11. Noise and vibration

The chapter summarises the *Sydney Light Rail Extension — Stage 1 Noise and Vibration Assessment* prepared by Heggies Pty Ltd, which is contained as Technical Paper 2 in Volume 2 of this environmental assessment (EA).

It outlines the potential noise and vibration impacts associated with the project, including impacts of construction and operation phases. The chapter also sets out mitigation and management measures to minimise impacts during construction and operation.

DGRs	Where addressed in the EA
General construction impacts — the EA must assess the impacts of, and present a management framework for:	
■ noise and vibration, with consideration given to:	
▸ the intensity and duration of noise and vibration impacts from all construction activities and sources on and off site;	Section 11.3.2
▸ the nature, sensitivity and impact to potentially affected receivers and structures (including heritage items),	Sections 11.3.1, 11.3.2 and 11.3.3
▸ scheduling construction works having regard to the nature of construction activities;	Section 7.8 (construction hours) and 11.3.2
▸ a strategy for managing construction noise and vibration, with a particular focus placed on those activities identified as having the greatest potential for adverse noise or vibration impacts, and a broader, more generic approach developed for lower-risk activities; and	Section 11.3.3 and Section 19.2.3
▸ the *Interim Construction Noise Guidelines* (DECC, 2009) and *Assessing Vibration: A Technical Guideline* (DEC, 2006);	Section 11.3.1
Operational noise and vibration — including but not limited to:	
■ noise and vibration impacts along the corridor associated with light rail operations, including specific consideration of impacts on sensitive receivers;	Section 11.4.2
■ establishing applicable noise criteria for the project in consultation with the Department of Environment Climate Change and Water, with the objective of achieving best practice in Australia for light rail, and	Section 11.4.1
■ taking into account the *Inner West Light Rail Extension activity approval* dated 3 March 1999, *NSW Industrial Noise Policy,* and *Assessing Vibration: A Technical Guideline* (DEC, 2006).	Section 11.4.1

11.1 Assessment approach

Construction noise has been assessed in accordance with the Department of Environment, Climate Change and Water's (DECCW) *Interim Construction Noise Guideline* (DECCW 2009). The assessment is based on the airborne construction noise impacts associated with the project. Ground-borne construction noise has not been assessed, as the nature of the project means that ground-borne noise impacts are expected to be negligible.

Operational noise for the light rail operations has been assessed consistent with the criteria adopted for the existing light rail, outlined in the *Inner West Light Rail Extension activity approval* dated 3 March 1999, and in consultation with DECCW. Noise from the operation of the substations has been assessed in accordance with DECCW's *Industrial Noise Policy* (INP), with guidance on sleep disturbance criteria taken from the online Application Notes to the INP and DECCW's *Environmental Criteria for Road Traffic Noise* (ECRTN).

Construction and operation vibration has been assessed in accordance with DECCW's *Assessing Vibration: A Technical Guideline* (DEC 2006) and with specific operation criteria for light rail determined in consultation with DECCW.

It includes an assessment of the noise and vibration impacts of construction of the GreenWay shared path. There is no requirement to assess operational noise impacts from users of the GreenWay shared path. No noise and vibration impacts are anticipated from the operation of the GreenWay shared path.

The following terms are used to describe noise emissions in the following sections:

- Airborne construction noise — noise that propagates through the air from the source to the receiver.
- Ground-borne construction noise — internal noise, generated by vibration transmitted through the ground into a structure.
- a-weighted sound measured in decibels (dBA) — a-weighted noise measurements have been scaled to account for the differential response of the human ear to different sound frequencies.
- L_{Amax} —the 'maximum noise level' occurring during an event, i.e. when a light rail vehicle (LRV) passes by.
- L_{Aeq} — the 'equivalent continuous noise level', sometimes also described as the 'energy-averaged noise level'. It may be likened to a 'noise dose', representing the cumulative effects of all the noise events occurring in the relevant time period.
- L_{Aeq} Day — the daytime 'equivalent continuous noise level' represents the cumulative effects of all the train noise events occurring in the daytime from 7 am to 7 pm at existing residential facades.
- L_{Aeq} Evening — the evening 'equivalent continuous noise level' represents the cumulative effects of all the train noise events occurring in the evening period from 7:00 pm to 11:00 pm at existing residential facades
- L_{Aeq} Night — the night-time 'equivalent continuous noise level' represents the cumulative effects of all the train noise events occurring in the night-time period from 11:00 pm to 7:00 am at existing residential facades
- $L_{Aeq(15\ minute)}$ — the 'energy average noise level' during construction activities, which is evaluated over a measurement period of 15 minutes and used to assess construction noise impacts.

- $L_{A1(1minute)}$ — the 'typical maximum noise level' for an event, used to assess potential sleep disturbance during night-time periods. Alternatively, assessment may use the LAmax or maximum noise level.

- L_{A90} — the 'background noise level' in the absence of construction activities represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction noise management levels are based on the L_{A90} background noise levels.

- L_{AE} — the 'sound exposure level' indicates the total acoustic energy of an individual noise event, and is used to calculate L_{Aeq} values from individual noise events.

- NML — noise management level; the noise goals for construction works for affected receiver groups.

- RBL — rating background level, which is the overall single figure background level representing quiet ambient conditions in each assessment period (daytime, evening and night-time).

11.2 Existing environment

As discussed in Chapter 9, the project would be located in an established urban corridor and involve converting a disused goods line into commuter transport. Much of the corridor has residential zoning comprising a mix of single and multiple dwellings. Other existing land uses in the study area include industrial areas, schools and child-care centres, active recreation areas, retail areas, existing CityRail lines, and open space.

The ambient noise environment of the area is variable. In many areas it is controlled by road traffic noise. Some areas already experience rail traffic noise from the existing Inner West and Bankstown rail lines and Port Botany freight line. Due to the closeness to Sydney's Kingsford Smith Airport, noise from aircraft is at times clearly audible. Some locations are also subject to noise from industrial sources.

In addition to the existing residential areas along the proposed alignment, a number of sites have been identified as potential future development sites. These include the Summer Hill Mills site (former Mungo Scott Mills) on the western side of the line near the proposed Lewisham West stop, and the McGill Street precinct on the eastern side of the line in the same area. A further future development site has been identified at Grove Street near the proposed Arlington stop.

Noise and vibration impacts on these future developments have not been assessed in this report as development applications have not yet been made. Any future developments near to the proposed SLRE should be planned in accordance with the *State Environmental Planning Policy (Infrastructure) 2007* (the 'Infrastructure SEPP'), as supported by the NSW Department of Planning's *Development Near Rail Corridors and Busy Roads — Interim Guideline*. However, it is noted the future development of these sites would be comparable to the completed development of the Waratah Mills site, and that noise and vibration impacts from the light rail would not be expected to limit or constrain future development.

11.2.1 Ambient noise surveys

Monitoring locations

To characterise the existing ambient noise environment across the project area and establish present ambient noise levels to base noise emission targets, environmental noise was monitored at a number of representative locations during August 2010.

Table 11.1 lists the noise monitoring locations. These are also shown in Figure 11.1a to 11e. The locations were chosen to be representative of the local area around each proposed stop location. Both attended and unattended measurements were taken at each monitoring location.

Table 11.1 Noise monitoring locations

Location	Address	Light rail stop area
B01	121 Francis Street	Leichhardt North
B02	23 Lyall Street	Hawthorne
B03	122 Hawthorne Parade	Marion
B04	14 Hathern Street	Taverners Hill
B05	4 William Street	Lewisham West
B06	77 Weston Street	Waratah Mills
B07	66 Constitution Road	Arlington
B08	8/14 Hercules Street	Dulwich Grove
B09	9 Bedford Crescent	Dulwich Hill Interchange

Unattended noise monitoring

The purpose of the unattended noise monitoring was to determine the existing L_{Aeq}, L_{A90} and other relevant statistical noise levels during the daytime, evening and night-time periods. These are required to determine the appropriate noise design goals and as a basis for assessing the potential noise impacts during construction.

Unattended noise loggers were deployed next to sensitive receivers over a minimum period of one week to measure the prevailing levels of background and ambient noise. The measurements were generally taken at a height of 1.5 metres above the ground level and one metre from the facade of the subject dwelling/building, where possible.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of AS 1259.2-1990 '*Acoustics — Sound Level Meters. Part 2: Integrating — Averaging*'.

The results of the unattended ambient noise surveys are presented in Table 11.2. The results are presented as representative rating background levels (RBL) and L_{Aeq} (energy averaged) noise levels during DECCW's standard daytime, evening and night-time hours.

Table 11.2 Summary of unattended noise logging

Location	Noise level (dBA)[1]					
	Daytime 7:00 am–6:00 pm		Evening 6:00 pm–10:00 pm		Night 10:00 pm–7:00 am	
	RBL	LAeq	RBL	LAeq	RBL	LAeq
B01	53	65	49	63	42	59
B02	41	59	41	55	37	51
B03	48	62	46	58	36	53
B04	52	65	48	63	42	61
B05	50	61	47	60	42	59
B06[2]	39	61	39	54	31	48
B07	44	60	42	54	36	52
B08	44	60	42	58	35	51
B09	44	58	42	56	36	54

Note 1: The RBL and LAeq noise levels have been obtained using the calculation procedures documented in DECCW's Industrial Noise Policy.

Note 2: Daytime LAeq noise levels at B06 (77 Weston Street) were affected by noise from trackwork throughout the week of logging, in particular by equipment accessing the rail corridor through the nearby access gate.

