Fairmead Business Proprietary Ltd

HOMEBUSH BAY BRIDGE

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Homebush Bay Bridge | Environmental Assessment

APPENDIX K

Noise and vibration assessment report

Fairmead Business Proprietary Ltd

Homebush Bay Bridge

Noise Impact Assessment

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Contents

1 Introduction

Fairmead Business Pty Ltd (Fairmead) is currently coordinating the development of a bridge spanning Wentworth Point and Rhodes Peninsula (called the Homebush Bay Bridge). Arup has been commissioned by Fairmead to undertake an assessment of noise impacts associated with the construction and operation of the proposed bridge.

1.1 Proposal and site description

The Homebush Bay Bridge is proposed to be 11.4 m wide and 455 m long and is to span Homebush Bay between Wentworth Point and the western most point of Rhodes Peninsula. The bridge is to accommodate pedestrians, cyclists, public buses and emergency vehicles.

There is currently remediation and building construction works unassociated with the bridge on the northern half of the Rhodes Peninsula. There is also multi-storey development in progress at the southern end of the Wentworth Point side of the bay.

1.1.1 Noise-sensitive receiver locations

Potentially noise affected residential receivers in the vicinity of the development include:

- Existing residences.
- Residences under construction.
- Residences proposed for development.

For the purpose of assessing potential construction noise impacts, residential receivers that currently exist and are in the process of being built have been grouped into Noise Catchment (NC) areas, identified in Figure 1, as follows:

- NC1 – Southern end of Rhodes Peninsula – various multi-storey residential buildings currently occupy and are being built immediately to the east of the entry point to the bridge and extending further south on the Rhodes Peninsula side of the bay.
- NC2 – Meadowbank – residential receivers are located approximately 1 km to the northwest of the development` with an unshielded view of the proposed bridge.
- NC3 – Melrose Park – residential receivers are located approximately 850 m to the northwest of the western end of the proposed bridge. Residences at this location are afforded some acoustic shielding by way of intervening warehouse structures with the industrial development on the Wentworth Point side of the bay.
- NC4 – Southern end of Wentworth Point – multi-storey residential receivers currently occupy and are being built at the southern end Wentworth Point. These are located some 600 m to the southwest of the bridge on the outskirts of the industrial complex.

Other sensitive receivers include:

- Meadowbank Park, which is located in the order of 1 km to the north of the proposed bridge. For the purpose of assessment, this area is defined as a place of "Active Recreation".
- Sydney Olympic Park, which is located some 900 m to the southwest of the proposed bridge. Various parklands associated with the park are similarly regarded as active recreation areas for the purpose of assessment.

- Concord House Lutheran Church and the Coptic Orthodox Church of St Marys and Merkorius, which are located approximately 500 m to the east of the proposed bridge development. For the purpose of assessment, these premises are defined as being places of worship.
- Melrose Park Public School, which is located some 1.5 km to the northwest of the development. This School receives significant shielding from intervening warehouse building envelopes within the industrial complex on Wentworth Point.

Figure 1 presents an aerial view of the development site in the context of its surroundings. Unattended noise monitoring locations (discussed in detail in Section 2.1 below) are also shown along with residential receiver locations grouped into noise catchment areas discussed further in the following section.

As part of the greater area surrounding the bridge, it is proposed to develop various residential areas on both the Wentworth Point and Rhodes Peninsula side of the bay. For the purpose of assessing potential operational road traffic noise impacts, both existing and proposed residential receivers will be assessed based on their proximity to the road alignment. This is discussed further in Section 4.2.

Figure 1 Aerial View of Development Site

2 Noise survey

2.1 Unattended noise monitoring

2.1.1 Noise logging locations

Unattended environmental noise monitoring was conducted in the vicinity of the proposed development from Monday 28 February to Monday 7 March 2011. Two noise loggers were deployed at locations shown in Figure 1, to record continuously ambient noise levels at nearby residential receiver locations.

Due to extensive remediation and construction works observed in the area during the noise survey set-up period, the existing ambient noise environment was considered to be potentially uncharacteristic of typical background noise levels usually experienced by residents. As such, noise logging locations were selected after a detailed inspection of the area by taking advantage of acoustic shielding afforded by intervening building structures and reasonable distances from works.

Prior to deployment of the noise loggers, the unattended noise monitoring methodology was confirmed with a representative from the NSW Office of Environment and Heritage. In order to confirm consistency in measured ambient noise logging results, correlation was also made against prior noise logging conducted for other developments[1] in the area as available on the Department of Planning and Infrastructure website[2].

Table 1 lists notes and observations made while at the monitoring locations while on site.

Table 1 Unattended Noise Monitoring Locations

Logger Location	Address	Notes
1	138 Lancaster Avenue, Melrose Park	Single-storey residence approximately 800 m to the northwest of the proposed development site. Some shielding from most construction works by intervening warehouse buildings within industrial complex.
2	9 Jean Wailes Avenue, Rhodes	Ground floor residence in multi-storey residential building. Set back approximately 4 apartments from the water's edge on the Rhodes Peninsula. Located approximately 500 m to the south of the proposed development. Significant acoustic shielding provided from construction/remediation works by intervening residential apartment blocks.

2.1.2 Instrumentation

Equipment for the continuous unattended noise surveys included RTA Technology Type 1 Noise Loggers (serial numbers 082 and 083) fitted with microphone windshields. Calibration of the loggers was checked prior to and following measurements using a Brüel & Kjær Electronic Calibrator Type 4230 with no significant drift in calibration being recorded. The sample time interval was set at 15 minutes and the time weighting function set to "Fast".

[1] Site 2A and 3A Walker Street, Rhodes

[2] http://majorprojects.planning.nsw.gov.au/index.pl?action=search&page_id=&search=&authority_id=453&x=53&y=10

2.1.3 Weather data

Continuous weather data obtained from the Bureau of Meteorology's (BOM) nearby weather station at Sydney Olympic Park was reviewed to identify periods of adverse weather during the unattended noise logging surveys. Where appropriate, periods of high winds and/or rain were excluded from the analysis. Other extraneous noise events were also excluded from the analysis as required. The removal of the weather affected noise data did not significantly affect the resulting background noise levels.

2.1.4 Unattended noise monitoring results

The results of the unattended noise survey are presented in Table 2 and Table 3 and graphically in **Appendices B1** and **B2**. In addition, ambient noise monitoring results from a previous study[3] nearby are also provided for comparison (i.e. Logger Location 3 - 40 Walker Street).

