Gold Coast
Rapid Transit

16 Noise and Vibration

Contents

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1. Introduction

The purpose of this chapter is to identify potential noise and vibration impacts as a result of the construction and operation of the proposed Gold Coast Rapid Transit (GCRT) corridor.

It provides a preliminary assessment of the noise and vibration impacts for the following alignments and options:

» Section 2: University Hospital[1] up to and including Sundale Bridge; and

» Section 3: Sundale Bridge to Broadbeach South station.

Results from the noise and vibration assessment at identified receiver locations along the GCRT alignment, considering both Bus Rapid Transit (BRT) and Light Rail Transit (LRT) modes, will be presented in this chapter. Mitigation strategies in response to predicted impacts will also be discussed.

For detailed information on the noise and vibration issues associated with the construction and operation of the GCRT, for each section of the alignment, refer to the Volume 7 technical report titled, *Noise and Vibration*.

[1] Further to work undertaken in preparing this CDIMP, there has been significant additional activity to finalise the concept design for the rapid transit alignment along the Parklands Knowledge Precinct and a rapid transit station to serve the main entrance of the new Gold Coast University Hospital. Reference should be made to the *Parklands Knowledge Precinct Report* that supplements the CDIMP and provides updated information on the proposed concept design and assessment of impacts.

2. Description of the Existing Environment

2.1 Study Area

The study area includes adjacent residential properties, commercial properties, educational facilities, parks and outdoor educational and recreational areas that can be considered as potentially noise sensitive places.

Table 16-1 presents the breakdown of areas for Section 2 and Section 3 of the alignment, which will be used throughout this noise impact assessment.

Table 16-1 BRT and LRT Noise Study Areas

Section	Area	Roadway	Between Streets
Section 2	A	Parklands Drive/Rapid Transit/Baratta St	Olsen Ave to Wardoo Street
	B	Wardoo Street	Baratta Street to Queen Street
	C	Queen Street[2]	Wardoo Street to Whitby Street
	D	Queen, Nerang	Whitby Street to High Street
	E	Nerang, Scarborough[3]	High Street to Lather Street
	F	Queen, Gold Coast Highway	Lather St to South Gold Coast Highway
Section 3	A	Gold Coast Highway	Sundale Bridge to Tedder Avenue
	B	Gold Coast Highway	Tedder Avenue to Ferny Avenue
	C	Gold Coast Highway	Ferny Avenue to Cypress Avenue
	D	Gold Coast Highway	Cypress Avenue to Beach Road
	E	Gold Coast Highway	Beach Road to Rememberance Drive
	F	Gold Coast Highway	Rememberance Drive to Monaco Street
	G	Gold Coast Highway	Monaco Street to Australia Avenue
	H	Gold Coast Highway	Australia Avenue to TE Peters Drive
	I	Gold Coast Highway	TE Peters Drive to Surfers Avenue

2.2 Noise and Vibration Sensitive Buildings

Noise and vibration receivers along the GCRT alignment have been identified based on site visits and aerial photography. These receivers have been considered in this report when assessing potential noise and vibration impacts.

Key identified receivers are listed in Table 16-2. Note residential dwellings have not been included in this list, and this list is not all inclusive of all receivers along the alignment.

Table 16-2 Noise and Vibration Educational and Health Receivers

Type	Facility	Location	Project Section
Education	Griffith University[1]	Parklands Drive, Parkwood	Section 2
Hospital	Proposed Hospital Precinct[1]	Parklands Drive, Parkwood	Section 2
Education	Southport State School	Queen Street, Southport	Section 2
Aged Care	Trinity Gardens Aged Hostel	135 Nerang Street, Southport	Section 2
Aged Care	Independent Inhome Care	127 Nerang Street Southport	Section 2
Hospital	Gold Coast City Hospital	108 Nerang Street Southport	Section 2
Hospital	Allamanda Private Hospital	144-152 Queen Street Southport	Section 2

3. Methodology

3.1 Baseline Noise Monitoring

A pre-construction noise monitoring program was undertaken by GHD to provide information on the existing ambient noise environment of the GCRT study area. The objectives of the noise monitoring program were to:

» provide a noise climate of pre-construction noise levels;

» provide baseline data for comparative assessment of pre and post construction noise levels;

» determine the relevant assessment criteria to be based on pre-construction noise levels; and

» provide information for noise modelling (road traffic noise model verification).

3.1.1 Noise Monitoring Methodology

Noise monitoring was undertaken at each residential noise monitoring location for up to one week, with data being excluded for the following periods:

» weekends;

» school and public holidays;

» during extraneous noise;

» during atypical traffic flows; and

» during adverse weather conditions.

Noise Monitoring Equipment and Calibration

Noise monitoring was undertaken at all noise monitoring locations using the equipment as outlined in the Volume 7 technical report titled, *Noise and Vibration*. Supplementary attended noise measurements were undertaken using a Bruel & Kjaer 2250 sound level meter (SLM).

A calibration check was performed before and after each measurement set and all measurements were conducted and data interpreted by GHD personnel.

Meteorological Monitoring

A Davis Vantage Pro weather station located at the Council Depot of Michelin Street, Southport was used to record wind speed and direction, rainfall periods and air temperature.

For noise measurements conducted over a 24-hour day, the acceptable values of the two weather factors for wind and rain conditions were:

» average wind speed up to three metres per second; and

» rainfall up to 0.3 millimetres per hour.

Noise measurements conducted during a 24-hour day were to be discarded under the following weather conditions:

» more than two continuous hours of adverse weather conditions; and

» more than three non-continuous hours of adverse weather conditions.

Where possible, the measured noise data collected during the hours of adverse weather conditions were discarded and replaced with values determined by simple linear arithmetic interpolation of the other data collected during that day.

3.1.2 Monitoring Locations

Noise monitoring was undertaken at 24 locations adjacent to the transport corridor which were selected from pre-defined monitoring sections and with consideration to the following factors:

» each location was chosen as representative of the receivers in the surrounding area with similar intervening source to receiver noise paths; and

» a majority of the noise monitoring locations were chosen at residences directly adjacent to the corridor and hence most exposed to existing road traffic noise. These measurements were undertaken to provide a baseline for future noise monitoring and provide data for road traffic noise model verification.

Limitations that were encountered during the selection of the noise monitoring sites included:

» availability of residents/landowners;

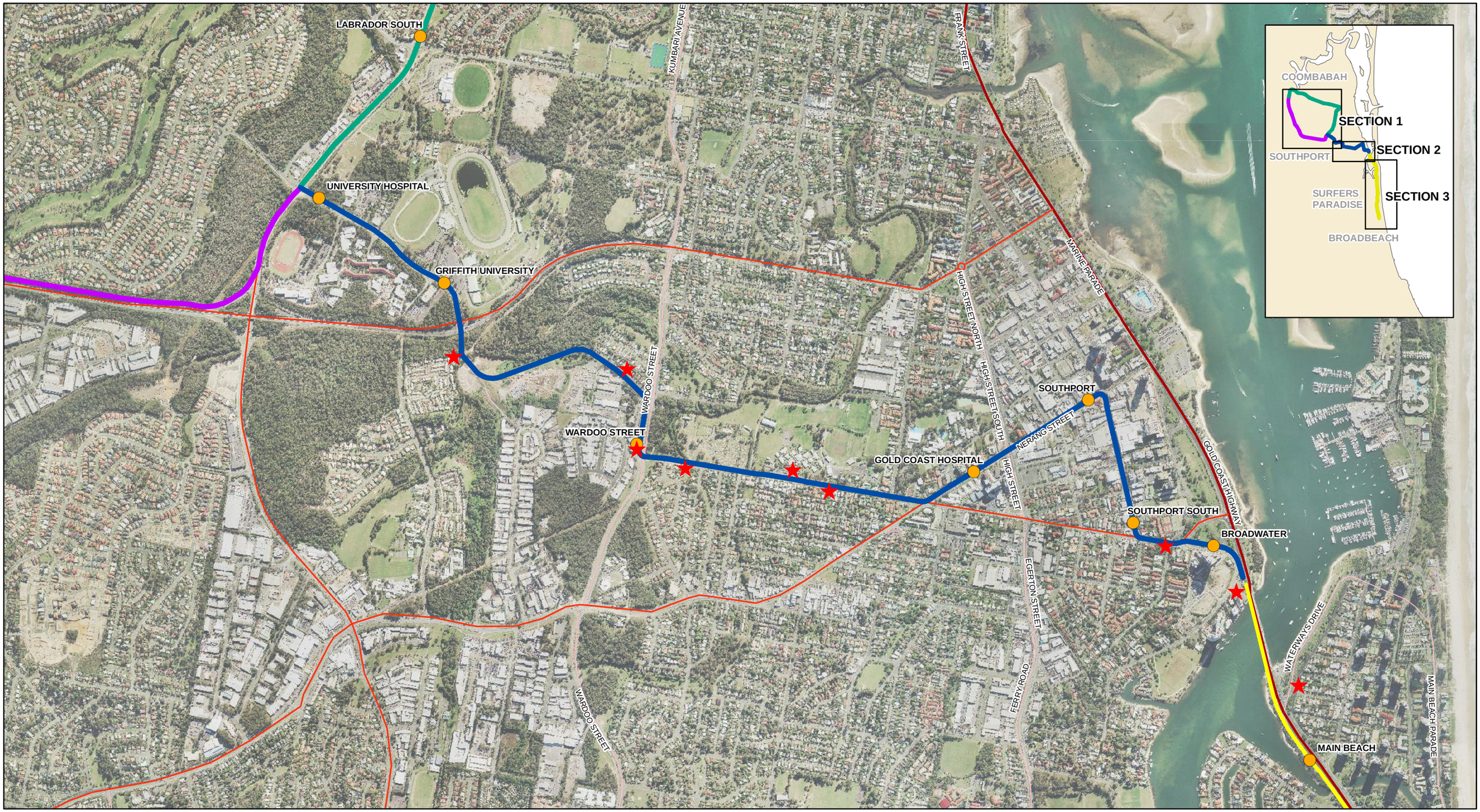
» sites with extraneous noise sources other than the current road traffic noise from the study area could not be selected;

