# BaT project

## Environmental Impact Statement

## Technical Report 4 – Operational Noise and Vibration

August 2014

# EXECUTIVE SUMMARY

## 1. EXECUTIVE SUMMARY INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by the SKM-AECOM Joint Venture (JV) to prepare an assessment of the noise and vibration aspects of the operational phase for Underground Bus and Train project (BaT) for inclusion in the Environmental Impact Statement (EIS).

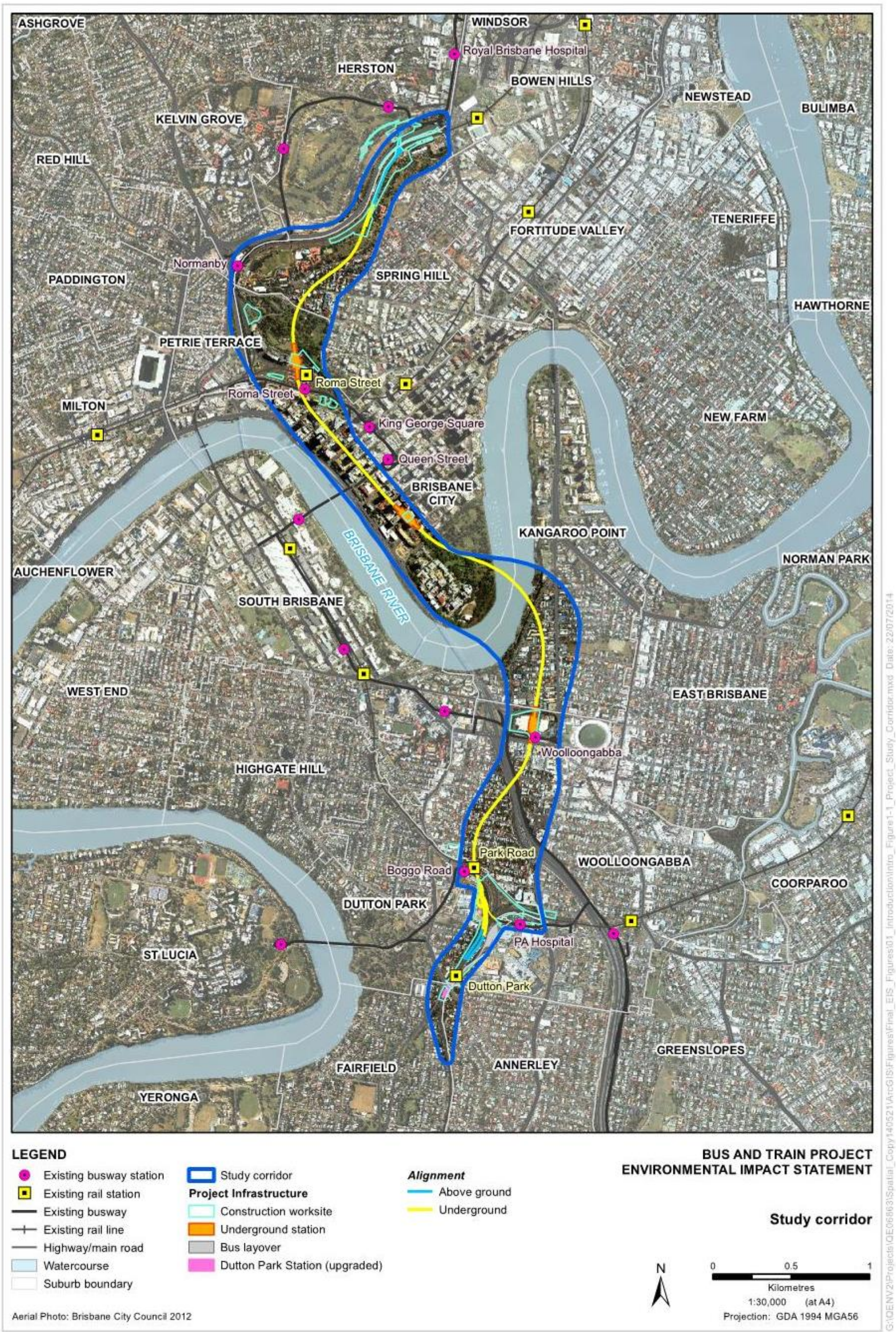
BaT is a major project for the City of Brisbane, South East Queensland and the State of Queensland. It will provide a new north-south rail line in Brisbane's inner city that includes a new river crossing and inner city train stations. From the existing southern rail network, it will pass under the central business district (CBD) of Brisbane and connect with the existing northern rail network.

Please note that all table and figure numbers in this executive summary have been kept the same as the corresponding tables and figures in the main body of the text for ease of reference.

## EXECUTIVE SUMMARY

### 1.1 Study Area

The figure below shows an overview of the study area including the Study Corridor and the BaT Reference Design alignment.



# EXECUTIVE SUMMARY

## 1.2 Methodology

The study methodology for the BaT project operational noise and vibration assessment involved:

- A review of literature prepared for current and completed major tunnelling projects in Brisbane including methodologies relevant to noise and vibration minimisation.
- A review of existing legislation, standards and guidelines as well as BaT project documents including the Terms of Reference (TOR) January 2014 and Initial Advice Statement (IAS) November 2013.
- Identification of sensitive locations in relation to construction noise and vibration.
- Carrying out field studies to characterise the existing noise and vibration environment within the study corridor.
- Defining noise and vibration goals by which operational noise and vibration impacts at sensitive locations may be evaluated.
- Describing noise and vibration levels associated with the BaT project through detailed computer noise modelling.
- Evaluating the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies.
- Recommending appropriate mitigation measures and noise and vibration performance requirements in order to protect community values and sensitive locations.

The above study methodology for the operational noise and vibration assessment for the BaT project was developed for the purpose of achieving the objective of the TOR, being:

> *Development is planned, designed, constructed and operated to protect the environmental values of the acoustic environment.*

## 1.3 Legislative and Policy Framework

### 1.3.1 Community Values Relating to Noise and Vibration

The EPP(Noise) defines the values to be protected as the qualities of the acoustic environment that are conducive to:

- The qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems.
- The qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following-
  - a. Sleep
  - b. Study or learn
  - c. Be involved in recreation, including relaxation and conversation
- The qualities of the acoustic environment that are conducive to protecting the amenity of the community.

## EXECUTIVE SUMMARY

### 1.3.2 Surface Rail Operations

The applicable noise goals for the railway surface track airborne noise emissions are in accordance with Queensland Rail's Code of Practice – Railway Noise Management (Queensland Rail's Code of Practice).

Queensland Rail's Code of Practice outlines the operational "planning levels" applicable to this project.

The Planning Levels are:

- 65 dBA, evaluated as the 24 hour average equivalent continuous A-weighted sound pressure level, LAeq(24hour).
- 87 dBA, evaluated as a Single Event Maximum sound pressure level.

The planning levels refer to an assessment location one metre in front of the facade of an affected noise sensitive building.

### 1.3.3 Surface Bus and Road Operations

The applicable noise criteria for the surface busway and road alignments are in accordance with the Department of Transport and Mains Roads (DTMR) Transport Noise Management Code of Practice (Code of Practice).

**Table 1** lists the Code of Practice noise goals applicable to this project.

**Table 1 Road Categories and Criteria**

| **Categories** | **Criteria (dBA)** | | |
|---|---|---|---|
| | **Existing Residences** | **Educations, Community and Health buildings** | **Outdoor Educational and Passive Recreational areas (Parks)** |
| *Multi-modal Corridor* | | | |
| New Road – Access Controlled | 63 LA10 (18hour) existing level > 55LA10 (18(hour)<br>60 LA10 (18hour) existing level ≤ 55LA10 (18(hour) | 58 LA10 (1hour) | 63 LA10 (12 hour) |
| Upgrading Existing Road | 68 LA10 (18 hour) | 65 LA10 (1hour) | |
| *Busway* | | | |
| New Busway | 55 LAeq (1hour) day & evening<br>50 LAeq (1hour) night<br>64 LAmax night | 55 LAeq (1hour) operation hours<br>64 LAmax night | 57 LAeq (1hour) day<br>66 LAmax day |
| Upgrading Existing Busway | 60 LAeq (1hour) day and evening<br>55 LAeq (1hour) evening<br>69 LAmax night | 60 LAeq (1hour) operation hours<br>69 LAmax night | |

## EXECUTIVE SUMMARY

### 1.3.4 Ground-Borne Vibration

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

- Australian Standard AS 2670.2 1990 "Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)".
- The United States Federal Transit Administration (FTA) guideline "Transit Noise and Vibration Impact Assessment".
- British Standard BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting".
- The NSW Department of Environment, Climate Change and Water (now Environment Protection Authority) document "Assessing Vibration: A Technical Guideline".