Attended noise measurements

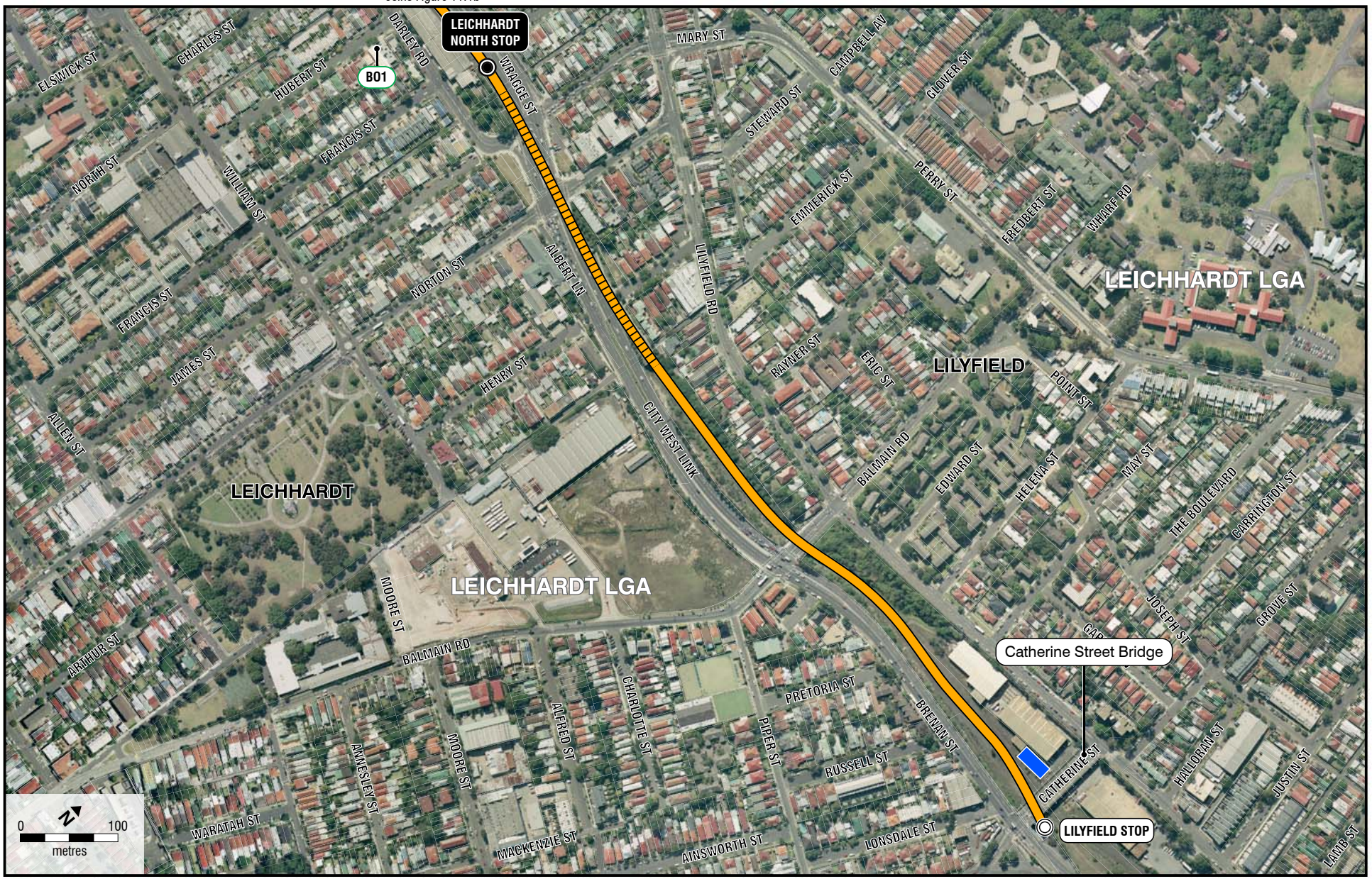
Attended noise measurements were taken at the locations listed in Table 11.3 to quantify the noise levels from the various noise sources near the unattended noise monitoring locations.

Track maintenance works (refer to Section 7.2), were occurring in the rail corridor at a number of locations during the attended measurements. Where this was the case, the typical noise levels due to trackwork are stated in Table 11.3**.** In particular, trackwork was observed during the attended measurements at locations B01 (121 Francis Street), B02 (23 Lyall Street), B03 (122 Hawthorne Parade) and B06 (77 Weston Street). In general, trackwork was observed to be intermittent rather than sustained, with machinery and workers moving steadily along the corridor.

Table 11.3 Attended noise monitoring results

Location	Date	Time of day	Noise levels (dBA)					Description and typical L_{Amax} levels (dBA)
			L_{Amax}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	
B01	13/8/2010	11:03	83	74	68	65	58	Trackwork (hammering) 72-74
		11:23	84	76	69	66	58	Trackwork (mowing) 58, 62, 71 Traffic Darley Road 63-71 Trucks 70, 76 Aircraft 80, 82, 74, 83,79, 77
B02	13/8/2010	11:46	71	66	59	56	51	Trackwork 56, 60, 64, 68
		12:02	71	64	58	55	49	Traffic Darley Road 53, 56, 61 Truck 67, 70 Aircraft 60, 62, 64, 71
B03	13/8/2010	12:25	86	73	66	63	55	Trackwork 60, 56, 79, 75, 83
		12:41	82	73	66	63	55	Local traffic 69, 73, 76, 69, 71 Trucks 80, 72 Aircraft 60, 58, 62, 66, 63 Motorbike 67, 76

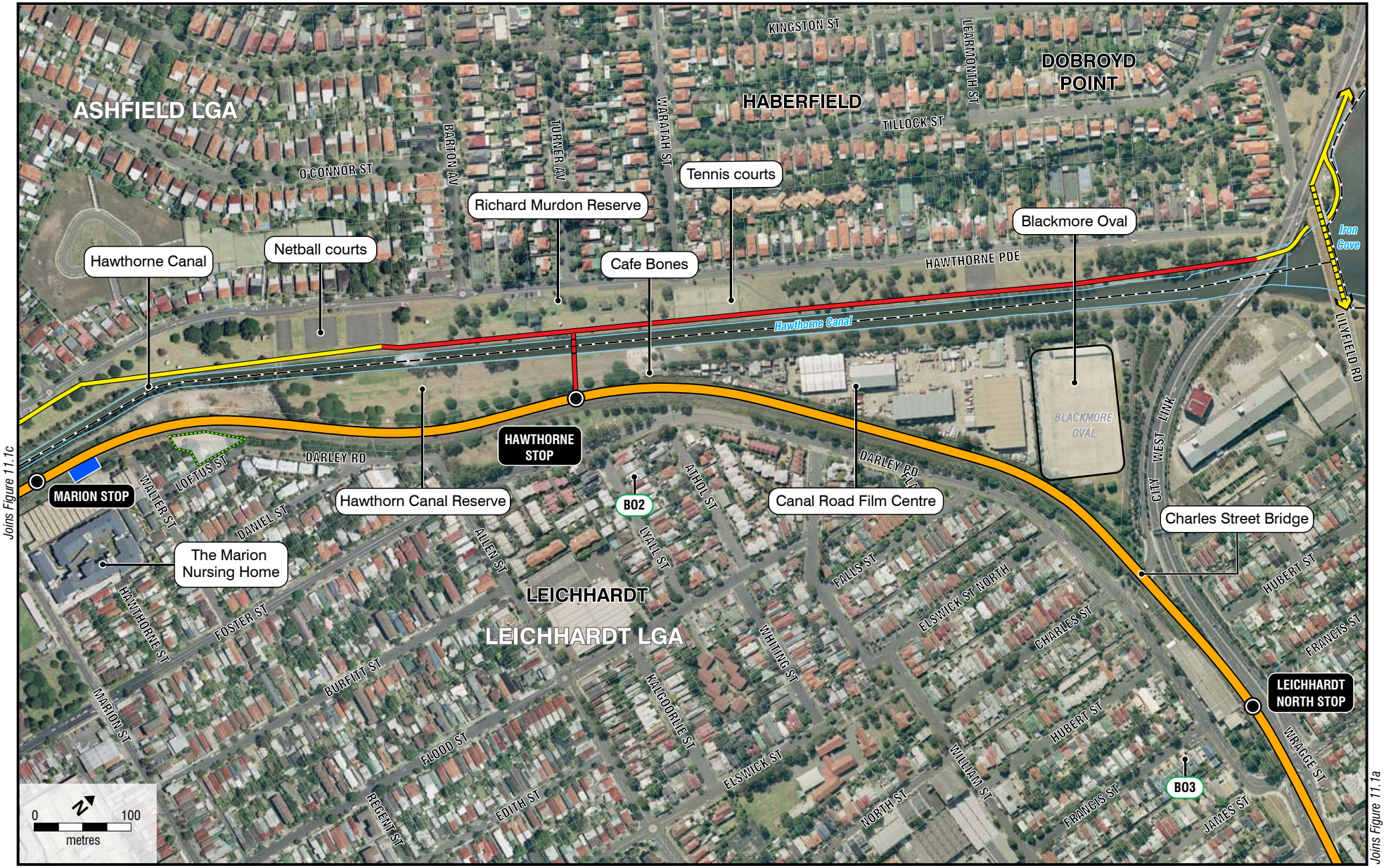
Location	Date	Time of day	Noise levels (dBA)					Description and typical L_{Amax} levels (dBA)
			L_{Amax}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	
B04	13/8/2010	13:47	86	79	72	69	62	Traffic 68, 72, 70, 77, 80
		14:02	88	78	72	69	59	Trucks 79, 81, 85, 88
								Motorbikes 81, 86, 73
								Distant trains 54
B05	13/8/2010	14:23	81	69	60	59	53	Local traffic 71, 72, 62, 73
		14:38	86	69	61	60	53	Distant traffic 67, 60, 58, 65
								Distant industrial 50, 51
								Distant trains 56, 58, 57
B06	5/8/2010	14:45	84	62	56	56	44	Construction (trackwork) 46-66
		15:00	73	68	63	58	44	Local traffic 50, 59, 64
								Aircraft 60, 64, 67
								Dogs 72
B07	5/8/2010	12:20	72	68	63	59	48	Local traffic 56, 60, 62
		12:35	76	73	65	61	47	Local industry 67, 70
								Aircraft 72, 51, 73
								Distant industrial 48
B08	5/8/2010	14:05	83	79	68	66	48	Local traffic 74, 68, 78
		14:20	82	76	68	64	49	Truck 83
								Distant traffic 46
								Children at school 48
								Aircraft 55, 79
B09	5/8/2010	11:20	80	71	63	60	47	Freight train 63, 70, 66
		11:35	73	67	60	57	45	Passenger train 61, 60, 55
								Distant traffic 43-46
								Aircraft 60, 68, 73
								Breeze in trees 55, 60



