"Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects"* (DECC - April 2007) (IGANRIP). Three noise modelling scenarios have been considered. These include the existing rail operations (Year 2007), the project commissioning scenario (Year 2013) and the future scenario ten years after the commissioning of the Quakers Hill to Vineyard Duplication (Year 2023).

For a rail upgrade project, the IGANRIP provides trigger levels relating to the overall noise levels (L_{Amax} and L_{Aeq}), as well as the increase in noise levels as a result of the project. In order to initiate an assessment of rail noise impacts and to investigate mitigation measures, both the increase in rail noise levels as a result of the project and the overall level of rail noise must exceed the respective trigger levels. No further assessment is required at locations where neither trigger levels are exceeded.

The future (Year 2023) noise levels are predicted to exceed the trigger levels at residential receiver locations at Manorhouse Boulevard (Quakers Hill), Bridge Street and Tain Place (Schofields). The predicted exceedances at Manorhouse Boulevard result from the proposed increase in train numbers. The predicted exceedances at the Bridge Street location result from the proposed increase in train numbers and the increased train speeds facilitated by the relocation of Schofields Station. The noise trigger levels are also exceeded at the Quakers Hill Pre-School as a result of the proposed increase in train numbers.

The potential mitigation options considered in this report include rail dampers, low profile noise barriers, conventional corridor noise barriers and architectural treatments. At this stage in the assessment process, the preferred mitigation option is the use of at source controls such as rail dampers on the Up and Down tracks adjacent to the affected residences, with the consideration of architectural treatments at residual receiver locations.

The selection of final noise mitigation measures requires further assessment to consider other factors including technical feasibility, community views, overshadowing (due to noise barriers), aesthetic impacts and the wider community benefits of the proposal. The proposed mitigation measures are indicative only and may be subject to change as more detailed project information becomes available and following consultation with affected stakeholders.

Operational Vibration

On the basis of measurements undertaken as part of the assessment, future vibration levels are predicted to comply with the dose-based vibration trigger levels at all locations.

Bus Interchanges and Commuter Car Parking

Schofields and Vineyard Train Stations are to be relocated and upgraded as part of the Quakers Hill to Vineyard Duplication Project. The upgrade of each station will include a new bus interchange and commuter car parking facilities.

As such, it is necessary to provide an assessment of the potential noise and vibration impacts that may result from the operation of the new bus interchanges and the commuter car parks.

It is recommended that ongoing consultation with the Growth Centres Commission (GCC) and other relevant stakeholders continues in order to reduce the potential noise related impacts through careful land use planning and operational measures. Land use planning measures may include options such as ensuring that commercial and industrial occupancies face onto the main operational zone of each precinct. Operational measures may include the careful selection of bus routes and the implementation of "quiet" buses into the area.

Construction Noise and Vibration

Construction noise modelling has been undertaken for fourteen different scenarios across a total of ten major work areas covering activities that are planned to occur during the construction programme.

At the majority of locations, the predicted L_{A10} construction noise levels will at times exceed the applicable noise goals when plant and equipment is located in close proximity to residential and commercial receiver locations. This results from the small offset distances, rather than from particularly noisy construction plant.

The highest construction noise impacts are predicted to occur adjacent to residential locations where rockbreakers or piling works may be required. It is anticipated that the rockbreakers and piling rigs would be used for relatively short periods of time, therefore resulting in lower construction noise levels for the majority of the works.

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 in order to minimise both the noise levels and the duration of the predicted exceedances. The identification of feasible and reasonable mitigation measures will be implemented in accordance with TIDC's *Construction Noise Strategy (Rail Projects)*.

Construction vibration levels are predicted to be acceptable in relation to building damage, but may be perceptible during activities such as vibratory rolling. Vibration monitoring should be undertaken in order to establish appropriate buffer distances when work is being conducted in close proximity to buildings, including the heritage-listed railway buildings.

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1 INTRODUCTION

1.1 Scope

Heggies Pty Ltd (Heggies) has been engaged by the Transport Infrastructure Development Corporation (TIDC) to undertake a noise and vibration assessment for the construction and operational phases of the Quakers Hill to Vineyard Duplication Project.

The Quakers Hill to Vineyard Duplication Project is one of a number of projects, which together, comprise the Rail Clearways Program, part of RailCorp's overall response to issues of operational reliability and passenger growth on the Sydney metropolitan network.

The primary objective of the project is to increase the capacity and reliability of the Richmond Line. The proposal involves the duplication of the existing single-line track between Quakers Hill and Vineyard. The existing stations at Schofields and Vineyard are to be relocated, whilst Riverstone station would be upgraded and refurbished.

The project area extends from Quakers Hill Station to approximately 250 m north of the Bandon Road level crossing (north of Vineyard Station).

1.2 Objective

The project will be delivered in two stages (Quakers Hill to new Schofields and then new Schofields to Vineyard). This report provides an assessment of the potential noise and vibration impacts that may result from the operation of the complete project (ie Quakers Hill to Vineyard).

The report has been structured with a description of the project and existing environment, followed by an assessment of the operational noise and vibration and an assessment of construction noise and vibration.

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 PROJECT DESCRIPTION

The Rail Clearways program has been developed to untangle the current complex Sydney rail network and provide a more frequent reliable train service. The Quakers Hill to Vineyard Duplication is currently scheduled to be constructed in two stages. Stage 1 between Quakers Hill and the new Schofields Station, is scheduled to commence in 2009 and take approximately 24 months to complete. Works associated with Stage 2 of the project will complete the duplication of the line between the new Schofields Station and Vineyard and would similarly take approximately 24 months to complete. The timing of Stage 2 is yet to be determined, however works are unlikely to commence prior to the commissioning of Stage 1.

The existing line between Quakers Hill and Vineyard is a predominantly single-track line. The existing line to the south of Quakers Hill Station is dual track and there is also an existing section of duplicated track at Riverstone Station that functions as a passing loop for the single line running operations. The line provides direct suburban services to and from the city.

A number of options were described and studied as part of the options development process for this project, these are:

- Option 1 – Up Side Duplication (East of existing line)
- Option 2 – Down Side Duplication (West of existing line)
- Option 3 – A combination of Up and Down Side Duplication with a nominal 4 m track separation
- Option 4 – A combination of Up and Down Side Duplication with a nominal 6.4 m track separation

The options development process concluded that Option 4 incorporating Up and Down Side Duplication with a nominal 6.4 m track separation was the preferred option from an engineering and environmental perspective. The potential noise and vibration impacts that may result from the construction and operation of the Option 4 track alignment has been assessed in this report and compared to the alternative Option 3 where relevant.

A summary of the proposed scope of work is provided below:

- Approximately 10.1 km of new track between Quakers Hill and Vineyard

  Note: The new track would be predominantly located on the western side of the existing track between Quakers Hill and New Schofields Station, before continuing north on the eastern side (ie opposite side) of the existing track between New Schofields and Riverstone Stations. North of Riverstone Station, the location of the new track would switch again to be located on the western side of the existing track to Vineyard.

  The separation distance between the existing and new tracks is proposed to be 6.4 m between Quakers Hill and New Schofields, and between Riverstone and New Vineyard Stations. The track separation distance for the middle portion between New Schofields and Riverstone Stations is proposed to be 4 m.
- Embankment and cutting widening, retaining walls, cutting stabilisation, drainage, combined services route, maintenance access tracks, landscaping and noise abatement measures
- Track slewing and new track for the new Schofields and Vineyard Stations
- Track for the refurbished siding at Riverstone
- Track, crossovers and turnouts at Vineyard to connect into the new turnback at Vineyard
- Track for the new turnback at Vineyard
- One new sliding buffer stop at the end of the new turnback at Vineyard

- New overhead wiring to suit new track and connections to existing track
- New signalling to suit the new and existing tracks
- Modification of the existing signalling system to suit the new track
- Bridge/culvert works including:
  - New drainage culverts along the route
  - Replacement and/or modifications to a number of other existing drainage culverts along the route
- New Schofields Station works including a new level access island platform, booking office, station staff amenities and public toilet; footbridge, 3 lifts, stairs to the street and the platform; communications, security, bus interchange and car-parking, and associated infrastructure works
- Riverstone Station works including widening of the existing Down platform and converting both the Up and Down platforms to level access; footbridge, 2 lifts, ramps and stairs to the street and platforms; communications, security, and associated infrastructure works
- New Vineyard Station works including a new level access island platform and a new level access side platform, booking office, station staff amenities and public toilet; footbridge, 3 lifts, stairs to the street and platforms; crew facilities, communications, security, bus interchange and car-parking, and associated infrastructure works
- New Quakers Hill footbridge and ramps to the street to replace the existing pedestrian level crossing.
- New footbridge and ramps to the street at existing Schofields Station to replace the existing pedestrian level crossing.
- Replacement of the existing Schofields traction substation and upgrading of the existing Vineyard traction substation.
- Utilities adjustments and protection.
- Relocation of existing signalling infrastructure, including signalling supplies and signal huts.
- 33 kV overhead and underground relocation of feeders and equipment.
- New regulated 11 kV supply for signalling and station supplies from Quakers Hill to Vineyard.
- 11 kV backup supply from Integral Energy at new Schofields, Riverstone and Vineyard Stations, and also at Quakers Hill and existing Schofields footbridges.
- New low voltage supplies/equipment throughout the project.
- Removal of the existing Schofields and Vineyard Stations platforms and buildings
- Removal of existing pedestrian level crossings at Quakers Hill, Schofields and Riverstone Stations.
- Refurbishment of the existing maintenance siding track at Riverstone.

The key objectives of the project are to:

- Increase the service capacity of the Richmond Line.
- Separate the Up and Down services on the Richmond Line to provide additional recovery time during delays.
- Improve on-time running and service reliability.
- Allow for turnback operations at Vineyard Station.

The proposed alignment (Stage 1 and Stage 2) is illustrated on the site plan in **Appendix B**.

3 BUILDING OCCUPANCY SURVEY INFORMATION

In order to assess the potential noise and vibration impacts, it is necessary to identify all potentially affected receivers in the vicinity of the project.

Of particular interest for the noise and vibration modelling are the following parameters:

- The building occupancy (residential, commercial, industrial, education, hospital, worship, etc).
- The number of floors in each building.
- The number of residential occupancies for each building.
- The floor height of the first occupied level of the building.
- The address of the building.

The above information was obtained by visiting the site and noting the relevant parameters for each building located within a distance of approximately 100 m from the railway corridor. This information was then collated in spreadsheet form prior to use as an input for the computer noise modelling.

A site plan indicating the location of each surveyed building is provided in **Appendix B**. The spreadsheet results are provided in the table in **Appendix C**.

The above survey was undertaken for buildings located on both sides of the railway corridor between Montrose Street and St James Road on the Up (eastern) side of the railway corridor and between Chisholm Street and St James Road on the Down (western) side of the railway corridor.

4 EXISTING ACOUSTIC ENVIRONMENT

4.1 Existing Acoustic Environment

Land use adjacent to the railway line varies throughout the project area. The land adjacent to the Up side of the corridor is predominantly residential and rural. There is an industrial area located between Hobart Street and Victoria Street.

The land adjacent to the Down side of the corridor is predominantly residential and rural. There is an industrial area located between King Street and Wellington Street. There are commercial buildings located near to Quakers Hill, Schofields and Riverstone stations. **Table 1** presents a summary of the land use breakdown within the project area.

Table 1 Land Use Adjacent to the Railway Corridor

Up Side		Land Use	Down Side		Land Use
From	To		From	To	
Montrose Street	Seldon Street	Residential	Chisholm Street	Quakers Hill Parkway	Residential
Seldon Street	Advance Street	Rural	Quakers Hill Parkway	Schofields Road	Rural
Advance Street	Kensington Street	Residential	Schofields Road	Grange Avenue	Residential
Kensington Street	Riverstone Road	Rural	Grange Avenue	Hunter Street	Rural
Riverstone Road	Castlereagh Street	Residential	Hunter Street	Garfield Road	Residential
Castlereagh Street	Market Street	Commercial	Garfield Road	King Street	Rural
Market Street	Hobart Street	Residential	King Street	Wellington Street	Industrial
Hobart Street	Victoria Street	Industrial	Wellington Street	St James Road	Rural
Victoria Street	St James Road	Rural			

There are also a number of roads running parallel to and/or intersecting with the railway corridor. The noise emissions from these roads contribute to increased ambient noise levels at nearby residential and other sensitive receiver locations.

4.2 Ambient Noise Survey

Unattended Noise Monitoring Locations

Unattended noise monitoring locations were selected near the proposed construction sites and adjacent to the existing operational rail line. The locations are also shown on the site plans in **Appendix B**. A list and brief description of the measurement locations is presented in **Table 2**.

Table 2 Unattended Noise Monitoring Locations

Measurement Location	Side of Corridor	Distance to Track (m)	Track Alignment	Additional Notes
BG1 – Kerry Jones Child Care Centre, Quakers Hill	Up	27	At Grade	Noise logger positioned 30 m from the child care centre boundary.
BG2 – 63 Manorhouse Boulevard, Quakers Hill	Up	41	At Grade	Noise logger positioned in the front yard 6 m from the nearest façade.
BG3 – Free Field adjacent Reycroft Avenue, Quakers Hill	Up	13	At Grade	Noise logger positioned in a free field adjacent to the residences on Reycroft Avenue.
BG4 – 155 Bridge Street, Schofields	Down	116	Embankment	Noise logger positioned in the front yard 6.5 m from the nearest façade.

Measurement Location	Side of Corridor	Distance to Track (m)	Track Alignment	Additional Notes
BG5 – 128A Railway Terrace, Schofields	Up	67	Embankment	Noise logger positioned 40 m to the north of the nearest façade.
BG6 – 51 Hunter Street, Riverstone	Up	89	At Grade	Noise logger positioned 1.5 m from the nearest façade.
BG7 – 3 Richards Avenue, Riverstone	Down	35	At Grade	Noise logger positioned 2 m from nearest façade.
BG8 – Corner Otago Street and Riverstone Parade	Up	40	At Grade	Noise logger positioned 15 m from Riverstone Parade.
BG9 – Corner Dulwich Road and Riverstone Parade	Up	62	At Grade	Noise logger positioned 35 m from Riverstone Parade.

Methodology

The existing noise environment varies along the length of the proposed Quakers Hill to Vineyard Duplication, as would be expected from the range of rural, suburban, commercial and industrial land uses within the project area and from the proximity of each location to roads and to the rail corridor.

Ambient noise surveys have been undertaken at a total of nine representative locations. The objective of the baseline noise monitoring was to establish existing background noise levels as a basis for assessing noise emissions for the construction phase of the project.

Noise logging was undertaken using ARL noise loggers, types 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.

Weather details for the period of noise logging were obtained from the Bureau of Meteorology. The wind speed and direction, temperature and rainfall information was sourced from the weather station located at Horsley Park.

Unattended 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.

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 Climate Change (DECC'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.

A summary of the processed noise levels is presented in **Table 3**.

The summary results in **Table 3** 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 noise emissions.

The full set of results for the Unattended Noise Monitoring is presented graphically in **Appendix D**. The weather records obtained from the Bureau of Meteorology for the monitoring period are overlaid on the daily noise plots.

Table 3 Summary of Ambient Noise Levels at Unattended Noise Monitoring Locations

Monitoring Location	Daytime Noise Level[1] (dBA)		Evening Noise Level[1] (dBA)		Night-time Noise Level[1] (dBA)	
	RBL	**L_{Aeq}**	**RBL**	**L_{Aeq}**	**RBL**	**L_{Aeq}**
BG1	45	55	45	53	37	49
BG2	33	55	36	52	32	43
BG3	34	59	37	58	33	55
BG4	36	54	36	50	33	43
BG5	44	58	40	56	38	55
BG6	37	54	40	61	39	51
BG7	41	53	37	50	31	47
BG8	38	61	34	58	30	54
BG9	40	60	34	56	30	54

Note 1 DECC'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 remaining periods.

4.3 Attended Noise Measurements

Attended Measurement Locations

Attended noise measurements were undertaken adjacent to the existing railway corridor at a total of nine locations in order to establish the existing noise levels from train operations at representative receiver locations. The measurement results at Locations N1 to N9 have also been used to validate the computer noise modelling for the existing and future rail operations.

Each measurement set (except for Location N8) included 20 train passby events, with typically 10 trains travelling in either direction on the existing single track.

Table 4 presents a description of the attended noise measurement locations. These locations are also shown on the site plan in **Appendix B**.

Table 4 Attended Noise Measurement Locations

Measurement Location	Side of Corridor	Distance to Near Track (m)	Façade Reflected	Mic Height (m) [1] / Mic Height relative to T.O.R. (m) [2]	Track Alignment
N1 – Adjacent to 27 Manorhouse Boulelvard, Quakers Hill	Up	17	No	1.2 / + 0.5	At Grade
N2 – 27 Reycroft Avenue, Quakers Hill	Up	13	No	1.2 / + 1	At Grade
N3 – Corner Pelican Road and Railway Terrace, Schofields	Up	11	No	1.2 / + 0.5	At Grade
N4 – 44 Bridge Street, Schofields	Down	16	No	1.2 / + 3.5	Cutting
N5 – 128 A Railway Terrace, Riverstone	Up	43	No	1.2 / + -2	Embankment
N6 – 36 Railway Terrace, Riverstone	Up	35	No	1.2 / + 1	At Grade
N7 – 4 Sydney Street, Riverstone	Up	35	No	1.2 / + 0	Slight Embankment
N8 – 153 Bridge Street, Schofields	Down	24	No	1.2 / + 1.2	Slight Embankment
N9 – Clyde Street, Vineyard	Up	30	No	1.2 / + 1.5	In Shallow Cutting

Note 1 The microphone height relative to ground level at the measurement location.
Note 2 The microphone height relative to top of rail (T.O.R).

Measurement Methodology

At each of the locations in **Table 4**, attended noise measurements were undertaken using a Brüel & Kjær Type 2260 precision sound level meter. The measurements were A-weighted, fast response L_{Amax} and L_{AE} (sound exposure level). The height of the microphone above local ground level is indicated in **Table 4**.

One-third octave L_{Amax} measurements were also obtained for each train passby event. These L_{Amax} values are the maximum levels occurring in each 1/3 octave band during the train passby. Individual bands are therefore not necessarily time coincident.

The L_{AE} measurements were commenced as the train noise rose significantly above the background level and were terminated as the train noise approached the background level. In the event that noise from passing vehicles or other sources significantly affected the measurement results, the measurement was discarded.

During the attended measurements, an observer noted the direction of each train passby event, as well as the number of carriages, train type and train speed. Calibration of the sound level meter was carried out before and after each series of measurements. In all cases, the calibration drift was less than the acceptable limit of 0.5 dBA.

Attended Noise Measurement Results

A summary of the overall L_{Amax}, L_{AE} and L_{Aeq} noise levels for each location is presented in **Table 5**. The L_{max} 1/3 octave band noise spectra for all train passby measurements are presented in **Appendix E**.

"L_{Amax}" refers to the maximum noise level registered during the train passby with the sound level meter set to fast response. "L_{AE}" refers to the sound exposure level, which is a measurement integrated over time, reflecting both the noise level and the duration of the event. L_{AE} values may be summed logarithmically and used to calculate the L_{Aeq} noise exposure for each assessment period (eg $L_{Aeq(24hour)}$, $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and $L_{Aeq(1hour)}$).

Table 5 Summary of Attended Noise Measurements (Electric Passenger Trains)

Measurement Location	Number of Trains	Average Speed (km/h)	Average L_{AE} Noise Level (dBA)	Calculated L_{Aeq} Noise Level (dBA)[1]				L_{Amax} Noise Level (dBA)	
				24hr L_{Aeq}	15hr Day	9hr Night	1hr Peak[2]	Average Maximum	95th Percentile Maximum
N1 – Adjacent to 27 Manorhouse Boulevard, Quakers Hill	20	82	89	59	60	56	60	83	85
N2 – Adjacent to 27 Reycroft Avenue, Quakers Hill	20	90	89	59	60	56	60	83	86
N3 – Corner Pelican Road and Railway Terrace, Schofields	20	80	91	60	61	58	61	85	88
N4 – 44 Bridge Street, Schofields	20	66	77	46	47	44	47	70	72
N5 – 128 A Railway Terrace, Riverstone	20	66	84	53	54	51	54	77	79
N6 – 36 Railway Terrace, Riverstone	20	57	81	50	51	48	51	73	82
N7 – 4 Sydney Street, Riverstone	20	60	83	52	53	50	54	76	79
N8 – 153 Bridge Street, Schofields	17	66	78	48	49	45	49	71	74
N9 – Clyde Street, Vineyard	20	75	78	47	48	44	49	72	77

Note 1 The calculated L_{Aeq} noise levels are based on the measured L_{AE} noise levels and the number of train passby events in each assessment period (based on the current CityRail timetable - dated 28 May 2006).

Note 2 The busiest 1 hour period occurs between 7 am and 8 am for the future scenarios. The existing timetable does not have a peak period.

4.4 Attended Vibration Measurements

Measurement Locations

Attended vibration measurements were undertaken adjacent to the existing railway corridor at five locations in order to establish the present vibration levels from train operations at representative receiver locations.

At each location, measurements were undertaken at two distances approximately five metres apart in order to determine the change in vibration levels with increasing distance from the track.

Each measurement set (except for Location V4) included 20 train passby events, with typically 10 trains travelling in each direction on the single track. The measurements were made on both sides of the railway corridor at locations considered to be representative of the nearest and potentially most affected residential receiver locations.

At location V2, a vibration transducer was mounted on an internal floor, with a second transducer positioned externally closer to the railway line. The purpose of these measurements was to determine how the source vibration levels (in the ground) transfer into the building structure at this location.

Table 6 presents a description of the attended vibration measurement locations. These locations are also shown on the site plan in **Appendix B**.