The vibration goals have been expressed both in terms of vibration velocity mm/s and decibels ($dB_V$ re $10^{-9}$ m/s). A level of 100 dB corresponds to 0.1 mm/s (rms) and a level of 120 dB corresponds to 1 mm/s (rms).

Based on the above references, the proposed vibration goals are listed in **Table 4**. For assessment purposes, these goals may be regarded as applicable to the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys.

**Table 4 Ground-borne Vibration Goals**

| Receiver Type | Period | Vibration Goal[1,2] (Vibration Velocity) |
|---|---|---|
| Residential | Day/Night | 0.2 mm/s (106 $dB_V$) |
| Commercial (including schools and places of worship) | When in use | 0.4 mm/s (112 $dB_V$) |
| Industrial | When in use | 0.8 mm/s (118 $dB_V$) |
| Sensitive equipment within medical or research facilities | When in use | 0.013 mm/s (82 $dB_V$) [3] |

Note 1: The vibration goals are based on the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys.
2: $dB_V$ re $10^{-9}$ m/s
3: Unless actual equipment manufacturer data are available.

In the case of railway tunnels, the ground-borne noise goals, presented below, almost always dictate lower vibration emission levels than the vibration goals indicated in **Table 4**. Hence other than at specific facilities with equipment with particularly high sensitivity to vibration, compliance with the ground-borne noise goals ensures that the vibration goals will also be achieved.

### 1.3.5 Ground-Borne Noise

There are no Australian Standards specifically addressing the issue of ground-borne noise from railway operations. Guidance can be obtained, however, from the following International and Australian references:

- International Standard ISO 14837-1:2005(E) Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance, First Edition 2005
- American Public Transit Association (APTA), Guidelines for Design of Rapid Transit Facilities, 1991
- Federal Transit Administration (FTA), US Department of Transport, Transit Noise and Vibration Impact Assessment, May 2006.

## EXECUTIVE SUMMARY

- The Association of Noise Consultants Measurements & Assessment of Groundborne Noise & Vibration, 2001.
- Harris Miller Miller and Hanson Inc. Transit Noise and Vibration Impact Assessment, 1995 (a guideline prepared for the United States Department of Transportation).
- NSW EPA Rail Infrastructure Noise Guideline (RING), May 2013.

All the above standards and guidelines acknowledge and are specifically designed to take into account the intermittent and low frequency character of ground-borne noise and subjective characteristics of underground rail operations as part of the assessment criteria. Therefore, these guidelines have been deemed more relevant than the more general (ie not specific to ground-borne noise from underground rail operations) Ecoaccess Draft Guideline *Assessment of Low Frequency Noise*.

ISO 14837 provides guidance in relation to the prediction of ground-borne noise levels and factors that need to be considered in the prediction process. Acceptability criteria are not included in Part 1 of the ISO Standard, but are anticipated to be included as Part 4 (when available).

Based on the criteria within the above Australian and International standards and guidelines, **Table 6** provides a summary of the proposed ground-borne noise goals for the Project.

**Table 6 Ground-borne Noise Goals**

| Receiver | Time of Day | Noise Trigger Level (dBA)[1] |
|---|---|---|
| Residential | Day (7.00 am to 10.00 pm) | 40 dBA |
| | Night (10.00 pm to 7.00 am) | 35 dBA |
| Schools, educational institutions, places of worship[2] | When in use | 40 dBA to 45 dBA |
| Retail Areas | When in use | 50 dBA to 55 dBA |
| General Office Areas | When in use | 45 dBA |
| Private Offices and Conference Rooms | When in use | 40 dBA |
| Theatres | When in use | 35 dBA |

Note 1: Evaluated as the $L_{Amax}$ “Slow” response noise level (interpreted as applicable to the 95th percentile train passby event ie typically the highest 1 in 20 event).

Note 2: The lower value of the range is primarily applicable where low internal noise levels are expected, such as in areas assigned to studying, listening, quiet contemplation and praying.

### 1.3.6 Mechanical Plant and Ventilation

Relevant assessment criteria for operational mechanical plant noise can be found in the following:

- EPP(Noise)
  - Minimising Background Creep – Existing $L_{A90}$ + 0 dBA
  - Acoustic Quality Objectives – Refer to Schedule 1 in EPP(Noise)
- DERM Ecoaccess Guideline Planning for Noise Control (Ecoaccess PNC)
  - Minimising Background Creep – Refer to Table 1 and Table 2 of Ecoaccess PNC
  - Planning Noise Levels (PNL) – Refer to Table 3 and Table 4 of Ecoaccess PNC
  - Specific (Intrusive) Noise Levels (SNL) – Existing Rating Background Level (RBL) + 3 dBA (assessed as $L_{Aeq}$)

## EXECUTIVE SUMMARY

- DERM Ecoaccess Draft Guideline *Assessment of Low Frequency Noise* (Ecoaccess ALFN) – Refer to Table 3 of the draft Ecoaccess ALFN.
- Brisbane City Council (BCC) Noise Impact Assessment Planning Scheme Policy (NIAPSP)
    - Minimising Background Creep – Existing $L_{A90}$ + 0 dBA (for noise categories R3 to R6 as per Appendix A of AS 1055.2)
    - Comparison of Like Parameters – Existing LA90 + 0 dBA
    - AS/NZS 2107: 2000 Acoustics – Recommended design sound levels and reverberation times for building interiors (AS 2107) internal noise levels – Refer to Table 1 in AS 2107

The applicable statutory requirement for noise emissions associated with fixed mechanical plant is the EPP(Noise). The EPP(Noise) nominates long term acoustic quality objectives and background creep criteria applicable to stationary mechanical plant.

The background creep criteria according to the EPP(Noise) are identical to the background creep criteria according to the BCC NIAPSP. The Ecoaccess PNC includes more complex background noise criteria. In determining the appropriate background creep goals, the statutory and Brisbane City Council criteria have been adopted.

Mechanical ventilation noise is generally steady state (ie the noise emission varies very little with time in the short term) and therefore the difference between the $L_{A90}$ the $L_{Aeq}$ will be small. As a result, based on the criteria/limits discussed above, the $L_{A90}$ based background creep criteria will be stricter than the $L_{Aeq}$ based intrusive noise criterion. In determining the appropriate goals, a conservative approach has been adopted and thus only a background creep goal has been recommended.

The Ecoaccess ALFN guideline gives advice regarding assessment of infrasound and low frequency noise. The mechanical ventilation and/or emergency ventilation noise associated with the BaT project is not anticipated to generate any infrasound or distinctly low frequency noise and therefore will not require a specific assessment.

On the basis of the above references and discussion, the proposed noise goals for mechanical plant are presented in **Table 7**.

## EXECUTIVE SUMMARY

**Table 7 Operational Mechanical Plant Noise Goals**

| Receiver | Time of Day | Background Noise Creep[1] dBA LA90(1hour) | Acoustic Quality Objectives[2] dBA LAeq(1hour) |
|---|---|---|---|
| Residential (for outdoors) | 7am to 10pm | b/g + 0 [3] | 50 [3] |
| | 10pm to 7am | b/g + 0 | - |
| Residential (for indoors) | 7am to 10pm | - | 35 |
| | 10pm to 7am | - | 30 |
| Library and educational institution (including a school, college and university) (for indoors) | when open for business or when classes are being offered | - | 35 |
| Commercial and retail activity (for indoors) | when the activity is open for business | - | 45 |

Note 1: Background creep criteria in accordance with the EPP(Noise) and BCC NIAPSP for continuous noise sources, adopting the Rating Background Level in accordance with the DERM Ecoaccess PNC. Applicable for noise contribution from the source only.