Light rail alignment
City West Link rail corridor tunnel
Local government area boundary
Sensitive receivers (non residential)
Monitoring location
Existing light rail stop
Proposed light rail stops
Potential substation location

Figure 11.1a Noise monitoring locations and sensitive receivers (non residential)

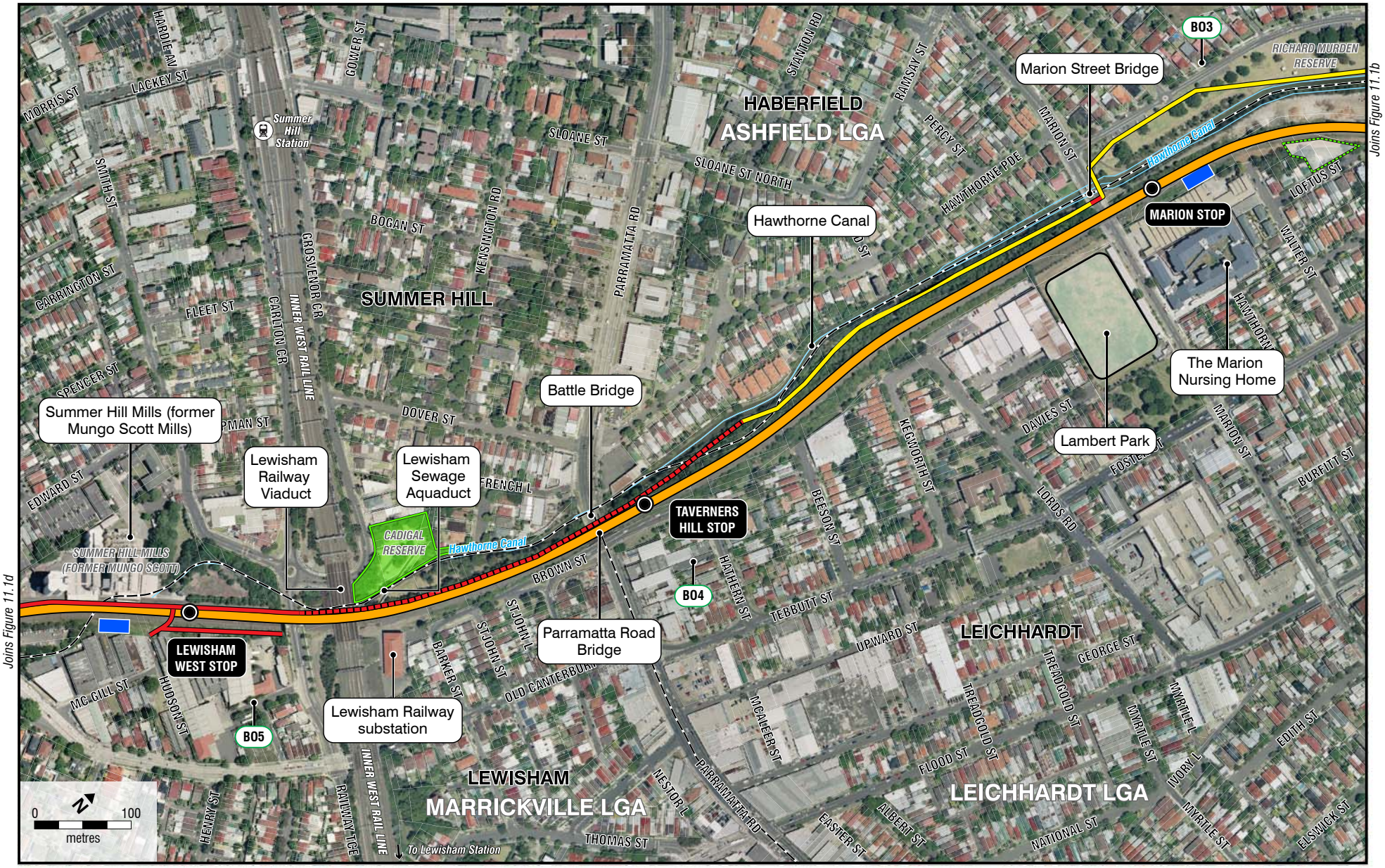
Note: Indicitive only, subject to detail design.



Light rail alignment
Proposed light rail stops
Local government area boundary
Watercourse
Existing GreenWay shared path (upgraded)
New GreenWay on-street cycle path
New GreenWay shared path (at-grade)
New GreenWay shared path (elevated)
Potential bushcare/landscaping
Potential substation location
Sensitive receivers (non residential)
Monitoring location

Figure 11.1b Noise monitoring locations and sensitive receivers (non residential)

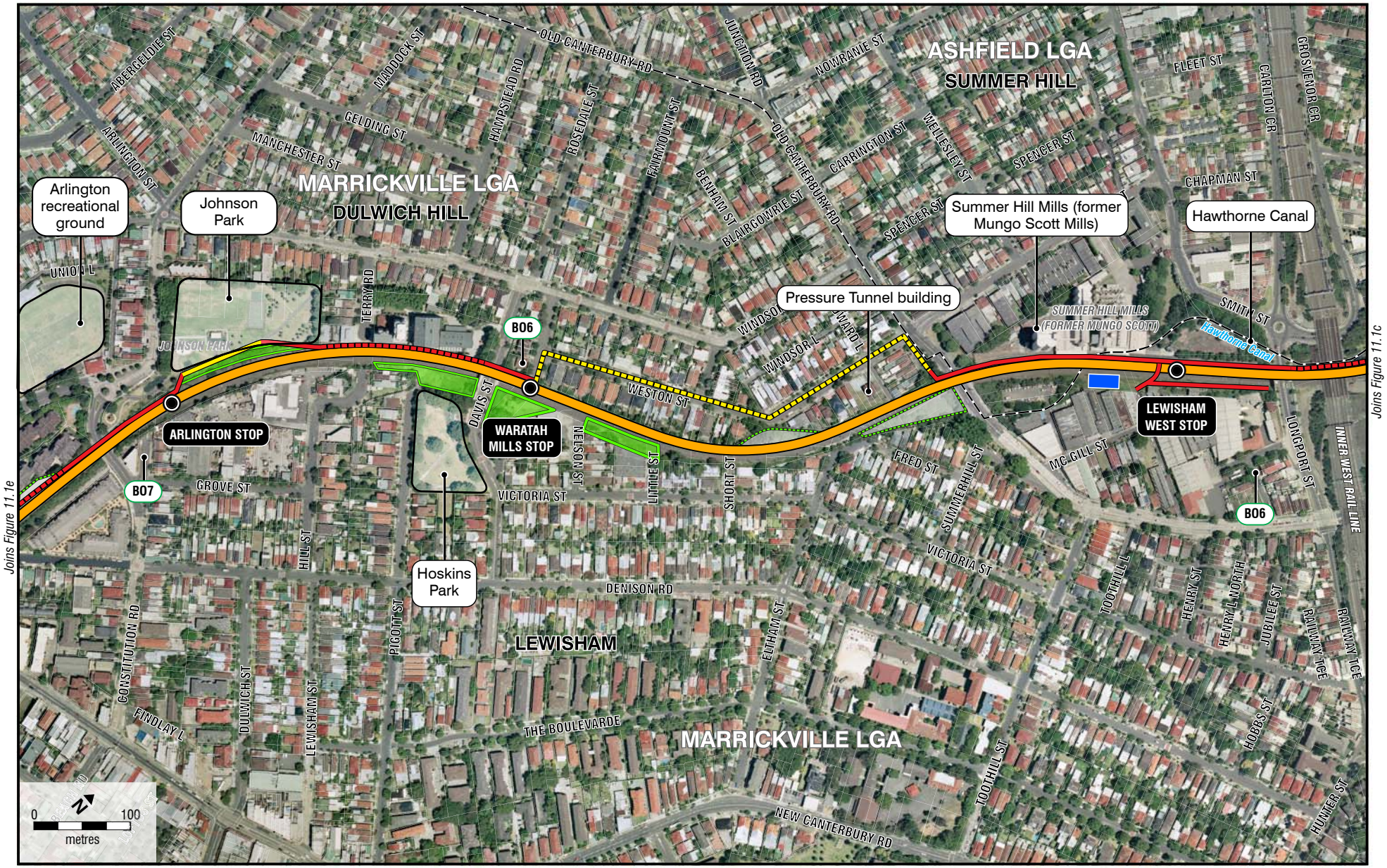
Note: Indicitive only, subject to detail design.



Light rail alignment
Proposed light rail stops
Local government area boundary
Watercourse
Existing GreenWay shared path (upgraded)
New GreenWay shared path (at-grade)
New GreenWay shared path (elevated)
Existing bushcare site
Potential bushcare/landscaping
Potential substation location
Sensitive receivers (non residential)
Monitoring location

Figure 11.1c Noise monitoring locations and sensitive receivers (non residential)

Note: Indicitive only, subject to detail design.



Light rail alignment
Proposed light rail stops
Local government area boundary
Watercourse

Existing shared path (upgraded)
New GreenWay shared path (at-grade)
New GreenWay shared path (elevated)
New GreenWay on-street cycle path

Existing bushcare site
Potential bushcare/landscaping
Potential substation location

Sensitive receivers (non residential)
Monitoring location

Figure 11.1d Noise monitoring locations and sensitive receivers (non residential)

Note: Indicitive only, subject to detail design.