Table 6 Attended Vibration Measurement Locations

Measurement Location	Side of Corridor	Accelerometer	Distance to Track (m)	Track Alignment	Additional Notes
V1 - Adjacent to 27 Manorhouse Boulevard, Quakers Hill	Up	Channel 1	12	At Grade	Ch1 located 2.2 m back from the rail corridor boundary.
		Channel 2	17		
V2 – 63 Manorhouse Boulevard, Quakers Hill	Up	Channel 1	11	At Grade	Ch1 located on the rail corridor boundary.
		Channel 2	18		Ch2 located on a floor within the residence.
V3 - Adjacent to 27 Reycroft Avenue, Quakers Hill	Up	Channel 1	14	At Grade	Ch1 located 5 m back from the rail corridor boundary.
		Channel 2	19		
V4 – 153 Bridge Street, Schofields	Down	Channel 1	14	Slight Embankment	Ch 1 located 3.5 m from the rail boundary.
		Channel 2	19		
V5 – 44 Bridge Street, Schofields	Down	Channel 1	10	In Cutting	Ch1 located on the rail corridor boundary.
		Channel 2	15		

Measurement Methodology

The attended measurements were undertaken using a combination of accelerometer (Brüel & Kjær Type 4370) and geophone (Geospace 20dx) vibration transducers. The vibration levels during train passby events were stored on a Sony PC208Ax Digital Recorder.

An OROS OR25 Spectrum Analyser was used to analyse the recorded train vibration levels. The Spectrum Analyser performed a 1/3 octave band frequency analysis on the signals from the vibration transducer, and stored the maximum vibration levels (in each 1/3 octave band) during each train passby event. The RMS averaging time of the measurements was 1 second.

The analyser was set to run as each train approached and was stopped when the vibration levels approached the background levels. During the attended measurements, an observer noted the direction of each train passby event, as well as the number of carriages, train type and train speed.

Measurement Results

A summary of the measured vibration levels at locations V1 to V5 are presented in **Table 7**. The overall maximum-hold vibration spectra are presented in **Appendix F** for each train passby measurement.

Table 7 Summary of Attended Vibration Measurement Results

Measurement Location	Number of Trains	Average Speed (km/h)	Distance to Track (m)	Vibration Level[1] (mm/s)	
				Average Maximum	95th Percentile Maximum
V1 - Adjacent to 27 Manorhouse Boulevard, Quakers Hill	20	82	12 (Ch 1)	0.22	0.50
			17 (Ch 2)	0.14	0.30
V2 – 63 Manorhouse Boulevard, Quakers Hill	20	83	11 (Ch 1)	0.20	0.36
			18 (Ch 2)	0.05	0.08
V3 - Adjacent to 27 Reycroft Avenue, Quakers Hill	20	90	14 (Ch 1)	0.09	0.11
			19 (Ch 2)	0.08	0.10
V4 – 153 Bridge Street, Schofields	17	66	14 (Ch 1)	0.08	0.10
			19 (Ch 2)	0.04	0.05
V5 – 44 Bridge Street, Riverstone	20	66	10 (Ch 1)	0.09	0.13
			15 (Ch 2)	0.06	0.09

Note 1 Vibration levels are the maximum 1-second RMS vibration levels measured for individual train events.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Assessment Process

Guidance in relation to the operational assessment process for the project is provided in the Department of Environment and Climate Change's (DECC's) *"Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects". April 2007* (IGANRIP). The main purpose of the guideline is to assist the ongoing expansion of rail transport by ensuring that potential noise impacts associated with rail developments are assessed in a consistent and transparent manner. The guidelines are not mandatory but are intended to encourage the best outcomes for the community as a whole, given the application of feasible and reasonable means to control noise and vibration generated by rail traffic.

For new and upgraded railway lines, the assessment process is set out in **Figure 1**.

Figure 1 Assessment Process (based on Figure 2 in IGANRIP)

Pre Environmental Assessment Stage (Completed)

Consult with the community and relevant agencies to determine the environmental noise and vibration values to be protected.

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Environmental Assessment (Exact Purpose of this Report)

1. Determine the noise and vibration trigger levels (refer **Sections 5.4)**

2. Undertake a noise and vibration assessment to determine locations where the noise and vibration trigger levels are likely to be exceeded as a result of the project (refer **Sections 5.8**).

3. At locations exceeding the noise and vibration trigger levels, undertake a cost-benefit analysis of feasible and reasonable mitigation measures and prioritise these to maximise the protection of the environment. This includes noise, vibration, community views and aesthetic impacts (refer **Section 6.2**).

4. Incorporate the proposed mitigation measures and identify the noise and vibration levels achievable for the project (refer **Section 6.3**).

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Public Exhibition and Submissions Report Stage

1. Consult with the affected community to review the noise and vibration levels achievable for the project (exhibition stage of the Environmental Assessment).

2. Review the proposed mitigation measures following community consultation and produce a report (eg submissions report) documenting the proposed mitigation measures and achievable noise and vibration levels for the project.

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Planning Approval Stage

Achievable noise and vibration levels and/or mitigation measures for the project are included in the approval conditions.

Pre-Environmental Assessment Stage

The pre-environmental assessment stage includes a community information session to inform and consult with local residents and other stakeholders about the Quakers Hill to Vineyard Duplication project and the associated assessment process, and obtain feedback on the environmental values that need to be protected.

Environmental Assessment Stage

This report forms part of the Environmental Assessment and describes in detail the noise and vibration assessment process. This includes:

- Determining the noise and vibration "trigger levels" at sensitive receiver locations in accordance with the relevant guidelines.
- Identifying sensitive receiver locations where the project-related noise and vibration "trigger levels" are likely to be exceeded.
- At locations where the noise and vibration trigger levels are likely to be exceeded as a result of the project, the guideline requires further assessment to be undertaken to identify the feasible and reasonable mitigation measures and achievable noise and vibration levels for the project.

Section 3.1 of the IGANRIP provides the following guidance in relation to determining feasible and reasonable mitigation measures:

- *Feasibility* relates to engineering considerations and what can practically be built or modified, given the opportunities and constraints of a particular site.
- *Reasonableness* relates to a judgement which takes into account the following factors:
    - Noise-mitigation benefits - noise reduction provided, number of people protected.
    - Cost of mitigation - total cost and cost variation with level of benefit provided.
    - Community views.
    - Aesthetic impacts.
    - Track maintenance and access requirements.
    - Noise levels for affected land uses - existing and future levels, expected changes in noise levels.
    - Benefits arising from the development or its modification.

In this report, the reasonableness assessment primarily addresses the first two points (ie the noise mitigation benefits and the cost of mitigation). Other factors including community views or vistas, visual impacts (including noise barriers), aesthetic impacts and the wider community benefits of the project have also been considered and discussed. The community vistas noted above include those of train travellers as well as those of the wider community. Any noise mitigation used along the rail corridor therefore has to consider any adverse impact on commuters' views.

Public Exhibition and Submissions Report Stage

During the public exhibition of the EA, the community and other stakeholders are invited to provide formal feedback on the EA (via written submissions), including the indicative noise and vibration mitigation measures.

Following a review of the submissions received, the proponent is required to produce a Submissions Report responding to all of the issues raised in submissions received during the public exhibition period. This report will provide a summary of any changes to the proposed mitigation measures and the achievable noise and vibration levels (after considering the input from the community, other stakeholders and feasible/reasonable measures).

Planning Approval Stage

During the planning approval stage, the achievable noise and vibration levels and/or the proposed mitigation measures (as documented in the Submissions Report) will be included in the approval of the project. The achievable noise levels refer to the future predicted noise levels (incorporating the proposed feasible and reasonable mitigation measures).

A statement of commitments will also be included as part of the EA. If approved, the Minister for Planning may apply additional conditions of approval for the project.

5.2 Operational Noise Metrics

The 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.
$L_{Aeq(24\ hour)}$	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.
$L_{Aeq(15\ hour)}$	the Daytime "Equivalent Continuous Noise Level". The $L_{Aeq(15hour)}$ represents the cumulative effects of all the train noise events occurring in the daytime period from 7.00 am to 10.00 pm.
$L_{Aeq(9\ hour)}$	the Night-time "Equivalent Continuous Noise Level". The $L_{Aeq(9hour)}$ represents the cumulative effects of all the train noise events occurring in the night-time period from 10.00 pm to 7.00 am.
$L_{Aeq(1\ hour)}$	the busiest 1-hour "Equivalent Continuous Noise Level" The $L_{Aeq(1hour)}$ represents the typical L_{Aeq} noise level from all the train noise events during the busiest 1-hour of the assessment period.
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} 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 Noise Modelling Scenarios

In order to assess the operational noise emissions for the Quakers Hill to Vineyard Duplication Project, three noise modelling scenarios have been considered:

- **Scenario 1** - Existing Situation (Year 2007). This model incorporates the existing ground terrain, buildings, passenger rail traffic and tracks. This scenario was used in order to determine the existing noise levels and to perform a validation of the computer noise model.
- **Scenario 2** - After Opening Situation (Year 2013). This model incorporates the future ground terrain following the construction of the rail duplication and passenger train movements on the new track.
- **Scenario 3** - Long-term Situation (Year 2023). This model incorporates the proposed future rail traffic on the new tracks at an indicative period into the future to represent the expected typical level of train usage.

As detailed earlier, the project is proposed to be constructed in two stages. Stage 1 between Quakers Hill and the new Schofields Station, is scheduled to commence in 2009 and take approximately 24 months to complete. Works associated with Stage 2 of the project will complete the duplication of the line between the new Schofields Station and Vineyard and would similarly take approximately 24 months to complete.

Whilst the timing of Stage 2 has yet to be determined, for the purposes of the assessment the opening situation (Scenario 2) assumes that both Stages 1 and 2 would be commissioned by 2013. This represents a conservative estimate of the likely earliest time at which the second stage would be constructed and commissioned.

5.4 Operational Noise Trigger Levels

The IGANRIP provides “noise trigger” levels that flag the need for an assessment of the potential noise and vibration impacts from a project to be conducted. The IGANRIP also suggests feasible and reasonable mitigation measures which may be applied in order to reduce a project’s impacts.

For airborne noise created by the operation of surface track, trigger levels are provided for rail infrastructure projects including a “new railway line” or a “redevelopment on an existing railway line”.

The corresponding noise trigger levels for residential and other noise sensitive receiver locations are provided in **Table 8** and **Table 9**.

In assessing noise levels at residential receiver locations, the outdoor noise level to be addressed is that prevailing at a location 1 m in front of the most affected building facade.

Table 8 Airborne Noise Trigger Levels for Surface Track - Residential

Type of Development	Residential noise trigger levels (dBA)		
	Day (7 am to 10 pm)	**Night (10 pm to 7 am)**	**Commentary**
New rail line development	Development increases the existing rail noise levels AND Resulting rail noise levels exceed:		These numbers represent the levels of noise that trigger the need for a rail infrastructure project to conduct an assessment of the potential noise impacts.
	60 $L_{Aeq(15hour)}$ 80 L_{Amax}	55 $L_{Aeq(9hour)}$ 80 L_{Amax}	
Redevelopment of existing rail line	Development increases the existing rail noise levels AND Resulting rail noise levels exceed:		An increase in existing rail noise levels is taken to be an increase of 2.0 dB or more in the L_{Aeq} in any hour or an increase of 3.0 dB or more in the L_{Amax}.
	65 $L_{Aeq(15hour)}$ 85 L_{Amax}	60 $L_{Aeq(9hour)}$ 85 L_{Amax}	

Table 9 Airborne Noise Trigger Levels for Surface Track - Other Sensitive Land Uses

Sensitive Land Use	Noise trigger levels (dBA)	
	New rail line development	**Redevelopment of existing rail line**
	Development increases the existing rail noise levels by 2.0 dBA or more of the L_{Aeq} in any hour AND Resulting rail noise levels exceed:	
Schools, educational institutions – internal	40 $L_{Aeq(1hour)}$	45 $L_{Aeq(1hour)}$
Places of worship - internal	40 $L_{Aeq(1hour)}$	45 $L_{Aeq(1hour)}$

Sensitive Land Use	Noise trigger levels (dBA)	
	New rail line development	**Redevelopment of existing rail line**
Hospitals – internal	35 $L_{Aeq(1hour)}$	35 $L_{Aeq(1hour)}$
Hospitals – external	60 $L_{Aeq(1hour)}$	60 $L_{Aeq(1hour)}$
Passive recreation	L_{Aeq} as per residential noise level values in **Table 8** (does not include the maximum noise level component)	
Active recreation (eg, golf course)	65 $L_{Aeq(24hour)}$	65 $L_{Aeq(24hour)}$

Non-residential receiver locations within the subject project area include several educational institutions located adjacent to the railway corridor. The approximate chainage of the educational receivers considered in this assessment are summarised in **Table 10**.

For these locations, the noise trigger levels are based on the $L_{Aeq(1hour)}$ internal noise levels. Any "internal noise level" refers to the noise level at the centre of the habitable room that is most exposed to the noise source and apply with windows sufficiently open to provide adequate ventilation (notionally an open area equal to 5% of the floor area of the room).

Table 10 Location of Educational Receivers

Side of Corridor	Chainage	Distance to Track	Name
Up	40.25 km	35 m	Quakers Hill Pre-school
Up	40.27 km	55 m	Quakers Hill Child Care Centre
Down	40.50 km	240 m	Wyndham and Terra Sancta Colleges
Up	46.10 km	273 m	Riverstone Child Care Centre
Up	49.42 km	126 m	Early Learning Centre, Vineyard

Table 11 shows the average and maximum number of trains per hour during the 15-hour daytime period. On the basis of this information, it can be seen that the $L_{Aeq(1hour)}$ noise levels are 1 dBA to 2 dBA higher than the $L_{Aeq(15hour)}$ daytime noise levels.

Table 11 Difference Between $L_{Aeq(1hour)}$ and $L_{Aeq(15hour)}$ Noise Levels

Modelling Scenario	Average Number of Trains per hour during 15-hour daytime	Maximum Trains per hour during 15-hour daytime	Difference in $L_{Aeq(1hour)}$ and $L_{Aeq(15hour)}$
Year 2007	4	5	1 dBA
Year 2013	5	8	2 dBA
Year 2023	10	16	2 dBA

These corrections are used to determine the $L_{Aeq(1hour)}$ noise levels for the relevant "Other Noise Sensitive Receiver" locations. The corrections for each modelling scenario are discussed in the following paragraphs.

The $L_{Aeq(1hour)}$ noise levels during the busiest 1-hour daytime period would be approximately 1 dBA higher than the $L_{Aeq(15hour)}$ daytime noise level for the Year 2007 Scenario on the basis that the maximum number of train movements in any hour is 5 compared to an average of 4 movements per hour during the daytime period.

The train movements for the Future Year 2013 Scenario indicate that during the morning and afternoon peak, the total number of hourly train movements is expected to be 8 compared to an average of 5 movements per hour during the daytime period. The train movements for the Future Year 2023 Scenario indicate that during the morning and afternoon peak, the total number of hourly train movements is expected to be 16 compared to an average of 10 movements per hour during the daytime period.

This represents an increase of 2 dBA above the $L_{Aeq(15hour)}$ daytime noise level for both the Year 2013 and Year 2023 Scenarios. In other words, the $L_{Aeq(1hour)}$ noise levels during the busiest 1-hour daytime period would be approximately 2 dBA higher than the $L_{Aeq(15hour)}$ daytime noise level.

The trigger levels in **Table 9** refer to an internal $L_{Aeq(1hour)}$ noise level of 45 dBA for schools. With windows open along the noise exposed facade to allow for natural ventilation, this would correspond to an external $L_{Aeq(1hour)}$ noise level at the building façade of approximately 55 dBA. The trigger level may be considered somewhat conservative, since the morning and afternoon peak will typically occur outside normal teaching hours.

Active recreational areas such as golf courses, swimming clubs and sports fields are assessed against an external $L_{Aeq(24hour)}$ noise trigger level of 65 dBA.

External playground areas for educational receivers should be considered to have the same trigger levels as residential receivers, ie $L_{Aeq(15hour)}$ 65 dBA.

Noise Trigger Levels and Assessment Parameters

In order to undertake an assessment of the future rail operations, **Table 8** provides noise trigger levels for both the daytime and night-time assessment periods. In terms of the L_{Amax} assessment parameter, the noise trigger levels at residential receiver locations are the same during the daytime and night-time periods, whereas the L_{Aeq} noise trigger levels are 5 dBA lower (ie more stringent) during the night-time period.

Table 13 provides a summary of the total train movements during the daytime and night-time periods. If it is assumed that the average number of rail cars (ie train length) is similar during the daytime and night-time periods, and that all other operating patterns are similar (eg train speeds, percentage of non-stopping trains, etc), then the daytime $L_{Aeq(15hour)}$ noise levels would be approximately 4 dBA higher than the night-time $L_{Aeq(9hour)}$ noise levels for both Scenario 1 (Year 2007) and Scenario 2 (Year 2013). The daytime $L_{Aeq(15hour)}$ noise levels would be approximately 6 dBA higher than the night-time $L_{Aeq(9hour)}$ noise levels for Scenario 3 (Year 2023).

The above calculation results indicate that the daytime $L_{Aeq(15hour)}$ noise trigger levels will be (approximately 1 dBA) more difficult to achieve than the night-time $L_{Aeq(9hour)}$ noise trigger levels for the future scenario (Year 2023). Hence, for the Year 2023 noise modelling scenario, noise calculations have been performed only for the more stringent daytime period. Compliance with the daytime noise trigger levels will ensure therefore that compliance with the night-time noise trigger levels is also achieved.

The increase in L_{Aeq} noise levels as a result of the proposal are made on the basis of the existing (Year 2007) versus future (Year 2023) scenarios.

Compliance with the trigger levels (daytime and night-time) would be tested upon commissioning (in Year 2013) and ten years after commissioning (in Year 2023) as part of the operational noise compliance monitoring program required under the IGANRIP.

The L_{Amax} noise levels from individual train passbys would be the same during the daytime and night-time periods, assuming similar train speeds.

The “redevelopment of an existing rail line” trigger levels are applicable where residential or other sensitive receivers are subject to existing rail noise at or above the “new rail line” noise trigger levels in **Table 8**. For this project, the “redevelopment of an existing rail line” trigger levels are considered appropriate.

In order to initiate an assessment of rail noise impacts and investigate mitigation measures, both the increase in rail noise levels as a result of the project **AND** the overall level of rail noise must exceed the trigger levels. No further assessment is required at locations where neither trigger levels are exceeded.

5.5 Operational Noise Sources for Noise Modelling

5.5.1 Noise Modelling

SoundPLAN Version 6.5 has been used to calculate railway noise emission levels for this project. Of the train noise prediction models available within SoundPLAN, the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) has been selected, since it is capable of calculating both the L_{Amax} and the L_{Aeq} noise levels.

5.5.2 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 with “smooth” rails and wheels, noise would occur as a result of the elastic deformation at the rolling contact point and due to the finite residual roughness 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 in noise level compared with the wheel-rail interaction, unless the train is travelling at very low speed or is stationary.

Impacts from rail discontinuities such as turnouts and mechanical joints or uneven welded joints also have an effect on the level of wheel-rail noise emission, as impulsive noise is emitted as each wheel of the train impacts the discontinuity. Radiation from some types of rail bridges (especially open-transom, steel bridges) may also increase the overall levels of noise emission.

In areas where there are tight radius curves, flanging noise or curve squeal may also increase the levels 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 (ie CityRail trains, etc). The reference noise levels used for the noise modelling (see **Table 12**) were based on the attended noise measurements undertaken adjacent to the railway corridor between Quakers Hill and Vineyard (see **Table 5**) and were consistent with other measurements undertaken by Heggies on recent projects.

Table 12 Reference Noise Levels used for Modelling

Train Types	Reference Conditions	L_{Amax}	L_{AE}
Millennium/Tangara	15 m, 80 km/h	85 dBA	88 dBA
Double Deck Suburban	15 m, 80 km/h	87 dBA	91 dBA

The modelling includes allowances for local increases in noise emission as follows:

- Turnouts +6 dBA over 10 m.
- A façade reflection of 2.5 dBA for receivers located adjacent to buildings.

5.5.3 Noise from Bridges/Culverts

When trains operate on elevated structures, including bridges or culverts, vibration of the rails is also transmitted into the supporting structure, resulting in noise radiation from the bridge. Depending on the design of the structure, wayside noise levels may exceed the typical noise levels adjacent to at-grade track by as much as 10 dBA.

Noise emissions from elevated structures are dependent on the mass and 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 provided by the parapets.

No new underbridges are proposed to be constructed as part of the subject project. The computer noise modelling in this assessment assumes that all new culverts would be of ballasted concrete construction designed to incorporate reasonable measures to mitigate noise.

5.6 Noise Modelling Inputs

Ground Terrain

Ground terrain data for the current modelling was provided by TIDC for the Clearways Projects. The ground terrain data (X, Y, Z coordinates) were provided in the form of 1 m and 2 m contours in DXF format.

Track Alignment Strings and Ground Terrain within Railway Corridor

Track alignment strings and ground terrain data within the railway corridor were also provided by TIDC. This information was provided in the form of 3-dimensional AutoCAD drawings of the existing and future alignment options.

Rail Traffic Data

Train speeds and track features (eg turnouts) were derived from site observations, the posted line speeds, information provided by TIDC and aerial photography. The speed profiles for the existing and future scenarios used for noise modelling purposes are provided in **Figure 2**, **Figure 3**, **Figure 4** and **Figure 5**. The average, 95^{th} percentile and maximum speeds indicated on these figures were those measured at discrete locations adjacent to the existing alignment.