» security of monitoring equipment from theft or vandalism; and

» safety of monitoring technicians entering a residents yard (e.g. domestic dogs on site).

Noise monitoring has been undertaken at locations directly adjacent to the GCRT corridor in order to characterise the existing ambient noise environment. Figure 16-1 and Figure 16-2 show the monitoring locations.

Gold Coast
Rapid Transit



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Noise Survey Point
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Section 1: Option H1
Section 1: Option H2
Section 2
Section 3

Road Centrelines
Highway
Secondary Road
Local Connector Road

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Gold Coast Rapid Transport
FINAL CDIMP
NOISE MONITORING
Section 2
FIGURE 16 - 1

Gold Coast Rapid Transit

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Gold Coast Rapid Transit

FINAL CDIMP

NOISE MONITORING

Section 3

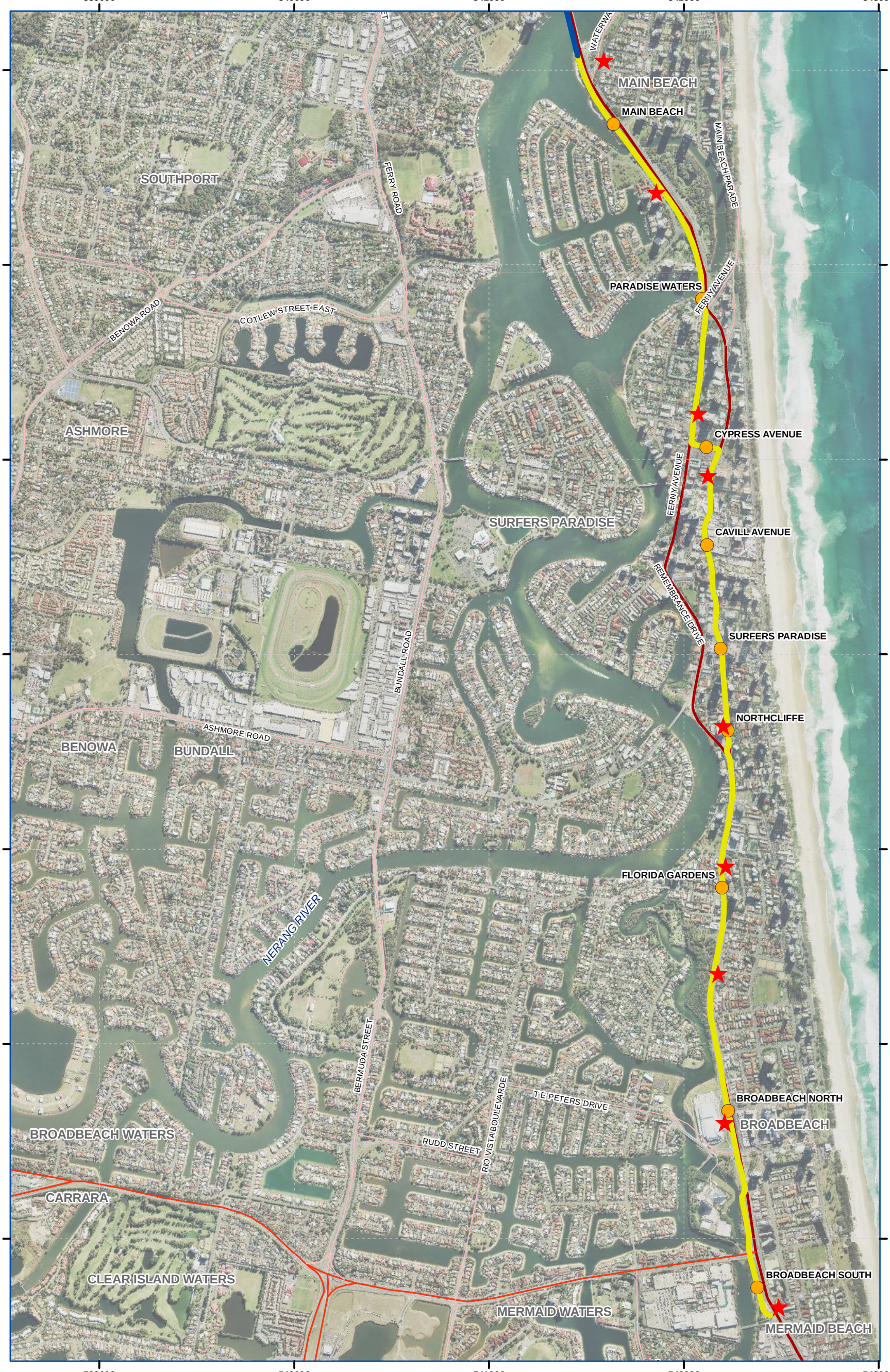
FIGURE 16-2

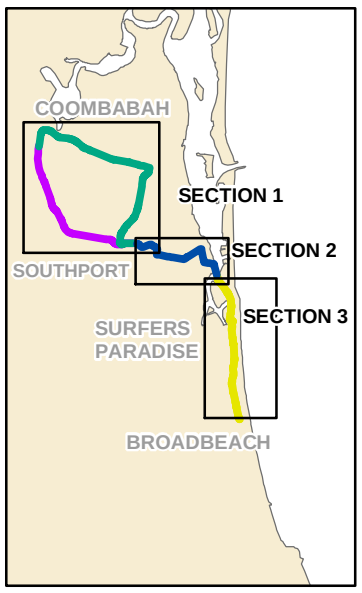
Legend

- Noise Survey Point
- Station
- Section 2
- Section 3

Road Centrelines

- Highway
- Secondary Road
- Local Connector Road





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3.2 Baseline Vibration Monitoring

Locations that are representative of the proposed GCRT alignment were selected in order to characterise the existing vibration environments in the vicinity of the proposed works. Consideration was given to the following for the determination of these locations:

» availability of residents/landowners;

» existing land uses; and

» potentially vibration sensitive locations (i.e. industry, residences and existing public infrastructure).

Details of vibration monitoring sites are listed in Table 16-3.

Table 16-3 Vibration Monitoring Locations

Location	Major Vibration Source
2 Barney Street, Southport	Gold Coast Highway (Sundale Bridge)
Southport Primary School	Queen Street (car park in between)
1 Olympic Court	Wardoo Street (and car park adjacent)
2607 Gold Coast Highway	Gold Coast Highway
21 Blackwattle Circuit	Gold Coast Highway
87 Olsen Avenue	Olsen Avenue
Unit 1 88 Greenacre Drive	Smith Street Motorway
41 Carner Court	Smith Street Motorway
20 Commodore Crescent	Gold Coast Highway (Commodore Crescent in between)
33 Thornton Street	Gold Coast Highway

A summary of the average vibration monitoring results over the measurement period is shown in Table 16-4 – Summary of Vibration Monitoring for each monitoring location.