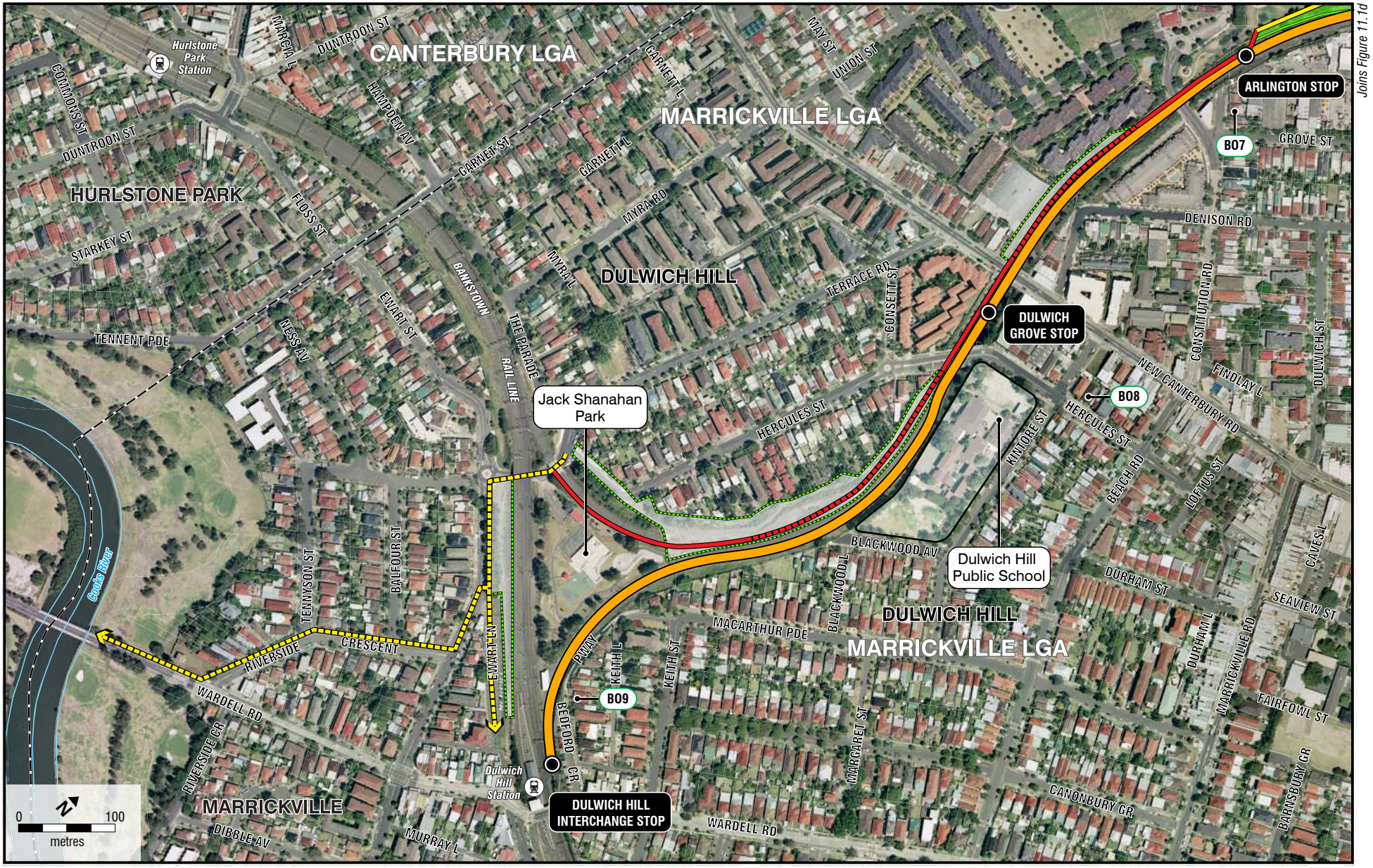


Figure 11.1e Noise monitoring locations and sensitive receivers (non residential)

Note: Indicitive only, subject to detail design.

11.2.2 Identification of noise and vibration sensitive receivers

The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities within the affected premises. For example, recording studios are more sensitive to noise and vibration than residential premises, which in turn are more sensitive than typical commercial premises. The sensitivity may also depend on the existing environment. For example, DECCW's '*Industrial Noise Policy'* and AS/NZS 2107-2000 '*Recommended Design Sound Levels and Reverberation Times for Building Interiors'* recommend higher acceptable noise levels in urban areas compared with suburban areas. Receivers may be classified into the following categories:

- residential
- educational
- hospitals
- places of worship
- commercial
- industrial
- other (for example museums, heritage items, recreation areas).

For this assessment all residential receivers are considered to be sensitive. Most commercial and industrial receivers are less sensitive to noise and vibration. Table 11.4 lists sensitive receivers, excluding those of a residential nature, situated along the alignment. These sensitive receivers are also identified on Figures 11.1a to 11.1e. Heritage items are listed only where there is a potential noise or vibration impact on the item. Note that heritage listed residential dwellings have been assessed as residential receivers, and are therefore not included in this list. Commercial or industrial receivers are included only in cases where they are close to the alignment or a proposed stop and where the business is considered potentially sensitive to noise or vibration impacts. The relevant construction and operational noise goals for these receivers are identified in Sections 11.3.1 and 11.4.1, respectively.

Table 11.4 Identified noise and/or vibration sensitive receivers (non-residential)

Receiver	Light rail stop area	Receiver type
Catherine Street Bridge*	Lilyfield	Heritage Item
Charles Street Bridge*	Leichhardt North	Heritage Item
Blackmore Park	Leichhardt North	Active recreation
Canal Road Film Centre	Leichhardt North, Hawthorne	Film industry
Hawthorne Canal Reserve	Hawthorne	Active recreation
Café Bones	Hawthorne	Commercial
Richard Murden Reserve	Hawthorne	Active recreation
Netball courts	Hawthorne	Active recreation
Tennis courts	Hawthorne	Active recreation
Lambert Park	Marion	Active recreation
The Marion Nursing Home	Marion	Other (residential)
Marion Street Bridge*	Marion	Heritage Item

Receiver	Light rail stop area	Receiver type
Hawthorne Canal*	Marion, Taverners Hill, Lewisham West	Heritage Item
Battle Bridge	Taverners Hill	Heritage item
Parramatta Road Underbridge*	Taverners Hill	Heritage Item
Lewisham Railway Substation*	Lewisham West	Heritage Item
Lewisham Railway Viaduct	Lewisham West	Heritage item
Lewisham Sewage Viaduct	Lewisham West	Heritage item
Summer Hill Mills (former Mungo Scott Mills) *	Lewisham West	Heritage Item
Pressure Tunnel Building*	Lewisham West / Waratah Mills	Heritage Item
Hoskins Park	Waratah Mills	Active recreation
Johnson Park	Arlington	Active recreation
Arlington Recreation Ground	Arlington	Active recreation
Dulwich Hill Public School	Dulwich Grove	Educational
Jack Shanahan Park	Dulwich Hill Interchange	Active recreation

Note: Receivers marked with an asterisk are vibration-sensitive only.

11.3 Construction noise and vibration assessment

11.3.1 Criteria

Project specific noise management levels — general construction activities

Construction noise has been assessed in accordance with DECCW's *Interim Construction Noise Guideline*. These guidelines require the determination of project-specific noise management levels (NMLs) for noise-affected receivers.

Residential receivers

The existing noise environment varies along the alignment. Location specific $L_{Aeq(15minute)}$ NMLs for sensitive residential receivers are determined along the alignment based on the background noise monitoring, as described in Table 11.5**.** The resulting construction NMLs derived from the noise monitoring locations are listed in Table 11.6.

Table 11.5 Noise management levels for residential receivers

Time of day	NML
Daytime (7.00 am to 6.00 pm)	RBL or L_{A90} Background +10 dBA
Evening (6.00 pm to 10.00 pm)	RBL or L_{A90} Background +5 dBA
Night-time (10.00 pm to 7.00 am)	RBL or L_{A90} Background +5 dBA

Table 11.6 Residential NMLs

Monitoring location	$L_{Aeq(15\ minute)}$ construction NMLs (dBA)		
	Daytime	Evening	Night-time
B01	63	54	47
B02	51	46	42
B03	58	51	41
B04	62	53	47
B05	60	52	47
B06	49	44	36
B07	54	47	41
B08	54	47	40
B09	54	47	41

In additional to the NMLs, where construction would be required during night-time the potential for sleep disturbance should be assessed. DECCW's current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background plus 15 dBA (as described in the online Application Notes to the INP), and to do further detailed analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during night-time.

Where the screening criterion cannot be met, the additional analysis should consider the number of potential sleep disturbance events during the night, the level of exceedance and noise from other events.

Other sensitive land uses

The project-specific $L_{Aeq(15minute)}$ NMLs for other sensitive receivers are listed in Table 11.7.

Table 11.7 NML for other sensitive receivers

Land use	NML $L_{Aeq(15minute)}$[1]
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas	External noise level 65 dBA
Passive recreation areas	External noise level 60 dBA

Note 1 NML applies when properties are being used.

As described in DECCW's *Interim Construction Noise Guideline*, internal noise levels are to be assessed at the centre of the occupied room. External noise levels are to be assessed at the most affected point within 50 metres of the area boundary. Where internal noise levels cannot be measured, external noise levels may be used. A conservative estimate of the difference between internal and external noise levels is 10 dB with windows open.

Commercial and industrial premises

For commercial premises, which include offices, retail outlets and small commercial premises, an external NML of $L_{Aeq(15minute)}$ 70 dBA has been adopted. For industrial premises, an external NML of $L_{Aeq(15minute)}$ 75 dBA is appropriate. In both cases the external noise levels should be assessed at the most affected occupied point of the premises.

Construction traffic noise assessment goals

DECCW's recommended noise goals for the three most common road categories are set out in Table 11.8.

Table 11.8 DECCW road traffic noise goals

Development	Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)
Land use developments with potential to create additional traffic on existing freeways/ arterial roads	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
Land use developments with potential to create additional traffic on collector roads	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA
Land use developments with potential to create additional traffic on local roads	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA

Where the L_{Aeq} traffic noise levels already exceed the above noise goals, a 2 dBA increase in the overall traffic noise levels is normally regarded as an alternative target (having investigated the application of all feasible and reasonable noise mitigation) to maintain the general acoustic amenity of the area.