Measured noise data was processed in accordance with the procedures outlined in the Office of Environment and Heritage's *Environmental Criteria for Road Traffic Noise* and *Industrial Noise Policy*.

Table 2 presents measured ambient L_{Aeq} noise indices across time periods as defined in the ECRTN relevant to the assessment of operational road traffic noise.

Table 2 Ambient L_{Aeq} Noise Monitoring Results during ECRTN defined Time Periods

Logger Location	**Address**	**Road Traffic Noise Indices**			
		Daytime (7.00am to 10.00pm)		Night-time (10.00pm to 7.00am)	
		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	$L_{Aeq(9hour)}$	$L_{Aeq(1hour)}$
1	138 Lancaster Avenue, Melrose Park	57	59	58	61
2	9 Jean Wailes Avenue, Rhodes	52	55	52	55
3	40 Walker Street, Rhodes	63	n/a	58	n/a

Table 3 presents Rating Background Level (RBL[4]) ambient noise levels at noise monitoring locations for the assessment of construction noise emissions.

Table 3 Ambient L_{A90} Noise Monitoring Results during ICNG defined Time Periods

Logger Location	**Address**	**Construction Noise Indices - dBA RBL[4]**		
		OEH Preferred Construction Hours [1]	Evening Period [2]	Night-time Period [3]
1	138 Lancaster Avenue, Melrose Park	40	43	45
2	9 Jean Wailes Avenue, Rhodes	44	44	41
3	40 Walker Street, Rhodes	50	48	38

[3] Refer Acoustic Logic Report 2010964.1/1810A/R0/GC

[4] Refer to Appendix A for a glossary of terms and abbreviations.

Note 1: OEH's standard construction hours: 7.00 am to 6.00 pm Monday to Friday, 7.00 am to 1.00 pm (if inaudible at residential premises) otherwise 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Note 2: Evening hours: 6.00 pm to 10.00 pm.

Note 3: Night-time hours: 10.00 pm to 7.00 am Sunday to Friday, 10.00 pm Saturday to 8.00 am Sunday.

Note 4: Taken as the lower of the weekday and weekend RBL.

In general, ambient noise levels measured are fairly consistent over a 24 hour period with the night-time noise levels at Logger Location 1 being higher than during the daytime. A review of daily noise graphs presented in **Appendices B1** and **B2** reveals no obvious artefacts that would indicate the influence of extraneous or uncharacteristic noise events. A comparison of noise logger results and recommendations is discussed further in Section 2.3.2.

2.2 Attended noise measurements

Operator attended noise monitoring was also conducted at each noise logger location during the daytime to provide spectral data and observe the prevailing ambient noise environment.

The local ambient noise environment at Logger Location 1 was dominated by distant construction noise, distant rail activity along the rail bridge including freight and passenger trains, a helicopter flyover and local bird noise.

The local ambient noise environment at Logger Location 2 was dominated by some local construction noise, intermittent local traffic flows and occasional community noise.

2.3 Discussion of results

2.3.1 Operational noise

It can be seen from the daily graphs presented in **Appendices B1** and **B2** that measured L_{Aeq} noise levels are not consistent with expected ambient noise levels due to existing traffic flows. Rather, the erratic nature of measured L_{Aeq} levels indicates that measured noise levels were dominated by local noise artefacts (e.g. bird and insect noise, human activity, etc.).

Further, it is important to note that existing road traffic activity in the vicinity of the development site is not representative of “future existing” traffic levels in light of residential development of the area and redevelopment of industrial land uses. Traffic noise levels are expected to increase due to increased traffic flows associated with new residential development in the area.

2.3.2 Construction noise

With the exception of the night-time period, measured ambient background noise levels are lower than previously measured background noise data of the area (refer Table 3). It is recommended for assessment purposes that the previously measured RBL of 38 dBA be adopted as the background for the night-time period should assessment of this time be required.

3 Noise and vibration criteria

3.1 Director General requirements

The following is an excerpt from the Director General's Requirements for Homebush Bay Bridge (10_0192) relevant to noise and vibration:

> *"an assessment of the construction and operational noise and vibration impacts of the project, in accordance with the Interim Construction Noise Guideline (DECC 2009), Environmental Criteria for Road Traffic Noise (EPA 1999)* and *Assessing Vibration: a Technical Guideline (DEC 2006)".*

These guidelines are therefore used as the basis for assessing operational and construction noise and vibration for the project.

3.2 Project specific construction noise objectives

When dealing with noise from construction works, OEH recognises that higher levels of noise are likely to be tolerated by people in view of the relatively short duration of the works. As a result, the OEH has published guidelines in its Interim Construction Noise Guideline, 2009 (ICNG) for the management of construction works noise.

The Guideline recommends the following approaches to mitigating adverse noise impacts from construction sites.

3.2.1 Hours of construction

The ICNG recommends confining permissible work times as outlined in Table 4.

Table 4 Preferred Hours of Construction

Day	**Preferred Construction Hours**
Monday to Friday	7.00 am to 6.00 pm
Saturdays	8.00 am to 1.00 pm
Sundays or Public Holidays	No construction

3.2.2 Construction noise assessment method

The OEH's guideline recognises that people are usually annoyed more by noise from longer-term works than by the same type of works occurring for only a few days. For this reason the Guideline identifies two methods of assessing noise from construction:

- The quantitative assessment method which applies to long-term duration work; and
- The qualitative assessment method which applies to short-term duration work.

3.2.2.1 Quantitative assessment method

The ICNG recommends that the $L_{Aeq(15minute)}$ noise levels arising from a construction project, measured at boundary or within 30 m of an occupied noise-sensitive premises, whichever is the lesser, should not exceed the levels indicated in Table 5. These Noise Management Levels (NML) are generally consistent with community reaction to construction noise.

Table 5 Recommended OEH General NMLs for Construction Works

Period of Noise Exposure	$L_{Aeq(15minute)}$ Construction NML
Recommended Standard Hours	Noise affected[1] RBL + 10 dBA
	Highly noise affected[2] 75 dBA
Outside Recommended Standard Hours	Noise affected[1] RBL + 5 dBA

Note 1: The noise affected level represents the point above which there may be some community reaction to noise.
Note 2: The highly noise affected level represents the point above which there may be strong community reaction to noise.