Table 16-4 Summary of Vibration Monitoring

	X (mm/s)	Y (mm/s)	Z (mm/s)
2 Barney Street, Southport	0.18 +/- 0.05	0.16 +/- 0.03	0.19 +/- 0.05
Southport Primary School	0.06 +/- 0.01	0.06 +/- 0.00	0.08 +/- 0.01
1 Olympic Court	0.09 +/- 0.01	0.07 +/- 0.00	0.07 +/- 0.00
2607 Gold Coast Highway	0.27 +/- 0.03	0.34 +/- 0.03	0.27 +/- 0.03
21 Blackwattle Circuit	0.07 +/- 0.00	0.07 +/- 0.00	0.08 +/- 0.00
87 Olsen Avenue	0.15 +/- 0.03	0.19 +/- 0.03	0.18 +/- 0.03
Unit 1 88 Greenacre Drive	0.08 +/- 0.00	0.06 +/- 0.00	0.07 +/- 0.01
41 Carner Court	0.10 +/- 0.03	0.08 +/- 0.02	0.10 +/- 0.05
20 Commodore Crescent	0.09 +/- 0.02	0.16 +/- 0.01	0.10 +/- 0.02
33 Thornton Street	0.09 +/- 0.02	0.17 +/- 0.02	0.11 +/- 0.03

3.3 Construction Noise Prediction Methodology

A detailed description of construction noise levels would require a comprehensive list of plant items, proposed operation times and their location with respect to receivers. This information was not known at the time of this assessment, so potential noise emissions have been estimated using reference sound power levels for typical construction plant anticipated on the worksite. Noise levels have been predicted from five different plant items that represent a spread of different noise levels common on construction sites. Construction equipment has been assumed to operate continuously at maximum sound power levels.

Indicative noise emissions and potential impacts from construction activities have been estimated with the following process:

- construction noise levels have been estimated for clusters of like receivers along the alignment;
- all construction activities have been assumed to be undertaken during the daytime period (6am to 6pm);
- calculation of external noise levels at the receiver locations from specified construction plant took into account distance attenuation and where relevant existing noise barriers or mitigation devices were located;
- predicted levels have been compared with external noise goals to assess potential noise impact on receivers; and
- areas where noise mitigation strategies may be required have been identified.

3.4 Construction Vibration Prediction Methodology

Potential vibration impacts have been assessed using typical vibration levels in Table 16-5. These vibration levels have been used to estimate vibration impact from construction activity at receivers adjacent to the proposed alignment.

Table 16-5 Typical Vibration Generation Levels from Construction Plant

Activity	Peak Particle Velocity (PPV) Vibration Level (mm/s) at Distance		
	10m	**20m**	**30m**
Concrete Sawing	0.5	0.3	0.2
4-Tonne Vibratory Roller (High)	2.0-2.4	0.4-1.2	0.2-0.8
Hydraulic Hammer (30 tonne)	3	1.5	0.4
Impact Pile Driver	3.3	0.95	0.45

3.5 Operational Noise Modelling Methodology

3.5.1 Operation Noise Models

The following scenarios have been considered in the noise assessment:

» existing conditions have been modelled to verify the noise model;

» 2021 BRT operations; and

» 2021 LRT operations.

3.5.2 Noise Modelling Software

Acoustic modelling was undertaken using Computer Aided Noise Abatement (CadnaA) to predict the effects of traffic noise from the proposed development. CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation according to *ISO 9613-2:1996, Acoustics – Attenuation of sound during propagation outdoors*. Ground absorption, reflection, terrain and relevant shielding objects are taken into account in the calculations.

Traffic noise modelling was conducted using the United Kingdom Department of Environment's '*Calculation of Road Traffic Noise'* (1988) (CoRTN). CoRTN was used for both the traffic noise model and the proposed busway in the BRT design model. Railway traffic noise modelling was conducted using the Nordic Prediction Method. The proposed development has been modelled based on available data at the time of assessment.

The noise models incorporate three-dimensional alignments of the proposed designs, noise sensitive buildings and receivers, traffic flow, busway and rail traffic flow, travel speeds and road surface characteristics. All of these inputs are discussed in more detail below.

Noise predictions were undertaken for the noise receivers most exposed to road traffic and railway noise along the proposed corridor and have been segmented into the areas as outlined in Table 16-1.

3.5.3 Road Traffic Noise Model Verification

Since the proposed alignment is contained within existing road corridors it is a requirement that an existing noise model be generated to calculate year 2008 noise levels and compare them with year 2008 noise monitoring results for noise model verification.

The verification noise model used all external digital data from outside of the design alignment with receiver locations set at the height and location of measurements. The main difference between the verification noise model and the design noise model is the road alignment and noise source data.

With consideration to the Department of Main Roads (DMR) guidelines *"Road Traffic Noise Management: Code of Practice*" (DMR 2007) (DMR *Code of Practice*), the model is deemed to be verified if the average difference between the measured and calculated values of the descriptors is within +/-2.0 dB(A). The relevant pavement surface correction factors for the existing roads were applied from Table 4.3.4.1 of the DMR *Code of Practice* (DMR 2007) and the respective verification factors for Queensland roads were also applied from Table 4.3.2.1 (-1.7 dB for one metre in front of building facades and - 0.7 dB for free field calculations) prior to verifying the model against the measured noise levels.

For a section of road, if the average measured noise levels exceed the calculated noise levels then an adjustment equal to the exceeded value is applied to the calculated and predicted noise levels.

For a section of road, if the calculated noise levels exceed the measured noise levels then no correction is applied to the predicted noise levels.

3.5.4 Verification of Predicted Results

Existing (2008) traffic data was used in the noise model to verify the predicted results against noise monitoring results. Verification of predicted results for noise receivers at noise monitoring locations can be seen in the Volume 7 technical report titled, *Noise and Vibration* - Table 5.2. All calculated results located one metre from the most exposed building façade include a façade correction of 2.5 dB(A), as per CoRTN guidelines (1989).

The average difference between the measured and calculated results is 1.0 dB(A) therefore the noise model is deemed to be verified as per the DMR *Code of Practice* (DMR, 2007).

As a result of model validation, the following corrections have been applied to the design noise model for receivers where the calculated result was lower than measured levels in their areas:

- a factor of 1.6 dB(A) has been applied to all noise receivers on Queen Street, west of the Queen Street and Nerang Street intersection; and
- a factor of 0.4 dB(A) has been applied to all noise receivers on the Gold Coast Highway, between Ferny Avenue and Pandanus Avenue.

Calculated results at all other noise receivers were above measured results and therefore, no verification factors were required.

3.5.5 Design Noise Model Generation

The following data processing was undertaken to generate the 3-dimensional (3D) digital noise model in CadnA:

- a 3D digital terrain model of the existing ground was generated using Aerial Land Survey (ALS) data of the study area with 1-metre topographic contours. The terrain model was filtered to remove irrelevant data in order to reduce computational time;
- a 3D design model of BRT and LRT Section 2 and 3 alignments was completed, including lane line markings, edge of carriageway and kerb lines, service roads, embankments, safety barriers and retaining walls;
- digital cadastral boundaries were established;
- a digital building survey was generated using Airborne Laser Scanning (ALS) data. This allowed 3D building data for the entire stretch of Sections 2 and 3 to be imported into the noise model. Some building facades were then modified or 'cleaned' where considered appropriate;
- the 3D digital terrain model and 3D digital design model were merged and the building envelopes were overlaid to create the design noise model for BRT and LRT 2021 scenarios; and
- 2021 traffic bus and rail data was then incorporated into the noise model (refer to Section 5.3 of the Volume 7 technical report titled, *Noise and Vibration*).

Correction factors have been applied to the LRT noise model for tight radius corners, to account for frictional noise such as wheel squeal and for bridges. In the absence of measured noise data, GHD has assumed that correction factors provided to GHD by Queensland Rail[4]. The correction factors used in the rail noise model are summarised below:

- radius turn less than 300 metres: + 8 dB(A) to sound power;
- radius turn between 300 metres and 500 metres: + 3 dB(A) to sound power; and
- concrete bridge (with parapets): + 1 dB(A) to sound power.

GHD understand that these correction factors would normally be adopted for freight trains and, as such, are expected to be conservative for use with the LRT noise model. Therefore, it is recommended that these correction factors be revised upon detailed design stage.

3.6 Operations Vibration Prediction Methodology

Light rail and bus vibration data was sourced from Chapter 10 of the U.S. Department of Transportation Federal Transit Administration '*Transit Noise and Vibration Impact Assessment'* (2006). This data was used to produce graphs of the Root Mean Square (RMS) vibration velocity level at distances from the railway track centre for light rail vehicles and for buses at various speeds. RMS vibration velocity levels for a locomotive powered passenger train were also graphed for comparison to the light rail.

Figure 16-3 shows the RMS vibration velocity levels adopted for this assessment.

[4] GHD understand that Queensland Rail use correction factors for their noise modelling with SoundPlan DOS version. These correction factors are not published by Queensland Rail.