2: Long term acoustic quality objectives according to EPP(Noise).

3: The lower of the background creep LA90(1hour) and Acoustic Quality Objectives LAeq(1hour) is applicable.

## 2. EXISTING ENVIRONMENT

### 2.1 Noise

Ambient noise monitoring was conducted at 18 residential and special use (ie educational or medical) locations providing good spatial coverage of the study corridor. The data for 11 of these locations were taken from a previous project where monitoring was conducted in May 2010. These locations were considered representative of the current BaT project. Both attended and unattended ambient noise measurements have been conducted at an additional seven (7) locations in order to accurately document the existing noise environment. The measured ambient noise levels have been used in part to determine applicable project noise goals.

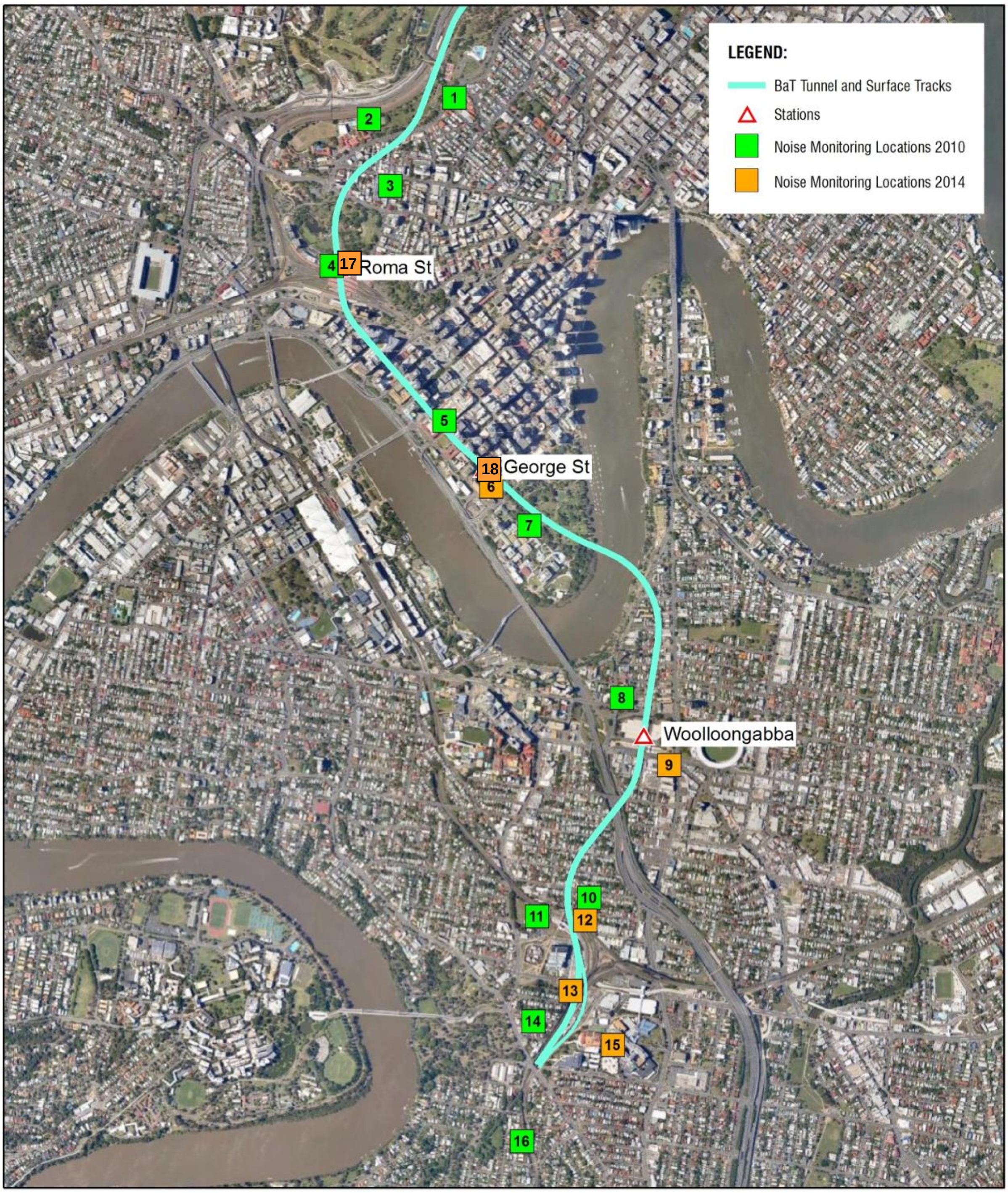
The noise monitoring undertaken in 2010, was performed between 7 May and 28 May 2010 for at least seven (7) days at each monitoring location. These locations are highlighted green in **Figure 5**. Noise monitoring at the additional seven (7) locations was undertaken between 11 March and 1 May 2014. These locations are highlighted orange **Figure 5**.

Noise monitoring locations have been selected to be representative of residential areas as well as special receivers (ie Educational and Health Care Facilities) along the corridor that may be potentially affected by the BaT project. Noise monitoring locations have been selected to provide spatial coverage of the areas with sensitive receivers along the length of the study corridor.

An overview of the selected monitoring locations is shown in **Figure 5.**

## EXECUTIVE SUMMARY

### Figure 5 Overview of Noise Monitoring Locations



## EXECUTIVE SUMMARY

The unattended ambient noise measurements were used to determine the Rating Background Levels (RBL) for the daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location. The RBL is the median of the 90th percentile background ($L_{A90}$) noise levels in each assessment period (day, evening and night) over the duration of the monitoring (as defined in the *Ecoaccess PNC*). **Table 9** contains the determined RBL for each measurement location.

**Table 9 Measured Rating Background Levels**

| Monitoring Location | | Rating Background Levels (RBL), LA90 (dBA) | | |
|---|---|---|---|---|
| | | Day | Evening | Night |
| 1 | St Joseph's College | 50 | 48 | 40 |
| 2 | Brisbane Girls Grammar | 61 | 60 | 46 |
| 3 | St Andrews War Memorial Hospital | 55 | 53 | 51 |
| 4 | Parkland Cres | 54 | 50 | 47 |
| 5 | 191 George St | 58 | 57 | 54 |
| 6 | 40 George Street, The Mansions | 59 | 55 | 51 |
| 7 | QUT Gardens Point | 49 | 48 | 46 |
| 8 | 58 Leopard St | 53 | 50 | 46 |
| 9 | 803 Stanley St [1] | 58 | 57 | 51 |
| 10 | 143 Park Rd | 43 | 39 | 34 |
| 11 | Dutton Park State School | 44 | 40 | 35 |
| 12 | 26 Elliot St | 46 | 44 | 40 |
| 13 | 68 Railway Tce, Leukaemia Foundation | 47 | 45 | 41 |
| 14 | 19 Dutton St | 43 | 42 | 37 |
| 15 | Princess Alexandra Hospital | 54 | 54 | 53 |
| 16 | 4 Fenton St | 39 | 38 | 34 |
| 17 | Parkland Boulevard (Level 3 conference meeting room, Building 3) [2] | RBL: 53 (30)<br>LAeq: 61 (37) | RBL: 50 (27)<br>LAeq: 58 (35) | RBL: 44 (<24) [3]<br>LAeq: 55 (31) |
| 18 | 21 Mary Street (Level 27 unit 1) [2] | RBL: 56 (33 – Living room)<br>LAeq: 58 (34) | RBL: 55 (-) [4]<br>LAeq: 56 (-) [4] | RBL: 53 (27 - Bedroom)<br>LAeq: 56 (30) |

Note 1: RBL based on only one (1) full day of data due to logger malfunction and access restrictions.
Note 2: Levels in brackets were measured inside the building.
Note 3: Actual noise level was below the instrument noise floor of 24 dBA.
Note 4: Evening period data not available due to logger malfunction at 21 Mary Street.