Construction vibration

The standard used as a basis for assessing the risk of vibration damage to structures is the British Standard BS 7385 *Part 2* (1993) — *Evaluation and measurement for vibration in buildings, guide to damage groundborne vibration*.

Indicative safe working distances for typical items of vibration intensive plant are listed in Table 11.9. The safe working distances would correspond to the nearest distance at which the maximum vibration level generated by the operation of a piece of construction plant would be predicted not to exceed the cosmetic damage threshold. The safe working distances apply to structural damage of typical buildings and with typical geotechnical conditions. It is noted that these safe working distances apply to all structures, including residences and the sensitive receivers identified in Table 11.4.

Table 11.9 Safe working distances — cosmetic damage

Plant items	Safe working distance (metres)
Hydraulic impact hammer — small	1
Hydraulic impact hammer — medium	4
Hydraulic impact hammer — large	15
Vibratory roller — 10 tonne	6
Vibratory trench roller — 3 tonne	1

Section 5.3 of Technical Paper 3 in Volume 2 details the human comfort vibration goals. Human comfort is normally assessed with reference to *Assessing Vibration: a technical guideline* (DEC 2006). For daytime activities, the limiting objective for continuous and impulsive vibration (human comfort) at residential receivers is 0.4 millimetres per second and 12.0 millimetres per second, respectively.

11.3.2 Construction impacts

General construction activities

Noise modelling

Computer noise models were developed to quantify noise emissions from the key construction sites. The model for these construction sites took into account source noise emission levels, location of sources and receivers, acoustic shielding provided by intervening ground topography and ground effects. Source noise emission levels were determined based on maximum sound power levels for the construction equipment described in Table 7.4 before mitigation. The sound power levels are presented in Table 9 of Technical Paper 3 in Volume 2.

Further detail on the modelling methodology and data inputs is presented in Section 4.5 of Technical Paper 3 in Volume 2.

Overview

The project would be constructed over approximately 12 months. Most works would be completed during standard daytime construction hours, however, some night works would also be required (refer to Section 7.8).

Construction works would take place along the full length of the project and many activities would be transient along the project area. Particular sites within the construction footprint would, however, have more concentrated activities occurring within them. These are classed as key construction sites with respect to noise impacts.

These key construction sites would include:

- stop construction sites (at each of the proposed nine stop locations)
- the Parramatta Road underbridge site and bridge underpass excavation work sites to accommodate the GreenWay shared path.

Away from the main construction footprint there would also be works at the stabling and maintenance facility at Pyrmont. This is classed as another key construction site because of its location away from the main project area.

'Worst case' noise impacts at nearby sensitive receivers have been assessed for each of these key construction sites and for general GreenWay shared path construction works.

Stop construction sites

Construction at the stop sites would occur during the daytime only. Scenarios developed for this assessment were representative of the activities having potentially the greatest noise impact on the surrounding receivers. The predicted noise levels presented are representative of the 'noisiest' construction periods. Generally, noise levels would be expected to be lower than those presented for a majority of the 12 month construction period.

It is assumed a range of noise levels would be experienced by receivers, as the distance between the noise sources and receivers would vary as the work progresses.

Section 4.6 of Technical Paper 3 in Volume 2 provides a detailed breakdown of predicted noise impacts near each of the stop construction sites. A summary of the impacts of noise at each of the stop construction sites with no mitigation measures applied is presented below:

- Construction works at and surrounding the existing Lilyfield stop would consist of activities in the nearby construction compound area, rail systems installation and other general rail infrastructure tie-in works. Due to the relatively large distances to receivers, and high NMLs as a result of existing traffic and other sources, there would be no impact to residential and commercial receivers to the north. At residences to the south on Brenan Street there would be a potential exceedance of up to 10 dBA. This would be classed as a moderate exceedance.

- At the Leichhardt North stop residences to the north are shielded by existing road traffic barriers, and compliance with the NML is predicted. To the south on Darley Road the NMLs could be exceeded by up to 10 dBA at residences and 3 dBA at commercial receivers. This would be classed as a moderate exceedance.

- At the Hawthorne stop residences to the west and east would have a clear view to the stop location, which would be elevated with respect to the residences. The NMLs are predicted to be exceeded by up to 11 dBA to the west, and 21 dBA to the east. These exceedances would be considered moderate to significant.

- At the Marion stop residences to the west and commercial receivers to the east would have a clear view to the stop location, which would be elevated with respect to these receivers. The NMLs are predicted to be exceeded by up to 5 dBA to the west, and 14 dBA to the east. These exceedances would be considered minor to moderate.

- At the Taverners Hill stop residences and commercial receivers to the west and residences and commercial receivers to the east would have a relatively clear view to the stop location (noting that eastern receivers may receive shielding from Brown Street), which would be elevated with respect to these receivers. The NMLs are predicted to be exceeded by up to 15 dBA for residences and 4 dBA for commercial receivers. These exceedances would be considered moderate to minor respectively.

- At the Lewisham West stop residences and commercial receivers would generally be on grade with the stop. The NMLs are predicted to be exceeded by up to 5 dBA for residences and up to 11 dBA for commercial. These exceedances would be considered minor to moderate respectively.

- At the Waratah Mills stop site residences and commercial receivers would generally be on grade with the stop. The NMLs are predicted to be exceeded by up to 32 dBA and 28 dBA for residences to the west and east respectively. These would be significant exceedances, as a direct result of the closeness of receivers and relatively lower ambient noise levels in the area. At commercial receivers the NML would be exceeded by up to 18 dBA.

- At the Arlington stop site residences and commercial would generally be on grade with the stop. The NMLs are predicted to be exceeded by up to 14 dBA and 23 dBA for residences to the west and east respectively. These would be moderate to significant exceedances, as a direct result of the closeness of receivers and relatively lower ambient noise levels in the area. At commercial receivers the NML would be exceeded by up to 25 dBA.

- At the Dulwich Grove stop site residences and commercial receivers would be generally overlooking the stop, which is in cut. The NMLs are predicted to be exceeded by up to 20 dBA at residences to the west, up to 22 dBA at commercial receivers to the east and up to 32 dBA at the school. These would be significant exceedances, as a direct result of the closeness of receivers. School exceedances assume open windows, and further investigation on the noise reduction from outside to inside is required during the construction planning and site establishment phases of the project, as well as liaison with the school.

- At the Dulwich Hill Interchange stop site residences and commercial receivers to the north would be generally partially shielded while those to the south would overlook the stop, which is in cut. At this site an excavation scenario using rock breakers has been modelled, as well as stop construction. During construction the NMLs are predicted to be exceeded by up to 12 dBA to 23 dBA at residences and up to 6 dBA at commercial receivers. During excavation higher exceedances of up to 22 dBA to 33 dBA at residences and up to 9 dBA to 16 dBA at commercial receivers are predicted.

Parramatta Road underbridge and bridge underpass excavation work sites

Construction at the Parramatta Road underbridge site (refer to Section 7.3.4) and at the bridge underpass excavation work sites to accommodate the GreenWay shared path would occur during the daytime and for certain activities during the night-time. Scenarios were developed for the construction works that were representative of activities having potentially the greatest noise impact on the surrounding receivers. These scenarios are:

- excavation and site establishment

- earthworks and general construction.

Piling works during the night-time may be required during these activities (as detailed in Section 7.3.4 (bridgeworks section)). The predicted noise levels were determined for each of the sites. These noise levels are representative of the ‘noisiest’ construction periods, however, generally noise levels would be expected to be lower than those presented for a majority of the construction period.

Section 4.7 of Technical Paper 3 in Volume 2 provides a detailed breakdown of predicted noise impacts near each of Parramatta Road underbridge work site and each of the bridge underpass excavation work sites to accommodate the GreenWay shared path. A summary of the impacts of noise at the each of these sites without mitigation measures applied is presented below:

- The Parramatta Road underbridge is elevated with respect to the surrounding residences and commercial receivers. For general bridge works that are likely to occur through the night-time during lower traffic periods, the NMLs are predicted to be exceeded by up to 22 dBA at the surrounding residences, if works were to occur during the daytime or evening lower exceedances would be predicted as a result of the higher NMLs. During the daytime period, NMLs would be predicted to be exceeded by up to 18 dBA at the surrounding residential receivers and up to 9 dBA at the surrounding commercial receivers during retaining wall construction activities.

- The Longport Street bridge underpass excavation works would generally be on grade with the surrounding receivers. At the residential receivers to the east, NMLs would be predicted to be exceeded by up to 19 dBA during the daytime and 24 dBA during night-time piling activities. At the remaining surrounding residential receivers NMLs would be predicted to be exceeded by up to 7 dBA during daytime construction and by up to 13 dBA during night-time piling activities.

- At the residences surrounding the Old Canterbury Road bridge underpass excavation works residences and commercial receivers would be generally on grade with the work site. The NMLs are predicted to be exceeded by up to 37 dBA during both daytime construction works and night-time piling works. The high exceedances would be as a result of lower ambient noise levels in the area and residential receivers located close to the works.

- At the Davis Street bridge underpass excavation site residences and commercial receivers are generally on grade with the works. The NMLs are predicted to be exceeded by up to 38 dBA and 34 dBA for residences to the north-east and north-west respectively. These would be significant exceedances, as a direct result of the closeness of receivers and relatively lower ambient noise levels in the area. Night-time piling works would exceed the NMLs by up to 42 dBA and 37 dBA for residential receivers to the north-east and north-west respectively.

- At the Constitution Road bridge underpass excavation site residences and commercial receivers would be generally on grade with the works. The NMLs would be predicted to be exceeded by up to 31 dBA and 18 dBA for residences to the west and east respectively. During night-time piling activities NMLs are predicted to be exceeded by up to 37 dBA and 30 dBA for residences to the west and east respectively.