The ICNG also recognises other kinds of noise sensitive receivers and provides recommended construction NMLs for them. Specific receivers relevant to the Proposal and their recommended noise levels are presented in Table 6.

Table 6 Noise Sensitive Land Uses (other than residences)

Land use	$L_{Aeq(15minute)}$ Construction NML
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Offices, retail outlets	External noise level 70 dBA
Industrial premises	External noise level 75 dBA

The ICNG recommends using the following quantitative assessment when the noise affected level (refer Table 5) is not likely to be met:

Recommended Standard Hours – Noise affected RBL + 10 dBA

- Where the predicted or measured $L_{Aeq(15minutes)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices in order to meet the noise affected level.
- The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Recommended Standard Hours – Highly Noise affected RBL 75 dBA

- Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours during which the very noisy activities can occur, taking into account:

1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences.
2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

3.2.2.2 Qualitative assessment method

The qualitative method for assessing construction noise is a simplified way to identify the cause of potential noise impacts. It avoids the need to perform complex predictions by using a checklist approach to assessing and managing noise.

The following checklist for work practice can be used:

- Community notification.
- Operate plant in a quiet and efficient manner.
- Involve workers in minimising noise.
- Handle complaints.

3.2.2.3 Construction Noise Management Levels

The assessment of the impact from on-site construction works is conducted according to the OEH's ICNG. The quantitative assessment method is considered the appropriate method for the bridge as it is a significant development that is likely to take a considerable amount of time to complete. Accordingly, the quantitative assessment method described in Section 3.2.2.1 is to be followed.

It is anticipated that bridge construction works will be undertaken during Recommended Standard Hours. Any works proposed outside of standard hours would require strong justification and have much more stringent noise mitigation requirements.

The OEH's interim guideline $L_{Aeq(15minute)}$ construction noise management levels (NMLs) are presented in Table 7 as based on the ambient noise monitoring results presented in Section 2.

Table 7 Recommended OEH NMLs for Construction Works

Location	**Noise Management Levels ($L_{Aeq(15min)}$)**
	Recommended Standard Hours[1]
138 Lancaster Avenue, Melrose Park	50
9 Jean Wailes Avenue, Rhodes	54

Note 1: OEH's standard construction hours: 7.00 am to 6.00 pm Monday to Friday, 7.00 am to 1.00 pm (if inaudible at residential premises) otherwise 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

For the purpose of this assessment, NML's listed in Table 7 will apply as follows:

- NC1 and NC4 - 54 dBA $L_{Aeq\ (15minute)}$
- NC2 and NC3 - 50 dBA $L_{Aeq\ (15minute)}$

3.3 Operational road traffic noise objectives

3.3.1 Environmental Criteria for Road Traffic Noise (ECRTN)

The OEH's Environmental Criteria for Road Traffic Noise (ECRTN) presents the NSW Government's guidelines for road traffic noise assessment and provides road traffic noise criteria for proposed road or residential land use developments as well as criteria for other sensitive land uses current at the time of this submission.

The road traffic criteria recommended in the ECRTN are based on the functional categories of the subject roads, as applied by the RTA, namely:

- Arterial Roads (including freeways and sub-arterial roads): These carry predominantly through traffic from one region to another, forming principal avenues of communication for urban traffic movements and are characterised by heavy and continuous traffic flow during peak periods
- Collector Roads: These connect the local road system in built-up areas to freeways, arterial and sub-arterial roads.
- Local Roads: These are the subdivisional roads within a particular developed area. These are used solely as local access roads and are characterised by intermittent traffic flow.
- New Road (any of the above categories): These are roads proposed on a corridor which has not previously been used for a freeway, arterial or sub-arterial road.
- Redeveloped Road (any of the above categories): An existing road corridor where, through design or engineering changes, the project is intended to (substantially) increase traffic-carrying capacity or the mix of traffic.

For the purpose of this assessment (and consistent with previous NSW Transitway studies[5]) the proposed bridge is identified as a New Local Road as it is a closed loop that services the local residential community Table 8 and Table 9 present the corresponding ECRTN criteria for new local road corridors and areas of active recreation affected by collector and local roads respectively. These criteria are applicable for traffic conditions prevailing *10 years* after the project opening.

It is noted that the noise criteria presented within the ECRTN noise policy document are guidelines only and as such are non-mandatory. In achieving compliance with the noise criteria, consideration needs to be given to aesthetics, cost implications, equity, community preferences and practicality.

Table 8 Road Traffic Noise Criteria for Residential Land Use Developments – ECRTN

Type of Development	Criteria		
	Day 7.00 am – 10.00pm (dBA)	Night 10.00 pm – 7.00 am (dBA)	Where Criteria Are Already Exceeded

[5] Refer *Proposed Northwest Trasitways Modification near Celebration Drive – Substantive Impacts Report – Appendix E* released by RTA Environmental Technology in February 2005.

Type of Development	**Criteria**		
	Day 7.00 am – 10.00pm (dBA)	**Night 10.00 pm – 7.00 am (dBA)**	**Where Criteria Are Already Exceeded**
New local road corridor in a metropolitan area	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 0.5 dBA. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In many instances this may be achievable only through long-term strategies, such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.
New local road corridor in a rural area	$L_{Aeq(1hour)}$ 50 (external)	$L_{Aeq(1hour)}$ 45 (external)	

Table 9 Road Traffic Noise Criteria for Sensitive Land Uses – ECRTN

Sensitive Land Use	**Criteria**		
	Day 7.00 am – 10.00 pm (dBA)	**Night 10.00 pm – 7.00 am (dBA)**	**Noise Mitigation Measures**
Existing school classrooms	$L_{Aeq(1hour)}$ 45 (internal)		In the medium to longer term, strategies such as regulation of exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium to long-term strategies apply equally to mitigating internal and external noise levels. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5 dBA for new roads and 2 dBA for redeveloped roads or land use development with potential to create additional traffic.
Places of worship	$L_{Aeq(1hour)}$ 40 (internal)	$L_{Aeq(1hour)}$ 40 (internal)	
Active recreation (for example, golf courses)	Collector and Local Roads $L_{Aeq(1hour)}$ 60		
Passive recreation and school playgrounds	Collector and Local Roads $L_{Aeq(1hour)}$ 55		

3.4 NSW Road Noise Policy

Effective 1 July 2011, OEH will introduce the NSW Road Noise Policy (RNP) to supersede the current ECRTN. The main difference between policies relevant to this study is criteria introduced specific to Transitways. The criteria are separated into "off-road" and "on-road" applications to account for the cumulative effect of existing and future traffic noise levels.