Attended ambient noise measurements were also conducted at each site to confirm background noise levels and to observe typical noise sources associated with the ambient noise environment during the daytime, evening and night-time periods. The attended ambient noise measurements were conducted for one (1) 15 minute period during each of the daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location (ie three (3) 15 minute attended measurements were taken at each location). The results of these measurements are summarised in the **Section 2.**

The attended measurements and observations identified that railway noise and/or road traffic noise is dominant at the majority of monitoring locations during daytime and evenings. The night-time period was dominated by road traffic noise at most locations, though it was mostly a distant traffic noise.

## EXECUTIVE SUMMARY

### 2.2 Vibration

Existing vibration levels along the study corridor were measured to (if required) compare with future vibration levels with the BaT project in operation. The data for eight (8) of these locations were taken from a previous project where monitoring was conducted in May 2010. These locations were considered representative of the current BaT project. Ambient vibration measurements have been conducted at an additional two (2) locations in order to accurately document the existing vibration environment.

Vibration monitoring locations have been selected to be representative of residential areas as well as special receivers (ie educational/research or health care facilities) along the corridor that may be potentially affected by the BaT project. Vibration monitoring locations have been selected to provide spatial coverage of the areas having sensitive receivers within the whole study corridor.

An overview of the selected vibration monitoring locations is shown in **Figure 6**, with locations monitored in 2010 highlighted green and locations monitored in 2014 highlighted orange.

The unattended ambient vibration measurements were used to determine the Average Minimum Background Level ($V_{90}$), Average Maximum Level ($V_{10}$) and Maximum Level ($V_1$) for the daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location. **Table 11** contains the determined vibration levels for each measurement location.

**Table 11 Measured Existing Ambient Vibration**

| Monitoring Location[1] | Average Minimum Background Vibration $V_{90}$ (mm/s) [2] | | | Average Maximum Vibration $V_{10}$ (mm/s) [3] | | | Maximum Vibration $V_1$ (mm/s) [4] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day | Evening | Night | Day | Evening | Night | Day | Evening | Night |
| 1 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.08 | 0.05 | 0.05 |
| 2 | 0.03 | 0.03 | 0.02 | 0.08 | 0.05 | 0.04 | 0.17 | 0.08 | 0.06 |
| 3 | 0.04 | 0.04 | 0.03 | 0.06 | 0.05 | 0.04 | 0.07 | 0.07 | 0.06 |
| 4 | 0.08 | - | - | 0.09 | - | - | 0.10 | - | - |
| 5 | 0.02 | - | - | 0.02 | - | - | 0.03 | - | - |
| 6 | 0.01 | 0.01 | 0.01 | 0.04 | 0.14 | 0.02 | 0.16 | 0.57 | 0.16 |
| 7 | 0.04 | 0.04 | 0.04 | 0.06 | 0.10 | 0.05 | 0.19 | 0.49 | 0.10 |
| 8 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.31 | 0.04 | 0.04 |
| 9 | 0.13 | 0.11 | 0.11 | 0.79 | 0.53 | 0.13 | 2.50 | 1.53 | 0.36 |
| 10 | 0.04 | 0.06 | 0.04 | 0.70 | 0.84 | 0.23 | 2.69 | 1.61 | 0.71 |

Note 1: All monitoring locations are residential excluding locations 2 to 5.

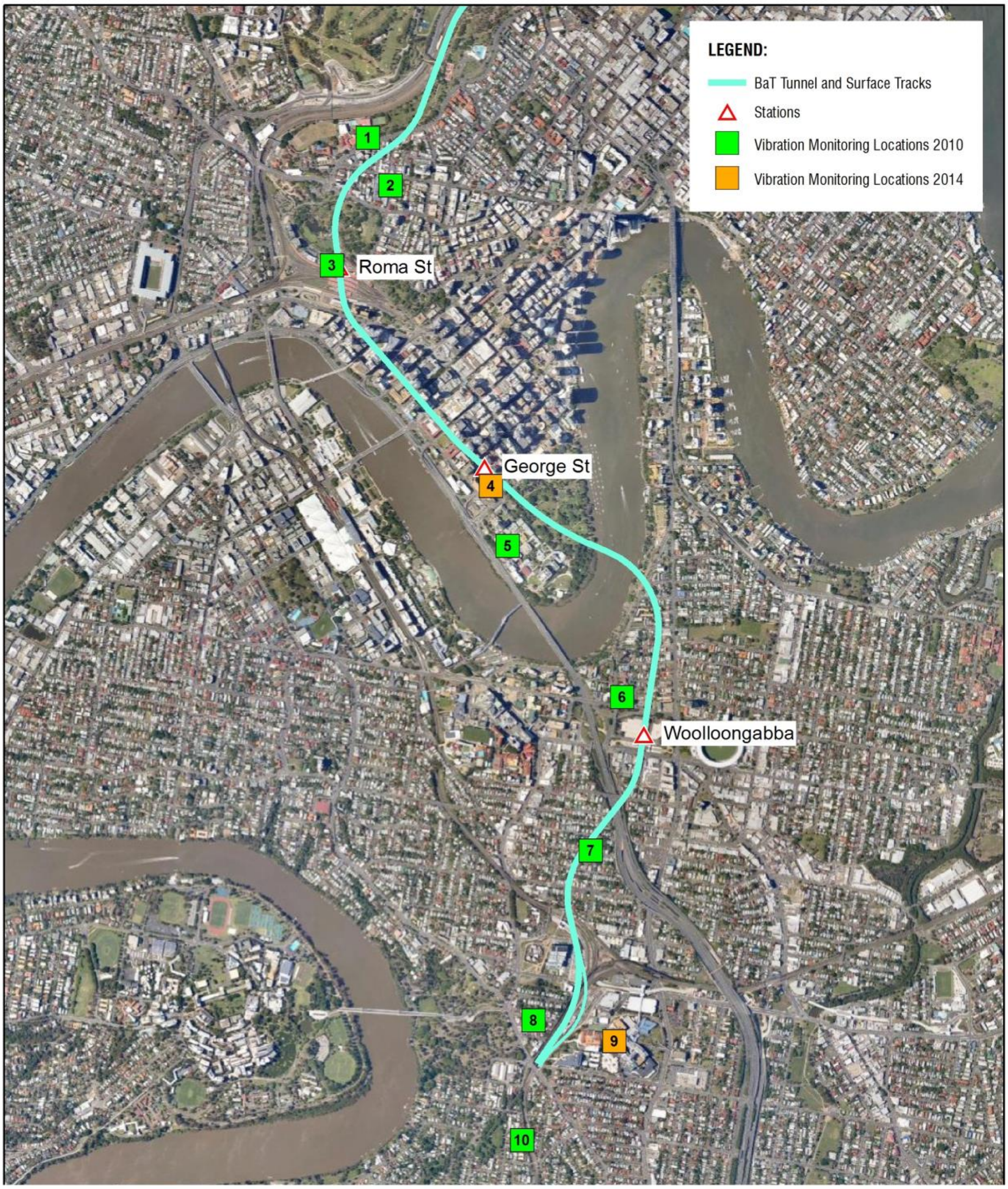
Note 2: The V90 is the vibration velocity exceeded 90% of a given measurement period and is representative of the average minimum background vibration.

Note 3: The V10 is the vibration velocity exceeded 10% of a given measurement period and is utilised normally to characterise average maximum vibration.

Note 4: The V1 is the vibration velocity exceeded for 1% of a given measurement period. This parameter is sometimes used to represent the maximum vibration in a given period. The absolute maximum peak particle velocity is higher than this V1 as can be seen in **Appendix D**.

## EXECUTIVE SUMMARY

### Figure 6 Overview of Vibration Monitoring Locations



**EXECUTIVE SUMMARY**

The background vibration level ($V_{90}$) for all sites varies between 0.01 mm/s to 0.13 mm/s during daytime and evening. During the night-time, the background vibration level ($V_{90}$) varies between 0.01 mm/s to 0.11 mm/s. Maximum vibration levels ($V_{1}$) for the residential monitoring locations were in the range of 0.11 mm/s to 2.69 mm/s during daytime and evening. During night-time, vibration levels ($V_{1}$) of 0.04 mm/s to 0.71 were measured. The average maximum levels ($V_{10}$) for the residential monitoring locations ranged 0.04 mm/s to 0.84 mm/s during daytime and evening.