Figure 2 Speed Profile (Up Track) – Existing Scenario

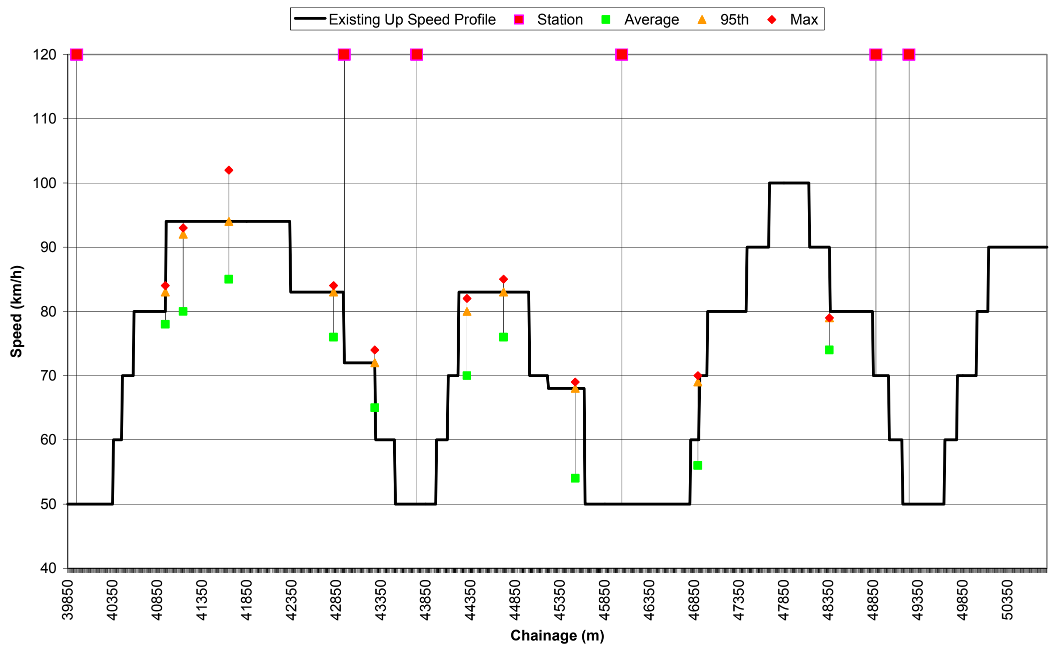


Figure 3 Speed Profile (Down Track) – Existing Scenario

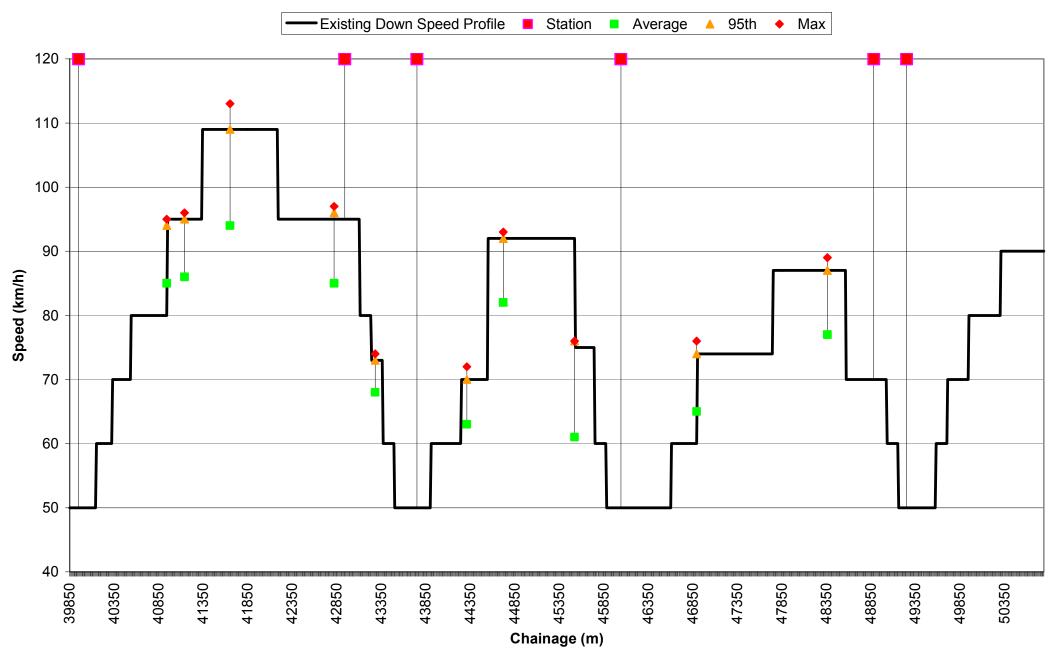


Figure 4 Speed Profile (Up Track) – Future Scenario

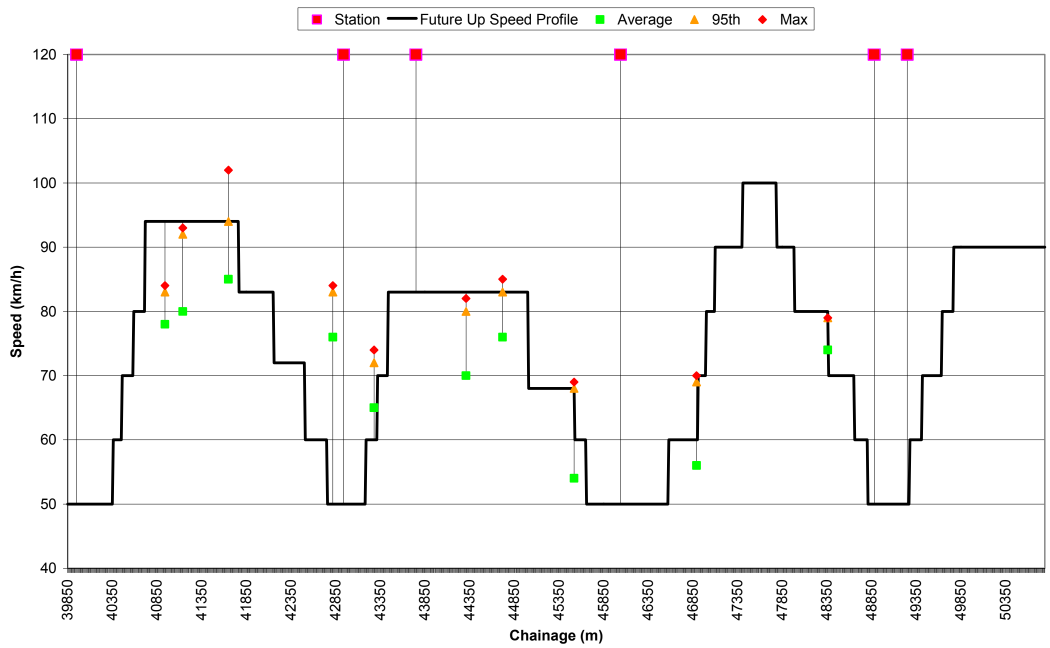
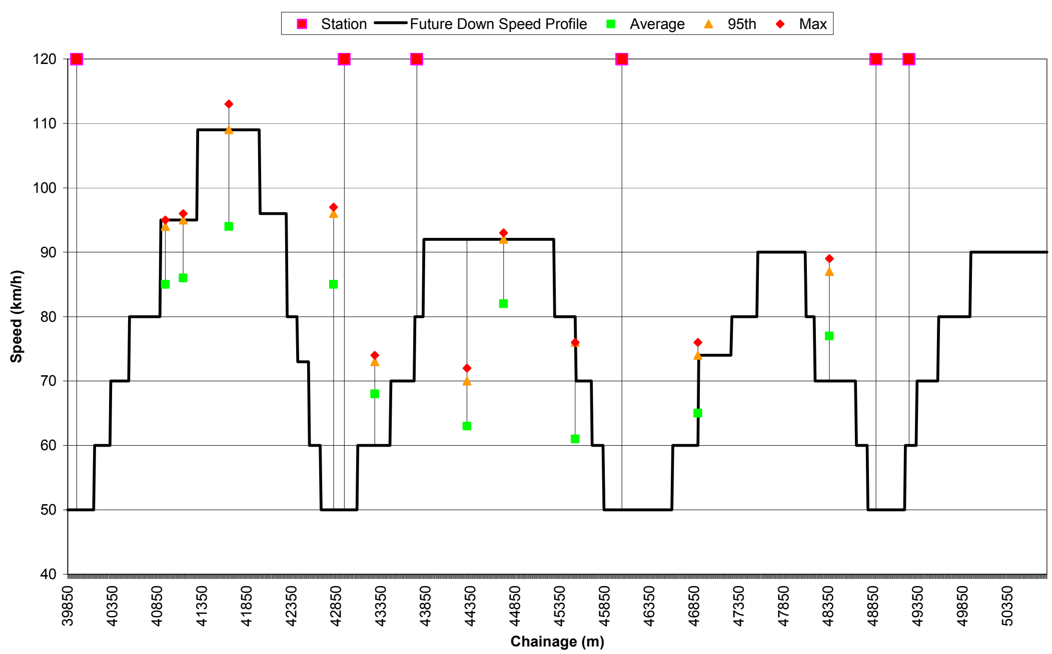


Figure 5 Speed Profile (Down Track) – Future Scenario



Existing rail traffic data for the Year 2007 noise model was based on the current City Rail timetable (dated May 2006, updated February 2007). The number of train movements is expected to increase in the AM and PM peaks upon commissioning of Stage 1 and Stage 2, the remaining services are expected to be the similar to the existing timetable.

The future noise modelling scenario (Year 2023) is based on 4 trains per hour in each direction and up to 8 trains per hour in each direction during the AM and PM peaks.

Under the current timetable (Year 2007), there are 74 train movements per day, compared to 178 per day for the future modelling scenario (Year 2023). This represents an approximate doubling in the number of train services as a result of the proposed upgrade and future traffic growth.

Train numbers for each of the future noise modelling scenarios are based on those provided by TIDC. The train numbers used in the modelling scenarios are summarised in **Table 13**.

Table 13 Modelled Train Numbers (24 Hour Period)

Time Period	Number of passenger train movements[1]					
	Existing (Year 2007)		Future (Year 2013)		Future (Year 2023)	
	Quakers Hill to Riverstone	Riverstone to Vineyard	Quakers Hill to Riverstone	Riverstone to Vineyard	Quakers Hill to Riverstone	Riverstone to Vineyard
00:00 - 01:00	2	2	2	2	2	2
01:00 - 02:00	0	0	0	0	2	2
02:00 - 03:00	0	0	0	0	0	0
03:00 - 04:00	0	0	0	0	0	0
04:00 - 05:00	2	0	2	2	2	2
05:00 - 06:00	4	4	4	4	4	4
06:00 - 07:00	4	4	4	4	8	8
07:00 - 08:00	4	4	8	6	16	16
08:00 - 09:00	4	4	8	6	12	12
09:00 - 10:00	4	4	4	4	12	12
10:00 - 11:00	4	4	4	4	8	8
11:00 - 12:00	4	4	4	4	8	8
12:00 - 13:00	4	3	4	4	8	8
13:00 - 14:00	3	2	4	4	8	8
14:00 - 15:00	4	2	4	4	8	8
15:00 - 16:00	5	3	4	4	8	8
16:00 - 17:00	4	4	4	4	12	12
17:00 - 18:00	4	4	8	6	12	12
18:00 - 19:00	4	4	8	6	16	16
19:00 - 20:00	4	4	8	6	12	12
20:00 - 21:00	4	4	4	4	8	8
21:00 - 22:00	2	2	4	4	4	4
22:00 - 23:00	2	2	4	4	4	4
23:00 - 00:00	2	2	2	2	4	4
Total 15 Hours	58	52	80	70	152	152
Total 9 Hours	16	14	18	18	26	26
Total 24 Hours	74	66	98	88	178	178

Note 1 The number of passenger movements per hour represents the combined total number of train movements per hour for both the Up and Down directions (eg 7.00 am to 8.00 am for the Year 2023 Scenario will have 8 trains per hour in each direction for a total of 16 trains per hour).

RailCorp are planning to introduce a new timetable in 2009 in order to integrate the new Epping to Chatswood Rail Link and other recently completed projects.

The proposed timetable will see additional peak hour services, 6-car trains increased to 8-car trains on more services across Sydney in order to provide extra capacity, as well as additional off-peak services added to the late morning period on the Western, Northern, North Shore and Southern lines.

Proposed improvements for services on the Richmond Branch line include:

- A new morning peak service will operate from Quakers Hill to the North Shore via the CBD.
- Two services from Quakers Hill to the City which currently terminate at Central in the morning peak will now extend to the North Shore via the CBD.
- The hourly City to Riverstone service will now extend to Richmond, providing 2 services an hour during the weekday off-peak.
- A new semi-fast afternoon peak service will operate to Quakers Hill via the CBD.
- Some additional movements may be required (empty trains) between Quakers Hill and Vineyard in order to position trains for the peak periods.

It should be noted that the changes proposed in the 2009 timetable are in Draft format and are subject to confirmation. The proposed timetable changes, if adopted for the Existing Scenario, would not affect the outcome of the IGANRIP operational noise assessment for the following reasons:

- The L_{Amax} noise levels expected with the Year 2009 Draft timetable would be no different from the L_{Amax} noise levels with the current Year 2007 timetable. This is because the type of trains and the train speeds would not change. Therefore the IGANRIP assessment of the increase in L_{Amax} between the Existing Scenario and Year 2023 would not change if the Year 2009 Draft timetable was introduced.
- The L_{Aeq} noise levels expected with the Year 2009 Draft timetable would be less than 1dBA higher than the L_{Aeq} noise levels with the existing Year 2007 timetable (used for the 'Existing Scenario'). The IGANRIP assessment using the current Year 2007 timetable for the Existing Scenario indicates a 3 dBA increase in $L_{Aeq(15hour)}$ between Year 2007 and Year 2023. If the Year 2009 Draft timetable was adopted for the Existing Scenario, a 2 dBA to 3 dBA increase in $L_{Aeq(15hour)}$ would be expected. A 2 dBA increase in $L_{Aeq(15hour)}$ is one of the IGANRIP trigger levels. Therefore (with reference to **Section 5.4**), the IGANRIP assessment of the increase in $L_{Aeq(15hour)}$ between the Existing Scenario and Year 2023 would not change if the Year 2009 Draft timetable was introduced.

Buildings and Receiver Locations

A visual inspection was undertaken of existing buildings adjacent to the Richmond Line in order to determine the occupancy type, number of levels, number of receivers per level, address and height above ground of the first residential level. This information is reported in **Appendix C**.

The location of buildings and their representation within the noise model was derived from aerial photography, provided by TIDC.

5.7 Validation of the Computer Model

Noise measurements have been undertaken as part of this current study at nine locations adjacent to the Richmond line between Quakers Hill and Vineyard. The attended noise measurements were undertaken at free field locations and were modelled as such (ie the noise model did not include a façade reflection at these locations).

A summary of the measured noise levels, together with the modelling results for the same locations, is provided in **Table 14.** The noise model validation for the L_{Aeq} assessment parameter has been compared with the $L_{Aeq(24hour)}$, representing the equivalent continuous noise level of all trains during a typical 24 hour period.

Table 14 Measured vs Modelled Noise Levels - Electric Passenger Trains

Measurement Location	Number of Train Events	Measured Noise Levels (dBA)			Modelled Noise Levels (dBA)[1]		Difference - Modelled minus Measured (dBA)	
		Highest LAmax	95th Percentile LAmax	LAeq (24hour)[2]	95th Percentile LAmax	LAeq (24hour)	LAmax [3]	LAeq (24hour)
N1 – Adjacent to 27 Manorhouse Boulevard, Quakers Hill	20	86	85	59	85	56	+ 0	- 3
N2 – Adjacent to 27 Reycroft Avenue, Quakers Hill	20	87	86	59	87	59	+ 1	+ 0
N3 – Corner Pelican Road and Railway Tce, Schofields	20	93	88	60	89	60	+1	+ 0
N4 – 44 Bridge Street, Schofields	20	73	72	46	74	47	+ 2	+ 1
N5 – 128A Railway Terrace, Riverstone	20	80	79	53	79	51	+ 0	- 2
N6 – 36 Railway Terrace, Riverstone	20	86	82	50	79	52	- 3	+ 2
N7 – 4 Sydney Street, Riverstone	20	81	79	52	76	49	- 3	- 3
N8 – 153 Bridge [4] Street, Schofields	17	75	74	48	76	50	+ 2	+ 2
N9 – Clyde Street, Vineyard	20	81	77	47	82	52	+ 5, (+ 3)	+ 5, (+ 3) [5]

Note 1 Modelled noise levels based on reference levels presented in **Table 12**.

Note 2 The calculated $L_{Aeq(24hour)}$ noise levels are based on the measured L_{AE} noise levels and 74 (66 north of Riverstone) train passby events in a 24 hour period.

Note 3 Representing the notional 95th percentile of L_{Amax} train noise levels.

Note 4 A property boundary fence was included in the noise validation model at this location in order to match the noise measurement conditions.

Note 5 The modelled noise levels at this location are representative of trains travelling at speeds of 80 km/h on the Down track and 90 km/h on the Up Track, whilst the measured sample of trains had an average speed of approximately 75 km/h. The result is that the modelled noise levels will be slightly higher than measured sample at this location. The modelled speeds are deemed representative of the 95th percentile line speeds at this location.

The predicted L_{Amax} and $L_{Aeq(24hour)}$ noise levels for electric passenger train movements on the existing line are within -3 dBA and +3 dBA of the attended measurement results. These results are within the normal tolerances for railway noise predictions.

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

5.8 Prediction of Operational Noise Emissions

The results for the noise modelling scenarios described in **Section 5.4** are discussed in the following paragraphs. Noise trigger level exceedances have been predicted at two existing residential locations within the project area for the Year 2023 situation. The predicted L_{Amax} and L_{Aeq} noise levels at these locations are discussed for both the Year 2013 and the Year 2023 Scenarios.

5.8.1 Existing Situation (Year 2007)

The predicted L_{Amax}, $L_{Aeq(15hour)}$ daytime and $L_{Aeq(9hour)}$ night-time noise levels for the existing situation (Year 2007) are presented in the form of noise contours in **Appendix G**, evaluated at a calculation height of 2 m above ground level (representative of the first occupied level at the nearest receiver locations).

A summary of the predicted exceedances of the IGANRIP trigger levels (overall component only) for the Existing (Year 2007) Scenario is provided in **Table 15**.

Table 15 Summary of IGANRIP Trigger Level Exceedances – Year 2007

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA)[1]	Overall Noise Trigger Level (dBA)	Number of Exceedances within Zone
LAeq(15hour)	Manorhouse Boulevard (40+940 – 41+310)	Up	61	65	0
	Reycroft Avenue (41+670 – 41+760)	Up	60		0
	Bridge Street (43+530 - 43+720)	Down	54		0
LAeq(9hour)	Manorhouse Boulevard (40+940 – 41+310)	Up	58	60	0
	Reycroft Avenue (41+670 – 41+760)	Up	57		0
	Bridge Street (43+530 - 43+720)	Down	51		0
LAmax	Manorhouse Boulevard (40+940 – 41+310)	Up	89	85	32
	Reycroft Avenue (41+670 – 41+760)	Up	88		4
	Bridge Street (43+530 - 43+720)	Down	80		0

Note 1 The predicted noise levels provided in the table are representative of the highest levels within the exceedance zone.

For the existing situation (Year 2007), the predicted L_{Amax}, $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels from electric passenger trains comply with the L_{Amax} 85 dBA, $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA noise trigger levels at all residential receiver locations, except for receivers located on Manorhouse Boulevard and Reycroft Avenue (Quakers Hill) that face directly onto the railway corridor, where the L_{Amax} trigger level is exceeded by up to 4 dBA.

5.8.2 After Opening Situation (Year 2013 – Stage 1 and Stage 2 Commissioned)

Manorhouse Boulevard Receivers

Residential receivers at this locality are situated approximately 15 m to 20 m from the future Up track (existing single line track). The track alignment may be described as “at grade” adjacent to these receivers (the track elevation is approximately equal to that of the adjacent terrain). The new track will be constructed on the western (Down) side of the existing track at a nominal track centre of 6.4 m (ie the new track will be further from the existing residential dwellings on Manorhouse Boulevard than the existing track).

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2013) Scenario is provided in **Table 16**.

Table 16 Summary of IGANRIP Trigger Level Exceedances - Manorhouse Blvd (2013)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Manorhouse Boulevard (40+940 – 41+310)	Up	62 (61)	65	1	2 or more	0
LAeq(9hour)			58 (58)	60	0	2 or more	0
LAmax			89 (89)	85	0	3 or more	0

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2013) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located on Manorhouse Boulevard. The $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 1 dBA at the nearest receiver locations. Compliance is therefore achieved at all locations for the L_{Aeq} assessment parameter.

The future (Year 2013) noise levels are predicted to exceed the trigger level of L_{Amax} 85 dBA at all receivers located on Manorhouse Boulevard that face directly onto the rail corridor (as is currently the case for the existing situation). However, the L_{Amax} noise levels are not predicted to increase by 3 dBA or more as a result of the project at this location as the new track will be located further from the existing residents and existing train speeds on this section of the Richmond Line are expected to remain unchanged. Compliance is therefore achieved at all locations for the L_{Amax} assessment parameter.

Since compliance is achieved for both the L_{Aeq} and L_{Amax} noise trigger levels, further consideration of noise mitigation measures is not required for the after opening situation (Year 2013).

The predicted noise levels indicate that the L_{Amax} noise levels will not increase for the Year 2013 scenario, utilising the Option 4 track alignment. This confirms the selection of Option 4 as the preferred alignment from a noise perspective when compared to a predicted increase of 7 dBA in L_{Amax} above existing levels for the Option 3 alignment with the new track located closer to the residential receivers at this location.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix H**.

Reycroft Avenue Receivers

Residential receivers at this locality are situated approximately 15 m to 20 m from the future Up track (existing single line track). The track alignment may be described as "at grade" adjacent to these receivers (the track elevation is approximately equal to that of the adjacent terrain). The new track will be constructed on the western (Down) side of the existing track at a nominal track centre of 6.4 m (ie the new track will be further from the existing residential dwellings located on Reycroft Avenue than the existing track).

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2013) Scenario is provided in **Table 17**.

Table 17 Summary of IGANRIP Trigger Level Exceedances – Reycroft Ave (2013)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Reycroft Avenue (41+670 – 41+760)	Up	61 (60)	65	1	2 or more	0
LAeq(9hour)			58 (57)	60	1	2 or more	0
LAmax			88 (88)	85	0	3 or more	0

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2013) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located on Reycroft Avenue. The $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 1 dBA at the nearest receiver locations. Compliance is therefore achieved at all locations for the L_{Aeq} assessment parameter.

The future (Year 2013) noise levels are predicted to exceed the trigger level of L_{Amax} 85 dBA at four receivers located directly adjacent to the rail corridor. However, the L_{Amax} noise levels are not predicted to increase by 3 dBA or more as a result of the project at this location as the new track will be located further from the existing residents and existing train speeds on this section of the Richmond Line are expected to remain unchanged. Compliance is therefore achieved at all locations for the L_{Amax} assessment parameter.