Table 10 is an excerpt from Section 2.3.3 of the RNP, outlining the new assessment criteria.

Table 10 Transitway Noise Assessment Criteria for Existing Residential Land Uses - RNP

Transitway Type	**Assessment Criteria (dBA)**		**Additional Considerations**
	Day 7.00 am – 10.00 pm	**Night 10.00 pm – 7.00 am**	
Off-road transitway	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 50 (external)	The total noise level from the transitway is to be assessed against the criteria.
On-road transitway	The noise assessment criteria in [**Table 8**] apply as appropriate to the existing road classification (e.g. freeway /arterial/sub-arterial or local road classification.		The total combined noise level from the road including the transitway and other traffic is to be assessed against the criteria.

In addition to the above absolute noise objectives, the RNP also stipulates relative increase criteria for resultant cumulative noise levels above existing road traffic noise levels. Table 11 is an excerpt from Section 2.4 of the Policy.

Table 11 Relative Increase Criteria for Residential Land Uses

Road Category	**Type of Project/Development**	**Total Traffic Noise Increase (dBA)**	
		Day 7.00 am – 10.00 pm	**Night 10.00 pm – 7.00 am**
Freeway/arterial/sub-arterial roads and transitways	New road corridor/redevelopment of existing road/ land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq(15hour)}$ +12 dB (external)	Existing traffic $L_{Aeq(15hour)}$ +12 dB (external)

It is noted that the new Road Noise Policy criteria do not pertain to the subject development as per the Director General's Requirements, however they are presented here for the information of the reader.

3.4.1 Existing road traffic noise

It should be noted that it is considered inappropriate to take into account the contribution of noise from current local road traffic activity in the vicinity of the bridge development for the purpose of this assessment. Existing traffic flows are likely to be considerably altered at bridge opening due to the following factors:

- Proposed redevelopment of the industrial complex to residential.
- Current composition of local traffic flows due to extensive construction works in the area.

As such, the absolute daytime and night-time noise objectives as listed in Table 8 and Table 9 have been adopted as the overriding criteria for assessing operational noise emissions.

3.5 Vibration design criteria

3.5.1 Building damage

There is the potential for vibration associated with construction of the bridge to adversely impact upon nearby building structures. There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage[6]. There are however several standards that can be referred to. These include:

- German standard DIN 4150: Part 3[7]: 1999.
- Swiss standard SN 640 312[8]:1978.
- British standard BS7385: Part 2: 1993[9]
- Australian Standard AS 2187.2 - 1993[10]

British Standard **BS 7385 Part 2:1993** is taken to be the most relevant to this study, being the most up to date and relevant to Australian building types. The only Australian guidance is concerned with rock blasting which is not applicable in this case.

It must be remembered that the limits set are for cosmetic damage and for minor and major damage to occur these levels would need to be significantly higher. Even for cosmetic damage to occur these levels are conservative. Vibration will be noticed by building occupants at comparatively low levels.

3.5.1.1 British Standard 7385 Part 2

The relevant standard is BS7385: Part 2: 1993. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

Limits on the foundations of the building as proposed in the Standard are listed in Table 12.

Table 12 Transient Vibration Guide Values for Cosmetic Damage

Category	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
1) Reinforced or framed structures industrial and heavy commercial buildings	50mm/s @ 4Hz and above	
2) Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4 Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15 Hz increasing to 50mm/s @ 40 Hz and above

6 Building Research Establishment (1995), 'Damage to Structures from Ground-borne Vibration', BRE Digest
7 DIN 4150-3 (1999-02) Structural vibration – Effects of vibration on structures.
8 SN 640 312 (1978), Association of Swiss Highway Engineers
9 BS 7385: Part 2: 1993 Evaluation and Measurement for vibration in Buildings-Guide to damage levels from ground-borne vibration
10 AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives

3.5.2 Human exposure

Vibration levels caused by both construction and operation of the bridge should not exceed the levels specified in the OEH *Assessing Vibration: a Technical Guideline (DEC 2006)* at any place of different occupancy in the vicinity of the site. The guideline provides vibration criteria for maintaining human comfort within different space uses.

The *Assessing Vibration* guideline recommends "preferred" and "maximum" weighted vibration levels for continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472: *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*.

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the Vibration Dose Value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event.

Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as "impulsive" sources for the purposes of assessment.

The vibration limits recommended by OEH for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 13 and respectively.

Table 13 Preferred and Maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2) 1-80 Hz

Location	**Assessment Period**[1]	**Preferred Values**		**Maximum Values**	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.64	0.46	1.28	0.92

Note 1: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Table 14 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	**Daytime**[1]		**Night-time**[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

Note 1: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

4 Noise and vibration impact assessment

4.1 Construction noise and vibration

Given the early stage of the development, exact plant/equipment selection and construction methodology has not been finalised. As such, assessment is based on indicative schedule based on current understanding of the project. Where there is uncertainty between options, the scenario with the greatest potential for acoustic impact has been assessed.

The following sections provide a synopsis of input information provided along with assessment of noise and vibration impacts.

4.1.1 Construction Compounds

There will be two construction site compounds: Wentworth Point on the west and Rhodes on the east. The Wentworth Point site will be the primary site with all material storage, site offices and reinforcement assembly uses, as Rhodes has limited storage area and access. Figure 2 roughly depicts the extents of each construction compound.