It can be noted that high vibration levels have been monitored at locations 6, 7 and 10 which are on floors in a residential dwellings. This shows that normal activities (i.e. closing doors, drawers and cupboards, walking, moving and sitting on furniture etc.) in this residential dwelling generated vibration levels above the vibration goals presented in **Section 2.4**.

For receivers with vibration sensitive equipment locations 3 (St Andrews Hospital), location 5 (QUT) and location 9 (PA Hospital), background vibration levels ($V_{90}$) of 0.02 mm/s to 0.06 mm/s and maximum vibration levels ($V_{1}$) of 0.03 mm/s to 2.69 mm/s, were measured. It can be noted that the monitoring location just outside the MRI room at the PA Hospital registered significantly higher vibration levels than at QUT and St Andrews Hospital.

## 3. IMPACT ASSESSMENT

The following discusses the potential impact from operational bus and train noise and vibration on the existing environment.

### 3.1 Ground-borne Vibration Assessment

Railway vibration is generated by dynamic forces at the wheel-rail interface and occurs, to some degree, even with continuously welded rail and smooth wheel and rail surfaces (due to the moving loads, finite roughness and elastic deformation of the surfaces). Higher vibration levels occur in the presence of rail and wheel surface irregularities.

This vibration propagates via the rail mounts into the ground or track support structures. It then travels through the ground or structures and in some circumstances may sometimes be felt as tactile vibration by the occupants of buildings. If the levels of vibration are sufficiently high (ie in buildings very close to rail tracks), then rattling or visible movement of loose objects (crockery, plants, etc) may also sometimes occur.

For the ground-borne noise and vibration modelling, there are currently no commercially available modelling software packages. The modelling for this project was therefore carried out using an SLR-developed modelling process for the core calculations. The algorithms incorporated into the in-house model are well documented in authoritative references and are widely used within the acoustical consulting profession, both in Australia and internationally.

This model was validated using measurement data collected from the Epping to Chatswood Railway Line (ECRL) in Sydney. The ECRL and the Project share similar design characteristics in relation to a circular tunnel cross-section embedded in rock and similar slab track design. Where differences exist between the ECRL and the Project (eg tunnel dimensions, ground conditions, rolling stock and track/rolling stock maintenance practices), these have been accounted for in the ground-borne noise and vibration predictions. To ensure ground conditions along the BaT alignment were taken into account, borehole vibration testing at three locations was undertaken to determine the ground vibration attenuation versus distance characteristics.

## EXECUTIVE SUMMARY

The modelling approach was based on the guidelines contained in International Standard ISO 14837-1 2005 "Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance", taking into account the source vibration levels, the propagation in the ground between the source and receiver and the vibration propagation within the building.

For most new railway lines, the standard track design usually incorporates resilient rail fasteners to reduce the dynamic forces that occur at the wheel-rail interface. This resilience also serves to provide some isolation of ground-borne vibration, which in turn reduces the ground-borne noise levels in buildings near the railway tunnel.

For the proposed BaT project, three trackforms have been proposed as part of the Reference Project to achieve the ground-borne vibration and noise objectives. These comprise a "Direct Fixation" trackform incorporating standard "stiff" rail fasteners (i.e. not specifically designed for vibration isolation – merely track durability), "Resilient" trackform incorporating moderately resilient rail fasteners and "Highly Resilient" trackform incorporating highly resilient rail fasteners. The latter two types are specifically designed to reduce vibration and ground-borne noise propagation.

Whilst the Reference Project is based on the Pandrol Sleeper systems – Pandrol HDPE (Direct), VIPA (Resilient) and Vanguard (Highly Resilient) – equivalent performance track design options are available from several other suppliers (i.e. Delkor, Sonneville etc.). These may be adopted for the final design (on the proviso that the acoustic performance is equivalent to or better than the Pandrol Sleeper systems).

On the basis of the speed profile for the BaT project, the proposed vertical alignment and modelling assumptions, **Table 19** presents a summary of the predicted ground-borne vibration levels for buildings located above or near the proposed rail tunnel alignment.

## EXECUTIVE SUMMARY

**Table 19 Summary of Predicted Ground-borne Vibration Levels (Reference Project Trackform)**

| Chainage (km) | Type of Building | Min. Slant Distance to Track Level | Predicted Ground-borne Vibration Level (mm/s)[1] | Residential Night-time Vibration Goal (mm/s)[1,2] | Reference Design |
|---|---|---|---|---|---|
| 0.37 – 1.8<br>Southern Connection to Woolloongabba Station | Residential<br>Commercial<br>Educational<br>Worship<br>Hotel | 23 m – 134 m<br>40 m – 234 m<br>98 m – 176 m<br>116 m – 154 m<br>79 m | 0.002 to 0.048 mm/s<br>0.001 to 0.018 mm/s<br>0.002 to 0.002 mm/s<br>0.001 to 0.002 mm/s<br>0.005 mm/s | 0.2 mm/s | Direct Fixation Rail Fasteners |
| 1.8 – 3.55<br>Woolloongabba Station to George Street Station | Residential<br>Commercial<br>Educational<br>Worship<br>Medical<br>Hotel | 43 m – 310 m<br>42 m – 293 m<br>103 m – 173 m<br>39 m – 312 m<br>311 m<br>54 m – 251 m | 0.00 to 0.019 mm/s<br>0.00 to 0.012 mm/s<br>0.001 to 0.003 mm/s<br>0.00 to 0.015 mm/s<br>0.00 mm/s<br>0.00 to 0.008 mm/s | 0.2 mm/s | Direct Fixation Rail Fasteners |
| 3.55 – 4.8<br>George Street Station to Roma Street Station | Residential<br>Commercial<br>Educational<br>Worship<br>Medical<br>Hotel | 37 m – 97 m<br>33 m – 311 m<br>67 m – 267 m<br>241 m – 278 m<br>232 m – 249 m<br>35 m – 304 m | 0.003 to 0.043 mm/s<br>0.00 to 0.041 mm/s<br>0.00 to 0.003 mm/s<br>0.001 to 0.001 mm/s<br>0.001 to 0.001 mm/s<br>0.00 to 0.050 mm/s | 0.2 mm/s | Direct Fixation Rail Fasteners |
| 4.8 – 6.05<br>Roma Street Station to Northern Connection | Residential<br>Commercial<br>Educational<br>Medical<br>Hotel | 41 m – 124 m<br>40 m – 131 m<br>41 m – 161 m<br>88 m<br>58 m – 119 m | 0.001 to 0.020 mm/s<br>0.002 to 0.015 mm/s<br>0.002 to 0.020 mm/s<br>0.005 mm/s<br>0.003 to 0.012 mm/s | 0.2 mm/s | Direct Fixation Rail Fasteners |

Note 1: The predicted vibration levels and vibration goal are based on the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys.

Note 2: The residential night-time vibration goal is the most stringent operational vibration goal, except at a few special receivers with potentially highly vibration sensitive equipment (refer to **Section 6.4.1**).

**EXECUTIVE SUMMARY**

Compliance with the ground-borne vibration limits is predicted for all sensitive receiver locations above or near the proposed alignments.

The predicted ground-borne vibration levels for the electron microscope at the Eco-science precinct complies with the instrument specific vibration criteria supplied by the tenant.

Princess Alexandra Hospital, QUT at 2 George Street and St Andrews Hospital have been identified as having special vibration sensitive equipment (i.e. electron microscope or Magnetic Resonance Imaging (MRI) systems). For the purpose of assessment, it has been assumed all nearby research and medical facilities may contain vibration sensitive equipment. All identified special receivers have predicted ground-borne vibration velocity below the limit of 0.013 mm/s (82 dBv) per octave band.

The predicted vibration levels associated with train operations in the tunnels are less than 0.144 mm/s at any buildings near the tunnels and therefore the risk to any heritage buildings is negligible. Similarly, the potential for damage to other key utilities/ infrastructure is also negligible on the basis that the tunnel wall vibration levels are anticipated to be approximately 0.1 mm/s (100 $dB_V$).