Since compliance is achieved for both the L_{Aeq} and L_{Amax} noise trigger levels, further consideration of noise mitigation measures is not required for the after opening situation (Year 2013).

The predicted noise levels indicate that the L_{Amax} noise levels will not increase for the Year 2013 scenario, utilising the Option 4 track alignment. This confirms the selection of Option 4 as the preferred alignment from a noise perspective when compared to a predicted increase of 7 dBA in L_{Amax} above existing levels for the Option 3 alignment with the new track located closer to the residential receivers at this location.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix H**.

Bridge Street and Tain Place Receivers

Residential receivers at this locality are situated between approximately 10 m to 20 m from the future Down track (existing single line track). The track alignment may be described as "on embankment" adjacent to these receivers (ie the track elevation is greater than that of the adjacent terrain). The new track will be constructed on the eastern (Up) side of the existing track at a nominal track centre of 4 m (ie the new track will be further from the existing residential dwellings located on Bridge Street and Tain Place).

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2013) Scenario is provided in **Table 18**.

Table 18 Summary of IGANRIP Trigger Level Exceedances – Bridge Street/Tain Place (2013)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Bridge Street (43+530 - 43+720)	Down	59 (54)	65	5	2 or more	0
LAeq(9hour)			56 (51)	60	5	2 or more	0
LAmax			87 (80)	85	7	3 or more	6

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2013) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located on Bridge Street and Tain Place. The $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 5 dBA at the nearest receiver locations. Compliance is therefore achieved at all locations for the L_{Aeq} assessment parameter.

The future (Year 2013) noise levels are predicted to exceed the trigger level of L_{Amax} 85 dBA at six receivers located on Bridge Street and Tain Place. The L_{Amax} noise levels are predicted to increase by up to 7 dBA at these receiver locations. The increase in L_{Amax} noise levels is due to the increased line speed on this section of track.

Exceedances of the IGANRIP noise trigger levels are therefore predicted based on the absolute L_{Amax} trigger level being exceeded at six locations with a corresponding increase of 3 dBA or more. Accordingly, further assessment is warranted for the consideration of reasonable and feasible noise mitigation at this location.

The predicted increase in L_{Aeq} noise levels for the Year 2013 scenario, utilising the Option 4 track alignment is less than that for Option 3. This confirms the selection of Option 4 as the preferred alignment from a noise perspective as the new track will be located further away from the existing residential receivers due to the increased 6.4 m track centres.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix H**.

Other Noise Sensitive Receivers

Noise levels have been predicted at "Other Noise Sensitive" receiver locations as listed in **Table 9**. The future (Year 2013) noise levels are predicted to comply with the trigger level of $L_{Aeq(1hour,internal)}$ 45 dBA at all locations.

The nearest potentially affected “Other Noise Sensitive Receiver” is the Quakers Hill Pre-School, located on the corner of Pearce and Lalor Roads. A summary of the predicted noise levels at this location is provided in **Table 19**.

Table 19 Summary of IGANRIP Trigger Level Exceedances – Other Noise Sensitive Receivers (2013)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(1hour) Internal	Quakers Hill Pre-School (40+200 - 43+250)	Up	44 (42)	45	2	2 or more	0
LAeq(15hour)	Quakers Hill Pre-School Active Recreational Area (40+200 - 43+250)	Up	52 (51)	65	1	2 or more	0

The noise levels at this location are predicted to increase by approximately 2 dBA for the Year 2013 scenario. The noise levels predicted at the active recreational area attached to the pre-school are predicted to comply with the trigger level of $L_{Aeq(15hour)}$ 65 dBA by up to 10 dBA.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix H**,

Temporary Turnout – Stage 1 Commissioning

A new turnout will be installed to the north of new Schofields Station for the commissioning of Stage 1 in the Year 2011. This turnout is temporary and will be removed following the commissioning of Stage 2.

As discussed in **Section 5.5.2**, conventional turnouts result in higher noise levels than standard track. In addition to the increased noise levels, the discontinuity in the rail running surface also changes that character of the noise emissions which has the effect of increasing the perceptibility or “loudness” of the noise. Installing a turnout into existing continuously welded rail (CWR) track will therefore result in an increase in noise levels at adjacent receivers.

The nearest potentially affected receivers are located on Railway Terrace (Up Side) and Bridge Street (Down Side) between track chainages 43.3 km and 43.4 km. The nearest residential receivers are located approximately 30 m to 40 m from the proposed turnout. The noise emissions from the proposed turnout at this location have been included in the noise modelling for the Year 2013 scenario.

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2013) Scenario is provided in **Table 20**.

Table 20 Summary of IGANRIP Trigger Level Exceedances – Temporary Turnout (2013)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Bridge Street (43+300 - 43+500)	Down	52 (50)	65	2	2 or more	0
LAeq(9hour)			49 (46)	60	3	2 or more	0
LAmax			78 (76)	85	2	3 or more	0

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2013) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located immediately adjacent to the proposed turnout. A localised increase of up to 3 dBA in the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels is predicted at the nearest receiver locations. Compliance is therefore achieved at all locations for the L_{Aeq} assessment parameter.

The future (Year 2013) noise levels are predicted to comply with the trigger level of L_{Amax} 85 dBA at all receivers located immediately adjacent to the proposed turnout. A localised increase of up to 3 dBA in the L_{Amax} noise levels is predicted at the nearest receiver locations. Compliance is therefore achieved at all locations for the L_{Amax} assessment parameter.

Since compliance is achieved for both the L_{Aeq} and L_{Amax} noise trigger levels, further consideration of noise mitigation measures is not required for the after opening situation (Year 2013) at receiver locations adjacent to the temporary turnout.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix H**,

5.8.3 Long Term Situation (Year 2023 – Stage 1 and Stage 2 Ten Years After Opening)

The predicted L_{Amax}, $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels for the long-term situation (Year 2023) are presented in the form of noise contours evaluated at a calculation height of 2 m above ground level (representative of the first occupied level at the nearest receiver locations).

Manorhouse Boulevard Receivers

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2023) Scenario is provided in **Table 21**.

Table 21 Summary of IGANRIP Trigger Level Exceedances – Manourhouse Blvd (2023)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Manorhouse Boulevard (40+940 – 41+310)	Up	65 (61)	65	4	2 or more	8
LAeq(9hour)			59 (58)	60	1	2 or more	0
LAmax			89 (89)	85	0	3 or more	0

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2023) noise levels are predicted to exceed the trigger level of $L_{Aeq(15hour)}$ 65 dBA at eight receivers immediately facing onto the railway corridor. The $L_{Aeq(15hour)}$ noise levels are predicted to increase by up to 4 dBA at each of the affected receiver locations.

The future (Year 2023) noise levels are predicted to comply with the trigger level of $L_{Aeq(9hour)}$ 60 dBA for all receivers at this location. The $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 1 dBA.

Exceedances of the IGANRIP noise trigger levels are therefore predicted based on the absolute $L_{Aeq(15hour)}$ trigger level being exceeded at eight locations with a corresponding increase of 2 dBA or more. Accordingly, further assessment is warranted for the consideration of reasonable and feasible noise mitigation at this location.

The future (Year 2023) noise levels are predicted to exceed the trigger level of L_{Amax} 85 dBA at all receivers located on Manorhouse Boulevard that face directly onto the rail corridor. However, the L_{Amax} noise levels are not predicted to increase by 3 dBA or more as a result of the project at this location as the new track will be located further from the existing residents and existing train speeds on this section of the Richmond Line are expected to remain unchanged. Compliance is therefore achieved at all locations for the L_{Amax} assessment parameter.

The predicted noise levels indicate that the L_{Amax} noise levels will not increase for the Year 2023 scenario, utilising the Option 4 track alignment. This confirms the selection of Option 4 as the preferred alignment from a noise perspective when compared to a predicted increase of 7 dBA in L_{Amax} above existing levels for the Option 3 alignment with the new track located closer to the residential receivers at this location.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix I.**

Reycroft Avenue Receivers

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2023) Scenario is provided in **Table 22**.

Table 22 Summary of IGANRIP Trigger Level Exceedances – Reycroft Ave (2023)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Reycroft Avenue (41+670 – 41+760)	Up	64 (60)	65	4	2 or more	0
LAeq(9hour)			59 (57)	60	2	2 or more	0
LAmax			88 (88)	85	0	3 or more	0

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2023) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located on Reycroft Avenue. The $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 4 dBA and 2 dBA respectively at the receivers located immediately adjacent to the corridor. Compliance is therefore achieved at all Reycroft Avenue receiver locations for the L_{Aeq} assessment parameter.

The future (Year 2023) L_{Amax} noise levels are predicted to exceed the trigger level of 85 dBA at four receivers located on Reycroft Avenue. However, the L_{Amax} noise levels are not predicted to increase by 3 dBA or more as a result of the project at this location as the new track will be located further from the existing residents and existing train speeds on this section of the Richmond Line are expected to remain unchanged. Compliance is therefore achieved at all Reycroft Avenue receiver locations for the L_{Amax} assessment parameter.

Since compliance is achieved for both the L_{Aeq} and L_{Amax} noise trigger levels, further consideration of noise mitigation measures is not required for the future situation (Year 2023) at this location.

The predicted noise levels indicate that the L_{Amax} noise levels will not increase and that the potential increase in $L_{Aeq(15hour)}$ has been minimised for the Year 2023 scenario, utilising the Option 4 track alignment. This confirms the selection of Option 4 as the preferred alignment from a noise perspective compared to a predicted increase of 7 dBA in L_{Amax} above existing levels for the Option 3 alignment with the new track located closer to the residential receivers at this location.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix I.**

Bridge Street and Tain Place Receivers

A summary of the predicted exceedances of the IGANRIP trigger levels for the Future (Year 2023) Scenario is provided in **Table 23**.

Table 23 Summary of IGANRIP Trigger Level Exceedances – Bridge Street / Tain Place (2023)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(15hour)	Bridge Street (43+530 - 43+720)	Down	63 (54)	65	9	2 or more	0
LAeq(9hour)			57 (51)	60	6	2 or more	0
LAmax			87 (80)	85	7	3 or more	6

Note 1 The predicted noise levels provided in the table are for the receiver representative of the highest levels within the exceedance zone.

The future (Year 2023) noise levels are predicted to comply with the trigger levels of $L_{Aeq(15hour)}$ 65 dBA and $L_{Aeq(9hour)}$ 60 dBA at all receivers located on Bridge Street and Tain Place. The $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels are predicted to increase by up to 9 dBA and 6 dBA respectively at this location. Compliance is therefore achieved at all locations for the L_{Aeq} assessment parameter.

The future (Year 2023) noise levels are predicted to exceed the trigger level of L_{Amax} 85 dBA at six receivers located on Bridge Street and Tain Place. The L_{Amax} noise levels are predicted to increase by up to 7 dBA at these receiver locations. The increase in L_{Amax} noise levels is due to the increased line speed on this section of track.

Exceedances of the IGANRIP noise trigger levels are therefore predicted based on the absolute L_{Amax} trigger level being exceeded at six locations with a corresponding increase of 3 dBA or more. Accordingly, further assessment is warranted for the consideration of reasonable and feasible noise mitigation at this location (as also identified for the after opening situation).

The predicted increase in L_{Aeq} noise levels for the Year 2023 scenario, utilising the Option 4 track alignment is less than for Option 3. This confirms the selection of Option 4 as the preferred alignment from a noise perspective as the new track will be located further away from the existing residential receivers than the existing track.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix I.**

Other Noise Sensitive Receivers

Noise levels have been predicted at "Other Noise Sensitive Receiver" locations as listed in **Table 9**. The future (Year 2023) noise levels are predicted to exceed the trigger levels at one location only. A summary of the predicted noise levels at this location is provided in **Table 24**.

Table 24 Summary of IGANRIP Trigger Level Exceedances – Other Noise Sensitive Receivers (2023)

Noise Level Descriptor	Exceedance Zone (Chainage - km)	Side of Track	Predicted Noise Level (dBA) (Y2007)	Overall Noise Trigger Level (dBA)	Predicted Noise Level Increase (dBA)	Noise Level Increase Trigger (dBA)	Number of IGANRIP Exceedances within Zone
LAeq(1hour) Internal	Quakers Hill Pre-School (40+200 - 43+250)	Up	46 (42)	45	4	2 or more	1
LAeq(15hour)	Quakers Hill Pre-School Active Recreational Area (40+200 - 43+250)	Up	55 (51)	65	4	2 or more	0

The noise levels at the Quakers Hill Pre-School, located on the corner of Pearce and Lalor Roads, are predicted to exceed the overall $L_{Aeq(1hour-internal)}$ 45 dBA trigger level by 1 dBA, with a noise level increase of approximately 4 dBA. The noise levels predicted at the active recreational area attached to the pre-school are predicted to comply with the trigger level of $L_{Aeq(15hour)}$ 65 dBA.

This facility is open between 7 am and 6 pm, with the morning peak hour occurring between 7 am and 8 am. The trigger level exceedance is based on the overall $L_{Aeq(1hour-internal)}$ trigger being exceeded with a corresponding increase of more than 2 dBA of the hourly L_{Aeq} (refer **Table 8**).

Therefore, further assessment is warranted for the consideration of reasonable and feasible noise mitigation at this location.

The $L_{Aeq(15hour)}$, $L_{Aeq(9hour)}$ and L_{Amax} noise contours for this location are presented in **Appendix I.**

5.9 Summary of Predicted Noise Levels

Summaries of the predicted IGANRIP noise trigger level exceedances at each of the areas identified in **Section 5.8.3** for the Year 2013 (After Opening) Scenario and Year 2023 (Long Term) Scenario are provided in **Table 25** and **Table 26** respectively.

Table 25 Predicted Trigger Level Exceedances - Future Situation (Year 2013)

Location	Number of Receivers	LAeq(15hour)[1]		LAeq(9hour)		LAmax		Further Assessment Required?
		> 65 dBA	Increase >= 2 dBA	> 60 dBA	Increase >= 2 dBA	> 85 dBA	Increase >= 3 dBA	
Manorhouse Boulevard (Quakers Hill)	8	No	Yes	No	Yes	Yes	No	No
Reycroft Avenue (Quakers Hill)	4	No	No	No	No	Yes	No	No
Bridge Street, Tain Place, (Schofields)	6	No	Yes	No	Yes	Yes	Yes	**Yes**
Quakers Hill Pre-School	1	No[2]	Yes	N/A	N/A	N/A	N/A	No

Note 1 The largest increase in noise levels is predicted during the daytime period.

Note 2 The Quakers Hill Pre-School is subject to the 45 dBA LAeq(1hour-internal) trigger level.

Table 26 Predicted Trigger Level Exceedances - Future Situation (Year 2023)

Location	Number of Receivers	LAeq(15hour)[1]		LAeq(9hour)		LAmax		Further Assessment Required?
		> 65 dBA	Increase >= 2 dBA	> 60 dBA	Increase >= 2 dBA	> 85 dBA	Increase >= 3 dBA	
Manorhouse Boulevard (Quakers Hill)	8	Yes	Yes	No	No	Yes	No	**Yes**
Reycroft Avenue (Quakers Hill)	4	No	Yes	No	Yes	Yes	No	No
Bridge Street, Tain Place, (Schofields)	6	No	Yes	No	Yes	Yes	Yes	**Yes**
Quakers Hill Pre-School	1	Yes[2]	Yes	N/A	N/A	N/A	N/A	**Yes**

Note 1 The largest increase in noise levels is predicted during the daytime period.

Note 2 The Quakers Hill Pre-School is subject to the 45 dBA LAeq(1hour-internal) trigger level.

A review of **Table 25** indicates that further assessment for the need for mitigation is required for receivers located on Bridge Street and Tain Place for the Year 2013 (After Opening) Scenario).

A review of **Table 26** indicates that further assessment for the need for mitigation is required at each of the identified locations (with the exception of the Reycroft Avenue Receivers) for the Year 2023 (Long Term) Situation.

IGANRIP noise trigger level exceedances were predicted for the $L_{Aeq(15hour)}$, $L_{Aeq(1hour,internal)}$ and L_{Amax} noise level descriptors. As such, further assessment of the need for noise mitigation is required on the basis of these exceedances at the locations provided in **Table 25** and **Table 26**.

6 OPERATIONAL NOISE MITIGATION

The noise modelling results discussed in **Section 5.8** identified a number of locations along the Quakers Hill to Vineyard corridor where there is a need to undertake a further assessment of feasible and reasonable noise mitigation measures.

6.1 Summary of Options Considered for Noise Control

A summary of noise control options considered for the Quakers Hill to Vineyard Project are listed in **Table 27**, along with comments on their feasibility and reasonableness. It is noted that whilst estimates of potential noise reductions are provided for various measures, these are approximations only, and would be subject to variation based on local land conditions and design considerations.

Table 27 Summary of Noise Control Options Considered

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Planning Measures		
Incorporate receiver controls from above, or, orientation of single family dwellings such that habitable rooms are located away from facades exposed to rail noise	5dB to 10dB reduction in L_{Amax} and L_{Aeq} noise levels.	Can be achieved through statutory planning and Development Control Plans. Part 87 of the *State Environmental Planning Policy (Infrastructure) 2007* (Infrastructure SEPP) requires sensitive non-rail developments to achieve internal L_{Aeq} noise levels of 35 dBA during 10pm to 7am night-time period within bedrooms and 40 dBA in other habitable areas at any time of the day.
Increase offset distance between railway line and sensitive receiver locations	Increasing receiver distance from 20 m to 40 m would reduce $L_{Amax,95\%}$ noise levels by 4 dB and L_{Aeq} noise levels by 3 dB.	To be discussed with Land Use Planners Limits land use along rail corridor
Locate less sensitive land uses (including roadways, playing fields, etc) adjacent to rail corridor to provide buffer to residential areas	Distance benefit as above, plus noise shielding from any buildings	To be discussed with Land Use Planners Commercial buildings located between rail corridor and sensitive receivers can be seen as practical and cost effective noise barriers. Co-ordinated design of adjacent commercial buildings could optimise noise shielding.
Path Control Options - Within Rail Corridor		
Noise Barriers on at-grade track	2 dB (1m above rail) to 12 dB (4m above rail) depending on distance and source to receiver geometry	Noise barriers will be most effective located close to the near track. Minimum structure clearance, to track centreline, is 4.25m and 6.2m if vehicle access is required. Ongoing issues with maintenance and graffiti. Negative visual impact on broader community and commuters. Mixed reaction from affected residents due to overshadowing, loss of views and visual impact. Some residents have unreasonable expectations about barrier performance and are disappointed with perceived poor performance of barriers.
Noise Barriers on embankment track	Additional 2 dB compared to at-grade barriers of similar height	Likely to be feasible and reasonable for 1-2 storey dwellings due to reduced barrier height requirements. Clearance issues greater than at-grade track due to space restrictions on embankment. Similar issues as above in relation to maintenance, graffiti and visual impact remain.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Earth mounds	Smaller noise reduction than noise barriers of similar height, performance compromised by need to be located further from near track than a barrier.	Likely to be cost effective if sufficient spoil and space available. Not feasible on all embankments due to extra footprint required for embankment.
Receiver Controls		
Property boundary fence	Up to 5 dB at ground floor for 1.8m solid fence. Less than 2 dB reduction for upper floor receivers.	Cost effective option for new developments where rear boundary fence faces rail corridor. Noise benefit is reduced for track on embankment.
Noise Barrier close to railway corridor boundary	Noise reduction dependent on distance, geometry, etc.	This option may be cost effective for track in cutting or at-grade for sensitive receiver locations with property access facing rail corridor. Same issues as for barriers within rail corridor, as listed above, in relation to maintenance, graffiti and visual impact. Sometimes considered by residents as a refuge for “undesirables”.
Fresh air mechanical ventilation to allow windows to be closed (if desired)	10dB to 15dB reduction in internal noise levels compared with windows open. No benefit for outdoor areas or if windows are opened.	This option is only applicable as a final measure for existing developments or as a final mitigation strategy to achieve acceptable indoor noise levels for future developments. Part 87 of Infrastructure SEPP requires sensitive non-rail developments to achieve internal LAeq noise levels of 35 dBA during 10pm to 7am night-time period within bedrooms and 40 dBA in other habitable areas at any time of the day.
Operational Measures		
Reduce Train Speeds	If maximum train speed is 125 km/h, reducing the maximum speed to 100 km/h would reduce $L_{Amax,95\%}$ noise levels by 2.5 dB and L_{Aeq} noise levels by 1.5 dB	Not feasible due to impact on services.
Reduce Overall Number of Train Passbys	No Change in $L_{Amax,95\%}$ 1 dB reduction in L_{Aeq} for 20% change 2 dB reduction in L_{Aeq} for 35% change	Not feasible, train numbers required to meet service frequency demands.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Reduce Train Lengths	Negligible change in $L_{Amax,95\%}$ 1.3 dB reduction in L_{Aeq} for 6-car trains in lieu of 8-car trains 3 dB reduction in L_{Aeq} for 4-car trains in lieu of 8-car trains No change in L_{Aeq} noise levels if total number of cars is the same (ie one 8-car train is the same as two 4-car trains)	Not feasible, train lengths required to meet capacity demand.
Reduce Train Lengths for night-time period	As above, but noise reductions only applicable for night-time period	Not feasible, 8 car sets required to maintain train balance within system.
Exclude "Noisier" Train types	Up to 3 dB reduction in $L_{Amax,95\%}$ Up to 2 dB reduction in L_{Aeq} Estimated noise reductions based on the noisiest 20% of trains not operating on Quakers Hill to Vineyard Line	This option requires a permanent monitoring system to identify louder trains and a strategy to remove/fix louder trains. Significant impact on RailCorp's maintenance strategy, fleet allocation and budget.
Exclude "Noisier" Train types during night-time period	As above, but noise reductions only applicable for night-time period	This option would require a strategy to hold noisier trains in a stabling facility during night-time periods. Impractical to identify noisier trains on an ongoing basis.