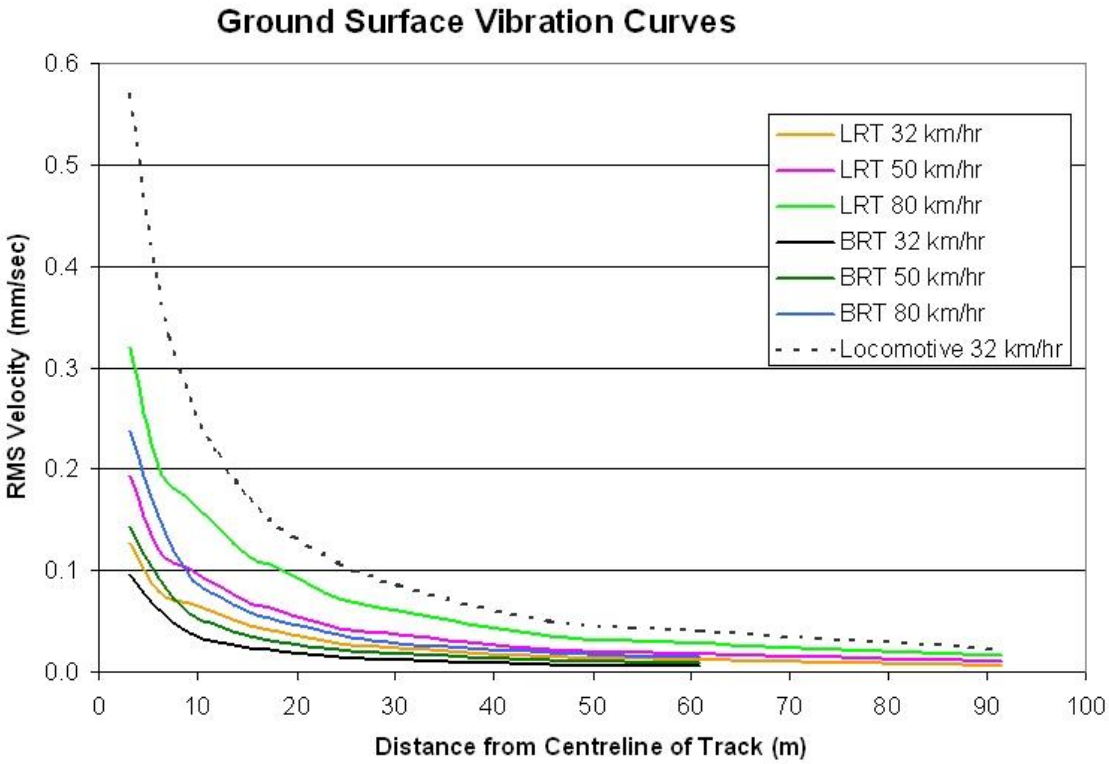

Figure 16-3 - RMS Vibration Velocity Levels (Source: U.S. Federal Transit Administration)

4. Potential Benefits, Impacts and Mitigation Measures

4.1 Construction Phase

4.1.1 Construction Noise Guidelines

The Queensland Government *Environmental Protection Regulation 1998* requires that a builder or building contractor carry out building work on a building or construction in accordance with the limitations outlined in Table 16-6.

Table 16-6 Noise Guidelines for Construction Activity

Day	Operating Limitations
Monday to Saturday	6:30 am – 6:30 pm – no numerical noise limits
Sunday, Public Holiday and all other times	Construction must be inaudible at noise receivers

The time restrictions are designed to strike a balance between protecting noise amenity and the need to start construction activities early in the morning.

» If works are being undertaken in accordance with a development approval then conditions may exist stipulating project specific noise criteria.

» Also, if construction activities are required outside of the hours mentioned above then approval might be required. There is no specific legislation governing works outside normal construction hours, although potential impacts of long term construction noise can be assessed using the following criteria:

» sleep disturbance criteria published by the QLD Environmental Protection Agency (EPA) or local council;

» recommended internal noise levels for building uses specified in *AS/NZS 2107: 2000 Acoustics – Recommended design sound levels and reverberation times* for building interiors; and

» comparison with the existing ambient noise environment.

The QLD EPA's *Ecoaccess Guideline Planning for Noise Control* (2004) recommends maximum internal noise levels in sleeping areas to avoid sleep disturbance. The guideline states as a rule for planning short term events, the indoor sound pressure level should not exceed approximately 45 dBA $_{maxLpA}$ more than 10-15 times per night.

The maximum recommended internal noise levels specified in *AS/NZS 2107* have been adopted for the construction noise goals and are shown in Table 16-7 for a selection of building uses that may be relevant to building uses near construction sites.

Table 16-7 Recommended Internal Noise Design Levels from AS 2107:2000

Type of Building Occupancy/ Activity	Maximum Recommended Design Sound Level L_{Aeq} dB(A)
Educational area – Teaching space	45

Type of Building Occupancy/ Activity	Maximum Recommended Design Sound Level L_{Aeq} dB(A)
Educational area – Libraries – general areas	50
Educational area – Gymnasium	55
Health building – Consulting room	45
Health building – Operating theatres	45
Health building – Ward	45
Office building – General office areas	45
Public buildings – exhibition areas	50
Place of worship – with speech amplification	40
Residential building – sleeping area near major road	40
Residential building – living area near major road	45

4.1.2 Construction Vibration Guidelines

The New South Wales Department of Environment and Climate Change (DECC) has published a set of technical papers that make reference to a number of international standards. Consideration was given to each of the following publications for the determination of monitoring sites and appropriate measurement parameters:

- *NSW DECC Assessing Vibration: A Technical Guideline, 2006;*
- *British Standard BS6472:1992 Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz);*
- *British Standard BS7385-2:1993 Evaluation and Measurement for Vibration in Buildings, Part 2 - Guide to damage levels from ground borne vibration;* and
- *German Standard DIN 4150 and BS 7385: Part 2 – 1993*.

These standards are typically adopted by industry in Australia for the assessment of construction vibration impacts.

DECC 2006 considers impacts from vibration in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). The guideline gives “preferred” and “maximum” vibration levels at buildings exposed to continuous and impulsive vibration.

4.1.3 Human Subjective Response

German Standard *DIN 4150 Part 2-1975* summarises human tactile perception of vibration and can be seen in Table 16-8 below.

Table 16-8 Vibration Levels and Human Perception of Motion (Source: DIN 4150 Part 2-1975)

Approximate vibration level	Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1.0 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

4.1.4 Effect of Vibration on Structures

Transient and continuous vibration guidelines in order to ensure a minimal risk of cosmetic damage to residential and other sensitive buildings are presented in Table 16-9. These guide values are conservative, as the actual degree of tolerance of a building depends on the structural characteristics and frequency spectrum of the vibration. In the case of continuous vibration, *BS7385-2:1993* recommends that targets outlined below be reduced to 50 percent.

Table 16-9 Transient Vibration Guidelines for Cosmetic Damage (*BS7385 – 2:1973 – Evaluation and measurement for vibration in buildings*)

Vibration Type	Peak Particle Velocity (PPV)		
	Reinforced or framed structures Industrial and heavy commercial buildings	Un-reinforced or light framed structures Residential or light commercial type buildings	
Transient vibration	50 mm/s at 4 Hz and above	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Continuous vibration	25 mm/s at 4 Hz and above	7.5 mm/s at 4 Hz increasing to 10 mm/s at 15 Hz	10 mm/s at 15 Hz increasing to 25 mm/s at 40 Hz and above

4.1.5 Human Comfort

Acceptable values of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space. Satisfactory vibration levels are established with respect to human response as shown in Table 16-10 below and are from *AS 2670.2–1990 Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz).* The RMS is a vibration level averaged within a defined time period. For peak vibration levels to be readily monitored during construction, the RMS vibration levels need to be multiplied by an appropriate

"crest" factor (i.e. ratio of the peak level to RMS level). Crest factors vary from 1.4 for construction activities of a sinusoidal nature (i.e. rolling plant) and up to 4 or more for intermittent activities such as blasting.

Table 16-10 Criteria for Exposure to Continuous and Impulsive Vibration (Source: DECC 2006)

Place	Time	Assessment Criteria			
		RMS Velocity mm/s		Peak Velocity mm/s	
		Preferred	Maximum	Preferred	Maximum
Continuous vibration					
Critical working areas (eg hospital operating theatres, precision laboratories	Day or Night time	0.1	0.2	0.14	0.28
Residences	Day time	0.20	0.40	0.28	0.56
	Night time	0.14	0.28	0.20	0.40
Offices	Day or Night time	0.40	0.80	0.56	1.1
Workshops	Day or Night time	0.80	1.6	1.1	2.2
Impulsive Vibration					
Critical working areas (eg hospital operating theatres, precision laboratories	Day or Night time	0.10	0.20	0.14	0.28
Residences	Day time	6.0	12.0	8.6	17.0
	Night time	2.0	4.0	2.8	5.6
Offices	Day or Night time	13.0	26.0	18.0	36.0
Workshops	Day or Night time	13.0	26.0	18.0	36.0

4.1.6 Potential Impacts

Noise levels at residential receivers from construction activity were predicted along the length of Sections 2 and 3 of the proposed development.