### 3.2 Ground-borne Noise Assessment

Train noise in buildings adjacent to rail tunnels is predominantly caused by the transmission of ground-borne vibration rather than the direct transmission of noise through the air. The vibration is initially generated by wheel/rail interaction (as described above) and is transmitted from the trackbed, through the tunnel structure, via the ground and into the adjacent building structures. After entering a building, this vibration causes the walls and floors to vibrate faintly and hence to radiate noise (commonly termed “ground-borne 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 commonly experienced in buildings adjacent to urban underground rail systems.

The ground-borne noise modelling methodology followed the same calculation procedure discussed in the ground-borne vibration modelling section, with the addition of two final steps to account for the conversion of vibration in a building into noise.

The ground-borne noise predictions for the sensitive receivers along the tunnel alignment (with the Reference Project trackform configuration) are provided in **Table 21**.

Exceedences are shown in **bold**.

## EXECUTIVE SUMMARY

### Table 21 Summary of Predicted Ground-borne Noise Levels (Direct Fixation Trackform)

| Chainage (km) | Type of Building | Min. Slant Distance to Track Level | Predicted Ground-borne Noise Level (dBA) | Ground-borne Noise Goal (dBA) | Reference Design |
|---|---|---|---|---|---|
| 0.37 – 1.8<br>Southern Connection to Woolloongabba Station | Residential<br>Commercial<br>Educational<br>Worship<br>Hotel | 23 m – 134 m<br>40 m – 234 m<br>98 m – 176 m<br>116 m – 154 m<br>79 m | <10 dBA to **46 dBA**<br><10 dBA to 36 dBA<br><10 dBA to 11 dBA<br><10 dBA<br>15 dBA | 35 dBA (night-time)<br>40 dBA<br>40 dBA<br>40 dBA<br>35 dBA (night-time) | Direct Fixation Rail Fasteners |
| 1.8 – 3.55<br>Woolloongabba Station to George Street Station | Residential<br>Commercial<br>Educational<br>Worship<br>Medical<br>Hotel | 43 m – 310 m<br>42 m – 293 m<br>103 m – 173 m<br>39 m – 312 m<br>311 m<br>54 m – 251 m | <10 dBA to 33 dBA<br><10 dBA to 29 dBA<br><10 dBA<br><10 dBA to 32 dBA<br><10 dBA<br><10 dBA to 24 dBA | 35 dBA (night-time)<br>40 dBA<br>40 dBA<br>40 dBA<br>40 dBA<br>35 dBA (night-time) | Direct Fixation Rail Fasteners |
| 3.55 – 4.8<br>George Street Station to Roma Street Station | Residential<br>Commercial<br>Educational<br>Worship<br>Medical<br>Hotel | 37 m – 97 m<br>33 m – 311 m<br>67 m – 267 m<br>241 m – 278 m<br>232 m – 249 m<br>35 m – 304 m | <10 dBA to **42 dBA**<br><10 dBA to **42 dBA**<br><10 dBA<br><10 dBA<br><10 dBA<br>10 dBA to **43 dBA** | 35 dBA (night-time)<br>40 dBA<br>40 dBA<br>40 dBA<br>40 dBA<br>35 dBA (night-time) | Direct Fixation Rail Fasteners |
| 4.8 – 6.05<br>Roma Street Station to Northern Connection | Residential<br>Commercial<br>Educational<br>Medical<br>Hotel | 41 m – 124 m<br>40 m – 131 m<br>41 m – 161 m<br>88 m<br>58 m – 119 m | <10 dBA to 35 dBA<br><10 dBA to 33 dBA<br><10 dBA to 35 dBA<br>10 dBA<br><10 dBA to 25 dBA | 35 dBA (night-time)<br>40 dBA<br>40 dBA<br>40 dBA<br>35 dBA (night-time) | Direct Fixation Rail Fasteners |

Note: Predictions are for the $L_{Amax,Slow}$ noise level and refers to the 95th percentile train passby event. The ground-borne noise level of the "average" or median train event would be approximately 3 dB lower than the 95th percentile event.

## EXECUTIVE SUMMARY

The predicted ground-borne noise levels indicate that there are three track sections where there are residential receivers exceeding the night-time ground-borne noise goal of 35 dBA for the Direct Fixation trackform.

The assessment concluded that the track forms contained in **Table 22** are required to achieve compliance with the nominated goals.

**Table 22 Proposed Trackforms to Comply with the Ground-borne Noise Goals**

| Down Track | | | Up Track | | |
|---|---|---|---|---|---|
| Chainage (km) | | Trackform | Chainage (km) | | Trackform |
| From | To | | From | To | |
| 0 | 0.35 | Direct Fixation | 0 | 0.79 | Direct Fixation |
| 0.35 | 0.45 | Resilient | 0.79 | 1.245 | Resilient |
| 0.45 | 0.78 | Direct Fixation | 1.245 | 4.43 | Direct Fixation |
| 0.78 | 1.25 | Resilient | 4.43 | 4.64 | Resilient |
| 1.25 | 4.41 | Direct Fixation | 4.64 | 6.735 | Direct Fixation |
| 4.41 | 4.63 | Resilient | | | |
| 4.63 | 6.725 | Direct Fixation | | | |

Note 1: The direct fixation, resilient and highly resilient trackforms are specified in **Figure 11**.

In total, 790 m of resilient rail fasteners for the Down Track, 665 m of resilient rail fasteners for the Up Track are required to achieve compliance with the ground-borne noise goals at all sensitive receiver locations.

A summary of the predicted ground-borne noise levels with the proposed trackform configuration including the additional “Resilient” trackform discussed above is shown in **Table 23.** Compliance with the ground-borne noise goals is achieved at all sensitive receivers with the proposed “Resilient” trackform.

## EXECUTIVE SUMMARY

### Table 23 Summary of Predicted Ground-borne Noise Levels (Proposed Trackform)

| Chainage (km) | Type of Building | Min. Slant Distance to Track Level | Predicted Ground-borne Noise Level (dBA) | Ground-borne Noise Goal (dBA) | Proposed Mitigation Measure[1] |
|---|---|---|---|---|---|
| 0.37 – 1.8<br>Southern Connection to Woolloongabba Station | Residential | 23 m – 134 m | <10 dBA to 35 dBA | 35 dBA (night-time) | Resilient Rail Fasteners (Chainage 0.35 – 0.45 km, only for Down Track) and (Chainage 0.78 – 1.25 km, both tracks)<br>Direct Fixation Rail Fasteners (elsewhere) |
| | Commercial | 40 m – 234 m | <10 dBA to 36 dBA | 40 dBA | |
| | Educational | 98 m – 176 m | <10 dBA | 40 dBA | |
| | Worship | 116 m – 154 m | <10 dBA | 40 dBA | |
| | Hotel | 79 m | 15 dBA | 35 dBA (night-time) | |
| 1.8 – 3.55<br>Woolloongabba Station to George Street Station | Residential | 43 m – 310 m | <10 dBA to 33 dBA | 35 dBA (night-time) | Direct Fixation Rail Fasteners |
| | Commercial | 42 m – 293 m | <10 dBA to 29 dBA | 40 dBA | |
| | Educational | 103 m – 173 m | <10 dBA | 40 dBA | |
| | Worship | 39 m – 312 m | <10 dBA to 32 dBA | 40 dBA | |
| | Medical | 311 m | <10 dBA | 40 dBA | |
| | Hotel | 54 m – 251 m | <10 dBA to 24 dBA | 35 dBA (night-time) | |
| 3.55 – 4.8<br>George Street Station to Roma Street Station | Residential | 37 m – 97 m | <10 dBA to 34 dBA | 35 dBA (night-time) | Resilient Rail Fasteners (Chainage 4.41 – 4.63 km, both tracks)<br>Direct Fixation Rail Fasteners (elsewhere) |
| | Commercial | 33 m – 311 m | <10 dBA to 37 dBA | 40 dBA | |
| | Educational | 67 m – 267 m | <10 dBA | 40 dBA | |
| | Worship | 241 m – 278 m | <10 dBA | 40 dBA | |
| | Medical | 232 m – 249 m | <10 dBA | 40 dBA | |
| | Hotel | 35 m – 304 m | 10 dBA to 35 dBA | 35 dBA (night-time) | |
| 4.8 – 6.05<br>Roma Street Station to Northern Connection | Residential | 41 m – 124 m | <10 dBA to 35 dBA | 35 dBA (night-time) | Direct Fixation Rail Fasteners |
| | Commercial | 40 m – 131 m | <10 dBA to 33 dBA | 40 dBA | |
| | Educational | 41 m – 161 m | <10 dBA to 35 dBA | 40 dBA | |
| | Medical | 88 m | 10 dBA | 40 dBA | |
| | Hotel | 58 m – 119 m | <10 dBA to 25 dBA | 35 dBA (night-time) | |

Note: The LAmax,Slow noise level refers to the 95th percentile train passby event. The ground-borne noise level of the “average” or median train event would typically be approximately 3 dB lower than the 95th percentile event.