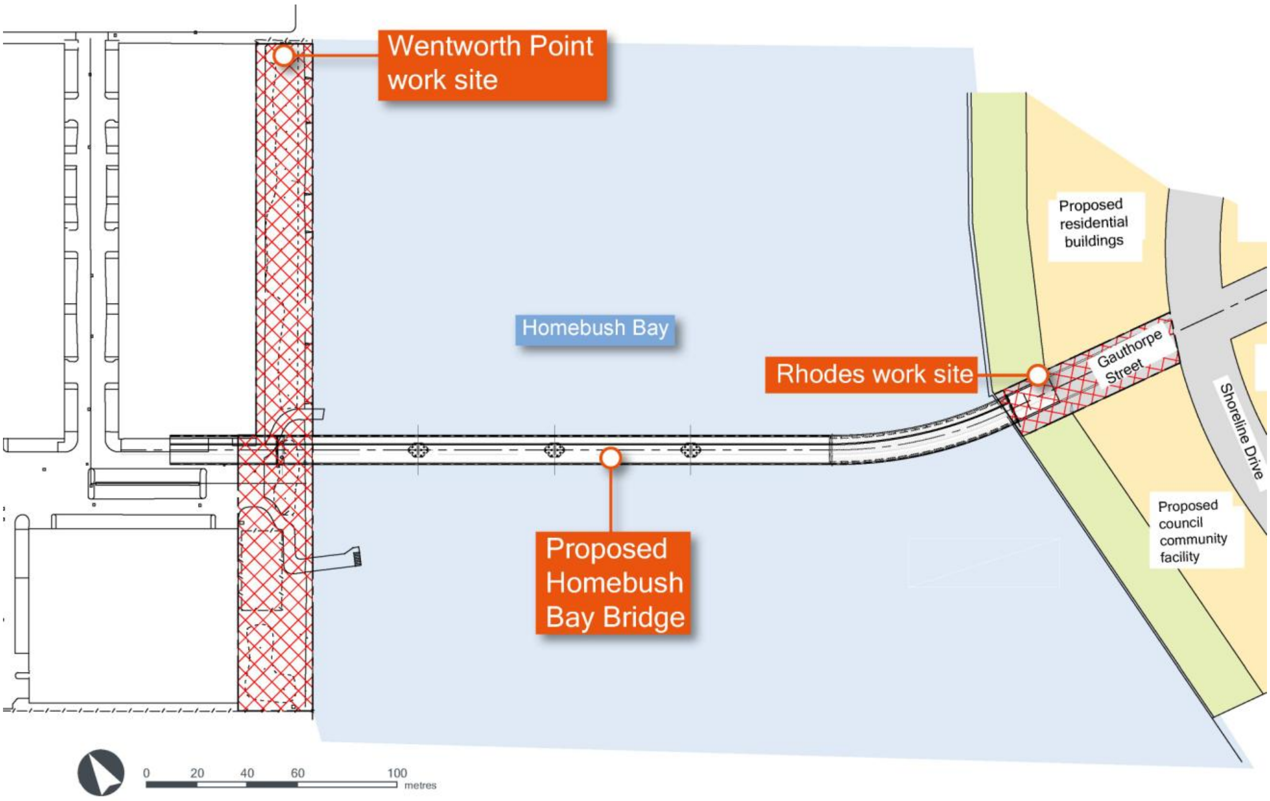

Figure 2 Construction compound sites

4.1.2 Construction Programme

A program of the construction is estimated below. As the project is in its preliminary stages, the following timeframes are approximate within an overall 2 year construction period.

Table 15 Estimated Construction Timeframe

Stage	Timeframe
Earth Works and Pier/Foundation Construction	10 months
Bridge Construction	12 months
Finishing Works	2 months

4.1.3 Construction activities

The Bridge Construction section of this report outlines potential construction options and associated activities proposed at this stage of the project. The following is a brief synopsis of the main acoustically relevant activities and likely associated plant/equipment broken down into representative stages. Additional items of plant typical for this type of construction have been included where appropriate as identified in DEFRA[11] construction noise database.

Table 16 Acoustically significant items of plant per stage of construction

Construction Stage	Main Plant/Equipment
Excavation and site preparation	Tracked excavator, dozer, wheeled backhoe loader, articulated dump truck, vibratory roller, water pump, pneumatic breaker
Piling, pile cap and pier construction	Hydraulic hammer rig, tracked mobile crane, hand-welder, generator, gas cutter
Installation of superstructure	Tracked mobile crane, hand-welder, generator, gas cutter
Finishing works	Road planer, vibratory roller, bulldozer, water pump
Site compound activities	Cement mixer, concrete pumps, trucks and transport vehicles

4.1.4 Source noise levels

Construction source noise levels have been determined using published construction equipment noise levels from the AS 2436[12], BS 5228.1[13] and DEFRA construction noise database. Noise spectra used as the basis of this assessment for items of plant and equipment identified in Table 16 measured at 10 m are presented in Appendix C for reference. Penalties for annoying characteristics such as impulsiveness and tonality have been applied during the assessment process as appropriate.

4.1.5 Predicted Construction Noise Levels

Noise levels from construction activities for each stage have been calculated for each noise catchment area identified in Figure 1. Calculations take into account source-receiver distance, the directionality of the noise source, reflections of sound from nearby surfaces including the ground, and atmospheric absorption of sound.

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11 Department for Environment Food and Rural Affairs (United Kingdom) (2006), *Update of noise database for prediction of noise on construction and open sites*

12 Australian Standard AS2436 (2010) *Guide to noise and vibration control on construction, demolition and maintenance sites*

13 British Standard BS5228.1 (2009) *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*

Predicted cumulative noise levels are presented in Table 17. Exceedances of NMLs stipulated in Section 3.2.2.3 have been highlighted **in bold**. NMLs relevant to each noise catchment area are also provided for reference.

Table 17 Predicted L_{Aeq} noise levels per construction stage

Construction Activity	Predicted L_{Aeq} Noise Level (dBA)			
	NC1	NC2	NC3	NC4
Reference NMLs	54	50	50	54
Excavation and site preparation	**66**	43	43	54
Piling, pile cap and pier construction	**70**	**52**	**52**	**65**
Installation of superstructure	46	27	27	37
Road finishing works	**64**	45	45	54
Site compound activities	**74**	n/a*	n/a*	49
Roadworks at Rhodes landing	**77**	n/a*	n/a*	n/a*

* Note: L_{Aeq} noise levels have been predicted to the nearest, worst affected receiver for each noise catchment (refer to Figure 1). In the case of noise generated from 'site compound activities' and 'roadworks at Rhodes landing' the noise-sensitive receivers immediately adjacent to these works (ie. NC1: Rhodes) are the only receivers affected. Predicted noise levels for other noise catchments were found to be insignificant due to distance and shielding and therefore have been omitted from the assessment.

Noise levels from construction activities are generally predicted to exceed the ICNG criteria at the nearest residential receivers at Rhodes. The greatest acoustic impact is observed to be during piling and pier construction (i.e. up to 16 dBA) with exceedances being observed within each respective noise catchment area.