- At the Hercules St bridge underpass excavation site residences and commercial receivers would be generally overlooking the site which is in cut. The NMLs would be predicted to be exceeded by up to 33 dBA at residences to the west, and up to 22 dBA at the school. During potential night-time piling activities the NMLs would be predicted to be exceeded by up to 38 dBA. Exceedances at the school assume open windows.

General construction along GreenWay shared path

Construction of the GreenWay shared path would require works along the length of the project. The intensity of work required at each location would depend on the topography and whether the path is on the same level of as the surrounding land or elevated. Construction of the GreenWay shared path would occur during the daytime only (with the exception of the underpasses through the bridge abutments as discussed earlier). Two scenarios representative of the activities that could have the greatest noise impact on nearby receivers have been considered. These scenarios include general earthworks (using an excavator and a truck) and piling. The predicted noise levels presented in the following table are representative of the 'noisiest' construction periods at locations where the GreenWay shared path would be elevated. Generally, noise levels would be expected to be lower than those presented for a majority of the 12-month construction period.

The $LA_{eq(15minute)}$ noise levels without noise controls implemented on site have been predicted for a range of indicative receiver distances from the works for these two scenarios and are presented in Table 11.10. It is noted that as the work progresses along the alignment, the distance between the noise sources and each receiver would change.

Table 11.10 Indicative worst case construction noise along GreenWay shared path

Receiver distance (metres)	Earthworks LAeq noise level (dBA)	Piling LAeq noise level (dBA)
10	83	80
20	77	74
30	73	70
40	71	68
50	69	66

Stabling and maintenance facility, Pyrmont

At the stabling and maintenance facility in Pyrmont the main noise impacts would be due to rail track construction in the existing car park. The nearest noise sensitive receivers to this site are identified in Table 11.11. Also shown in Table 11.11 are the predicted noise levels and exceedances of the NMLs with and without mitigation in the form of three metre hoardings.

Table 11.11 Stabling and maintenance facility upgrade construction noise levels

Receiver area	Distance (metres)	Period	NML (dBA)	Predicted LAeq noise level (dBA)	NML Exceedance with level of noise mitigation (dBA)	
					No mitigation	3 metre hoarding
Novotel Hotel — North	55	Daytime	70 [1]	56-66	0	-
Pyrmont Street residential — West	42	Daytime	70 [1]	65-69	0	-
Commercial — East	50	Daytime	70	63-67	0	-

Note 1 The RBL + 10 dBA NML exceeds the 70 dBA "commercial" NML, hence an NML of 70 dBA has been adopted.

The residences and commercial receivers surrounding the site would be generally on the same level as or overlooking the worksite. Predicted noise levels for construction activities comply with the NMLs at all receivers even without hoarding.

Construction traffic

Daytime impacts

Indicative vehicle movements and estimates of heavy vehicle percentage for typical arterial, collector and local roads in the residential areas surrounding the worksites have been assumed for the assessment. The local roads would be the most sensitive to project construction traffic.

It is possible that on local roads immediately next to the various subject work sites, the community may associate heavy vehicle movements with the project. Once the heavy vehicles move further from each of the sites onto major collector or arterial roads, however, the noise would be perceived as part of the general road traffic.

A typical local road is Weston Street, Lewisham, which would serve the Waratah Mills stop construction site. The five-day AADT for Weston Street is 238, and daytime hourly flows range from 10 to 20 vehicles an hour with an estimated 5% of heavy vehicles. Construction traffic associated with the project at any construction site would likely be typical of two to three trucks an hour, and may peak at five trucks an hour during activities such as pouring concrete.

For a receiver on a typical local road, the baseline $L_{Aeq(1hour)}$ noise level is predicted to comply with the 55 dBA ECRTN criterion. The addition of the construction traffic is predicted to increase the daytime traffic noise levels typically by 2 dBA. This would result in an $L_{Aeq(1hour)}$ noise level of 53 dBA, which would comply with the 55 dBA criterion. In summary the project is not anticipated to generate any significant daytime traffic noise impacts as a result of traffic associated with construction.

Night-time impacts

As identified in Section 7.3.4 road closure works could be required for the Parramatta Road underbridge works and works associated with the underpass excavation works to accommodate the GreenWay shared path. To minimise disruption to traffic during heavy road usage, these road closure works could occur during the night-time. These works could involve activities such as piling, drilling, jacking structures, night-time deliveries and construction traffic movements.

For sensitive receivers with openable windows, the 55 dBA-based external sleep disturbance screening criterion is expected to be exceeded in the range of 4 dBA to 12 dBA. Further investigation would take place during the construction planning and site establishment phases of the project to confirm the number of existing sleep disturbing events that occur, as well as the external to internal noise reduction achieved at these locations.

Construction vibration impacts

Some items of equipment proposed to be used to construct the project could result in exceedances of the human comfort criteria at distances of up to around 40 metres, depending on the duration and nature of the construction activity. Any exceedances would, however, be expected to be of short duration.

The cosmetic damage threshold for structures could be exceeded. At locations where vibration intensive plant is proposed to be used within the identified safe working distances (identified in Table 11.9), the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would analysed in more detail to determine the applicable safe vibration level and minimise impacts.

Vibration monitoring would take place before construction to confirm safe working distances at specific vibration sensitive sites, such as the heritage items identified in Table 11.4, to minimise impacts on these structures.

11.3.3 Management of impacts during construction

Construction noise

DECCW's *Interim Construction Noise Guideline* describes strategies for construction noise mitigation and control that apply to this project. The approach to construction noise control involves:

- time restrictions for construction activities
- sound level restrictions
- feasible and reasonable mitigation measures.

Time restrictions

As identified in Section 7.8, the standard hours for normal construction work on the project are as follows:

- Monday to Friday 7:00 am to 6:00 pm
- Saturday 8:00 am to 1:00 pm

- no work on Sundays or public holidays.

The majority of construction work on the project would take place during these standard hours. Raising the Parramatta Road underbridge and constructing underpasses to accommodate the GreenWay shared path have been identified by the proponent as potentially requiring night works to minimise disruption to the road network. Where night works are proposed, a construction noise and vibration management plan (CNVMP) would be developed in the detailed design phase when more information is available on the schedule for the works and the equipment to be used.

Noise level restrictions

The NMLs at potentially affected sensitive receivers have been identified in this report. Where exceedances of the NMLs have been predicted during the daytime (standard construction hours), receivers are considered to be noise affected. To mitigate impacts all feasible and reasonable work practices (refer below) would be applied to meet the NMLs. All potentially affected residents would also be informed of the nature of works to be carried out, the expected noise levels and duration, and construction contractor(s) contact details for further information.

Receivers are considered to be highly noise affected if noise levels exceed 75 dBA during the standard construction hours. The assessment indicates the worst case noise scenarios may lead to noise levels exceeding 75 dBA during the daytime at two of the stop locations (Dulwich Grove and Dulwich Hill Interchange), near Parramatta Road during bridge raising works, at the locations where bridge underpass excavation works are required and where the GreenWay shared path construction works involve earthwork or piling activities and are within 10 or 20 metres of a sensitive receiver, respectively. For these locations, site-specific CNVMPs would be developed. These works would be scheduled to provide respite periods from the noisiest activities, and potentially affected residents advised of the duration and noise level of the works.

The proposed night works to construct underpasses under existing bridges to accommodate the GreenWay shared path are predicted to result in significant exceedances of the NMLs. All feasible and reasonable work practices (refer below) to mitigate impacts would be identified in the CNVMP. Where all feasible and reasonable practices have been applied and noise would be more than 5 dBA above the noise affected level, the community would be consulted regarding the construction schedule.

Feasible and reasonable mitigation measures

Where the NMLs are exceeded, DECCW's *Interim Construction Noise Guideline* requires all feasible and reasonable mitigation measures to be applied. Feasible and reasonable measures to be applied would include:

- the construction contractor(s) would prepare and implement site-specific CNVMP, including consideration of the measures listed below and any other initiatives identified to minimise the noise impact

- for construction of the stops and at the bridge and underpass sites, perimeter hoarding three metres high should be considered, noting that these are effective for receivers at or near ground level and not effective for receivers overlooking the sites

- noise intensive construction works would be carried out during normal construction hours, wherever practical
- residents would be notified to advise of the nature and timing of works and how to obtain more information; surrounding noise sensitive receivers would be provided with appropriate notice of all out of hours work
- the noisiest construction activities would take place before 10.00 pm wherever feasible, with as much preparation work as feasible done during daytime hours
- the quietest available plant suitable for the relevant tasks would be used
- the duration of noise intensive activities would be minimised, as far as possible
- where appropriate and effective, construction site hoardings or temporary noise barriers would be used to provide acoustic shielding of noise intensive activities or fixed plant items
- rock breakers would be of the 'Vibro-silenced' or 'City' type, which have been specifically designed to minimise noise, where feasible and reasonable
- activities resulting in highly impulsive or tonal noise emission (e.g. rock breaking) would be limited to standard working hours (except where essential during road closure construction events and subject to additional approvals where required)
- high noise generating activities should run for no longer than three continuous hours with a minimum respite of one hour where necessary
- noise awareness training would be included in inductions for site staff and contractors
- noise generating plant would be orientated away from sensitive receivers, where possible
- the offset distance between noisy plant items and nearby sensitive receivers would be maximised
- the simultaneous use of more than one noisy plant item next to sensitive receivers would be avoided to the greatest extent possible
- discussions would take place with nearby schools about possible noise management measures, such as the scheduling of noisy construction activities outside of exam periods, wherever possible
- regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than predicted; it would also identify defective silencing equipment on the items of plant
- deliveries would be carried out within standard construction hours, except as directed by the Police or Roads and Traffic Authority (RTA), or as required for road closure works
- non-tonal reversing beepers or equivalent would be fitted and used on all construction vehicles and mobile plant regularly used on site and other vehicles where possible

- trucking routes would be via nominated construction access routes and major roads, where possible
- trucks would not be permitted to queue with engines running near residential dwellings, unless no feasible or reasonable alternatives exist.

There is also a requirement to protect the occupational health and safety (OHS) of staff during the proposed construction activities. The CNVMP would address Section 49 of the *Occupational Health and Safety Regulations 2001*.