Residential noise receivers have been grouped into areas within the proposed Sections (2 and 3), as outlined in Table 16-1. The construction noise and vibration impacts are set out below in Table 16-11.

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Table 16-11 Construction Noise and Vibration Impacts

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
Section 2 Area B	Baratta Street, Southport	The nearest receivers to the worksite include residential dwellings along Baratta Street.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 30 dB greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedance of the construction activities above the prevailing noise environment may be considered intrusive and interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 2 Area B	Wardoo Street, Southport	The nearest receivers to the worksite include commercial premises on Olympic Court adjacent to Wardoo Street.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels up to 20dB greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 2 Area C and D	Queen Street, Southport	The nearest receivers to the worksite include residential dwellings adjacent to Queen Street, a childcare centre, Southport School, Gold Coast	**Gold Coast Hospital** It is not known what the hospital buildings directly adjacent to the worksite are used for and this should be clarified and further assessed during detailed design. Noise levels may exceed the external noise goals by up to 25 dB(A) and may cause interference with passive listening, resting and conversation.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
		Hospital and Doctor Surgery as well as other health buildings located on Nerang Street.	Noise mitigation is recommended for this construction activity to attenuate construction noise levels inside the Gold Coast Hospital to within reasonable levels. Further investigations are required to further explore the extent of impacts and recommend the need for additional noise mitigation. **Southport School** Noise levels have potential to exceed the external noise goals by up to 20 dB(A) at building facades and may cause interference with passive listening, resting and conversation. Noise mitigation is recommended for this construction activity to attenuate construction noise levels inside the Southport School to within reasonable levels. Further investigations are required to further explore the extent of impacts and recommend the need for additional noise mitigation. **Houses and Childcare** Based on analysis undertaken, significant exceedences of desired noise goals and noise levels up to 27dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	
Section 2	Queen Street,	The nearest	Based on analysis undertaken, significant exceedences of	Due to the separation distances

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
Area E and F	Southport	receivers to the worksite include residential dwellings on both sides of Queen Street, including some multi story low-rise apartments. There are numerous retail stores and restaurants on either side of Queen Street.	desired noise goals and noise levels more than 22 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 2 Area F	Gold Coast Highway, Southport	The nearest receivers to the worksite include an apartment block and restaurant on the western side of the Gold Coast Highway.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels up to 20 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area A	Gold Coast Highway, Main Beach	The nearest receivers to the worksite include single and two storey residential dwellings along Rankin Parade, Main Beach.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 10 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. Noticeable exceedences of the desired noise goals have been predicted due specified construction activities. This has the potential to result in significant impacts and is dependent on the activity being undertaken. Impacts are	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
		Closest receivers range from 10m up to 100m from the construction site.	likely to be limited to rooms orientated towards the construction site.	
Section 3 Area B	Gold Coast Highway, Surfers Paradise	The nearest receivers to the worksite include multi storey dwellings and high rise residential apartments on Commodore Crescent. A water body exists between many of these receivers and the construction site.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels up to 18 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area C	Ferny Avenue, Surfers Paradise	The nearest receivers to the worksite include high-rise residential, resorts and motels as well as some restaurants and cafés.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels up to 20 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area D	Gold Coast Highway, Surfers	The nearest receivers to the worksite include	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 20 dB(A) greater than the existing ambient noise levels may occur	Due to the separation distances between the construction site and nearby receivers, significant vibration

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
	Paradise	high-rise residential, resorts and motels as well as some restaurants, retail stores and cafés.	during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area E	Gold Coast Highway, Surfers Paradise	The nearest receivers to the worksite include low and high-rise residential, resorts and motels as well as some restaurants.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 30 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may be considered intrusive and interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area F	Gold Coast Highway, Surfers Paradise	The nearest receivers to the worksite include low and high-rise residential, resorts and motels as well as some restaurants.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 25 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may be considered intrusive and interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area G	Gold Coast Highway, Broadbeach	The nearest receivers to the worksite include low rise residential on the east of Gold	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 20 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedance of the construction activities above the	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
		Coast Highway, motels as well as some restaurants.	prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended.	vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area H	Gold Coast Highway (Convention Centre)	The nearest receivers to the worksite include the Gold Coast Convention Centre, low-rise residential and motels and some commercial receivers.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 20 dB(A) greater than the existing ambient noise levels may occur during construction activities, without noise mitigation. The exceedance of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and conversation. Further consideration of noise mitigation for these locations is recommended. **Convention Centre** Exceedences of desired noise goals of up to 10 dB(A) over the existing ambient noise levels may occur during construction activities, without noise mitigation. Further assessment is required during detailed design of the acoustic properties of the convention centre prior to recommending appropriate construction noise mitigation.	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.
Section 3 Area I	Gold Coast Highway, Surfers Paradise	The nearest receivers to the worksite include the low-rise and high-rise residential and motels and some commercial receivers.	Based on analysis undertaken, significant exceedences of desired noise goals and noise levels more than 29 dB(A) greater than the existing ambient noise levels may occur during construction activities at residential receivers, without noise mitigation. The exceedence of the construction activities above the prevailing noise environment may have significant acoustic impact on rooms facing the worksite and may interfere with passive listening, resting and	Due to the separation distances between the construction site and nearby receivers, significant vibration levels are not anticipated from construction activities and should meet vibration goals. However, this should be clarified and further assessed during detailed design.

Location	Address	Description	Potential Noise Impact	Potential Vibration Impacts
			conversation. Further consideration of noise mitigation for these locations is recommended. **Jupiters Casino** Exceedences of desired noise goals of up to 10 dB(A) over the existing ambient noise levels may occur during construction activities, without noise mitigation. Further assessment is required during detailed design of the acoustic properties of the casino prior to recommending appropriate construction noise mitigation.	

4.2 Construction Noise Conclusions

4.2.1 General Conclusions

The construction noise and vibration assessment has been prepared based on information available during the assessment. The report provides a preliminary assessment on potential noise and vibration levels at receivers in relation to proposed construction works. A detailed description of construction noise and vibration levels would require a comprehensive list of plant items, proposed operation times and their location with respect to receivers. This information is not known at this point of time; however, so potential noise emissions have been estimated using reference sound power levels for typical construction plant anticipated on the worksite.

As the understanding of the construction methodology evolves, a detailed Construction Noise and Vibration Plan should be prepared.

4.2.2 Recommended Noise and Vibration Criteria for Construction

The management of construction noise and vibration should aim to maintain reasonable noise and vibration levels at surrounding receivers for the duration of the project. Reasonable construction noise and vibration levels are recommended in order to develop detailed design mitigation strategies and may also assist in establishing project specific regulatory noise and vibration goals. Summary of these criteria have been presented in Table 16-12 for noise and Table 16-13 for vibration.

Table 16-12 Recommended Construction Noise Criteria

Time	Type of noise	Recommended Criteria
Daytime	Continuous	“Maximum” recommended design levels advised in *AS/NZS 2107:2000* LAeq (15minute)
	Transient	“Maximum” recommended design levels advised in *AS/NZS 2107:2000* plus 10 dB(A), LAmax
Evening	Continuous	“Satisfactory” recommended design levels advised in *AS/NZS2107:2000*, or not greater than the external background noise level (LA90) whichever is lower, LAeq,adj
	Transient	As above and EPA maximum indoor noise level for sleep disturbance of 45dB(A) LAmax 10 – 15 times per night.

Table 16-13 Recommended Construction Vibration Criteria

Time	Location	Recommended Criteria
Day	General	Transient vibration guidelines for cosmetic damage (*BS7385 – 2:1973*)
Night	General	Criteria for exposure to continuous and impulsive vibration (DECC 2006)
	Health Buildings	As per building specific vibration sensitivity investigations that are to be undertaken prior to finalisation of a Construction Noise and Vibration Management Plan

4.2.3 General Construction Works

Noise

Construction noise levels along most of the alignment are expected to exceed nominated criteria during site works. However, long term noise monitoring shows that the existing ambient noise levels can also exceed the nominated construction noise criteria at most of the closest receivers. Therefore, site-specific noise mitigation strategies should be prepared when more detailed design and construction methodologies become available, which reflect the ambient noise levels in each specific area.

Vibration

Some construction activities may impact on vibration receivers, including the Gold Coast medical precinct on Queen Street, Southport. Building specific vibration sensitivity investigations should be undertaken on receivers to determine appropriate vibration levels, to be included if required in a Construction Noise and Vibration Management Plan.