Site compound activities at the Rhodes landing are also predicted to exceed noise management levels by up to 20 dBA. This is due to the proximity of residential receivers to the site.

Finishing works at the Rhodes landing leading up to the bridge are predicted to exceed the highly affected noise level of 75 dBA due to their proximity to noise sensitive receivers.

4.1.6 Noise mitigation options

Noise mitigation measures for each major construction activity are discussed in the following sections. These mitigation measures are considered to represent all "feasible and reasonable" mitigation measures suitable for being implemented for the project.

4.1.6.1 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Ensure site managers periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.

- Turn off all plant and equipment when not in use.

4.1.6.2 Mitigated noise source levels

Various mitigation measures for different types of construction activity are provided in Table C1 of AS2436 as approaches to reducing noise levels at source. Indicative noise mitigation for different noise mitigation measures at source relevant to construction activities for the project have been obtained from the guidance of AS2436 and BS5228.1, as summarised below in Table 18

Table 18 Indicative Noise Reduction Provided by Noise Mitigation Measures

Construction Equipment	Noise Mitigation Measure	Indicative Noise Reduction	Source
Jackhammer	Muffler and screen	20 dBA	Table C2 AS2436:2010
Compressor Cement mixers Hand-held tools	Screening	5 dBA	Table C3 AS2436:2010
Excavators/loaders Trucks Mobile cranes Asphalt paver Bulldozers Road graders Rollers/compactors	Residential-grade silencer	10 dBA	Table C2 AS2436:2010 Table B1 BS5228.1:2009
Excavator with hammer attachment	Residential-grade silencer Screening of hammer attachment	15 dBA	Table C2 AS2436:2010
Piling impact	Resilient pad (dolly) between pile and hammerhead	10 dBA	Table C2 AS2436:2010 Table B1 BS5228.1:2009

Mitigated noise levels using these noise reduction values are presented in Table 19.

Table 19 Predicted L_{Aeq} noise levels per construction stage

Construction Activity	Predicted L_{Aeq} Noise Level (dBA)			
	NC1	NC2	NC3	NC4
Reference NMLs	54	50	50	54
Excavation and site preparation	**56**	33	33	44
Piling, pile cap and pier construction	**60**	42	42	**55**
Installation of superstructure	46	27	27	37
Road finishing works	**58**	39	39	48
Site compound activities	**65**	n/a*	n/a*	42
Roadworks at Rhodes landing	**71**	n/a*	n/a*	n/a*

* Note: L_{Aeq} noise levels have been predicted to the nearest, worst affected receiver for each noise catchment (refer to Figure 1). In the case of noise generated from 'site compound activities' the noise-sensitive receivers immediately adjacent to these works (ie. NC1: Rhodes and NC4: Wentworth Point) are the only receivers affected. In the case of noise generated from 'roadworks at Rhodes landing' the noise-sensitive receivers immediately adjacent to these works (ie. NC1: Rhodes) are the only receivers affected. Predicted noise levels for other noise catchments were found to be insignificant due to distance and shielding and therefore have been omitted from the assessment.

Noise levels **in bold** still exceed the noise affected level; however they have been significantly reduced via all feasible and reasonable approaches to mitigation.

The highly affected noise level of 75 dBA is no longer exceeded during roadworks adjacent to residential receivers on Rhodes landing, however, noise levels of up to 71 dBA are still expected.

It is imperative that residents in the area are kept informed and up to date with the proposed schedule of works in the interest of keeping good community relations and proactively managing expectations and adverse reaction.

4.1.7 Construction Traffic

Most construction materials and plant will be transported by road but construction access by boat or barge or pontoon from the water will be considered where feasible, in order to reduce road traffic.

Construction of the Homebush Bay Bridge will generate vehicle trips primarily on the Wentworth Point side as the Rhodes side has limited storage and access available. As such, Rhodes will generate only minimal traffic and heavy vehicles will not access this site. The main access roads for Wentworth Point will be via Hill Road and the M4 Motorway directly for traffic from the west. For traffic from the east, access will be via Silverwater Road and Holker Street, then Hill Road.

Vehicles that will access the site during construction will mainly comprise private vehicles for workers. Heavy vehicles including Articulated Vehicles (AV) such as precast girder delivery trucks and Heavy Rigid (HR) such as concrete trucks are also expected to access the site. These different types of vehicles may access the site at the same time.

It is estimated that, due to limited storage on the Rhodes site, less than 10 vehicles per hour will be generated on the surrounding network. A worst case increase in existing road traffic along Hill Road is estimated to be in the order of up to 20% of daily traffic, with a potential increase in peak hour activity of up to 25%. A doubling of traffic flows is required to result in a 3 dB increase in existing road traffic noise. This also roughly corresponds to a subjectively noticeable difference in noise level. As such, the increase in road traffic due to construction activity is considered to be acoustically insignificant.

Depending upon the stage of construction, the percentage of heavy vehicles accessing the site has the potential to increase above existing flows, however, this is not envisaged to cause significant increases in noise level, in the context of the number of trucks currently entering the industrial estate on Wentworth Point.

4.1.8 Construction vibration

The major potential sources of construction vibration would include excavation and piling activities. Vibration from these works has been predicted using guidance from the UK Transport Research Laboratory (TRL)[14].

4.1.8.1 Excavation

The TRL guidance recommends the use of the following relationship for the prediction of *upper bound* vibration velocity levels from tunnelling works

$$v_{res} = 180\, r^{-1.3}$$

Where v_{res} is the resultant PPV velocity level, and r is the distance from the source. This relationship has been shown to reasonably represent *upper bound* vibration from hydraulic hammering, rock sawing and drilling into rock.

Typical vibration levels for excavation are usually somewhat lower than this upper bound, and have been predicted based on measured data from Figure 46a[15] of the TRL guidance.

Based on the measured vibration levels from JLE, resultant vibration levels at the nearest affected residential receivers during excavation works on Rhodes landing are calculated to be in the order of up to 0.1 mm/s. This is well below the threshold for cosmetic damage presented in Table 12. Further, calculated vibration levels likely represent an unrealistically high level of vibration in relation to the proposed works.

The corresponding VDV for excavation works have been estimated based on a 15 Hz dominant frequency and a nominal duration of half the assessment period as per the OEH vibration guideline. Resultant vibration levels in the order of 0.18 $m/s^{1.75}$ which are within preferred levels for human comfort as stipulated in Section 3.5.2.