Note 1: The extent of the proposed mitigation measures (ie trackforms) is detailed in **Table 23**.

**EXECUTIVE SUMMARY**

## 3.3 Airborne Noise Assessment – Train Operations

### 3.3.1 Methodology

A SoundPLAN (Version 6.5) computer noise model has been used for the prediction of noise levels at sensitive receivers. The noise model comprises topography, buildings, number of trains and calibrated noise emission levels (against measurements), rail movements and the location of noise sensitive receivers.

Two different computation algorithms were utilised within the SoundPLAN model. The Nordic Rail Traffic Noise Prediction Method (Kilde 130) has been used for all surface rail noise assessments and the CONCAWE industrial prediction model has been used to account for the additional noise emission through the portal openings and for the noise from stationary trains in the stabling yard (ie auxiliary equipment and air conditioning units).

The SoundPLAN model was created from topography, rail alignments, existing buildings, resumption plans and traffic volumes supplied by the project team. The topography, reference design rail alignments and existing buildings were supplied in 3-D; the existing rail alignments and resumption plans were supplied in 2-D. A digital ground model was created, based on the supplied topography, and applied to the existing rail alignment strings to generate the 3-D model for the model verification. Details of existing noise barriers along the Cleveland line were supplied by Queensland Rail, all other existing noise barriers were digitised from aerial and on-site surveys.

Train noise source data for the existing fleet have been taken from Queensland Rail's standard table of noise emissions. Based on advice from the Project team, all suburban trains were modelled as the proposed new 7-car passenger trains. The Project team advised these new trains have similar specifications to the existing EMU fleet, therefore the noise emission levels for the 7-car passenger trains were extrapolated from those for a 6-car EMU citytrain.

A "typical-maximum" speed profile for passenger trains was provided by the Project team. These speeds have been applied to all passenger trains within the study area. Acceleration and deceleration rates (for approach to and departure from stations) have been roughly estimated in this initial stage of modelling as no data is available for the proposed new 7-car passenger trains.

In the absence of any data, all freight traffic was modelled as double-header locomotives (current generation) with 1,500 m of consist. All freight movements were assumed to travel at a constant speed of 60 km/h and the locomotives were assumed to be at a notch setting of 6.

Corrections for curves, bridges and turnouts have been modelled based on features identified in the Reference Design, existing track alignments and aerial photography.

Portal noise emissions have been modelled as a vertical area noise source across the tunnel portal openings. A sound power level has been assigned to these portal noise sources based on in tunnel noise measurements in rail tunnels in Sydney. The source level has for the Reference Project assumed no absorption in the tunnel, resulting in a higher reverberant build up noise level in the tunnels. The average LAeq(24hour) sound power level for the portals have been calculated following the methodology outlined in a paper "*Prediction of sound radiated from tunnel openings*" by Wolfgang Probst, 2010.

Directivity for the portal opening area noise sources in accordance with recommendations in (Wolfgang Probst, 2010) has been adopted.

## EXECUTIVE SUMMARY

The predicted noise levels include contributions from the through traffic and tunnel portals and include shielding from any existing noise barriers. All predicted levels include a +3.0 dBA facade correction.

### 3.3.2 Results and Mitigation

***Portals***

In the northern section, all sensitive locations are predicted to comply with Queensland Rail's operational planning levels in Year 2031. Therefore, no mitigation measures are required in this section.

In the southern section, 19 sensitive locations are predicted to exceed Queensland Rail's operational planning levels in Year 2031. Noise barriers have been designed (as far as practicable – eg noise barrier heights have been limited to 6 m) for these locations to target compliance with Queensland Rail's operational planning levels. The recommended noise barrier is:

Railway Terrace Noise Barrier

Upgrading the existing noise barrier to a height of 6 m provides a significant noise reduction at most facades. However, this noise barrier is insufficient to achieve compliance with Queensland Rail's operational planning levels at all residences. It has not been proposed to extend this noise barrier in front of the Leukaemia Foundation building at the northern end as the building's height would make any noise barrier ineffective. The total area of the upgraded noise barrier is approximately 1,919 $m^2$.

Due to Queensland Rail's policy to not build noise barriers adjacent to existing train stations for safety reasons, there are 7 additional sensitive receivers adjacent to the Dutton Park (5) and Park Road (2) Stations exceeding Queensland Rail's operational planning levels taking into account the proposed Project noise barriers. Rail noise levels of up to 77 dBA $L_{Aeq(24hour)}$ and 97 dBA $L_{Amax}$ are predicted at these residences (directly adjacent station platforms), being an exceedance of 12 dBA and 10 dBA respectively.

During the detailed design phase, all noise barriers will need to be designed in cooperation with Queensland Rail to take into account all aspects of noise, visual amenity and safety.

Furthermore, it is recommended that the following actions take place at the detailed design phase:

- Review recent Development Applications (DAs) to ensure existing rail noise levels have been / are adequately addressed at the time of development (e.g. through the use of upgraded building facades where required).
- Undertake further detailed modelling to include a more accurate composition of passenger trains on surface tracks (eg mix of SMU and EMU, mix of 3-car, 6-car and 7-car sets), instead of the current conservative modelling assumption that all suburban train movements are EMU trains).
- Obtain the (external) pass-by noise level specifications for the new-generation rolling stock passenger trains and incorporate this into the detailed design stage modelling.

As part of Queensland Rail's ongoing community consultation process, Queensland Rail has committed to progressively introduce quieter "new generation" freight locomotives. The noise reduction with the introduction of the quieter freight locomotives is expected to be 7 to 8 dBA. This is another aspect that is recommended to be considered in the detailed design phase.

## EXECUTIVE SUMMARY

### *Rail Network between Portals*

The rail tracks between the portals in Dutton Park and Victoria Park will not be changed as part of the BaT project. However, the BaT project will free up capacity on these surface tracks by redirecting a significant portion of the passenger rail operation through the rail tunnels.

The passenger and freight train numbers for assessing the incremental change to the daily averaged $L_{Aeq(24hour)}$ noise emission levels from the existing surface rail tracks between the portals have been provided by the BaT Rail Operations team.

The predicted noise levels indicate that the $L_{Aeq(24hour)}$ noise emission levels increase up to 2.5 dBA due to the change in passenger train traffic for the Year 2031 in the Northern Connection.

The $L_{Aeq(24hour)}$ noise emission levels decrease -0.7 dBA due to the change in passenger train traffic for the Year 2031 in the Southern Connection.

It is generally recognised in acoustics that changes in noise levels of 2 dBA or less are undetectable to the human ear. The absolute noise levels in the Northern Connection area are also below Queensland Rail's noise limits. Therefore, negligible impacts are predicted for the general rail network.

The maximum noise level during train passbys will not change due to a change in passenger and freight train numbers. There would only be a change to the number of train passby events. In fact, over time it is likely that the maximum noise levels from train passbys would be reduced as new generation rolling stock are progressively introduced into Queensland Rail's operation.

### 3.4 Airborne Noise Assessment – Bus Operations

### 3.3.1 Methodology

In order to predict both $L_{Aeq}$ and $L_{Amax}$ noise levels using the SoundPLAN software, the Nordic Rail Model was utilised, calibrated to the specific noise emission characteristics of BCC buses, to predict noise levels associated with the proposed busway corridor. The Nordic Rail Model is the only existing transportation model that predicts both $L_{Aeq}$ and $L_{Amax}$ noise levels. It models the same noise propagation behaviour as that of road traffic.