4.2.4 Noise Mitigation

Noise mitigation measures that may be implemented during construction should, where appropriate, include the following:

- selection of minimal noise plant and equipment;
- minimisation of construction plant and equipment noise through regular maintenance;
- fit all appropriate mobile plant with residential class mufflers;
- locate fixed plant and equipment (including material stockpiles and vehicle parking areas) as far as practical from noise sensitive areas;
- ongoing refinement of noise mitigation implementation;
- proactive community consultation specifically relating to:
  - the notification of the proposed time and duration of works;

  - progress of construction;
  - upcoming noise activities (blasting, drilling, rock breaking); and
  - efforts being made to minimise noise; and
- installation of appropriate noise mitigation devices such as barriers and screens.

4.2.5 Vibration Mitigation

Any residents that may be highly impacted by the works may need to be relocated during construction. Activities contributing to vibration may need to be limited in areas where high vibration levels are predicted. Further specific mitigation measures should be outlined in any building specific vibration sensitivity investigation as more information regarding the construction schedule becomes available.

4.3 Operational Phase

Noise and vibration levels were predicted for the 2021 operating scenarios for the BRT and LRT proposed designs. The road traffic, busway and railway components were assessed against their corresponding criteria to determine the mitigation requirements.

4.3.1 Operational Noise Criteria

Road Traffic Criteria

DMR's *Code of Practice* (DMR 2007) and the *Environmental Protection (Noise) Policy 1997 (EPP (Noise))* provide traffic noise criteria for roadways in Queensland.

The EPP (Noise) sets different noise criteria depending on if the roadway is a state-controlled road or a public road. For all state-controlled roadways, the DMR *Code of Practice* was adopted, while for all public or local council roads the EPP (Noise) criterion was adopted.

All identified state-controlled roadways within Sections 2 and 3 of the proposed alignment are listed below. It has been assumed that all other roadways are public roads:

- Queen Street – between Nerang Street and Ada Bell Way;
- Ada Bell Way;
- High Street;
- Hooker Boulevard; and
- Gold Coast Highway – South of Hooker Boulevard.

The applicable criteria for state-controlled roads for the 2021 operating conditions of the GCRT are detailed in Table 16-14. Operating noise goals have been based on the 'upgrade of existing road' condition outlined in the DMR *Code of Practice* (DMR 2007).

Table 16-14 Operating Noise Criteria for Noise Receivers – State-Controlled Roads

Receiver Type	Noise Criteria	Assessment Location [2]
Existing Residence	$L_{A10\ (18hour)}$ 68 dB(A)	1 metre in front of the most affected building façade
Educational and Health Buildings	$L_{A10\ (1hour)}$ 63 dB(A	1 metre in front of the most affected building façade
Parks, Outdoor Educational and Recreational Areas [1]	$L_{A10\ (12hour)}$ 63 dB(A)	Free-field location (excludes façade effects)

1. Sporting fields are not considered a noise receiver
2. Receiver heights should be 1.5 m above the floor level for each level of the building

For all other public roads a 63 $L_{A10\ (18\ hour)}$ dB(A) noise goal at noise receivers is recommended in the EPP (Noise).

The EPP (Noise) and DMR criteria do not specify noise limits specifically for busways. However, given that the proposed busway would closely follow major roadways for the majority of its length, traveling adjacent to significant road traffic noise sources, the $L_{A10\ (18\ hour)}$ assessment criteria from the EPP (Noise) and DMR *Code of Practice* is considered appropriate for determining the likelihood for impacts from the busway.

Traffic lanes for both BRT and LRT were modelled as provided in the concept design alignment. The location of the design traffic lanes included the additional BRT and LRT alignment, i.e. traffic lanes were not always modelled in their existing location to take into account the widening of the road due to BRT or LRT.

Rail Noise Planning Levels

The Queensland Rail (QR) *Code of Practice – Railway Noise Management* (2007) (QR *Code of Practice*) and the EPP (Noise) describe a railway as a "*Beneficial Asset*" and recognise that:

"Although the operation or use of Beneficial Assets may have significantly adverse effects on the Environmental Values, they are necessary for the community's environmental, social and economic wellbeing.

However, it is intended that, so far as practicable, any significantly adverse effects from their use or operation be progressively reduced".

The EPP (Noise) nominates "Planning Levels" for a Beneficial Asset such as a railway which may be used as a guide in deciding project specific noise goals for the proposed LRT development.

The QR *Code of Practice* aims to meet the railway long-term planning levels specified in the EPP (Noise) for all noise receivers. These noise goals are summarised below:

» 65 dB(A) $L_{Aeq\ (24hour)}$;and

» 87 dB(A) L_{Amax} (single event maximum sound pressure level).

Single event maximum level is defined as the arithmetic average of the highest 15 maximum levels per 24 hours.

Where appropriate, the planning levels are assessed 1 metre in front of the building façade of an effected noise sensitive place.

Station Warning Bell

The QR *Code of Practice* states that "*In general, public and employee safety must be satisfactorily protected and hence it is not appropriate to apply any particular noise criteria to these warning devices.*"" Therefore, rail horn or bell noise has not been considered at this stage. It is recommended that horn and bell noise be assessed at the detailed design stage.

4.3.2 Operational Vibration Criteria

Effect of Vibration on Structures

Transient and continuous vibration guidelines in order to ensure a minimal risk of cosmetic damage to residential and other sensitive buildings are presented in Table 16-15.

Table 16-15 Transient Vibration Guidelines for Cosmetic Damage (*BS7385 – 2:1973*)

Vibration Type	Peak Particle Velocity (PPV)		
	Reinforced or framed structures Industrial and heavy commercial buildings	Un-reinforced or light framed structures Residential or light commercial type buildings	
Transient vibration	50 mm/s at 4 Hz and above	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Continuous vibration	25 mm/s at 4 Hz and above	7.5 mm/s at 4 Hz increasing to 10 mm/s at 15 Hz	10 mm/s at 15 Hz increasing to 25 mm/s at 40 Hz and above

4.3.3 Human Comfort

Acceptable values of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space. Satisfactory vibration levels are established with respect to human response as shown in

Table 16-16 below and are from *AS 2670.2–1990*.

Table 16-16 Criteria for Exposure to Continuous and Impulsive Vibration (Source: DECC, 2006)

Place	Time	Assessment Criteria			
		RMS Velocity mm/s		Peak Velocity mm/s	
		Preferred	Maximum	Preferred	Maximum
Continuous vibration					
Critical working areas (eg hospital operating theatres, precision laboratories	Day or Night time	0.1	0.2	0.14	0.28
Residences	Day time	0.20	0.40	0.28	0.56
	Night time	0.14	0.28	0.20	0.40
Offices	Day or Night time	0.40	0.80	0.56	1.1
Workshops	Day or Night time	0.80	1.6	1.1	2.2
Impulsive Vibration					
Critical working areas (eg hospital operating theatres, precision laboratories	Day or Night time	0.10	0.20	0.14	0.28
Residences	Day time	6.0	12.0	8.6	17.0
	Night time	2.0	4.0	2.8	5.6
Offices	Day or Night time	13.0	26.0	18.0	36.0
Workshops	Day or Night time	13.0	26.0	18.0	36.0

The NSW DECC (2006) describes railway vibration as being intermittent in nature; however, do not provide specific vibration criteria for intermittent events. For the purpose of this assessment, GHD has adopted the more stringent 'continuous' vibration goals.

The NSW DECC '*Accessing Vibration: A Technical Guideline'* (2006) recommends that when assessing intermittent vibration (such as train pass-bys) the Vibration Dose Value (VDV) should be used. VDV accumulates the vibration energy received over the daytime and night time periods.

The preferred acceptable values of vibration dose are presented in Table 16-17.

Table 16-17 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (1)	Night time (1)
Critical Areas (2)	0.1	0.1
Residences	0.2	0.13
Offices, schools, educational institutions and places of worship	0.4	0.4
Workshops	0.8	0.8

(1) Daytime is 7am to 10pm and night time is 10pm to 7am.

(2) Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.

4.4 Potential Operational Impacts

4.4.1 Operational Noise Impacts

Table 16-18 presents a summary of the predicted results at educational and health buildings for the proposed BRT and LRT scenarios. Existing noise levels derived from noise monitoring data has also been provided as a comparison. Where noise measurements were not taken at a specific receiver, results from a representative location have been displayed.