4.1.8.2 Piling

The TRL guidance recommends the use of the following relationship for the prediction of *upper bound* vibration velocity levels from piling works

$$v_{res} \le k_p \left[\sqrt{W}/r^{1.3}\right]$$

Where v_{res} is the resultant PPV velocity level (mm/s), W is the nominal hammer energy (kJ), r is the distance from the source (m) and k_p is an empirical scaling factor based on ground conditions.

14 Hiller, D.M. and Crabb, G.I. (2000) *Groundborne vibration caused by mechanised construction works*, Transport Research Laboratory Report 429.

15 JLE (Jubilee Line Extension) excavation works at Canning Town used as basis for predicted levels.

Worst case scenario of piles at refusal has been used as the basis of calculating vibration levels at nearby receivers.

Based on the above, resultant vibration levels at the nearest affected residential receivers due to hammer piling are calculated to be in the order of up to 2.16 mm/s. This is well below the threshold for cosmetic damage presented in Table 12.

Corresponding VDV for piling activity have been estimated based on typical piling parameters as defined by TRL for a 5 tonne hammer with a 0.5 m drop. One stroke every four seconds with a duration of 0.5 seconds per stroke across half of the assessment period with a 10 Hz resonant frequency has been assumed as the basis for calculation.

Corresponding VDV values of 0.74 $m/s^{1.75}$ have been estimated at the nearest potentially affected receivers during piling. This is an exceedance of the maximum recommended levels for human comfort as stipulated in Section 3.5.2.

In light of the temporary nature of the works and the varying distances between piles (i.e. the piling rig will not stay at the "worst case" location throughout the entire construction period), this calculated level is likely to be overly conservative. Nonetheless, vibration may be perceptible at nearby residential receivers for relatively short periods of time during piling.

It is recommended that the construction methodology, plant and equipment, management of vibration impacts and community consultation protocol be reviewed prior to commencing construction. This should be addressed as part of the Construction Noise and Vibration Management component of the Environmental Management Plan for the project.

Further, whilst predictions have been made based on worst case scenarios, results are largely dependent upon local soil conditions. As such, it is appropriate to conduct verification measurements prior to commencement of construction works.

4.2 Operational noise and vibration

4.2.1 Input data

4.2.1.1 Receiver locations

The potentially worst affected noise sensitive receivers are identified in Figure 3. Residential noise sensitive receivers are the propose multi dwelling developments at Rhodes and Wentworth Point (labelled as R2 and R3 respectively in Figure 3). Non-residential sensitive receivers are the proposed open air park at the western end of the bridge (labelled as R4 in Figure 3) and the proposed community facility at Rhodes (labelled as R1 in Figure 3).

Figure 3 shows the affected receiver locations in relation to the bridge alignment.

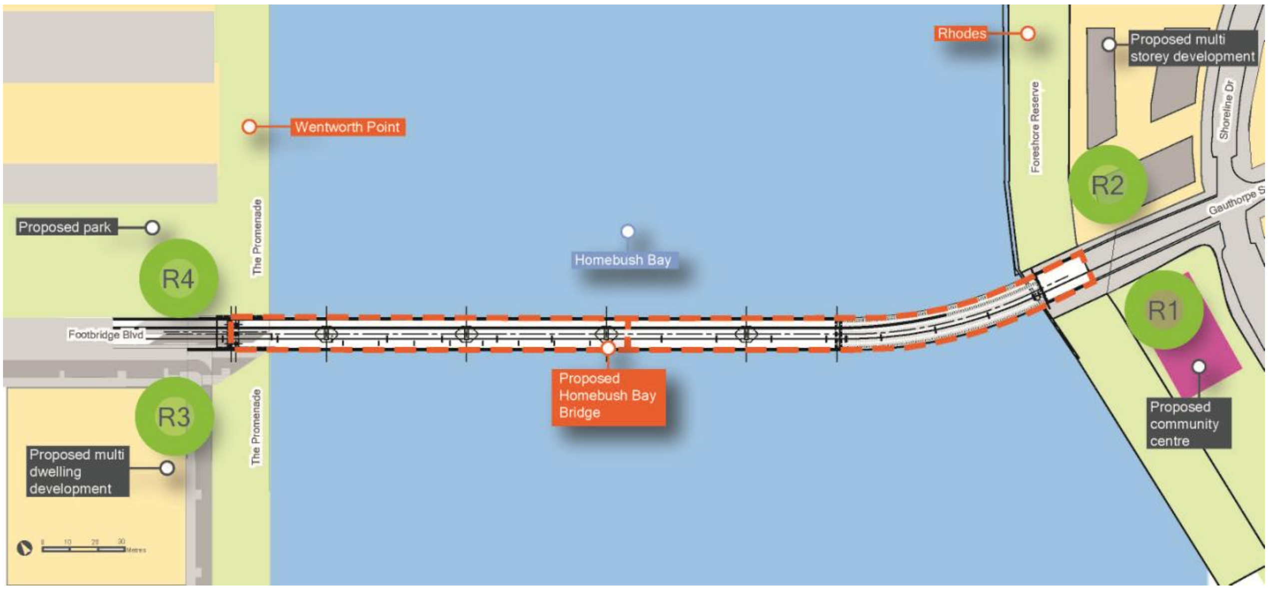

Figure 3 Nearest potentially affected noise-sensitive receivers

Noise impacts at residences have been evaluated via “single point receiver” (SPR) calculations, whereby a “receiver” is placed at a distance of 1 m from the most exposed facade of the critical residence. As a conservative approach, receiver heights have been taken as being 1.5 m above road level at each location.

4.2.1.2 Road topography and surface

Road gradients have been modelled, based on the design option that allows for a 6.5 m bridge vertical clearance over the navigational channel, as a potential worst case scenario. This equates to an approximate gradient of 3 % leading up to the crest of the bridge towards the Wentworth Point end.

The road surface has been taken as being 75 mm thick asphalt surface on the concrete deck. It should also be noted that a finger joint is currently proposed for both ends of the bridge.

4.2.1.3 Traffic volumes and vehicle speeds

Estimated bus operations have been derived from the assessment of potential use of the bridge as detailed in Section 6 of *Homebush Bay Bridge Traffic Management and Access Report* (Arup 2011) an inputs from the *Wentworth Point Traffic Management and Access Plan* (Cartell Cooper, 2011) and is based on a response to the forecasted change in population at Wentworth Point and Rhodes. The future predicted bus operations are presented in

Table 20. Predicted bus frequency is based on estimated potential bus users in the AM weekday peak hour.