Track Design Measures		
Rail Dampers	Up to 3 dB reduction in $L_{Amax,95\%}$ and L_{Aeq} noise levels.	Likely to be feasible, reasonable and cost-effective if full noise reduction can be achieved. Rail dampers are fixed to the rail track (both sides of the rail) by either mechanical means or by adhesive. Noise radiated from the rail is reduced by the damping afforded by tuned dampers. Trial of all available products recommended. Trials of one product in progress. RailCorp approval required.
Optimise track design (sleeper spacing, rail fasteners, etc)	Possible reduction of 1 dB in $L_{Amax,95\%}$ and L_{Aeq} noise levels.	Would require detailed analysis using a predictive computer program such as TWINS. Would need to be considered on an individual basis. Potential to explore through Rail Co-operative Research Centre.
Low profile noise barriers located close to track.	Likely noise reduction of 5 dB in $L_{Amax,95\%}$ and L_{Aeq}.	More cost-effective than barriers located on rail corridor boundary. RailCorp approval likely to be required. Implications for track maintenance.
Lower rail level by 1 m for at-grade sections	1 dB reduction at 30 m and 2 dB at 40 m ($L_{Amax,95\%}$ and L_{Aeq})	Implications on track gradient which has been optimised to take into account road crossings and land contours.

Description	Estimated Noise Reduction	Comments on Feasibility / Reasonableness
Lower rail level by 2 m for at-grade sections	5 dB reduction at 30 m and 5 dB at 40 m ($L_{Amax,95\%}$ and L_{Aeq})	Significant implications on track gradient which has been optimised to take into account road crossings and land contours.
Locate crossings to less noise-sensitive location	Locate turnouts away from residential receiver locations (ie, close to future stations assuming commercial use)	Good environmental outcome for sensitive receiver locations. For consideration on new sections of track
Install Quieter crossings	3 dB reduction in LAeq at 30 m and elimination of impulsive noise associated with standard turnouts	Good environmental outcome for sensitive receiver locations. For consideration on new sections of track
Construction of Quiet Bridges	Concrete ballasted bridges are up to 10 dB quieter than open transom steel bridges	The construction of quiet bridges is required as part of RailCorp's Pollution Reduction Program Strategy and standards for ballasted bridges on concrete.
Track Maintenance / Rollingstock Measures		
Rail Grinding Program	Rail condition contributes to the overall noise levels that result from steel wheel on rail contact. Implement a revised rail grinding program to reduce train noise emissions.	Heggies is planning to undertake field measurements of existing rail roughness condition and associated noise levels at two existing locations. Initial investigations are underway by RailCorp. This option is likely to be a feasible and reasonable long term strategy.
Wheel Maintenance Program	Wheel maintenance program would aim to maintain wheels in acceptable condition and reduce L_{Amax} and L_{Aeq} noise levels by approximately 2 dB or more over time. Noise levels from individual trains would be compared to benchmark trains.	Wheel condition of RailCorp's fleet is being continually monitored. Increased wheel maintenance is likely to have significant implications on fleet availability and on costs. Poor wheel condition can have a significant effect on levels of noise generated by trains.
Wheel Defect Research Study	Possible long-term decrease in L_{Amax} and L_{Aeq} noise levels by approximately 2 dB.	Research study would aim to identify reasons why wheel defects are generated in the first instance with a view to implementing preventative measures on existing rollingstock. Likelihood unknown.
Specifications for New Rollingstock (including maintenance)	Possible L_{Amax} and L_{Aeq} noise reduction of 3 dB, but only for new rollingstock.	Noise specifications would be provided based on best practice and maintenance programs established to maintain satisfactory noise levels. Not likely to be feasible for Quakers Hill to Vineyard Line as new rolling stock is not proposed to be used.

The only noise mitigation options listed in **Table 27** which are considered to be feasible and reasonable for reducing the impact of operational noise from the Quakers Hill to Vineyard Duplication project are listed below:

- Source mitigation – eg rail dampers.
- Acoustic shielding – earth mounds and trackside noise barriers.
- Setback zones – use parks and roads to separate sensitive users from rail corridor.
- Land use planning – locate commercial buildings along rail corridor.
- Prescribed building design and orientation along corridor.
- Dwelling treatments.

The hierarchy of noise control is to give preference to source control measures, then to physical mitigation measures (barriers and set back zones) between the source and receiver and as a final measure, receiver controls. It should be noted that the improvement of existing rollingstock and the implementation of new quieter rollingstock is continually being investigated by RailCorp. These measures may provide future benefits to receivers located adjacent to the Quakers Hill to Vineyard project area, however such benefits have not been included in the consideration of project specific noise mitigation measures as listed above.

Source Control Measures

The only identified source control measure which is considered capable of reliably delivering a substantive noise reduction on the Quakers Hill to Vineyard Duplication project is rail dampers. These consist of tuned masses fixed to the rails via resilient material and fasteners. Noise radiated by rails fitted with these devices is reduced by the damping effect they have on the rails.

Dampers have a long service life and are essentially maintenance free, requiring only periodic visual inspections to ensure that they remain attached to the rails. Dampers are designed not to interfere with normal track maintenance but can be removed and reused if rail welding is required. The small physical size of dampers means that they have no visual impact.

The potential noise reduction is dependent on the track design and the relative source noise levels of the track and wheels. The full benefit is achieved if the rail noise component controls the overall train passby noise levels. Additional detailed analysis would be required in order to estimate the potential noise reduction for the proposed track design.

Acoustic Shielding

This includes the construction of earth mounds and/or noise barriers (which shield some of the direct airborne noise that propagates between the source and receiver locations). The locations where earth mounds can be used on the project are limited because of the space required for an earth mound which is usually constructed with a batter of 2 to 1 on both sides of the mound.

Noise barriers can provide significant noise reductions in locations where source control measures are not able to mitigate noise levels adequately. 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 (of typical heights) are generally not as effective, however, for upper floor receivers and are usually ineffective above the second level.

In terms of noise reduction, noise barriers 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 land-take or fill material.

Land Use Planning

The IGANRIP notes that the control of noise and vibration issues resulting from rail traffic should be the joint responsibility of the rail operator and of surrounding land uses. Given that the Quakers Hill to Vineyard Duplication Project is being built, in part, in a greenfield area, there is potential for the application of appropriate land use planning principles along the rail corridor as a means of controlling the impact of rail noise and vibration. Appropriate land use can include the implementation of appropriate zoning controls adjacent to rail corridors to ensure that less sensitive uses (eg commercial, industrial or roads) can be used to shield more sensitive land uses, such as hospitals, schools and residential, from rail noise where possible.

It may be possible to achieve such shielding with a combination of appropriate land zoning and building restrictions which prescribe building placement and minimum height (near the rail corridor for maximum screening effect). The number of locations where this may be an effective tool to shield sensitive land users from rail noise can however be limited. The area of development land available along the rail corridor far exceeds the requirements for commercial and industrial uses. It is inevitable (and desirable) that a proportion of this land closest to the corridor also be used for residential purposes.

It is noted that this area is unique as it is part of the North West Growth Centre. The North West Growth Centre will contain sixteen precincts, six of which lie directly adjacent to the Richmond Line between Quakers Hill and Vineyard. Each of these precincts will be subject to a precinct planning process that includes numerous investigations including appropriate land use options and environmental and socio economic planning.

Discussions with the Growth Centres Commission (GCC) regarding the planning and location of sensitive noise receivers are ongoing regarding opportunities for setback zones and land use planning measures.

Increased separation distance from the rail corridor by the placement of roads or open recreational space can also be used as a noise mitigation measure. Acoustic setbacks and buffer zones can be employed, with roadways or open recreation areas providing the buffer zone. Where a buffer zone is insufficient or impractical for controlling noise, it may be necessary to control the layout and construction of buildings, with sensitive areas of occupancy in a building being placed away from the noise source.

The use of planned setbacks can reduce or eliminate the need for noise barriers (which can have detrimental visual, cost and social impacts). This project has the potential to employ the benefits of careful land use planning along the rail corridor.

The State Environmental Planning Policy (Infrastructure) 2007 provides legislation for the assessment of potential noise and vibration impacts on buildings that are proposed to be constructed adjacent to a rail corridor. Such buildings include:

- Buildings for residential use
- A place of public worship
- A hospital
- An educational establishment or child care centre

Prior to determining a development application, the policy requires that:

> *The following LAeq levels are not exceeded:*
>
> *(a) in any bedroom in the building—35 dB(A) at any time between 10.00 pm and 7.00 am,*
>
> *(b) anywhere else in the building (other than a garage, kitchen, bathroom or hallway)—40 dB(A) at any time*

The Infrastructure SEPP refers to guidelines that should be considered where development is proposed in or adjacent to railway corridors. The Department of Planning (DoP) has released an interim guideline that fulfills this purpose. Future developments adjacent to the Richmond line would be subject to the noise and vibration assessment guidelines contained in '*Development Near Rail Corridors and Busy Roads – Interim Guideline* - (DoP, 2008)'.

Locations that are currently undeveloped but that fall within the GCC master plans adjacent to the project area have not been assessed in detail at this stage. A review of the future (Year 2023) $L_{Aeq(15hour)}$ noise contours adjacent to these areas indicates the 65 dBA contour is typically located up to 10 m from the rail corridor boundary. Further discussions between TIDC and the GCC are required in to order determine the appropriate protocol in dealing with future rail noise levels at these locations.

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 minimise the transmissions of noise into the structure. 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 front or back yards. Building treatments are normally more costly than source control and source/receiver control measures. For these reasons, building treatments are generally not favoured until after all other options have been explored.

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 design of station PA systems should consider incorporation of 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 speaks 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.

Removal of Level Crossings

Level crossings are areas of intersection between the active railway line, pedestrian and road traffic. The risk of collision between rail, pedestrian and road traffic is increased at these locations. In order to mitigate this risk, a variety of warning devices may be installed including audible warning devices.

The existing pedestrian level crossings at Quakers Hill, Schofields and Riverstone Stations will be removed as part of the project. Removal of the audible warning devices associated with these level crossings would result in an improvement to the acoustic amenity of the noise sensitive receivers located immediately adjacent to the crossings.

6.2 Principles of Feasible and Reasonable Noise Mitigation

The determination of feasible and reasonable mitigation measures is based on a number of factors including engineering considerations, noise mitigation benefits, cost, community views, track maintenance and access requirements, aesthetic impacts, the change in noise levels and the wider community benefits of the project.

Reasonableness Assumptions

As indicated in **Table 8**, increases in noise level of up to 2 dBA in the L_{Aeq} or 3 dBA in the L_{Amax} are normally considered to be acceptable for an upgrade project on the basis that changes of this magnitude would not have a "noticeable" effect on acoustic amenity.

In order to initiate an assessment of rail noise impacts and investigate mitigation measures, both the increase in rail noise levels as a result of the project **AND** the overall level of rail noise must exceed the trigger levels. No further assessment is required at locations where both trigger levels are not exceeded.

Where exceedances of the overall trigger levels are indicated, and there is a noticeable increase in noise levels associated with the project, consideration has been given to reasonable and feasible mitigation measures such as source controls and noise barriers to reduce noise levels.

At locations where the future noise levels do not exceed the trigger levels, residential and other sensitive receiver locations will benefit from other long-term source mitigation measures such as the retiring of older, noisier rollingstock and improved maintenance of track and rollingstock.

In situations where it is not feasible or reasonable to mitigate noise emissions via source control measures or noise barriers, architectural building treatments may be considered after all other options have been explored.

Thus, for the proposal, noise barriers will only be considered at locations where:

- Source noise mitigation measures are not practicable, are not feasible or not effective.
- The future noise levels exceed the overall trigger levels, namely L_{Amax} 85 dBA or $L_{Aeq(15hour)}$ daytime 65 dBA **and** the predicted noise level increase as a result of the proposed upgrade is 2.0 dBA or more in L_{Aeq} in any hour or an increase of 3.0 dBA or more in L_{Amax}.

Feasibility Issues

Issues of engineering feasibility must also be taken into account in the design of noise barriers or other mitigation measures. If barriers cannot be physically constructed within the available space or present an operational impediment or safety hazard, then this must be taken into account in the design process. Such issues may include (but are not limited to):

- Civil/structural limitations (such as the size of footings required to withstand wind loads).
- Safe access requirements for inspection staff and, where required, train drivers.
- Safe access requirements for future railway maintenance (including access for large machines).
- Sighting of signalling infrastructure and utilities (which may be compromised by barriers on track curves).
- Safe access for future barrier maintenance (including for graffiti removal).

To address the feasibility issues, it may be necessary to redesign the mitigation measure with a change in location, height or structure (in the case of noise barriers) or, if an engineering solution cannot be found, to omit the mitigation measure from the design.

Cost Considerations

Capital cost, whole of life cost and cost-effectiveness are important when considering whether mitigation measures are reasonable. The costs of the construction and long term maintenance of noise mitigation will be addressed by TIDC as part of the design process.

Community Considerations

In all cases where noise barriers are proposed, the community would be consulted to address issues such as overshadowing, loss of outlook, damage to existing vegetation, vandalism concerns, etc. Where there is a clear community preference for no barriers, or for a particular style or scale of noise barrier, this would be given due consideration in the final assessment of what constitutes "reasonable". Community consultation meetings were conducted so that the design and environmental teams could gather information and feedback to inform the design and impact assessment processes.

Reflected Noise from Barriers

Noise barriers are normally constructed from hard materials that reflect, rather than absorb incident sound waves. While noise is reduced on the "shadow" side of a barrier, some noise is reflected away from the face of the barrier back in the direction of the noise source.

In the case of a noise barrier located adjacent to a railway line, it is therefore possible in some instances for noise emissions to be reflected over the top of (or under) the train towards receivers on the opposite side of the track. This effect generally only occurs with high noise barriers where the top of the noise barrier is higher than the top of the train.

Acoustic Treatment of Individual Dwellings

At some locations where the noise trigger levels are exceeded as a result of the project, the feasibility and reasonableness considerations discussed above may indicate that the construction of noise barriers is not feasible, reasonable or cost effective.

At such locations where residual impacts remain after all feasible and reasonable approaches are exhausted, noise mitigation in the form of acoustic treatment for existing individual dwellings may be considered to achieve a reduction in the internal noise environment.

The acoustic treatment of individual dwellings is generally not favoured for reasons including:

- It may not be cost effective if required on a widespread basis.
- It may not be effective for lightweight buildings.
- It provides no acoustic benefit to outdoor areas.
- Mechanical ventilation and/or air-conditioning may also be required, resulting in the need to keep windows closed (and higher energy consumption).

6.3 Reasonable and Feasible Noise Mitigation Options

Exceedances of the noise trigger levels listed in IGANRIP (which require further assessment of reasonable and feasible mitigation measures) are predicted to occur at a number of locations along the length of the Quakers Hill to Vineyard corridor.

The parameters which establish the threshold trigger levels and consideration of potential mitigation measures at existing noise sensitive receivers are the $L_{Aeq(15hour)}$ or L_{Amax} values for residential properties (no exceedances of the $L_{Aeq(9hour)}$ parameter were predicted). The 65 dBA $L_{Aeq(15hour)}$ and 85 dBA L_{Amax} noise levels (depending on whether $L_{Aeq(15hour)}$ or L_{Amax} triggered at a given location) have been adopted as project target levels to be achieved, at the relevant noise sensitive receivers, by adoption of feasible and reasonable mitigation measures (if available) within the rail corridor.

Project specific noise levels will be determined following the final selection of reasonable and feasible noise mitigation and will include consultation with the affected community.

The following paragraphs describe the indicative extent of potential reasonable and feasible noise mitigation measures that may be required in order to achieve the project target noise levels at the IGANRIP trigger level exceedance locations.

Rail Dampers

Based on the assumption of rail dampers being able to achieve a typical noise attenuation of up to 3 dBA, it is predicted that the $L_{Aeq(15\ hour)}$ target noise level of 65dBA will be achieved at all locations where exceedances were predicted (without mitigation). Similarly, noise attenuation from rail dampers would result in a reduction in L_{Amax} noise levels at Manorhouse Boulevard and the Quakers Hill Pre-School, and would result in compliance at all but one location on Bridge Street.

The use of rail dampers to confine the 65 dBA $L_{Aeq(15\ hour)}$ noise contour to the rail corridor at all affected locations is considered reasonable, feasible and cost-effective. Rail dampers have a long service life, low maintenance and no visual impact. Dampers would need to be installed on both rails of both tracks at any given location.

A summary of the potential extent of rail dampers on the Quakers Hill to Vineyard Duplication Project is provided in **Table 28**.

Table 28 Potential Extent of Rail Dampers

Location	Chainage (km)	Length (m) Per Rail	Length (m) Both Rails, Both Tracks
Manor House Blvd	40+900 – 41+350	450	1,800
Bridge Street and Tain Place	43+530 – 43+730	200	800
Quakers Hill Pre-School	40+180 – 40+280	100	400
Total Requirement	-	-	3,000 m

$L_{Aeq(15hour)}$ and L_{Amax} noise contours for Manorhouse Boulevard, Quakers Hill Pre-School, Tain Place and Bridge Street incorporating a 3 dBA reduction in source noise levels due to rail dampers are provided in **Appendix J**

Noise Barriers

Alternatively, noise modelling predicts that noise barriers (1.5 m above rail level) could be used to provide noise reductions similar to those given by rail dampers. It should be noted that a noise barrier 1.5 m above rail height will appear in its built form as a barrier at least 2 m high due to the configuration of the track formation.

The predicted noise levels at adjacent receivers was also modelled to determine the acoustic effectiveness of noise barriers (with nominal 1.5 m height above rail level) being constructed at exceedance locations. The results of the modelling identify that the $L_{Aeq(15\ hour)}$ target noise level of 65 dBA would similarly be achieved at all exceedance locations. Modelling, with a noise barrier at a height of approximately 1.5 m above rail at each exceedance location would result in a reduction in L_{Amax} noise levels at Manorhouse Boulevard and Quakers Hill Pre-School, and would result in compliance at **all** locations on Bridge Street and Tain Place.

$L_{Aeq(15hour)}$ and L_{Amax} noise contours for Manorhouse Boulevard, Quakers Hill Pre-School, Tain Place and Bridge Street incorporating noise barriers located on the rail corridor boundary are provided in **Appendix K.** It is noted that the noise barrier height provided in **Appendix K** is the height above local ground level (eg the track adjacent to Bridge Street and Tain Place is on an embankment, so the noise barrier height of 3 m infers that the noise barrier is located at the bottom of the embankment and the height above rail will therefore be in the order of 1.5 m).

A summary of the potential extent of noise barriers on the Quakers Hill to Vineyard Duplication Project is provided in **Table 29**.

Table 29 Potential Extent of Noise Barriers

Location	Chainage (km)	Length (m)	Height Above Rail (m)
Manor House Blvd	40+930 – 41+320	390	1.5
Bridge Street and Tain Place	43+530 – 43+720	190	1.5
Quakers Hill Pre-School	40+190 – 40+260	70	1.5
Total Requirement	-	650 m	-

While offering similar noise mitigation to that given by rail dampers, barriers have a visual impact and ongoing maintenance issues related to graffiti.

Residual Impact

At this stage in the assessment process, the preferred mitigation option is the use of rail dampers on both tracks adjacent to the affected receivers, with the consideration of architectural treatments (including boundary fence installation or upgrade) at residual receiver locations.

Further technical studies would be required in order to determine whether the full 3 dBA noise reduction is achievable on this line. It is estimated that approximately 3 km of rail dampers would be required (ie 750 m per rail per track). A residual exceedance is predicted at one receiver only and is located on Bridge Street.

It is recognised that property boundary fences located adjacent to the rail corridor, whilst not acoustically designed, may provide an additional level of noise attenuation at some receiver locations. It is likely that the incorporation of new fences, or the upgrading of existing boundary fences, would provide sufficient additional noise benefit (extra to the rail damper noise reduction) such that compliance is achieved at all exceedance locations. However, this option would not always be a feasible or reasonable noise mitigation option due to site specific conditions and constraints.

The consideration of architectural treatments would be subject to feedback from the community consultation process, detailed design and confirmation of the noise levels following post operation noise monitoring to validate predictions.

7 OPERATIONAL VIBRATION ASSESSMENT

7.1 Introduction

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.

Operational Vibration Metrics

The primary metrics used to describe ground-borne vibration from train passbys are as follows:

LVmax the "Maximum Vibration Level" occurring during a train passby event. This is normally defined as the maximum rms vibration level during the train passby averaged over a one second interval. The vibration level is usually expressed in dBV re 10-9 m/s.

VDV the "Vibration Dose Value" is sometimes used to indicate the total vibration exposure during the daytime or night-time period. It is a cumulative measure and indicates the combined effect of all train passby events within the daytime or night-time period.

LAmax(slow) the "Maximum Noise Level" occurring during a train passby noise event, measured with a slow time response.

Use of the LVmax vibration level is advantageous as it allows the variation in individual train passby events to be examined. The LVmax metric can also be compared directly with human response curves to determine whether the train passby vibration levels are likely to be perceived by building occupants.

The VDV metric is the preferred method of determining the total vibration exposure from train passbys at residential and other sensitive receiver locations. The VDV metric is determined from the individual frequency weighted fourth power of the rms acceleration (in m/s^2) for train passby events during a typical daytime and night-time period. The guideline also provides a method for estimating the VDV on the basis of the measured vibration velocity levels.

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 design goals requiring "no vibration", since there will always be some vibration in any environment. It is necessary therefore to set realistic design goals which minimise disturbance and adverse impacts on amenity. The recommended assessment approach is discussed in **Section 7.4**.

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 design goals will be the human comfort design goals, and it is therefore not necessary to set separate design goals 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 design goals will still be the human comfort design goals, and it is therefore not necessary to set separate design goals for this proposal in relation to building damage from railway vibration.

7.2 Ground-Borne Noise from Rail Operations

7.2.1 Overview

Ground-borne noise in buildings adjacent to railway lines is most common in railway tunnel situations where there is an absence of airborne noise to mask the ground-borne noise emissions. Ground-borne noise results from the transmission of ground-borne 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 faintly vibrate and hence to radiate noise (commonly termed "ground–borne noise" or "regenerated noise"). If it is of sufficient magnitude to be audible, this noise has a low frequency rumbling character, which increases and decreases in level as a train approaches and departs the site. This type of noise can be experienced in buildings adjacent to many urban underground rail systems.

7.2.2 Ground-Borne Noise Trigger Levels

Guidance in relation to the operational assessment process for the project is provided in the *"Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects"* (IGANRIP) (DECC - April 2007). Included in the IGANRIP document are trigger levels to be used for assessing the potential impact of ground-borne noise.