Construction vibration impacts

Vibration criteria could be exceeded during some construction activities. As such, vibration mitigation measures are recommended to minimise the impact at nearby residential receivers. Vibration monitoring would occur at the start of vibration generating activities to confirm compliance with vibration criteria. If compliance monitoring indicated exceedances of the criteria, additional mitigation measures may be applied. To avoid structural damage to buildings, the safe working distances listed in Table 11.9 of would be implemented as part of the project. The following measures would also be implemented:

- the construction contractor(s) would prepare and implement a site-specific CNVMP, including consideration of the measures listed below and any other initiatives identified to minimise the vibration impact
- any vibration generating plant and equipment would be located within construction areas in a manner that minimises vibration impacts, as far as practical
- the hours of operation of major vibration generating plant and equipment would be scheduled to minimise vibration impacts, as far as practical
- lower vibration generating items of construction plant and equipment (such as hydraulic rock breakers and bored piles) would be used, where feasible
- consecutive works in the same locality would be avoided, where feasible and reasonable
- high vibration generating activities would only be carried out in continuous blocks not exceeding three hours each, with a minimum respite period of one hour between each block where required
- safe operating parameters would be established for vibration producing construction equipment near heritage items, such as Hawthorne Canal, Lewisham railway viaduct, Lewisham sewage viaduct and the Battle Bridge
- attended vibration monitoring should occur to set operating limits for equipment to be used near heritage items and other sensitive structures identified before construction, to monitor any vibration caused by nearby construction works.

11.4 Operational noise and vibration assessment

11.4.1 Criteria

Light rail operation noise goals

The noise goals relating to airborne noise emissions from light rail vehicles are the same as those specified in the *Inner West Light Rail Extension Approval* dated 3 March 1999. The applicability of these operational noise goals has been confirmed in consultation with DECCW during the EA's preparation and are summarised in Table 11.12.

Table 11.12 Operational noise goals

Parameter	Criterion	Application
L_{Amax}	82 dBA at 7.5 metres	General requirement at 60 km/h on typical track
L_{Amax}	82 dBA	At existing residential facades
L_{Aeq} Day	60 dBA	7:00 am to 7:00 pm at existing residential facades
L_{Aeq} Evening	55 dBA	7:00 pm to 11:00 pm at existing residential facades
L_{Aeq} Night	50 dBA	11:00 pm to 7:00 am at existing residential facades

LRV noise levels

Noise emission limits from rail vehicles are normally specified in terms of the L_{AE} and L_{Amax} (fast) noise levels at a particular speed, measured at a particular distance from the track centreline.

The yearly noise compliance measurements of the existing light rail system (between 2004 and 2010) were reviewed to determine the following reference noise levels for the airborne noise modelling. The reference speed is 60 km/hour and measurement distance is 7.5 metres from the track centreline:

- L_{Amax} — 82 dBA (at 60 km/hour and 7.5 metres distance)
- L_{AE} — 83 dBA (at 60 km/hour and 7.5 metres distance).

Vehicle speeds

A maximum speed of 70 km/hour has been assumed for the LRVs, with a speed restriction of 20 km/hour through the stops (if not stopping to pick up or set down passengers). In practice, the existing LRVs rarely operate at faster than 60 km/hour although they have a theoretical top speed of 80 km/hour.

Between the stops, a speed profile has been assumed based on a typical sustained acceleration of 0.8 m/s/s and a typical deceleration of 1 m/s/s. It is noted that faster braking is achievable, but this would only occur in an emergency situation.

Substation operation noise goals

DECCW's *NSW Industrial Noise Policy* (INP) provides criteria to assess noise impact associated with industrial activities. As the proposed substations are fixed facilities, all operational noise emissions need to be assessed in accordance with the INP.

Section 8.1 of Technical Paper 3 in Volume 2 details the background behind determining the substation noise goals.

A summary of the operational noise goals for the substations is provided in Table 11.13.

Table 11.13 Summary of operational noise goals for the substations

Location	Period	Existing noise levels (dBA)[1]		Operational noise goals (dBA)		
		RBL	LAeq (Period)	LAeq(15min) Intrusive	LAeq(period) Amenity	LA1(60sec) Sleep Disturbance
Residential receivers near Catherine Street substation	Daytime	53	65	58	55	-
	Evening	49	63	54	53	-
	Night	42	59	**47**	49	**57**
Residential receivers near Marion substation	Daytime	48	62	54	52	
	Evening	46	58	51	48	
	Night	36	53	**41**	43	**51**
Residential receivers near Lewisham West substation	Daytime	50	61	55	52	-
	Evening	47	60	52	50	-
	Night	42	59	**47**	49	**57**

Note 1 Existing noise levels are based on the monitored existing noise levels at the closest noise monitoring location to each substation (i.e. for Catherine Street; monitoring location B01, Marion; monitoring location B03 and Lewisham West; monitoring location B05).

Note **Bold** text represents controlling criteria or the criterion that sets the noise goal.

The night-time intrusiveness criterion sets the noise goals at all three locations for the project.

Operation vibration goals

The vibration goals relating to ground-borne vibration emissions from the existing Light Rail vehicles are specified in the *Inner West Light Rail Extension Approval* dated 3 March 1999. These vibration goals are expressed in RMS vibration velocity and are summarised in Table 11.14.

Table 11.14 Operational vibration goals (from Inner West Light Rail Extension Approval)

Category	Criterion dB re 1E-6 mm/s	Application
Existing or zoned residential or other sensitive receivers as identified by the Environment Protection Authority	103	Facade L_{max}
Commercial	112	Facade L_{max}

DECCW's *Assessing Vibration — A Technical Guideline* specifies criteria for intermittent vibration, such as that from rail vehicles, in vibration dose values (VDVs). The VDV is a measure that takes into account the overall magnitude of the vibration levels when a train passes by, as well as the total number of trains that pass by during the daytime and night-time.

For intermittent vibration at residential receiver locations, vibration trigger levels are expressed in VDV during the daytime (7:00 am to 10:00 pm) and night-time (10:00 pm to 7:00 am). The guideline nominates 'preferred' and 'maximum' vibration dose values.

For offices, schools, educational institutions and places of worship, the guideline nominates VDVs twice the residential daytime levels.

The acceptable VDVs for intermittent vibration from DECCW's *Assessing Vibration — A Technical Guideline* are summarised in Table 11.15.

Table 11.15 Acceptable VDVs for intermittent vibration

Location	Preferred VDV ($m/s^{1.75}$)		Maximum VDV ($m/s^{1.75}$)	
	Day[1]	Night[1]	Day	Night
Residential properties	0.2	0.13	0.2	0.26
Offices, schools, educational institutions and places of worship	0.4	0.4	0.8	0.8

Note 1 Daytime is 7:00 am to 10:00 pm and night-time is 10:00 pm to 7:00 am.

Heritage structures

The levels of vibration required to cause damage to buildings tend to be at least an order of magnitude (10 times) higher than those at which people consider the vibration acceptable. Hence, the controlling criterion would still be the human comfort criterion, and it is not necessary to set separate criteria for this project in relation to building damage from LRV operations. This also applies to heritage structures, unless there is some reason to believe they are structurally unsound.

11.4.2 Operational impacts

Light rail operations

Noise modelling using SoundPLAN Version 6.5 calculated airborne noise emission levels for this part of the assessment. Further detail on the noise modelling method and input data assumptions are provided in Section 6.4 of Technical Paper 3 in Volume 2.

Table 11.16 presents predicted noise levels at different times of the day at the facades of the residences closest to the light rail alignment. The noise catchment areas indicated are divided by the stop locations. This division is because between stops the LRV's reach their maximum speeds, so noise levels are predicted to be higher between stops than next to the stops. Where the closest receiver is a multi-storey building, the levels shown are for the worst-affected storey.

Table 11.16 Predicted operational noise levels at residential receivers

Noise catchment area	Maximum predicted noise levels at residential receivers (dBA)			
	LAeq(day)	LAeq(evening)	LAeq(night)	LAmax
Residential noise goal	*60*	*55*	*50*	*82*
Lilyfield — Leichhardt North	56	55	50	80
Leichhardt North — Hawthorne	53	52	47	75
Hawthorne — Marion	52	52	46	74
Marion — Taverners Hill	51	50	45	74
Taverners Hill — Lewisham West	53	53	48	77
Lewisham West — Waratah Mills	59	**59**	**54**	**86**
Waratah Mills — Arlington	58	**57**	**52**	**83**
Arlington — Dulwich Grove	55	54	49	78
Dulwich Grove — Dulwich Hill Interchange	56	55	50	81

Note: **Bold text** indicates exceedances of residential noise goal

As shown by the bold text in Table 11.16, exceedances of the residential noise goals during the evening and night time periods have been predicted at seven residential locations between the Lewisham West and Arlington stops, as further detailed in Table 11.17. These noise levels have been calculated for a receiver location one metre from the worst affected level of the worst affected facade. In all cases these are locations where the LRVs are expected to reach their top speed. As no exceedances were identified for the daytime noise goals, they are not included in the table.

Table 11.17 Exceedances of residential operational noise goals

	Evening		Night		LA_{Max}	
	LAeq (dBA)	Exceedance (dB)	LAeq (dBA)	Exceedance (dB)	LAmax (dBA)	Exceedance (dB)
Residential noise goal	*55*		*50*		*82*	
115 Old Canterbury Road	56	1	51	1	82	-
29 Eltham Street	57	2	52	2	83	1
108 Victoria Road	57	2	52	2	83	1
1 Short Street	58	3	53	3	85	3
4 Short Street	59	4	54	4	86	4
10 Terry Road (former Waratah Mills)	57	2	52	2	84	2
5 Terry Road	56	1	51	1	83	1

No exceedances of the noise goals have been identified for sensitive non-residential receivers.

GreenWay operations

Operational noise impacts of the GreenWay shared path or on-street cycleway sections are not expected to be significant.