Noise modelling of the section of alignment adjoining the ICB (multi-modal) was carried out using the UK Department of Transport, *"Calculation of Road Traffic Noise*" (CORTN 1988) algorithms incorporated in the SoundPLAN 7.2 noise software. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers. The algorithm output of CORTN calculates the $L_{A10(18hour)}$ descriptor directly for comparison with the 'Multi-modal Corridor' road traffic noise goal.

In addition, calculations have also taken into consideration the contribution to overall traffic noise levels from the tunnel portals. All predicted levels include a +2.5 dBA facade correction.

Noise emissions from the tunnel portals have been modelled as vertical area noise sources across the tunnel portal openings. The source sound power for this area source and distribution of sound power over the portal area has been modelled as described by S. Olafsen's Inter-Noise 96 paper titled *"Noise from Road Tunnel Openings – An Engineering Approach"*. The propagation of the portal noise emissions has been modelled using the Concawe industrial noise model within the SoundPLAN modelling suite. The noise predictions for the portal noise model has then been added logarithmically

**EXECUTIVE SUMMARY**

to the noise predictions for the standard Kilde traffic noise predictions to generate overall noise levels for the combination of portals and busways.

### 3.3.2 Results and Mitigation

There are three (3) educational buildings (St Joseph's College buildings) and two (2) health buildings (RBH QIMR and RBH Surgical Building) which are predicted to exceed the DTMR Code of Practice 65 dBA $L_{A10(1hour)}$ noise criterion in the northern connection area.

Also in the northern section, one (1) health building (RBH Block 7) is predicted to exceed the DTMR Code of Practice 69 dBA $L_{Amax}$ noise criteria for upgraded busway.

For the southern section, all noise sensitive receivers are predicted to meet the relevant noise criteria.

Noise mitigation has not been recommended at any of the six (6) noise sensitive receivers which exceed the applicable noise goals. Noise modelling predictions have found that all six (6) exceedances listed above are contributable to the existing road networks (ICB and Northern Busway) and not the BaT project. Noise levels at the six (6) locations with noise contribution from only the BaT alignment (not including existing roads) would be significantly below the applicable criteria (at least 15 dBA below the relevant criteria).

There are two (2) proposed bus layovers for BaT. One is to be located in the southern connection precinct adjacent the Princess Alexandra Busway Station at Kent Street, the other is to be located in the northern connection precinct adjacent the existing Northern Busway, with access via Gilchrist Avenue, Herston.

It has been determined that there are no noise sensitive receptors surrounding the Bus Layovers and no further assessment of the bus layover noise emissions is necessary.

### 3.5 Airborne Noise Assessment - Mechanical Plant and Ancillary Facilities

Two (2) feeder stations are proposed to service the train operations for BaT. The locations of the feeder stations are near the northern connection at Victoria Park and near the southern connection at Woolloongabba adjacent to Princess Alexandra Hospital. Based on the location of the feeder stations and assuming a Sound Power Level according to AS 2374.6-1994 and a 20 dBA facade reduction for the enclosures, all two (2) feeder stations are predicted to comply with the project noise goals.

The modelling of the mechanical services airborne noise presented in this assessment is based on the preliminary plant locations which are still potentially subject to change. Specific equipment is also not known at this stage and the expected noise levels can therefore not be predicted. As such, the maximum total allowable emitted sound power at each ventilation stack and station ancillary facility has been calculated, specifying the acoustic emission limit for all equipment (combined operation) at each location. These results are shown in **Table 31**.

Mitigation measures are likely to be required for some station mechanical plant and ventilation stacks in order to comply with the project noise goals. Mitigation measures that may need to be considered at some locations include appropriate equipment selection, in-duct attenuators, noise barriers, acoustic enclosures and the strategic positioning of critical plant away from sensitive receivers.

The locations and designs of the mechanical plants, air exhausts and intakes and tunnel ventilation for the Project will need to be assessed in more detail during the detailed design phase.

## EXECUTIVE SUMMARY

**Table 31 Ventilation Stacks and Station Ancillary Facilities - Maximum Acceptable Noise Emissions**

| Site Location | Ancillary Location | Distance to Nearest Sensitive Receiver (m) | Noise Goal (dBA LA90)[1] | Maximum Acceptable Sound Power Level (dBA) |
|---|---|---|---|---|
| Boggo Rd Southern Ventilation Stack | Vent stack located above the busway adjacent to its connection with the Boggo Rd busway, 11m above roof of busway tunnel | ~150 | 40 | 92 |
| Woolloongabba Station | Main plant room with vent located at the north end of the station. | ~75 | 46 | 92 |
| Woolloongabba Ventilation Stack | Vent stack located at the north end of the station, 24m above ground level | ~ 75 | 46 | 92 |
| George St Station | Main plant room located underground, location of above ground ventilation louvres unknown at this stage. | ~4 | 51 | 71 (from each ventilation louvre) |
| George St Ventilation Stack | Along the southeast side of George Street Station | ~25 | 51 | 87 |
| Roma St Station | Main plant room located underground under Parkland Crescent car park, location of fresh air shaft east of car park 5m of nearest receiver. | ~65 | 47 | 91 (from ventilation louvres) |
| Roma St Ventilation Stack | Two exhaust shafts shown on the drawing, nearest to residences located north of platform 10 adjacent Parkland Crescent, 8m above ground level. | ~45 | 47 | 88 |
| Victoria Park Northern Ventilation Stack | Located west of the Gregory Terrace tennis courts | ~160 | 51 | 103 |

Note 1: Background creep noise goal in accordance with EPP(Noise) refer to **Table 7**. The background creep is the RBL + 0 assessed as the LA90 parameter. Existing background noise levels RBLs as presented in **Table 9**.

## EXECUTIVE SUMMARY

## 4 SUMMARY OF POTENTIAL IMPACTS AND IMPACT MANAGEMENT

### Summary of Potential Operational Noise and Vibration Impacts and Recommended Impact Management Measures

| Activity | Potential Impact | Recommended Management Measure |
|---|---|---|
| Ground-borne Noise from Train Operations | Southern Connection to Woolloongabba Station - residential receivers exceed the night-time ground-borne noise goal of 35 dBA.<br>Woolloongabba Station to George Street Station – compliance at all locations<br>George Street to Roma Street Station - residential receivers exceed the night-time ground-borne noise goal of 35 dBA.<br>Roma Street Stations to Northern Connection - residential receivers exceed the night-time ground-borne noise goal of 35 dBA. | 790 m of resilient rail fasteners for the Down Track and 665 m of resilient rail fasteners for the Up Track are required to achieve compliance with the ground-borne noise goals at all sensitive receiver locations. |
| Ground-borne Vibration from Train Operations | Predicted compliance with nominated vibration goals at all locations. | Nil |
| Airborne Noise from Train Operations | 19 sensitive receivers in the southern section are predicted to exceed the Queensland Rail planning noise levels. | Increase the height of one (1) existing noise barrier in the southern connection area to help meet the planning noise levels at sensitive receivers. The total recommended noise barrier requirement is 1,919 $m^2$. |
| Airborne Noise from Bus Operations | Three (3) educational buildings at St Joseph's College are predicted to exceed the DTMR Code of Practice 65 dBA LA10(1hour) noise criterion in the northern connection area.<br>Two (2) health buildings (RBH QIMR and RBH Surgical Building) are predicted to exceed the DTMR Code of Practice 65 dBA LA10(1hour) noise criterion in the northern connection area.<br>One (1) health building (RBH Block 7) is predicted to exceed the DTMR Code of Practice 69 dBA LAmax noise criteria for upgraded busway. | Noise mitigation is not recommended as the noise levels are attributable to the existing road networks, not BaT. Noise levels attributable to BaT busways only would be at least 15 dBA below the noise goals. |
| Airborne Mechanical Plant and Ancillary Noise | Potential impact at some locations from mechanical plant and ventilation stacks. | The locations and designs of the mechanical plants, air exhausts and intakes and tunnel ventilation for the Project will need to be assessed in more detail during the detailed design phase.<br>Mitigation measures that may need to be considered at some locations include appropriate equipment selection, in-duct attenuators, noise barriers, acoustic enclosures and the strategic positioning of critical plant away from sensitive receivers. |

.