A summary of the above-mentioned trigger levels is provided in **Table 30**.

Table 30 Ground-Borne (internal) Noise Trigger Levels

Receiver	Time of Day	Noise Trigger Levels
Development increases existing rail noise levels by 3 dBA or more **and** resulting rail noise levels exceed:		
Residential	Day(7am-10pm)	40 L_{Amax} (slow)
	Night(10pm-7am)	35 L_{Amax} (slow)
Schools, Educational Institutions, Places of Worship	When in Use	40-45 L_{Amax} (slow)

Note 1 The trigger levels are relevant only where ground-borne noise levels are audible and are of a higher level than airborne noise levels from rail operations.

The ground-borne noise trigger levels are considered to be exceeded only if ALL of the following conditions are met:

1. **Overall Noise Trigger Level** - Ground-borne noise levels at residential receiver locations are required to exceed an overall trigger level of 35 dBA $L_{Amax(internal,\ slow\ response)}$ during the daytime or night-time periods.

   The $L_{Amax(internal,\ slow\ response)}$ 35 dBA trigger level has been adopted on the basis that the same train types will be operating during both the daytime and night-time periods and hence the maximum noise levels would be the same independent of the number of trains operating during the daytime or night-time period.

   Other noise sensitive receivers are required to exceed an overall trigger level of 40 dBA to 45 dBA $L_{Amax(internal,\ slow\ response)}$ when in use.

2. **Noise Level Increase** - The $L_{Amax(internal,\ slow\ response)}$ ground-borne noise level is required to increase by 3 dBA or more as a result of the project.

3. **Audibility** - For surface track, the internal ground-borne noise levels should be audible and be higher in level than the internal airborne noise from rail operations.

7.2.3 Ground-Borne Noise Assessment

For surface rail projects, the effect of ground-borne noise tends to be less of an issue than for underground rail projects. This is because the airborne noise emissions in most circumstances are much higher than the ground-borne noise levels. In some situations, however, the ground-borne noise emissions may be audible (for example, at locations where airborne noise emissions are attenuated by a noise barrier, the track is located within a deep cutting or where there are no windows facing the railway corridor).

In accordance with IGANRIP, the ground-borne noise levels must be higher than the airborne noise levels in order to trigger further assessment. The airborne noise mitigation strategy will only be finalised during the detailed design stage of the project (ie following exhibition of the EA and feedback from the community and other relevant stakeholders). It will be at this stage that the locations and extent of mitigation measures (particularly if noise barriers are proposed) will be understood. Therefore, a detailed ground-borne noise assessment would be undertaken at the detailed design stage once the mitigated airborne noise levels are known at the relevant locations.

The ground-borne noise assessment would include the following as a minimum:

- Predict the ground-borne noise levels at each potentially affected receiver location adjacent to project alignment. The predictions would be based upon design inputs such as source-receiver distance, building construction, geological aspects and rail induced vibration levels.
- The predicted ground-borne noise levels for the future scenarios and the relative increases in $L_{Amax(slow\ response)}$ ground-borne noise levels together with a comparison between the predicted airborne noise levels would be utilised in determining the IGANRIP trigger level exceedance locations.

- Additional ground-borne noise measurements would be undertaken at a selection of locations (if any exceedances are predicted) in order to validate the predictions and for use as an additional mitigation design input.

Whilst the application of mitigation measures is not mandatory, it is necessary to investigate the potential requirement for mitigation at potentially affected locations. It is likely that exceedances of the ground-borne noise trigger levels would be noticeable in residential receiver locations. The degree of potential impact is dependent on the extent of the increase in overall ground-borne noise level, as well as the absolute level (loudness) of the ground-borne noise.

7.2.4 Ground-Borne Noise and Vibration Mitigation Measures

A number of measures are currently available for the mitigation of ground-borne noise and vibration levels including resilient ballast mat and resilient under sleeper pads. A brief description of each of each mitigation measure is provided below.

Resilient Ballast Mat

Ballast mats comprise a soft resilient layer, usually made from rubber or other synthetic compounds (typically 40 mm thick) and are placed beneath the track ballast to reduce the vibration transmitted into the surrounding ground. It is anticipated that ballast mat would mitigate vibration levels by up to 5 dB and would provide a corresponding reduction in ground-borne noise levels of 5 dBA to 10 dBA. In order to provide the required attenuation, the ballast mat treatment area is typically extended approximately 15 m to 20 m either side of the receiver location.

Resilient Under Sleeper Pads

Under sleeper pads do not have RailCorp type approval for use in NSW but are used in many locations across Europe for the purpose of reducing ground-borne noise and vibration levels from railway operations.

Under sleeper pads comprise a resilient material that can be retrofitted to existing sleepers or be included in the manufacturing process of new sleepers. Under sleeper pads are bonded to the underside of mono-block concrete sleepers, however various configurations are available including a full or partial sleeper boot that is designed to prevent contact between the ballast and the vertical surfaces of the sleeper (as well as under the sleeper). Current literature suggests that under sleeper pads would provide a reduction in vibration transmission of 6 dB to 10 dB in the 40 Hz to 250 Hz frequency range, with a similar reduction in overall ground-borne noise levels. The under sleeper pads are typically applied to the section of track up to 15 m to 20m either side of the receiver location to provide the required attenuation.

7.3 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.

7.4 Vibration Trigger Levels

As discussed in **Section 7.1** the human comfort design goals for vibration tend to be more stringent than other possible design goals relating to the disturbance of building contents or building damage.

For new or upgraded railway lines, the IGANRIP specifies that a separate guideline, *"Assessing Vibration: a technical guideline"* (DECC 2006) is to be applied. The DECC guideline is based on British Standard BS 6472-1992 and provides vibration trigger levels to minimise the disturbance to building occupants from continuous, impulsive and transient vibration. For train passbys, the DEC guideline classifies vibration levels as being intermittent.

For **intermittent** vibration at residential receiver locations, vibration trigger levels are expressed in terms of the Vibration Dose Value (VDV) during the daytime (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods. The VDV is a measure that takes into account the overall magnitude of the vibration levels during a train passby, as well as the total number of train passbys during the daytime and night-time periods.

For residential receiver locations, the guideline nominates "preferred" vibration dose values of 0.2 $m/s^{1.75}$ (daytime) and 0.13 $m/s^{1.75}$ (night-time) and "maximum" vibration dose values of 0.4 $m/s^{1.75}$ (daytime) and 0.26 $m/s^{1.75}$ (night-time). For this proposal, the more stringent "preferred" vibration dose values have been applied.

For offices, schools, educational institutions and places of worship, the guideline nominates VDVs twice the residential daytime levels (ie, 0.4 $m/s^{1.75}$ during the daytime and night-time periods).

The proposed vibration trigger levels are summarised in **Table 31**.

Table 31 Trigger Levels for Intermittent Vibration

Location	VDV ($m/s^{1.75}$)[1]	
	Day[2]	Night[2]
Residential Properties	0.2	0.13
Offices, Schools, Educational Institutions and Places of Worship	0.4	0.4

Note 1 Vibration Dose Values (VDVs) are based on the "preferred" values in the DEC guideline *Assessing vibration: a technical guideline (2006)*

Note 2 Daytime is 7.00 am to 10.00 pm and Night-time is 10.00 pm to 7.00 am

7.5 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 6** 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 change in vibration level is approximately proportional to 20 x log(speed/80 km/h), however the manual notes that sometimes the speed relationship has been observed to be as low as 10 to 15 x log(speed/80 km/h).

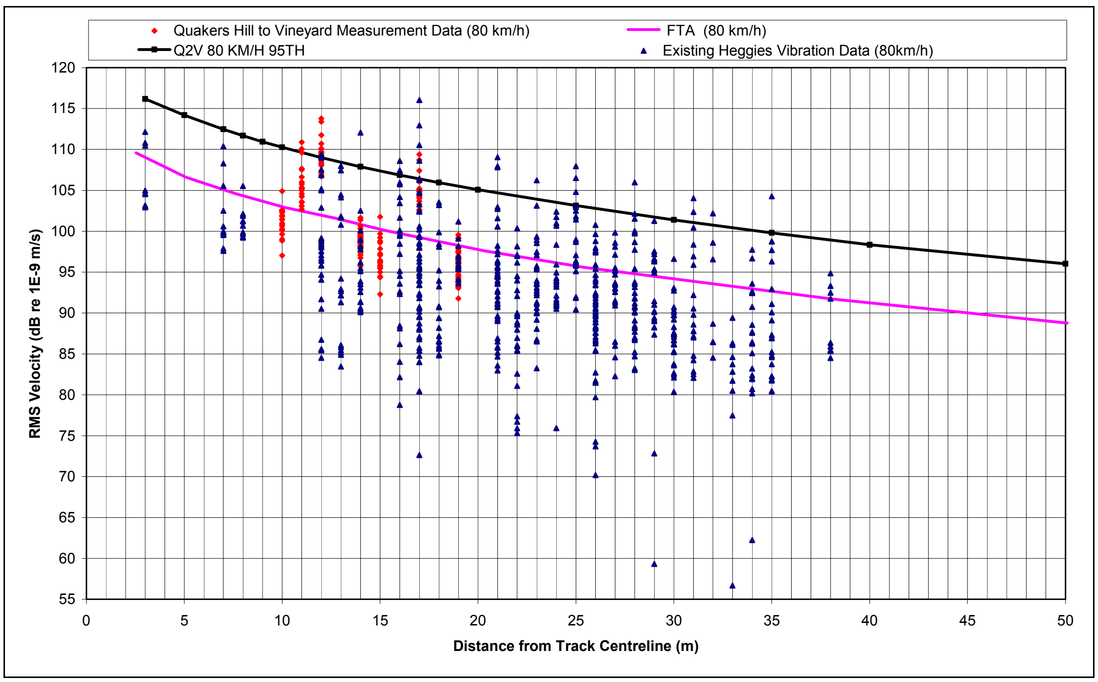
Vibration measurements undertaken adjacent to the Sydney metropolitan network on other projects undertaken by Heggies and the vibration measurements undertaken for the current study are also presented in **Figure 6** for comparison (adjusted for speed to represent the 80 km/h reference). The full results are presented in **Appendix F**. The vibration levels are expressed in terms of the rms vibration velocity level in dB (re 10^{-9} m/s). The measurement data obtained as part of the current study represent the maximum vibration levels observed during each train passby.

From the measurement results at five locations (V1 to V5) adjacent to the Richmond Line (2 measurement distances per location), it is evident that approximately 50% of the measurement results are above the reference line (for rapid transport or light rail vehicles) and 50% are below the reference line. The measurement results therefore appear to correlate well with the FTA reference levels for typical trains.

The upper line in **Figure 6**, labelled "95th Percentile Vibration Levels", represents the typical maximum vibration level and is 7 dB higher than the reference curve. On the basis of the measurement results and similar vibration measurements undertaken on other projects, the difference between the 95th percentile (highest 1 in 20 trains) event and the median event is approximately 7 dB.

The 95th percentile vibration curve, in conjunction with the typical 20 x log(speed/80 km/h) relationship has been used to predict the future vibration levels and the typical change in vibration levels as a result of the proposed upgrade. The 95th percentile vibration curve and the number of train passbys during the daytime and night-time periods have also been used to predict the VDVs at individual receiver locations adjacent to the proposal.

Figure 6 Ground Surface Vibration Levels Versus Distance (adapted from Figure 10-1 in FTA's Transit Noise and Vibration Impact Assessment Report)



Note 1: Vibration velocity depicted in dB re 1x10^{-9} m/s, where 0.01 mm/s is equivalent to 80 dB, 0.1 mm/s is equivalent to 100 dB and 1 mm/s is equivalent to 120 dB.

7.6 Assessment of Ground-Surface Vibration Levels

Section B2.3 of the DECC vibration guideline provides a calculation procedure for determining the Vibration Dose Values (VDV) on the basis of the measured (or predicted) rms vibration velocity levels.

For an individual train passby, the estimated Vibration Dose Value (eVDV) is based on the following formula:

$$eVDV = 0.07 \times V_{rms} \times t^{0.25} \ (m/s^{1.75})$$

Where: t represents the time period for the train passby

V_{rms} is the vibration level of the passby expressed in mm/s.

For the daytime and night-time periods, the eVDV(overall) is based on the following formula:

eVDV(overall) = 0.07 x V_{rms} x (t x N)$^{0.25}$ (m/s$^{1.75}$)

Where: t represents the time period for a representative train passby.

Vrms is the vibration level for a representative train passby

N represents the number of trains within the assessment period (daytime or night-time).

On the basis of the proposed track alignments, the number of passbys and the maximum train speeds on each line, it is possible to calculate the allowable maximum V_{rms} vibration level (on the near track) corresponding to the vibration trigger levels.

The vibration trigger levels of 0.2 m/s$^{1.75}$ daytime and 0.13 m/s$^{1.75}$ night-time would permit vibration levels of up to 0.45 mm/s rms (113 dB) during the day or night at residential properties. For offices, schools, educational institutions and places of worship, the vibration trigger levels would permit V_{rms} vibration levels 6 dB (2 times) higher than residential properties.

The 95th percentile vibration curve in **Figure 6** has conservatively been used, together with the proposed track alignment and train speeds on the nearest line to calculate the V_{rms} vibration levels at each sensitive receiver location adjacent to the proposal.

The V_{rms} vibration levels are predicted to comply with the 0.45 mm/s rms vibration trigger level (corresponding to a VDV of 0.2 m/s$^{1.75}$ during the daytime and 0.13 m/s$^{1.75}$ during the night-time) at all residential locations.

At offices, schools, educational institutions and places of worship, the V_{rms} vibration levels are predicted to comply with the 0.9 mm/s rms (119 dB) vibration trigger level (corresponding to a VDV of 0.4 m/s$^{1.75}$) at all locations.

The DECC vibration guideline indicates that the threshold of perception for most people is approximately 0.14 mm/s rms (103 dB). On the basis of the proposed train speeds and the 95th percentile vibration curve in **Figure 6**, it is anticipated that for some train passbys, vibration levels would be perceptible at buildings located within approximately 23 m from the nearest track (for train speeds of 80 km/h) or at buildings located within approximately 33 m from the nearest track (for train speeds of 115 km/h).

Because of the intermittent nature of the vibration generated by train passbys, the vibration trigger levels in the DECC guideline are set to be above the threshold of perception levels. The DECC guideline notes however that for intermittent vibration, there is a low probability of adverse comment or disturbance to building occupants at vibration levels below the trigger levels that have been adopted for this assessment.

8 BUS INTERCHANGE ROAD TRAFFIC NOISE

8.1 Overview

Schofields and Vineyard Train Stations are to be relocated and upgraded as part of the Quakers Hill to Vineyard Duplication Project. The upgrade of each station will include a new bus interchange and commuter car parking facilities. It is understood that there are currently very few active bus routes operating within the area adjacent to the project alignment and the new commuter car parking facilities represent a significant upgrade in localised road traffic potential (particularly during the morning and evening peak periods).

As such, it is necessary to provide an assessment of the potential noise impacts that may result from the operation of the new bus interchanges and commuter car parks.

All information regarding the bus interchange and associated facilities used within the scope of this assessment has been taken from the PB report *“Review of the Transport and Accessibility Impacts of the Quakers Hill to Vineyard Duplication Technical Paper”* dated October 2008.

Furthermore, the noise assessment is based upon the current available design information relating to the bus interchanges and commuter car parking facilities. The approximate size and locations of the bus interchanges and commuter car parking facilities are presented graphically in the site plan provided in **Appendix B**. A summary of this information is provided below.

Schofields Station

The new Schofields Station will include a bus interchange, commuter car park and a kiss-and-ride and taxi zone on the western side of Railway Terrace. The facility will accommodate a 70 m bus kerb to support up to 4 buses at a time and a 55 m long kiss-and-ride kerb, providing sufficient space for up to 9 kiss-and-ride vehicles and/or taxis at any one time.

The new commuter car park will provide parking facilities on the eastern and western side of New Schofields Station. The western car park would be accessed via Bridge Street. The car park will accommodate up to approximately 230 vehicles.

Vineyard Station

The new Vineyard Station will include a 69 m bus interchange, commuter car park and a 71 m kiss-and-ride and taxi zone on the western side of Railway Parade. The facility will accommodate up to 5 buses and 12 taxis and/or kiss-and-ride vehicles at any one time.

The new commuter car park will be located on the eastern side of Railway Parade. The car park will accommodate up to approximately 240 vehicles (an initial 70 spaces for the Stage 1 car park with up to an additional 170 spaces after the Stage 2 car park is complete).

8.2 Environmental Criteria for Road Traffic Noise

The Environmental Criteria for Road Traffic Noise (ECRTN) presents DECC’s guidelines for road traffic noise assessment. The policy document provides road traffic noise assessment guidelines for proposed road or residential land use developments as well as assessment criteria for other sensitive land uses.

Railway Terrace at Schofields Station and Riverstone Parade at Vineyard Station are regarded as existing collector roads. All other public roads used by buses in the vicinity of the development would be regarded as collector or local metropolitan roads.

The criteria as set out in the ECRTN would apply to noise from all bus movements and other road traffic associated with the development. The relevant categories are reproduced in **Table 32**.

It is noted that the noise criteria presented within the ECRTN noise policy document are guidelines and as such, are non mandatory.

Table 32 Road Traffic Noise Criteria

Type of Development	Criteria		
	Day 7am - 10pm (dBA)	**Night 10pm - 7am (dBA)**	**Where Criteria are Already Exceeded**
Criteria for Residences fronting Redeveloped Collector Roads			
Redevelopment of existing collector road	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may only be achievable through long-term strategies, such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.
Criteria for Residences fronting Local Roads			
Redevelopment of existing local road	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may only be achievable through long-term strategies, such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

Table 33 Road Traffic Noise Criteria for Sensitive Land Uses

Sensitive Land Use	Criteria		
	Day 7 am - 10 pm (dBA)	**Night 10 pm - 7 am (dBA)**	**Noise Mitigation Measures**
Places of worship [1] Proposed school classrooms	$L_{Aeq(1hour)}$ 40 dBA (internal)	N/A	To achieve internal noise criteria in the short term, the most practicable mitigation measures are often related to building or facade treatments. In the medium to longer term, strategies such as exhaust noise from in-service vehicles, limitations on exhaust brake use and restricting access for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium- to long-term strategies apply equally to mitigating internal and external noise levels. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control
Existing school classrooms	$L_{Aeq(1hour)}$ 45 dBA (internal)	N/A	

Sensitive Land Use	Criteria		
	Day 7 am - 10 pm (dBA)	Night 10 pm - 7 am (dBA)	Noise Mitigation Measures
Passive recreation and school playgrounds	Collector / local roads $L_{Aeq(1hour)}$ 55 dBA	N/A	measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5 dBA for new roads and 2 dBA for redeveloped roads or land use development with potential to create additional traffic.

Note1 Same noise level targets apply for night-time 10.00 pm to 7.00 am when the facility is in use

In addition to the L_{Aeq} criteria, the ECRTN includes a discussion on maximum noise levels and sleep disturbance. This concludes that night-time internal L_{Amax} noise levels up to 50 dBA to 55 dBA and one or two events at 65 dBA to 70 dBA would be acceptable. Acceptable external noise levels would be 10 dBA higher for buildings with open windows and at least 20 dBA higher for buildings with alternate ventilation.

It is noted that the assessment criteria as described within the ECRTN is stated as being applicable for a projected timeframe that extends to a period of 10 years immediately after the road opens. As such, an assessment year of 2023 (based on an opening year of 2013) has therefore been used in the following assessment.

8.3 Methodology

The existing and future road traffic volumes for the busiest 1 hour period during the daytime and night-time in the vicinity of each new bus interchange and commuter car park are presented in **Table 34**.

In the absence of any detailed information regarding the expected traffic volumes in the vicinity of the stations for the 2023 assessment year a worst-case assumption has been made that during the busiest 1 hour period each car parking space will be used once.

Existing volumes of vehicles have been taken from Section 5 of the PB traffic report.

The PB traffic report states that a 4 bay bus kerb is proposed at the Schofields Station bus interchange, with a capacity to serve up to 60 buses per hour when assuming a minimum of 4 minutes to load and unload passengers. The bus interchange at Vineyard Station provides space for 5 buses and has a maximum capacity of 75 buses per hour. It is noted that no hourly traffic movements are stated for the 2023 assessment year.

On the basis of the existing bus traffic information contained within the PB report (ie approximately 9 daytime bus services are currently scheduled for Quakers Hill and approximately 7 for Riverstone during the peak daytime hour) it has been assumed that these figures would be replicated at both Schofields and Vineyard Stations on opening in 2013. For the 2023 assessment year a conservative estimate that the opening year bus services would be seen to double in volume has been used. This results in the assumption that 18 services would be apparent during the worst case one hour period for both stations.

During the night-time there is currently a worst-case of approximately 2 bus services per hour at Quakers Hill Station. Again, this figure has been assumed to be replicated at both Schofields and Vineyard Stations at opening and to have doubled in 2023.

Table 34 Road Traffic Volumes

Vehicle Type	Vehicles Per Hour (Busiest Daytime 1 Hour Peak)		Vehicles Per Hour[1] (Busiest Night-time 1 Hour Peak)	
	Existing (2007)	Future (2021)	Existing (2007)	Future (2021)
Schofields Station				
Light Vehicles (Cars)	158	230	95	115
Heavy Vehicles (Buses)	0	18	0	4
Vineyard Station				
Light Vehicles (Cars)	0	240	0	120
Heavy Vehicles (Buses)	0	18	0	4

Note 1 It has been assumed that the busiest hour during the night-time would have 50% of the light vehicle traffic as would be experienced during the busiest daytime hour.

The L_{Aeq} calculation method has been based on the United States Environmental Protection Agency-Report 550/9-74-004 - March 1974 (as modified, based on equations in Appendix A-13 and CORTN amendments). This spreadsheet noise model takes into account the type and speed of the relevant vehicles, distance to receiver and any shielding or reflections.

The road traffic assessment is based on the increase in road traffic due to the project. Heavy vehicle movements (apart from buses) will not increase due to the project, and have therefore not been assessed.

The following assumptions have also been used in the calculations:

- Bus speeds of 40 km/h on approach and departure routes.
- Non bus traffic speeds of 40 km/h during peak hour and 60 km/h at other times.
- The traffic volume was assumed to be shared equally between the northbound and southbound lanes.