Substation operation impacts

Two new substations are proposed to be constructed as part of the project to feed traction supply for the light rail operations. Three locations are being considered for these substations all three of which have been assessed for potential impacts. The potential substation locations include:

- west of Catherine Street (near the existing Lilyfield stop)
- north of Marion Street (near the proposed Marion Stop)
- south of the proposed Lewisham West stop.

The substations would be enclosed in a building, be approximately 16 metres by 5 metres and produce 1.5 megawatts of power each.

The major noise sources at substations are electric transformers, which vibrate due to the transformer core expanding and contracting. Transformers operate continually throughout the day and night. Other noise sources at substations are transformer cooling fans, which operate when required, and circuit breakers, which operate only when fault conditions cause over-current trips.

The nearest residential receivers to the proposed Catherine Street substation are approximately 80 metres away. The distance to the nearest existing receivers at Marion Street is approximately 90 metres, and at Lewisham West the nearest residential receiver is around 60 metres away (and is shielded by existing industrial buildings).

The predicted L_{Aeq} and L_{Amax} noise levels at the nearest sensitive receiver to each of the substations are presented in Table 11.18.

Table 11.18 Operational noise goals and predicted substation noise levels

Substation	Nearest receiver distance (metres)	Operational noise goal			Predicted noise level (dBA)		
		Intrusive criteria LAeq(15min)	Amenity criteria LAeq(period)	Sleep disturbance criteria LAe1(60secs)	Scenario 1[1] LAeq	Scenario 2[1] LAeq	Scenario 3[1] LAmax
Lewisham West	60	47	49	57	16	25	64
Catherine Street	80	47	49	57	14	23	62
Marion	90	41	43	51	13	22	61

Note 1 Scenario 1 = Transformer (continuous) noise, Scenario 2 = Transformer (continuous with fans operating) noise, Scenario 3 = Circuit breakers (maximum) noise — this would be an occasional noise source only when there was a fault.

The predicted noise levels in Table 11.18 show compliance with the intrusiveness and amenity criteria at all existing residences for general substation operations.

The sleep disturbance screening criteria are exceeded at all three locations by between 5 dB and 10 dB for Scenario 3. However, taking account of the existing noise environment and the probable low frequency of Scenario 3 events (circuit breaker events), sleep disturbance due to the substation circuit breakers is considered unlikely at any nearby residential receivers.

Operation vibration impacts

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

This vibration passes via the sleepers or rail mounts into the ground or track support structure. It then travels through the ground and occupants of buildings may sometimes feel or perceive it as tactile or visible vibration.

Section 7.3 of Technical Paper 2 in Volume 2 details the source vibration levels used in the assessment to calculate vibration impacts.

Two residential receivers (1 Short Street and 4 Short Street Dulwich Hill) have been identified as potentially exceeding the 103 dB vibration design goal when a LRV passes by. These receivers are located approximately seven metres from the nearest track. The predicted maximum vibration level at these receivers is 105 dB, indicating a marginal potential exceedance of the 103 dB criterion. This predicted maximum level corresponds to an RMS vibration velocity of less than 0.2 millimetres per second, which is normally considered ‘barely noticeable’. The estimated VDV for these receivers is 0.03 millimetres per second$^{1.75}$ during the night and 0.05 millimetres per second$^{1.75}$ during the daytime, which would comply with the preferred VDV criteria.

The vibration source levels assumed in this assessment are conservative. It is expected that actual peak vibration levels due to any one LRV passby would lie in a range up to 10 dB below the predicted maximum levels.

With respect to operational vibration impacts on the heritage receivers listed in Table 11.4, it is noted that vibration levels from the light rail would be much lower than vibration levels generated by the freight vehicles that used the line previously, and structural damage is therefore unlikely.

No exceedances of the vibration criteria are expected for commercial or other sensitive receivers.

11.4.3 Management of impacts during operation

Light rail operational noise

The assessment of airborne operational noise indicates that noise levels are predicted to comply with the noise goals at most locations. However, some potential exceedances of the noise goals have been identified. The predicted exceedances are relatively low, between 1 dB and 4 dB.

The potential mitigation options include:

- source control measures, such as optimised track design, rail dampers
- operational measures, such as reduced speeds or reducing the number of LRV movements
- noise path control measures, such as acoustic shielding between the railway line and the receiver locations
- receiver controls at existing developments, such as building facade treatments or property noise barriers (solid fences).

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

Of the above mitigation options, the suggested operational measures are not considered feasible as they would restrict the efficiency and frequency of the service. The remaining control measures (source, path and receiver) are discussed in the following sections.

Source control measures

As the proposed extension would use the existing disused Rozelle goods line corridor, changing the track alignment is not a reasonable option.

Rail dampers are a potential source control measure for the light rail. Rail dampers are effective in situations where the rail is a significant contributor to rolling noise. This can occur where track decay rates are low (for example, on track with soft rail pads). If the rail pads are relatively stiff, rail dampers may also be effective if the rolling stock has relatively low wheel noise emissions. LRVs have smaller wheels than traditional rail rolling stock, and the wheels are resilient and partially shielded by the vehicle side-skirts.

These factors might mean rail dampers would be more effective for light rail than for heavy rail, even if the rail pads used are stiff. The reduction achievable through rail dampers would be up to 3 dB for LRVs, depending on the dynamic interaction between the track and wheels.

Noise path control measures

Noise barriers are a noise path control measure and are effective when they break the line of sight from the source to the receiver. Noise barriers placed at the corridor boundary typically provide a noise reduction of 5 dBA to 10 dBA at the ground floor of nearby receiver locations. For elevated receiver locations, the noise barrier attenuation reduces significantly and noise barriers are usually ineffective at building storeys two and above. Low profile noise barriers located close to the track could provide a similar benefit.

Earth mounds are sometimes proposed as an alternative to noise barriers, but are not feasible in this case due to space limitations.

Noise barriers are normally only cost-effective in situations where three or more locations are similarly affected by the noise source and the noise barrier would provide a noticeable benefit. For this project, the only location where noise barriers might be considered is on the eastern side of the track near Short Street.

Receiver controls

Treatments to buildings usually involve higher performance windows, doors and seals to keep noise out. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate air flow. An obvious disadvantage is that building treatments would not have any effect on the noise levels outside the dwelling in front or back yards.

The acoustic treatment of individual dwellings is generally not favoured because it:

- may not be effective for lightweight buildings
- provides no protection to outdoor areas
- requires mechanical ventilation and/or air-conditioning, resulting in higher energy consumption.

Noise mitigation recommendations

Measurements of the ambient L_{Aeq} noise levels along the alignment show that at eight out of nine locations the existing night-time L_{Aeq} values are already higher than the night-time noise criterion set for the light rail, and existing levels at the other location (near the Waratah Mills Stop) are within 2 dB of the night-time noise criterion. The existing evening noise levels are similarly already generally close to or higher than the evening L_{Aeq} criterion for the light rail.

Despite this, the receivers between Waratah Mills and Lewisham West with predicted exceedances of the noise goals are located in the area along the alignment with the lowest existing noise levels so noise mitigation may be required. The following sections discuss the likely mitigation requirements at each of the locations where potential exceedances have been identified.

155 Canterbury Road, 29 Eltham Street

The potential exceedances at these locations are minor (1 to 2 dB). These properties are isolated from other potentially affected properties and mitigation options other than individual dwelling treatments are unlikely to be cost-effective. As the noise modelling does not take into account any shielding provided by existing boundary fences at these locations, the need for mitigation would be determined on the basis of compliance measurements after operations start.

1 and 4 Short Street and 108 Victoria Road

This area is predicted to be most affected by noise from the project. At this location, the rail corridor is at its narrowest, and the houses at 1 and 4 Short Street and at 108 Victoria Road are closer to the tracks than other homes along the alignment.

At this location, potential mitigation measures include rail dampers, low profile noise barriers close to the track, noise barriers or fences at the corridor boundary, or individual dwelling treatments. Any one of these mitigation measures would be expected to meet the noise criteria at these locations.

On the basis the predicted exceedance of the noise criteria is relatively low, and because there are a number of potential mitigation options, the appropriate mitigation would be determined with attended measurements after operations start. However, it is noted that in-corridor noise barriers are unlikely to be cost-effective to install.

5 and 10 Terry Road

The properties on Terry Road (including the former Waratah Mills site) were developed while the Rozelle goods line was operational and the designs were required to take into account the noise impacts associated with rail operations.

On the basis the potential noise exceedances at these locations are only minor, and rail-related noise levels from the light rail would be less than the rail noise levels when the developments were approved, no mitigation measures are proposed for these locations.

Compliance monitoring

Attended measurements of operational noise are recommended after operations begin at the locations listed in Table 11.16 to confirm if mitigation measures are required.

Attended measurements would also be taken at other representative locations across the project area to validate the noise predictions and to determine if any additional feasible and reasonable mitigation measures are required.

Other recommended mitigation measures

During operations, curve flanging and curve squeal would be managed in accordance with the current operating procedure. It is anticipated that top of rail friction modification may be required at some locations, but that the existing application of lubricant would be sufficient. Regular attended measurements are recommended to monitor curving noise.

Between the hours of 10:00 pm and 7:00 am warning bells and horns would only be used where in the driver's opinion it is considered to be a danger to public safety. This is consistent with the current operating procedure for the existing light rail.

The locations of track crossover infrastructure would be determined to take their noise impacts into account. Where possible, crossovers would be located close to stops where speeds are at their lowest to minimise noise emissions.

Substation noise

Additional mitigation of the substation noise (beyond the proposed enclosure) is not required.

The assessment is based on assumed source sound power levels for substations; as a result actual source sound power levels would be checked against the assumed levels in the detailed design phase to confirm the conclusions of the substation noise assessment.

Light rail operational vibration

The assessment of operational vibration indicates that vibration levels are predicted to comply with the VDV criteria at all locations. Potential exceedances (up to 2 dB) of the more stringent façade vibration criterion on 103 dB have been predicted at two residences (1 and 4 Short Street Dulwich Hill). Attended measurements of operational vibration are recommended at Short Street after operations start to confirm the predicted vibration levels.