Table 16-18 Predicted Noise Levels at Educational and Health Receivers – dB(A) - Criteria 63 dB(A)$_{LA10, 1hour}$

Receiver	Existing Traffic (2008) $L_{A10, 1hour}$	BRT		LRT				
		2021 Road and Bus $L_{A10, 1hour}$	Complies	2021 Road Only (with LRT traffic volumes) $L_{A10, 1hour}$	Complies	Rail Only		Complies
						$L_{Aeq, 24hour}$	$L_{A, max}$	
Griffith University[5]	65	69	No	69	No	48	68	Yes
Proposed Hospital Precinct[5]	67	69	No	69	No	48	67	Yes
Southport	67	67	No	67	No	49	67	Yes

[5] Further to work undertaken in preparing this CDIMP, there has been significant additional activity to finalise the concept design for the rapid transit alignment along the Parklands Knowledge Precinct and a rapid transit station to serve the main entrance of the new Gold Coast University Hospital. Reference should be made to the *Parklands Knowledge Precinct Report* that supplements the CDIMP and provides updated information on the proposed concept design and assessment of impacts.

Receiver	Existing Traffic (2008) $L_{A10, 1hour}$	BRT		LRT				
		2021 Road and Bus $L_{A10, 1hour}$	Complies	2021 Road Only (with LRT traffic volumes) $L_{A10, 1hour}$	Complies	Rail Only		Complies
						$L_{Aeq, 24hour}$	$L_{A, max}$	
State School								
Trinity Gardens Aged Hostel	67	68	No	67	No	50	69	Yes
Independent In-home Care	67	68	No	67	No	50	69	Yes
Gold Coast City Hospital	70	71	No	71	No	51	69	Yes
Allamanda Private Hospital	72	76	No	76	No	40	55	Yes

Noise levels at residential noise sensitive receivers were predicted along the length of Sections 2 and 3 of the proposed development.

Residential noise sensitive receivers have been grouped into areas within the proposed Sections (2 and 3), as outlined in Table 16-1. Table 16-19 and display the predicted noise results at sensitive residential receivers along the concept design alignment as well as Area-specific noise criteria from either the DMR *Code of Practice* or EPP (Noise) depending on if the controlling noise source is a state or public controlled roadway. Existing noise levels derived from noise monitoring data within each Area has also been provided as a comparison. Where noise measurements were not taken in a specific Area, results from a representative location have been displayed. Where there was more than one monitoring location within each Area, the highest $L_{A10, 18hour}$ value has been presented.

Table 16-19 Predicted Noise Levels at Residential and Other Receivers BRT – dB(A)

Section	Area	BRT						
		Existing (2008) $L_{A10,18\ hour}$	**2021 Highest (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Average (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Bus Only highest** $L_{A10,\ 18\ hour}$	**Criteria** $L_{A10,\ 18hour}$	**Controlling Noise Source**	**Comments / Recommendations**
Section 2	A	62	68	63	53	63	Smith Street Motorway	Predicted noise levels may exceed EPP (Noise) criterion at some identified residential receivers.
	B	62	71	71	45	63	Wardoo Street	Predicted noise levels exceed EPP (Noise) criterion of 63 dB(A) $L_{A10,\ 18\ hour}$. A noise barrier of 30 metres in length and 2.5 metres high running along the edge of Wardoo St was shown to reduce noise levels to meet the EPP (Noise) criterion.
	C	67	69	66	61	63	Queen Street	Predicted noise levels at some residential receivers were shown to exceed EPP (Noise) criterion by up to 6 dB(A). Noise control has not been investigated at this stage. Average Noise levels were shown to be within 1 dB of existing levels.
	D	67	71	69	60	63	Queen Street	Predicted noise levels at residential receivers were shown to exceed EPP (Noise) criterion by between 1 and 7 dB(A). The higher noise levels were found at receivers closer to Queen St. Noise control has not been considered at this stage. Contribution from the proposed BRT did not influence noise levels.

		BRT						
Section	**Area**	**Existing (2008)** $L_{A10,18\ hour}$	**2021 Highest (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Average (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Bus Only highest** $L_{A10,\ 18\ hour}$	**Criteria** $L_{A10,\ 18hour}$	**Controlling Noise Source**	**Comments / Recommendations**
	E	67	70	66	59	63	Queen Street	Predicted noise levels at some residential receivers were shown to exceed the EPP (Noise) criterion by between 1 and 4 dB(A). Noise control has not been considered at this stage. Contribution from the proposed BRT did not influence noise levels.
	F	69	72	67	55	68	Queen Street	Predicted noise levels at some residential receivers were shown to exceed DMR criteria by up to 4 dB(A). This receiver was located on Queen St. A noise barrier two metres in height along Queen St, adjacent to the receiver was found to reduce noise levels to meet DMR criteria. Contribution from the proposed BRT did not influence noise levels.
Section 3	A	62	69	63	46	63	Gold Coast Highway	Predicted noise levels at some residential receivers were shown to exceed the EPP (Noise) criterion by up to 6 dB(A). Noise control has not been investigated at this stage. Contribution from the proposed BRT did not influence noise levels.
	B	64	68	61	56	63	Gold Coast Highway	Predicted noise levels were found to comply with EPP (Noise) criterion at most identified residential receivers. Noise exceedences of up to 5 dB(A) occurred at receivers very close to the alignment. Contribution from the proposed BRT did not influence noise levels.

		BRT						
Section	**Area**	**Existing (2008)** $L_{A10,18\ hour}$	**2021 Highest (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Average (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Bus Only highest** $L_{A10,\ 18\ hour}$	**Criteria** $L_{A10,\ 18hour}$	**Controlling Noise Source**	**Comments / Recommendations**
	C	69	76	69	65	63	Gold Coast Highway	Predicted noise levels at some residential receivers were shown to exceed EPP (Noise) criterion by up to 12 dB(A). Receivers include hotels and other retail/commercial area that are assessed against *AS/NZS 2107* (e.g. Crown Towers Resort). Potential exceedences may occur. Noise mitigation has not been considered at this stage. Contribution from the proposed BRT did not influence noise levels.
	D	67	69	67	61	63	Gold Coast Highway	Predicted noise levels at some residential receivers were shown to exceed EPP (Noise) criterion by up to 6 dB(A). Noise control has not been investigated at this stage. Retail areas and restaurants also exist in this area. An assessment of internal noise has not been made at this stage. Contribution from the proposed BRT did not influence noise levels.
	E	60	72	66	62	63	Gold Coast Highway	Predicted noise levels are expected to comply at most residential receivers, however noise levels at some receivers were shown to exceed DMR criteria by up to 9 dB(A). Receivers include hotels, restaurants and apartment blocks. An assessment of internal noise has not been made at this stage.

		BRT						
Section	**Area**	**Existing (2008)** $L_{A10,18\ hour}$	**2021 Highest (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Average (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Bus Only highest** $L_{A10,\ 18\ hour}$	**Criteria** $L_{A10,\ 18hour}$	**Controlling Noise Source**	**Comments / Recommendations**
	F	67	75	70	57	63	Gold Coast Highway	Predicted noise levels are predicted to exceed the EPP (Noise) criterion by up to 12 dB(A). A noise barrier three metres in height along the Gold Coast Hwy, adjacent to receivers was found to reduce noise levels to meet recommended levels. Additional receivers include hotels, restaurants and apartment blocks. An assessment of internal noise has not been made at this stage. Contribution from the proposed BRT did not influence noise levels.
	G	72	76	68	57	63	Gold Coast Highway	Noise levels are predicted to exceed the residential noise criteria by up to 12 dB(A). A noise barrier three metres in height along the Gold Coast Hwy, adjacent to receivers was found to reduce noise levels to meet recommended levels. Contribution from the proposed BRT did not influence noise levels.

		BRT						
Section	**Area**	**Existing (2008)** $L_{A10,18\ hour}$	**2021 Highest (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Average (Road and Bus)** $L_{A10,\ 18\ hour}$	**2021 Bus Only highest** $L_{A10,\ 18\ hour}$	**Criteria** $L_{A10,\ 18hour}$	**Controlling Noise Source**	**Comments / Recommendations**
	H	72	73	66	56	63	Gold Coast Highway	Predicted noise levels are expected to comply at most residential receivers, however noise levels at some receivers were shown to exceed the EPP (Noise) criterion by up to 10 dB(A). Receivers include hotels, restaurants and apartment blocks as well as the Gold Coast Convention Centre. An assessment of internal noise has not been made at this stage. Contribution from the proposed BRT did not influence noise levels.
	I	66	77	73	59	68	Gold Coast Highway	Noise levels are predicted to exceed the residential DMR noise criteria by up to 9 dB(A). Additional receivers include hotels, restaurants and apartment blocks. An assessment of internal noise has not been made at this stage. Contribution from the proposed BRT did not influence noise levels.