8.4 Road Traffic Noise Predictions

Noise from the bus, kiss-and-ride and taxi rank operations at the proposed interchange has been predicted at the potentially most affected receiver locations. Representative L_{Amax} noise levels of 84 dBA and 74 dBA at 7m were used for these calculations for buses and cars respectively.

These noise levels are based on measurement data for bus and light vehicle operations. The assumed number of vehicle movements at each station used for these calculations are provided in **Table 34**. The predicted noise levels for varying offset distances are presented in **Table 35.**

Table 35 Predicted Noise Levels Due to Road Traffic Movements

Distance	Daytime $L_{Aeq(1hour)}$ - dBA[1]			Night-time $L_{Aeq(1hour)}$ – dBA[1]		
	Existing (2007)	Future (2021)	Criterion (Collector/Local)	Existing (2007)	Future (2021)	Criterion (Collector/Local)
Schofields Station						
20 m	56	62	60/55	54	57	55/50
30 m	54	60	60/55	52	55	55/50
40 m	53	58	60/55	50	53	55/50
50 m	51	57	60/55	49	52	55/50
60 m	50	55	60/55	48	51	55/50
70 m	49	54	60/55	47	50	55/50
Vineyard Station						
20 m	0	62	60/55	0	57	55/50
30 m	0	60	60/55	0	55	55/50
40 m	0	58	60/55	0	53	55/50
50 m	0	57	60/55	0	52	55/50
60 m	0	55	60/55	0	51	55/50
70 m	0	55	60/55	0	50	55/50

L_{Aeq} Noise Levels – General Operational Noise

At **Schofields Station**, the future $L_{Aeq(1hour)}$ noise levels during the daytime and night-time are predicted to comply with the criterion for land use developments associated with collector roads at a distance of 30 m or more from the operational zone of the upgraded facilities. It would be likely for the ECRTN to be exceeded at a distance of 20 m and hence consideration of mitigation may be required.

The future $L_{Aeq(1hour)}$ noise levels at this station are predicted to comply with the criteria associated with local roads at a distance of 70 m or more from the operational zone of the upgraded facilities during the daytime and night-time periods. Exceedances of the ECRTN criterion are likely at distances less than 70 m, and hence mitigation may be required for existing receivers within this zone.

It is noted that new light vehicle traffic on Bridge Street would result from the construction of a car park on the western side of New Schofields Station. Assuming that 40 percent of the car park capacity was located on the western side of the station and therefore gained access via Bridge Street $L_{Aeq(1hour)}$ noise levels in the order of 55 dBA with a corresponding increase of up to 5 dBA would be expected. On this basis, further assessment is recommended at the detailed design stage (when car park designs and orientations have been finalised) in order to minimise the potential impacts and determine reasonable and feasible noise mitigation measures if necessary.

A shuttle service between the new and old Schofields Stations will be initiated upon commissioning of Stage 1. The predicted $L_{Aeq(1hour)}$ noise levels as presented in **Table 35** include the potential contribution from this shuttle service.

At **Vineyard Station**, the future $L_{Aeq(1hour)}$ noise levels during the daytime and night-time are predicted to comply with the criterion for land use developments associated with collector roads at a distance of 30 m or more from the operational zone of the upgraded facilities. At a distance of 20 m it is likely that the ECRTN criterion would be exceeded, and hence mitigation may be required for existing receivers within this zone.

The future $L_{Aeq(1hour)}$ noise levels at this station are predicted to comply with the criteria associated with local roads at a distance of 70 m or more from the operational zone of the upgraded facilities during the daytime and night-time periods. Exceedances of the ECRTN criterion are likely at distances less than 70 m, and hence mitigation may be required for existing receivers within this zone.

L_{Amax} Noise Levels at Residential Receivers – Potential for Sleep Disturbance

For residential receivers, L_{Amax} bus noise levels have also been calculated. Exact locations of future potential receivers are currently unknown (as the new Schofields and Vineyard Stations are planned to form the centre of the Schofields and Vineyard Growth Centre Precincts). Therefore external L_{Amax} noise levels were calculated for a variety of offset distances.

The calculations were based on a bus L_{Amax} sound pressure level of 87 dBA at 7 m. Assuming an offset distance of 30 m (typical nearest residential receiver location), the calculated external L_{Amax} noise level is 70 dBA. This would correspond to an internal noise level of 60 dBA, assuming windows open, and less than 50 dBA assuming windows closed.

Whilst this level exceeds the 55 dBA criterion, this represents no change to the “existing” exposure levels of these receivers, given their locations are subject to other heavy vehicle usage such as large trucks.

8.5 Potential Noise Mitigation Measures

A bus interchange facility is not currently in operation at either Schofields Station or Vineyard Station, hence the predicted increase in noise levels (particularly from bus operations) would be noticeable.

It is noted however that heavy vehicle road traffic is not new to this area. Other heavy vehicles such as large trucks regularly utilise nearby roads. On this basis it is unlikely that the L_{Amax} noise levels for the future situation would be greatly affected by the commissioning of the proposed bus interchange.

It is recommended that consultation with the GCC and other relevant stakeholders is undertaken in order to reduce the potential noise related impacts through careful land use planning and operational measures. Land use planning measures may include options such as ensuring that commercial and industrial occupancies face onto the main operational zone of each precinct. Operational measures may include targeted selection of bus routes and the implementation of “quiet” buses into the area.

It would be advantageous if this assessment is revisited once the design development and GCC planning processes are further progressed.

9 CONSTRUCTION ASSESSMENT – AIRBORNE 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 (i.e. A-weighted).

9.2 Construction Noise Goals

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

- **Limiting hours of operation for "noisy" construction work** - The DECC 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 will apply.

Some work is proposed to be carried out on weekends outside of the regular construction work hours during scheduled track possessions, night-time works and engineering hours.

Engineering hours refer to an overnight period when trains are not running (typically midnight to 5 am). Construction noise during these periods is discussed in **Section 9.3** and **Section 9.8.6**.

Unattended background noise monitoring was undertaken during February and March 2007 at nine locations in the vicinity of the proposed construction works between Quakers Hill and Vineyard. The full results of the unattended noise monitoring are provided in **Appendix D**.

The background noise data has been segregated into the relevant times of day to assist in setting noise criteria for construction noise emissions. The L_{A90} noise levels are the rating background noise levels (RBL), determined using the procedures set out in the DECC's Industrial Noise Policy.

The noise logging results have been used to estimate the L_{A90} background noise levels at locations throughout the proposed construction works for the purpose of determining the relevant L_{A10} construction noise objectives. **Table 36** presents the relevant L_{A10} construction noise objectives for nearby receiver groups, based on the L_{A90} background noise levels at the nearest equivalent unattended noise monitoring location.

Work areas and associated representative receiver groups for use in the construction noise model were selected on the basis of the information provided by TIDC.

Table 36 Summary of L_{A10} Noise Objectives for Nearby Receiver Groups

Work Area	Location of Work Area	Description of Nearest Receiver Locations to the Proposed Construction Works	L_{A10} Construction Noise Objective (dBA)[1] RBL+5 dBA		
			Day	Evening	Night
1	Quakers Hill Station (40.2 km)	Quakers Hill Pre-School (Daytime)	50	N/A	N/A
		Quakers Hill Child Care Centre (Daytime)	50	N/A	N/A
		The Quakers Inn (Commercial - RBL +10 dBA)	55	55	47
2	Manorhouse Boulevard (40.9 km)	25 Manorhouse Boulevard	38	41	37
		27D Manorhouse Boulevard			
		33 Manorhouse Boulevard			
3	Manorhouse Boulevard (41.1 km)	47 Manorhouse Boulevard	38	41	37
		55 Manorhouse Boulevard			
		63 Manorhouse Boulevard			
4	New Schofields Station (42.9 km)	217 Railway Terrace	41	41	38
		209 Railway Terrace			
		159 Bridge Street			
5	Old Schofields Station (43.8 km)	123 Railway Terrace	49	45	43
		82 Bridge Street			
		93 Bridge Street			
6	Westminster Street Overbridge (44.25 km)	2A + 2B Westminster Street	41	41	38
		21 Railway Terrace			
		44 Bridge Street			
7	Riverstone Station (45.96 km)	1 Richards Avenue	46	42	36
		4 West Parade			
		17 Richards Avenue			
8	Riverstone Meatworks	2 Bourke Street	43	39	35
		80 Riverstone Parade			

Work Area	Location of Work Area	Description of Nearest Receiver Locations to the Proposed Construction Works	LA10 Construction Noise Objective (dBA)[1] RBL+5 dBA		
			Day	Evening	Night
	(46.5 km)	76 Riverstone Parade			
9	New Vineyard Station (48.86 km)	6 Ashford Road	45	39	35
		21 Norwood Road			
		22 Ashford Road			
10	Old Vineyard Station (49.23 km)	8 Dulwich	45	39	35
		12 Dulwich			
		2 St James Road			

Note 1: The LA10 construction noise goals are applicable at the nearest and/or most affected residential receiver or other noise sensitive receiver location.

9.3 Construction Planning

Overall Planning

The construction scenarios presented in this report are based on the concept construction strategies discussed in the *Preliminary Concept Design Report (November 2007)* and the *Preliminary Constructability Review (November 2007)*.

Working Hours

The majority of the works can be carried out during standard construction hours:

- Monday to Friday between 7 am and 6 pm.
- Saturday between 8 am and 1 pm.
- No works on Sundays or public holidays.

Track Possessions

A track possession is a planned shutdown of a section of the network generally taking place on a weekend between midnight on Friday and 4 am on Monday. Possessions are required where works cannot be safely undertaken due to their proximity to the existing rail lines or where there would be a risk that the works may adversely affect the existing operating lines.

It is expected that up to 30 weekend track possessions may be utilised during the construction period. In addition, it is anticipated that approximately 4 closedowns (possessions with a duration of 1-2 weeks) would be utilised for this project.

Out of Hours Works

In addition to the planned track possessions, other construction works will be required outside of normal construction hours. These works may be undertaken during the evening (6 pm to 10 pm) and night-time (10 pm to 7 am) or during engineering hours. Engineering hours refer to an overnight period when trains are not running (typically midnight to 5 am).

Typical activities that would require out of hours works would include:

- Works within the live rail zone, or works with the potential to impact train operations (e.g. excavations in embankments, works around signals or power)
- Road works associated with bridge construction and modification.

- Bridge demolition and reconstruction of piers. These works would include activities such as abutment piling works, and demolition of bridge decks and abutment walls.
- Under track drainage works.
- Pre-possession works that are to occur during engineering hours may include activities such as the installation of temporary rail infrastructure such as signalling,

9.4 Compound Locations and Descriptions

Currently 11 construction compounds, either within or adjacent to the rail corridor, are proposed. The compound locations are identified on aerial photographs provided in **Appendix B**. The proposed compounds and locations are described in **Table 37**.

Table 37 Site Compound Locations

Compound		Timing	Description
1	Footbridge East	Stage 1	Located opposite Lalor St, Quakers Hill. The site will consist of 6 demountable buildings, parking for 6 light vehicles, laydown area and storage. Peak staff capacity will be 20.
2	Footbridge West	Stage 1	Located between Quakers Hill Inn and Douglas Rd. The site will be used as a lay-down area.
3	QH Parkway East	Stage 1	Located within Oddy Park, Quakers Hill. The site will consist of 6 demountable buildings, parking for 6 light vehicles, lay-down area and storage. This will be a major access point to the work site. Peak truck movements will be 3-4 per hour. Peak staff capacity will be 20.
4	QH Parkway West	Stage 1	Located north of Quakers Hill Inn. The site will consist of a lay-down area and storage.
5	Seldon St South	Stage 1	Located within the fields to the south of Seldon St, Quakers Hill. The site will consist of 4 demountable buildings, parking for 6 light vehicles, lay-down area and storage. Peak staff capacity will be 20.
6	RLA Project Office	Stage 1	Located adjacent to the new Schofields Station site. The site will consist of 20 demountable buildings, parking for 100 light vehicles, lay-down area and storage. This will be a major access point to the work site. Peak truck movements will be 3-4 per hour. Peak staff capacity will be 100.
7	Old Schofields	Stage 2	Located in the car park of the old Schofields Station (once station is demolished). The site will consist of 6 demountable buildings, parking for 20 light vehicles, lay-down area and storage. Peak staff capacity will be 20.
8	Westminster	Stage 2	Located adjacent to Westminster Bridge. The site will consist of 5 demountable buildings, parking for 10 light vehicles, lay-down area and storage. This will be a major access point to the work site. Peak truck movements will be 3-4 per hour. Peak staff capacity will be 10.
9	Riverstone	Stage 2	Located to the west of Riverstone Station. The site will consist of 10 demountable buildings, parking for 40 light vehicles, lay-down area and storage. Peak staff capacity will be 40.
10	Meatworks	Stage 2	Located within Roadmaster property. The site will consist of 20 demountable buildings, parking for 100 light vehicles, lay-down area and storage. This will be a major access point to the work site. Peak truck movements will be 3-4 per hour. Peak staff capacity will be 100.
11	Vineyard	Stage 2	Located adjacent to the new Vineyard Station. The site will consist of 10 demountable buildings, parking for 30 light vehicles, lay-down area and storage. This will be a major access point to the work site. Peak truck movements will be 3-4 per hour. Peak staff capacity will be 40.

Assessment of Site Compound Noise Emissions

Five construction compound noise modelling scenarios have been developed on the basis of the information supplied in **Table 37**. The noise modelling scenarios conservatively assess the maximum number of vehicles and plant that may operate simultaneously within a particular compound during a representative 15 minute period during the daytime, evening or night-time periods.

The following list describes five categories of site compounds and the items of plant and or vehicles assumed within the noise modelling scenario.

- Scenario 1 – Area dedicated for storage and lay-down area only with no demountable buildings (One truck and one backhoe).
- Scenario 2 – General storage and lay-down area with 4 to 6 demountable buildings and a peak staff capacity of up to 20 (One truck, one backhoe and two generators).
- Scenario 3 – General storage and lay-down area with 10 demountable buildings with a peak staff capacity of up to 40 (One truck, one backhoe and four generators).
- Scenario 4 – Major access point to the work site with 10 demountable buildings. Anticipated peak truck movements of 3 to 4 per hour and a peak staff capacity of up to 40 (Two trucks, one backhoe and four generators).
- Scenario 5 – Major access point to the work site with 20 demountable buildings and a peak staff capacity up to 100 (Three trucks, two backhoes and four generators).

The compound noise modelling has been undertaken using spreadsheet calculations for this assessment. The predicted noise levels have been calculated for "typical" activities and the results are presented in **Table 38**.

Table 38 Predicted Site Compound Noise Levels

Scenarios	$L_{A10(15min)}$ Predicted Site Compound Noise Level (dBA)				
	10 m	**20 m**	**30 m**	**40 m**	**50 m**
1	78	72	68	66	64
2	80	74	70	68	66
3	81	75	72	69	67
4	82	76	72	70	68
5	83	77	74	71	69

Potential Noise Mitigation Measures

It is recommended that the compound buildings be erected in locations that provide acoustical shielding to the surrounding residents as far as practicable. It also recommended that hoardings be erected on site compound boundaries where they would provide acoustical shielding to surrounding residents.

9.5 General Approach to Noise Modelling

SoundPLAN V6.4 software was used for modelling the construction noise. The model includes ground topography, buildings and representative noise sources as discussed below. At the relatively small distances between construction sites and receivers, weather effects have little influence on noise propagation and hence neutral meteorological conditions were assumed.

The calculated construction noise levels will inevitably depend on the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. Predicted noise levels have been calculated for both "typical" construction activities and "worst case" activities, assuming plant operating in the area closest to the respective receivers.

In practice the noise levels will vary due to the fact that plant and equipment will move about the work sites and will not all be operating at the same time. In some cases, reductions in noise levels will occur when plant are located in cuttings or behind embankments or buildings.

9.6 Typical Sound Pressure Levels

Sound pressure levels for typical items of plant required to carry out the works are listed in **Table 39**. These noise levels are representative of modern plant operating with noise control measures in good condition.

Table 39 Sound Pressure Levels for Plant Items

Item	Typical Plant Type	Noise Level at 7 m (dBA)	
		Typical Maximum Level	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 Agitator	-	80	78
Ballast Regulator	-	96	93
Ballast Tamper	-	96	93
Franna Crane	-	85	80
400t Crane	-	85	80
100t Crane	-	85	80
Road Profiler	-	83	82
Asphalter	-	83	82
Auger Piling Rig	-	85	82

Item	Typical Plant Type	Noise Level at 7 m (dBA)	
		Typical Maximum Level	Noise Level for Modelling (L_{A10})
Track Laying Machine	-	98	90
Ballast Tamper	-	96	88

9.7 Construction Noise Modelling Scenarios

On the basis of the proposed construction program and methodology it is anticipated that construction noise levels would be highest during the following scenarios.

The modelled construction scenarios are indicative only and are intended to identify the likelihood of any significant noise impacts that will need to be considered in further detail at a later design stage. Construction noise has been modelled at representative receivers in close proximity to the major construction zones. It is understood that certain works, such as track laying, overhead wiring installation and excavation will not be constrained to one construction zone. The potential noise impacts of such activities are dealt with in **Section 9.8.2**.

It is also understood that piling works will form an integral part of the retaining wall construction process. An indicative retaining wall construction scenario located away from other major construction zones has been modelled. The scenario is described below under Work Area 3.

Piling, Bridge and Station Works

- **Work Area 1 – Quakers Hill Station (40.2 km)**
  - **Scenario 1: Pedestrian Footbridge Construction (Including lift and stairs).** This scenario involves the use of cranes, semi-trailers, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.
  - **Scenario 2: Removal of Level Crossing.** This scenario involves the use of semi-trailers, generators, concrete saws, jackhammers, excavators and backhoes.
- **Work Area 2 – Manorhouse Boulevard (40.9 km)**
  - **Scenario 1: Culvert Replacement**. This scenario involves the use of cranes, semi-trailers, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.
- **Work Area 3 – Manorhouse Boulevard (41.1 km)**
  - **Scenario 1: Retaining Wall Construction (Piling).** This scenario involves the use of pile boring rigs, backhoes, semi trailers, generators, concrete pumps, concrete agitators and franna cranes.
- **Work Area 4 – New Schofields Station (42.9 km)**
  - **Scenario 1: Platform Construction (Including Footbridge).** This scenario involves the use of cranes, semi-trailers, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.
- **Work Area 5 – Old Schofields Station (43.8 km)**
  - **Scenario 1: Demolition of Existing Platform and Pedestrian Level Crossing.** This scenario involves the use of semi-trailers, generators, concrete saw, rock breakers, jackhammer, excavator and backhoe.

- **Work Area 6 – Riverstone Station (45.96 km)**
  - **Scenario 1: Overbridge Platform Construction (Including Footbridge).** This scenario involves the use of cranes, semi-trailers, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.
- **Work Area 7 – Riverstone Meatworks (46.5 km)**
  - **Scenario 1: Removal of Level Crossing.** This scenario involves the use of semi-trailers, generators, concrete saws, jackhammers, excavators and backhoes.
- **Work Area 8 – New Vineyard Station (48.46 km)**
  - **Scenario 1: Platform Construction (Including Footbridge).** This scenario involves the use of cranes, semi-trailers, generators, concrete saws, jackhammers, concrete trucks and concrete pumps.
- **Work Area 9 – Old Vineyard Station (49.23 km)**
  - **Scenario 1: Demolition of Existing Platform.** This scenario involves the use of semi-trailers, generators, concrete saws, rock breakers, jackhammers, excavators and backhoes.

Corridor Earthworks and Track Works

The following three scenarios are representative of typical activities and plant during track works. The duration of noisy work in close proximity to individual receivers will only be a relatively small proportion of the overall project duration as the construction works will move progressively along the rail corridor.

- **Scenario 1: Excavation and Compaction.** This scenario involves the widening and modification of embankments and cuttings and general earthworks in preparation for the laying of new track. Typical plant items may include excavators, graders, dump trucks, front end loaders, vibratory rollers, dewatering pumps and water carts. Construction of new retaining walls and drainage structures will form part of this scenario. It is anticipated that bored piling will be used to form the footings of the retaining walls. Vibratory sheet piling or rock breaking could potentially be required, subject to conditions found on site, but will not be typical activities in this scenario.
- **Scenario 2: Over Head Wiring (OHW) and Signalling.** This scenario involves the installation of over head wiring and supporting structures. Typical plant items include excavators, boring rigs, concrete mixers, mobile cranes and elevated work platforms.
- **Scenario 3: Track Laying.** This scenario involves the laying of new track. Typical plant items include work trains, track laying machines, tampers, ballast regulators, generators, mobile cranes, dump trucks, rail dump carts and rail grinders. Under normal conditions, only one of these machines would be operated at a time in the immediate vicinity of any given residence.

9.8 Predicted Construction Noise Levels

9.8.1 Bridge and Station Construction

Typical offset distances between the construction sites and residential receivers range from 10 m to 200 m.

Indicative construction noise levels at representative sensitive receiver locations in the vicinity of bridge and station work sites are shown in **Table 40**. The predicted LA10 noise levels at the nearest locations exceed the construction noise goals by clear margins (at some locations by more than 40 dBA). In order to reduce the potential impact of the construction noise emissions, the noise mitigation and management measures in **Section 9.9** should be implemented, where feasible and reasonable.

The highest noise levels are predicted to generally occur during piling works. This is due to the operation of noisier items such as the rock breaker and impact piling rig (if required). These works will generally be limited to daytime use only, including weekend track possessions. Where possible, bored piling will be used in lieu of sheet piling in order to reduce noise intrusion into the surrounding community. Indicative noise levels at sensitive receiver locations in the vicinity of bored piling operations are shown in **Table 40**.

Due to the close proximity of residential receivers to the works, the construction noise objectives will be exceeded at many locations along the corridor. This is relatively common on major infrastructure projects, particularly where there is no opportunity to provide a large buffer zone.

It is recognised that such exceedances may be of concern for surrounding residents and particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies. For new track sections, construction works will be limited to daytime hours only wherever possible to reduce potential impacts.

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 9.9**.