Table 16-20 Predicted Noise Levels at Residential and Other Receivers LRT – dB(A)

Section	Area	LRT						Comments / Recommendations
		Existing (2008) $L_{A10, 18 hour}$	2021 Road Only Highest $L_{A10, 18 hour}$	2021 Road Only Average $L_{A10, 18 hour}$	Rail Only – Maximum Levels $L_{Aeq, 24hour}$	Rail Only – Maximum Levels $L_{A, max}$	Controlling Noise Source	
Section 2	**Area A**	62	68	63	51	68	Smith Street Motorway	Predicted light rail noise levels were found to comply with QR criteria at all identified residential receivers. No assessment has been made on internal noise levels at other sensitive receiver types, such as hotels at this stage. Road traffic noise comments and recommendations as per BRT (Table 16-19).
	Area B	62	71	71	45	58	Wardoo Street	
	Area C	67	75	67	53	72	Queen Street	
	Area D	67	71	69	54	74	Queen Street	
	Area E	67	70	66	55	73	Queen Street	
	Area F	69	72	67	53	72	Queen Street	
Section 3	**Area A**	62	69	63	53	62	Gold Coast Highway	Predicted light rail noise levels were found to comply with QR criteria at all identified residential receivers. No assessment has been made on internal noise levels at other sensitive receiver types, such as hotels at this stage. Road traffic noise comments and recommendations as per BRT (Table 16-19).
	Area B	64	68	61	56	73	Gold Coast Highway	
	Area C	69	76	69	56	77	Gold Coast Highway	
	Area D	67	69	67	50	68	Gold Coast Highway	
	Area E	60	72	66	54	72	Gold Coast Highway	
	Area F	67	75	70	54	73	Gold Coast Highway	
	Area G	72	76	68	55	75	Gold Coast Highway	
	Area H	72	73	66	51	70	Gold Coast Highway	
	Area I	66	77	73	56	77	Gold Coast Highway	

4.4.2 Operational Vibration Impacts

The adopted vibration levels of LRT and BRT during the operational phase of the proposed development indicate that the preferred vibration goal of 0.1 millimetres per second RMS for critical working areas (e.g. operating theatres of Gold Coast City Hospital and Allamanda Private Hospital) may be exceeded. However, it has been assumed that the critical working areas, for which this criterion applies, are located along the façade of the building closest to the LRT or BRT alignment. Therefore, GHD recommend that the location of these critical working areas within the hospitals be identified during the detailed design stage, and the potential vibration impact be re-assessed accordingly.

The adopted vibration levels for BRT and LRT operations indicate that the vibration goals for residential and commercial receivers should be met along the length of Sections 2 and 3 of the proposed alignment.

A review of the proposed design speeds for BRT and LRT operations shows that in the areas where the proposed alignment is closest to vibration receivers, vehicle speeds are lower, thus producing less vibration. However, in areas of higher speeds (70 km/hr) and therefore higher vibration levels, the separation distance between the BRT and LRT alignments and vibration receivers is greatest, thus reducing the potential for vibration impacts.

Therefore, it is expected that the operational vibration goals should be met for all LRT and BRT operations at all other potential vibration receivers (non-critical working areas) along the alignment, including residential and commercial premises.

GHD also recommend that the operations vibration dose also be assessed once a more definitive operating schedule is known.

4.4.3 Summary of Noise and Vibration Results

Noise predictions indicate that the 2021 roadways (with rapid transit traffic volumes) are the controlling noise sources along the rapid transit corridor and that generally, based on the available information at the time of the assessment the introduction of the rapid transit busway or railway should have a negligible impact on existing traffic noise levels at receivers.

The introduction of the busway to 2021 traffic volumes showed a maximum increase of 5 dB(A) to the $L_{A10,\ 18\ hour}$ predicted noise levels at noise receivers located near the intersection of Nerang Street and Scarborough Street. However, these noise receivers are located in an area that is blocked off to public traffic and is only accessible by bus. Therefore noise contributions from local roadways were reduced, allowing for the incremental impact of the busway to become the controlling noise source.

The average increase in $L_{A10,\ 18\ hour}$ noise levels with the introduction of the rapid transit busway was calculated to be 0.4 dB(A) across the entire assessment area. Note this predicted increase is based on the 2021 traffic numbers that have taken into consideration the BRT and LRT operations. The 'do-minimum' information was unavailable at the time of this assessment.

Railway noise from the proposed LRT development was assessed individually from the roadway noise. Predicted rail noise showed that *QR Code of Practice* criteria are expected to be met at all noise receivers.

Predicted noise from the year 2021 traffic volumes (with LRT in operation) produced almost identical results as to the BRT modelled scenario, since the introduction of the busway was found to have negligible impact on existing noise levels at most receivers.

Adopted vibration levels for BRT and LRT operations indicate that the vibration goals should be met at all residential and commercial receivers along the alignment. Vibration levels have the potential to exceed the preferred 'Critical working area' vibration goals at Gold Coast City Hospital and Allamanda Hospital. However, this assessment has been based on the assumption of critical working areas such as operating theatres being located along the façade of the hospital closest to the LRT and BRT alignments. GHD recommend that this is further investigated in the detailed design stage.

4.5 Operational Noise and Vibration Recommended Mitigation Measures

4.5.1 Operational Noise Mitigation

The DMR's *Code of Practice* (2006) recommends several ways in which the impact of road traffic noise can be reduced. Subject to detailed design, selection of mode and selection of vehicles, the following may be required:

- controlling the noise at the source (i.e. Controlling the noise emitted by the vehicle);
- controlling the propagation of the noise (i.e. Attenuating the noise as it travels from the source to reception point, typically achieved by use of a noise barrier); and
- controlling the noise at the reception point. In an area where noise receivers already exist (such as along the rapid transit alignment), this typically means retro-fitting the existing building facades to minimise noise into the interior of the building.

4.5.2 Operational Vibration Mitigation

BRT Operations

On roadways that are well maintained, regenerated noise and vibration from individual vehicle movements is not considered to result in significant acoustical disruption to receivers and therefore no vibration mitigation measures have been outlined at this stage.

LRT Operations

An adequate level of track and wheel quality and maintenance is most critical to controlling the levels of ground-borne vibration from a rail system.

Assuming that the track and vehicles are in good condition, options to further reduce ground-borne vibration include:

- maintenance procedures to avoid increases in ground-borne vibration. This can include rail grinding for optimised track conditions, wheel truing and removal of wheel flats and reconditioning vehicles; and
- track support systems to reduce vibration levels. Examples of such management options include; floating slabs, ballast mats and high resilience fasteners. This option is typically employed at the design stage of the development.

The NSW DECC also notes that for railways, jointed rail may be replaced by continuous welded rail for rail lines passing near sensitive premises.

5. Conclusion

The noise and vibration impact assessment has focused on the potential impacts of noise and vibration from the proposed BRT and LRT developments during the construction and operations phase. Both developments have been assessed individually with the projected 2021 traffic data and proposed alignments. The following sections summarise the conclusions.

Construction Phase

The construction noise and vibration assessment has been prepared based on information available at the time of this assessment. The following conclusions were made:

» construction noise levels along most of the alignment are expected to exceed nominated criteria during site works. However, long term noise monitoring shows that the existing ambient noise levels can also exceed the nominated construction noise criteria at most of the receivers closest to the proposed alignment. Therefore, site-specific noise mitigation strategies should be prepared when more detailed design and construction methodologies become available, which reflect the ambient noise levels in each specific area; and

» some construction activities may impact on vibration receivers, including the Gold Coast medical precinct[6], on Queen Street, Southport. Building-specific vibration sensitivity investigations should be undertaken on receivers for a future detailed Construction Noise and Vibration Management Plan.

Operation Phase

» Noise predictions indicate that the 2021 roadways (with rapid transit traffic volumes) are the controlling noise sources along the rapid transit corridor and that generally, the introduction of the BRT or LRT has negligible impact on existing traffic noise levels at sensitive receivers;

» the average increase in $L_{A10,\ 18\ hour}$ noise levels at receivers with the introduction of the BRT was calculated to be 0.4 dB(A) across the entire assessment area;

» railway noise from the proposed LRT development was assessed individually from the roadway noise. Predicted rail noise showed that QR criteria are expected to be met at all noise receivers;

» the introduction of the light rail operations was found to have negligible influence on the overall noise levels predicted at noise receivers; and

» adopted vibration levels for BRT and LRT operations indicate that the vibration goals should be met at all residential and commercial receivers along the alignment. However, vibration levels have the potential to exceed the preferred 'Critical working area' vibration goals at Gold Coast City Hospital and Allamanda Hospital. However, this assessment has been based on the assumption of critical working areas such as operating theatres being located along the façade of the hospital closest to the LRT and BRT alignments. GHD recommend that this be further investigated in the detailed design stage.

[6] Further to work undertaken in preparing this CDIMP, there has been significant additional activity to finalise the concept design for the rapid transit alignment along the Parklands Knowledge Precinct and a rapid transit station to serve the main entrance of the new Gold Coast University Hospital. Reference should be made to the *Parklands Knowledge Precinct Report* that supplements the CDIMP and provides updated information on the proposed concept design and assessment of impacts.