Table 40 Predicted LA10 Construction Noise Levels – Piling, Bridge and Station Works

Work Area & Scenario	Description of Nearest Receiver Locations to the Proposed Construction Sites	Distance from Site	LA10 Daytime[1] Construction Noise Objective (dBA)	Predicted LA10 Daytime Construction Noise Levels (dBA)[2]
1.1 Quakers Hill Station (40.2 km)	Quakers Hill Pre-School	37 m	50	66 - 80
	Quakers Hill Child Care Centre	80 m		61 - 74
	The Quakers Inn (Commercial)	115 m		57 – 70
1.2 Quakers Hill Station (40.2 km)	Quakers Hill Pre-School	37 m	50	67 - 80
	Quakers Hill Child Care Centre	80 m		61 - 74
	The Quakers Inn (Commercial)	115 m		58 - 70
2.1 Manorhouse Boulevard (40.9 km)	25 Manorhouse Boulevard	50 m	38	70 - 76
	27D Manorhouse Boulevard	20 m		83 - 88
	33 Manorhouse Boulevard	60 m		65 - 72
3.1 Manorhouse Boulevard (41.1 km)	47 Manorhouse Boulevard	35 m	38	67 - 72
	55 Manorhouse Boulevard	10 m		83 - 85
	63 Manorhouse Boulevard	40 m		74 - 75
4.1 New Schofields Station (42.9 km)	217 Railway Terrace	80 m	41	65 - 71
	209 Railway Terrace	70 m		60 - 67
	159 Bridge Street	210 m		43 – 47
5.1 Old Schofields	123 Railway Terrace	50 m	49	65 - 75

Work Area & Scenario	Description of Nearest Receiver Locations to the Proposed Construction Sites	Distance from Site	LA10 Daytime[1] Construction Noise Objective (dBA)	Predicted LA10 Daytime Construction Noise Levels (dBA)[2]
Station (43.8 km)	82 Bridge Street	30 m		70 - 76
	93 Bridge Street	10 m		81 - 84
6.1 Riverstone Station (45.96 km)	1 Richards Avenue	20 m	46	70 - 75
	4 West Parade	70 m		64 - 70
	17 Richards Avenue	25 m		55 - 57
7.1 Riverstone Meatworks (46.5 km)	2 Bourke Street	100 m	43	61 - 69
	80 Riverstone Parade	25 m		68 - 78
	76 Riverstone Parade	50 m		65 - 74
8.1 New Vineyard Station (48.86 km)	6 Ashford Road	90 m	45	58 - 67
	21 Norwood Road	160 m		51 – 55
	22 Ashford Road	190 m		49 - 52
9.1 Old Vineyard Station (49.23 km)	8 Dulwich Road	110 m	45	55 - 62
	12 Dulwich Road	130 m		53 - 58
	2 St James Road	120 m		45 - 53

Note 1 Daytime construction noise objectives are presented in this table as most works will occur during this time period. Night-time noise objectives are listed in **Table 36** and are typically 10 dBA lower than the daytime objectives. Out of hours works are discussed further in **Section 9.3** and **Section 9.8.6**.

9.8.2 Corridor Earthworks and Track Works

The offset distances between the earthworks and track works and the nearest receivers range between 10 m and 200 m.

Noise emissions from the proposed track works, including earthworks, overhead wiring, signalling and track laying will progressively move along the railway corridor in stages, such that most residential receivers will 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 construction noise levels in **Table 41** represent the predicted LA10 noise levels during operation of typical plant items.

Table 41 Noise Levels during Corridor Earthworks and Track Construction versus Offset Distance from Receiver Locations

Offset Distance to Receiver (m)	L_{A10} Track Construction Noise Level (dBA)		
	Earthworks [1] (Excavation and Compaction)	Overhead Wiring, Signals and Cable Duct Installation	Track Installation
10	82	80	90
20	79	77	84
30	76	74	81
40	74	72	79
100	66	64	73

Note 1 Rock breakers will generally not be required for excavation works, as the cuttings are predominantly in clay and shale. If required, noise from a rockbreaker would be 10 dBA to 15 dBA higher than predicted for earthworks (Although this may be reduced by shielding if the works are being undertaken at the base of a cutting).

Although some track construction activities will have only a short duration at any given location, the long term criteria have been applied for this assessment, in recognition of the overall duration of the project.

For short periods of time, criterion exceedances of over 20 dBA and up to 40 dBA are likely at the nearest receivers, with the greatest exceedances occurring during the track laying activity. Noise levels during other activities are predicted to be 5 dBA to 10 dBA lower, but may occur over a longer period of time than the track works. In all cases, the predicted noise levels will not be sustained. Lower noise levels will occur when the plant is located away from receivers or is operating on a less noise intensive task.

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 9.9**.

9.8.3 On-Site Truck and Vehicle Movements

The maximum (L_{Amax}) noise emission of a typical truck in good condition is in the order of 83 dBA at 7 m. Skidsteer loaders generate similar noise levels. This level applies only when the truck engine is at high load. The $L_{A10(15minute)}$ or average maximum noise levels would always be somewhat lower. Depending on the number of trucks operating, their positions and the general intensity of movements, the $L_{A10(15minute)}$ noise levels would be approximately 5 dBA or more lower than the L_{Amax} levels.

Noise sources associated with truck operations also include the short-term noise events of material being dumped into stockpiles or into the trucks. While trucks move about on worksites, nearby receivers tend to associate truck noise emission with that of other construction equipment on the site. Hence, representative truck noise sources have been included in each of the site noise models.

Spoil will be re-used where possible, but precise details of spoil management and re-use plans are not known at this early stage. A Spoil Management Plan will be developed as part of the detailed construction design process, and will also include a Traffic Noise Impact Assessment.

9.8.4 Noise from Construction Traffic on Local Roads

On the local roads immediately adjacent to the site, the community may associate truck movements with the Quakers Hill to Vineyard Duplication 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.

Access to work areas would be provided by the existing vehicle gates along the rail corridor. Some additional access gates may be added where streets or reserves adjoin the rail corridor or some existing gates could be relocated. Construction traffic will be dependent on the active work areas and minimising the number of days of heavy vehicle traffic at each access point.

Where possible, construction traffic will utilise major roads, including Westlink M7, Quakers Hill Parkway, Riverstone Parade, Railway Terrace and Windsor Road, however to access most worksites, it is likely that construction vehicles will need to travel short distances on local roads.

The EPA (now part of DECC) published the Environmental Criteria for Road Traffic Noise 1999 (ECRTN) and are appropriate for assessing road traffic noise. The criteria for arterial, collector and local roads are set out in **Table 42**.

Table 42 DEC Road Traffic Noise Criteria

Development	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Land use development with potential to create additional traffic on existing freeways / arterials	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
Land use development with potential to create additional traffic on collector roads	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA
Land use development with potential to create additional traffic on local roads	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA

Where L_{Aeq} noise levels already exceed the above targets, a 2 dBA increase in the overall traffic noise levels is normally regarded as an alternative target in order to maintain the general acoustic amenity of the area. In order to achieve this, it is necessary for the noise from the additional traffic to be at least 2 dBA below the existing traffic noise level.

Truck Noise Assessment

During the bulk earthworks stage, a total of 4 to 8 truck movements per hour are expected in busy periods, with lower numbers during quieter periods.

A summary of the predicted noise contribution of these trucks at various offset distances is presented in **Table 43**.

Table 43 Predicted Off Site Truck Noise

Distance	LAeq(1hour) Sound Pressure Level (dBA)			
	Predicted (Daytime) 2	Criteria (Daytime)1	Predicted (Night-time) 2	Criteria (Night-time) 1
10 m	57	55	51	50
20 m	54	55	48	50
30 m	52	55	46	50
40 m	50	55	44	50
50 m	49	55	43	50

Note 1 ECRTN local road criteria as shown in **Table 42**.

Note 2 2 trucks per hour were assumed for the night-time scenario and 8 trucks per hour were assumed for the daytime scenario.

The predictions show that off site truck noise levels would comply with the relevant road traffic noise criteria at offset distances greater than 20 m. Whilst individual truck noise events will be clearly perceptible, the L_{Aeq} assessment indicates that they will not have a major impact on the acoustic amenity of this area.

The following mitigation measures are recommended in order to minimise the risk of exceeding the criteria at residential receiver locations, particularly where the offset distance is 20 m or less:

- All trucks to have mufflers and any other noise control equipment in good working order.
- Truck drivers are to avoid heavy acceleration and braking as far as is practicable.
- Truck drivers are to avoid compression braking as far as is practicable.
- Speed is to be minimised as far as is practicable.
- Truck movements are to be restricted to the daytime period to the furthest extent possible.

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. The finalised construction traffic arrangements will be reviewed during the CNVMP assessment.

9.8.5 Increase in Road Traffic Noise Due to Traffic Diversions during Construction

An increase in local traffic volume of 80% corresponds to a noise increase of approximately 2.5 dBA for a given receiver, assuming other factors such as speed and percentage of heavy vehicles remains the same.

The DECC's ECRTN (Environmental Criteria for Road Traffic Noise) recommends that developments creating additional traffic on existing roads should be designed in such a way as to not increase the existing road traffic noise levels by more than 2 dBA.

9.8.6 Works Outside of Normal Construction Hours

As discussed in **Section 9.3**, there are a number of work activities that will be required to be undertaken outside of normal construction hours.

Where out of hours work is required, the works should be managed to avoid any unnecessary noise emission. Where programming permits, noise intensive activities should be scheduled during the daytime period.

For out of hours work, the more noise intensive activities would potentially exceed the night-time construction goals by significant margins. Activities such as rock breaking, pavement sawing and ballast tamping/regulating should therefore be scheduled during daytime hours, where possible.

The following would need to be undertaken in relation to out of hours work:

- A detailed out of hours noise impact assessment, would be required to be undertaken by the contractor when the specifics of the work type, sites and timing are known.
- Nearby sensitive receivers should be provided with appropriate notice of all out of hours work.
- The noisiest construction activities should take place before 10:00 pm wherever feasible, and the contractor should endeavour to undertake as much preparation work as feasible during the day-time period.
- The identification of feasible and reasonable mitigation measures should be identified and implemented in accordance with TIDC's *Construction Noise Strategy (Rail Projects)*.

9.8.7 Occupational Health and Safety Noise Criteria

There is also a requirement to protect the occupational health and safety (OHS) of passers by, patrons and staff during construction activities for the subject works.

Noise induced hearing loss generally occurs when individuals are exposed to excessive noise levels for extended periods of time (normally several years) or when exposed to extremely loud noise levels for a short period of time.

The Occupational Heath and Safety Regulation 2001 states, in Section 49, that:

(1) An employer must ensure that appropriate control measures are taken if a person is exposed to noise levels that:

(a) exceed an 8-hour noise level equivalent of 85 dB(A), or

(b) peak at more than 140 dB(C).

It is generally possible to maintain construction noise levels below these limits, however the specific measures required to achieve this need to be determined and documented during the process of preparing the Construction Noise and Vibration Management Plan (CNVMP).

9.9 Potential Noise Mitigation

In view of the predicted noise criteria exceedances during construction, noise mitigation is recommended to minimise the impact of construction noise at nearby residential receivers.

It will be necessary for the contractor(s) to prepare and implement a site-specific Construction Noise and Vibration Management Plan (CNVMP) including consideration of the measures listed below and any other initiatives identified to minimise the noise impacts.

- Noise intensive construction works would be carried out during normal construction hours wherever practicable. Where works involving the operating line need to be carried out during track possessions, noise intensive activities should be scheduled to occur during the daytime, where possible.
- Quietest available plant suitable for the relevant tasks would be used.
- The duration of noise intensive activities would be minimised insofar as possible.
- Where feasible and reasonable, site hoardings or temporary noise barriers would be used to provide acoustic shielding of noise intensive activities.
- Rock breakers (if required) would be of the "Vibro-silenced" or "City" type, where feasible and reasonable.
- Activities resulting in highly impulsive or tonal noise emission (eg rock breaking) would 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) or when otherwise approved.
- Noise awareness training would be included in inductions for site staff and contractors.
- Noise generating plant would be orientated away from sensitive receivers, where possible.
- Notification would 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 would 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 39**.
- Deliveries would be carried out within standard construction hours, except as directed by the Police or RTA.
- Non-tonal reversing beepers or equivalent would be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
- Trucking routes to be via major roads, where possible.
- Trucks would not be permitted to queue near residential dwellings with engines running.

As discussed in **Section 9.8.6**, for work outside of normal construction hours:

- A detailed construction noise impact assessment when the specifics of work type, sites and timing are known.
- Council and other stakeholders to be provided with appropriate notice of all out of hours work.
- The noisiest construction activities to take place before 10:00 pm wherever feasible, and endeavour to undertake as much preparation work as feasible in the day-time hours.
- The identification of feasible and reasonable mitigation measures should be identified and implemented in accordance with TIDC's Construction Noise Strategy for Rail projects.

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 ASSESSMENT – GROUND-BORNE NOISE

10.1 Ground-borne Noise Goals

Ground-borne or regenerated noise in buildings is caused by the transmission of ground-borne vibration rather than the direct transmission of noise through air. Vibration may be generated by construction equipment such as rockbreakers and transmitted through the ground into the adjacent building structures. After entering a building, this vibration causes the walls and floors to faintly vibrate and hence to radiate noise.

Attenuation with distance occurs due to the geometric spreading of the wave front and due to other losses within the ground material, known as "damping". In addition, losses occur with the transfer of vibration from floor-to-floor within buildings (typically 2 dBA per floor).

TIDC's *Construction Noise Strategy (Rail Projects)* references an acceptable target objective during the night-time period of $L_{Aeq(15minute)}$ 35 dBA in residences with a maximum permissible level of 40 dBA applicable providing the proponent or contractor is able to demonstrate that Best Available Technology (BAT) and Best Management Practices (BMP) are being employed to minimise emission levels.

10.2 Ground-borne Noise Assessment

The major source of ground-borne noise during the construction phase for this project would result from excavation using rockbreakers and soil compaction using vibratory rollers. Typical regenerated noise levels within a building from heavy, medium and light rockbreakers, operating in hard sandstone, are presented in **Table 44.**

Table 44 Regenerated Noise Levels versus Distance

Equipment	LAmax Regenerated Noise Levels (dBA) at Given Distances							
	10 m	20 m	30 m	40 m	50 m	65 m	85 m	110 m
Heavy Rockbreaker (eg 1600 kg)	75	62	55	50	45	40	35	30
Medium Rockbreaker (eg 900 kg)	72	59	52	47	42	37	32	27
Light Rockbreaker (eg 300 kg)	69	56	49	44	39	34	29	24

Note: These ground –borne noise levels (inside buildings) are indicative only. Actual levels are dependent on factors such as geotechnical conditions, building construction, machine intensity etc.

10.3 Predicted Regenerated Noise Levels at Nearby Receivers

The typical L_{Amax} noise levels versus distance, in conjunction with the offset distance between the site and the receivers, have conservatively been used to predict the $L_{Aeq(15minute)}$ regenerated (ground floor) noise levels. The nearest receivers to any site activity are generally no closer than 10 m to 20 m. At these locations the predicted regenerated noise levels are expected to be approximately 56 dBA to 69 dBA (for a light 300 kg rockbreaker) and 62 dBA to 75 dBA (for a heavy 1600 kg rockbreaker). This represents a potential exceedance of up to 35 dBA of the 40 dBA $L_{Aeq(15minute)}$ regenerated noise criterion.

In light of the above, at locations close to sensitive receivers, it is recommended that only light rockbreakers (approximately 300 kg) and light vibratory rollers be used where possible.

11 CONSTRUCTION ASSESSMENT - GROUND-BORNE VIBRATION

11.1 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.

11.2 Construction Vibration Goals

The DECC's *"Assessing Vibration: a technical guideline"* is based on the guidelines contained in British Standard BS 6472-1992. BS 6472 refers only to the human comfort criteria for vibration, hence the vibration due to construction has been assessed in accordance with the German Standard DIN 4150 Part 3-1999 and British Standard BS 7385 Part 2-1993. These are the standards normally used for assessing the risk of vibration damage to structures.

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 (i.e. those unlikely to cause resonance or fatigue), DIN 4150 offers the criteria shown in **Table 45**. These are maximum levels measured in any direction at the foundation or in the horizontal axes, in the plane of the uppermost floor.

Table 45 DIN 4150 - Structural Damage - Safe Limits for Short Term Building Vibration

Group	Type of Structure	Peak Particle Velocity (mm/s)			
		At Foundation			Plane of Floor of Uppermost Storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz [1]	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 at 10 Hz increasing to 40 at 50 Hz	40 at 50 Hz increasing to 50 at 100 Hz	40
2	Dwellings and buildings of similar design and/or use	5	5 at 10 Hz increasing to 15 at 50 Hz	15 at 50 Hz increasing to 20 at 100 Hz	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 at 10 Hz increasing to 8 at 50 Hz	8 at 50 Hz increasing to 10 at 100 Hz	8

Note 1: For frequencies above 100 Hz the upper value in this 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 the NSW Department of Environment and Conservation document *Assessing vibration: a technical guideline* which is based on British Standard BS 6472-1992 *Evaluation of human exposure to vibration in buildings (1–80 Hz)*. 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.

11.3 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 46**. Safe working distances are quoted for both "cosmetic" damage (refer DIN 4150) and human comfort (refer DECC Guideline).

Table 46 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (DIN 4150)	**Human Response (DECC Guideline)**
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
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	73m
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 46** are indicative and will vary depending on the particular item of plant and local geotechnical conditions. **Table 46** 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. Monitoring at the commencement of vibratory compaction or hydraulic hammering within 30 m of residential buildings will be required to determine compliance or non-compliance. In the event that non-compliance occurs, immediate corrective action should be taken. The safe working distances apply to structural damage of typical buildings and typical geotechnical conditions.

The Riverstone Station and Yard Group is identified as an item of state significance on the State Heritage Register. Typically, heritage structures can are considered more sensitive to vibration and therefore appropriate consideration must be applied when undertaking vibration intensive construction activities adjacent to such structures.

In accordance with DIN 4150, construction related vibration levels should not exceed the structural damage safe limits as provided for Group 3 in **Table 45**. Accordingly, vibration monitoring is recommended to confirm the safe working distances before commencement of vibration intensive activities adjacent to the Riverstone Station and Yard Group.

11.4 Assessment of Construction Vibration Impact

It is reasonable to assume that the construction activities will 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 46** 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.

As indicated in **Table 46**, several plant items have the potential to have an adverse human response impact at receivers close to construction sites (the closest will be typically 10 m to 15 m from these activities). It is recommended therefore, that where necessary, equipment be reselected to reduce the vibration impact (for example by using a smaller vibratory roller) insofar as possible (without compromising the ability to complete the required task). It is recommended that before the commencement of any vibration intensive works (such as vibratory rolling, pile driving or jackhammer), monitoring be carried out to determine acceptable locations and durations of activities.

Ground vibration levels for vibratory sheet piling are likely to comply with the human comfort criteria at distances exceeding 20 m from a building. Vibration levels vary considerably with ground conditions, and vibratory piles are sometimes used at closer distances without significant vibration impact.

Vibration emissions from impact piling activities, if they are required, should be assessed on a case by case basis.

12 CONCLUSION

The purpose of this report is to assess the potential noise and vibration emissions associated with the construction and operation of the proposal. Based on the proposed rail alignment, this report identifies the principle areas where noise or vibration mitigation is considered likely to be required.

The operational noise assessment was undertaken in accordance with the DECC's *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*. This document provides noise trigger levels, the exceedance of which requires an assessment of the potential noise impacts and consideration of mitigation measures.

At the majority of sensitive locations adjacent to the project area, the future noise levels resulting from the Quakers Hill to Vineyard Duplication Project comply with the noise trigger levels and consequently no further assessment of mitigation measures is required at these locations. The project-related noise levels exceed the trigger levels at two locations on the Up Side of the railway corridor and one location on the Down Side of the railway corridor. These exceedances are predicted to occur at the residential receivers located on Manorhouse Boulevard, Bridge Street and Tain Place. There was one trigger level exceedance in relation to "Other Noise Sensitive Receivers", that being the Quakers Hill Pre-School.

At this stage in the assessment process, the preferred mitigation option is the consideration of at source mitigation measures such as the application of rail dampers to the existing and future tracks adjacent to the residential exceedance locations, with building treatments to be applied at residual exceedance locations. Building treatments would however be subject to feedback from the community consultation process, detailed design and confirmation of noise levels following post operational noise monitoring to validate the predictions.

As discussed in **Section 6**, by accounting for the high cost of maintaining standard (corridor) noise barriers and to a lesser extent, low-profile noise barriers, it is likely that rail dampers would provide the highest cost-benefit. In addition, rail dampers are claimed to have a similar service life to the rail itself and the integration of additional maintenance procedures into existing track maintenance processes should be possible.

It should also be noted that the implementation of rail dampers and/or low-profile noise barriers would avoid many of the additional problems potentially encountered with standard noise barriers such as interference with natural light, airflow and visual amenity impacts.

On the basis of measurements undertaken as part of the proposal and the proposed alignment of the new track, future vibration levels are predicted to comply with the vibration dose-based vibration trigger levels.

An assessment of the potential noise impacts that may result from the new bus interchange and commuter car parking facilities at the new Schofields and Vineyard Stations has also been conducted. The assessment indicates the need for careful land use planning design methodologies in order to minimise the potential road traffic noise impacts that may result from the operation of the bus interchanges and commuter car parks.

Construction noise modelling has been undertaken for fourteen different scenarios across a total of ten major work areas covering activities that are planned to occur during the construction programme.

Construction noise levels are likely to exceed the relevant objectives, however this is common on projects of this nature as the objectives are set close to the background noise level. In practice, many other sources also exceed these levels in the ambient noise environment.

The predicted exceedances of the construction noise objectives indicate that the project should be managed to avoid unnecessary noise emission and that feasible and reasonable mitigation measures should be implemented in order to minimise noise emissions.

Construction vibration levels at residential receivers are predicted to comply with building damage criteria, but may be perceptible during vibratory rolling. Vibration monitoring should be undertaken in order to establish appropriate buffer distances, particularly in relation to heritage structures.

The mitigation measures described in **Section 9.9** will be undertaken in order to minimise potential noise and vibration impacts.