Table 20 Estimated Future Predicted AM Weekday Peak Hour Bus Operation

Year	**Type of Vehicle**	**Estimated Frequency (in both directions)**	**Sign Posted Speed Limit (km/h)**
Year of opening	Standard Size Bus	8-10 buses per hour	50
At full development	Standard Size Bus	20 buses per hour	50

A vehicular speed limit of 50 km/h was agreed and adopted. Average vehicle speeds will be reduced at each end of the bridge and at crossing locations. For the purpose of assessment, a conservative approach to 50km/h has been adopted across the span of the bridge.The assessment was carried out against operating conditions at the time of opening and 10 years thereafter.

4.2.2 Noise modelling methodologies

In correspondence with OEH, various approaches to operational noise modelling were discussed. The following approaches were recommended for the purpose of cross-checking against each other:

- Calculation of Road Traffic Noise (CoRTN) – UK 1988.
- Federal Highway Administration (FHWA) – US 2004.

Methods and results of the abovementioned approaches for the assessment are discussed in detail in the following sections. The results of each modelling methodology are presented in Section 4.2.3.

4.2.2.1 Calculation of Road Traffic Noise (CoRTN)

The UK Department of Transport released its "*Calculation of Road Traffic Noise*" (CoRTN) algorithms in 1988. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, ground absorption and shielding from ground topography and physical noise barriers.

The algorithm output of CoRTN is an $L_{10(1hour)}$ parameter. This has been modified to calculate the relevant L_{Aeq} road traffic noise emission descriptors, as required for this assessment by subtracting the 3 dBA empirical correction between L_{Aeq} and L_{A10} for free-flowing traffic. Additionally, 100% heavy vehicle content was used as the input noise source data.

It should be noted that CoRTN is not calibrated for vehicle flows of less than 50 per hour. In discussions with OEH, it was agreed that a reasonable approach to assessment would be to calculate the impact of 50 buses during the AM peak period and logarithmically scale for 20 buses (i.e. subtract 4 dB from results).

4.2.2.2 Federal Highway Administration (FHWA)

The Federal Highway Administration (FHWA) released the first version of its Traffic Noise Model (TNM) in March 1998. Subsequent improvements to algorithms and assessment options have been introduced. The version of TNM used for this study is Version 2.5 released in April 2004.

As compared with CoRTN, the FHWA TNM allows for the assessment of five standard vehicle types, including buses, and accommodates for constant-flow and interrupted-flow traffic based on an empirical database. The ECRTN claims the calculation algorithms to generally be more mathematically rigorous than those of CoRTN, leading to greater accuracy and a wider range of validity at low traffic flows. Additionally, the algorithm output of TNM is L_{Aeq} and requires no conversion.

Bridge alignment and gradients were imported directly into TNM from design drawings.

4.2.3 Road traffic noise predictions

Table 21 provides a summary of results from each assessment methodology for the worst case scenario of 10 years after opening. $L_{Aeq\ (1hour)}$ noise levels are presented for each of the four potentially worst affected noise sensitive receivers shown in Figure 3 with a comparison against the relevant noise level target.

Table 21 Resultant $L_{Aeq(1hour)}$ Road Traffic Noise Levels during AM Peak Period

Scenario	Receiver Location	Resultant $L_{Aeq(1hour)}$ (dBA)		Criterion $L_{Aeq(1hour)}$ (dBA)	
		CoRTN	FHWA	Daytime 7am-10pm	Night-time 10pm-7am
At full development	R1	60	60	55	50
	R2	58	55	55	50
	R3	56	53	55	50
	R4	58	59	60	

It can be seen from the data presented in Table 21 that resultant noise levels have been calculated to be within 3 dB for each modelling methodology. For the purpose of assessment, the higher of the two predictions will be used at each receiver location.

Road traffic noise levels during the AM peak period at nearest affected residential receivers are observed to be in the order of up to 5 dB above the daytime criterion and in the order of up to 10 dB above the night-time criterion.

Noise levels are in the order of 1 dB below the recommended noise criterion of 60 dBA for areas of “active recreation”.

It should be noted that predicted noise levels are for the highest AM peak period and therefore apply predominantly to the daytime criterion. There is, however, an opportunity for traffic flows between the hours of 6am-7am to experience some influence from the beginning of bus activity. It is recommended that any such noise be treated as a “shoulder period” to the daytime noise objectives

4.2.3.1 Available mitigation options

In broad terms, noise mitigation options that are generally available for road traffic include the following:

EXTERNAL

- **Road Surface Treatments**. This would include the use of a lower noise road surface such as Dense Graded Asphaltic Concrete (DAGC) or Open Graded Asphaltic Concrete (OGAC). At the vehicle speeds proposed, an overall reduction in noise level in the order of 1 dB is predicted. This is considered acoustically insignificant and subjectively imperceptible.
- **Speed Limitations**. It is possible to marginally reduce road traffic noise levels via the use of speed restrictions. This is generally only effective at higher speeds. Given the already low proposed speed limit of 50 km/hr, this approach to noise mitigation would not be effective.
- **Noise Barriers**. Substantial noise reductions are achievable across noise barriers and earth mounds or a combination thereof. Given the relationship between the proposed roadway and residential receivers, the implementation of this form of noise mitigation is not practicable. Further, the size of barrier required to be effective for multi-storey dwellings characteristic of the area is not feasible.

INTERNAL

- **Architectural Treatments**. Where it is not possible to achieve external noise criteria, suitable amenity within buildings should be sought. Architectural treatments aim to ensure that satisfactory internal noise levels are achieved, as a minimum. In some cases, provision of mechanical ventilation to allow windows to be kept shut in order to minimise noise intrusion may be adequate, together with door and window seals. In cases where higher noise reductions are required, architectural treatments may also require upgrading the existing glazing (say to thick laminate or double glazing) and doors to solid-core doors, together with acoustic seals as appropriate.

4.2.3.2 Discussion and recommendations

In light of considerations listed above, at-dwelling mitigation measures constitute the only feasible and reasonable approach to reducing the impact of road traffic noise.

Given that worst case exceedances of external noise criteria at the nearest affected residential receivers are in the order of 5 dB, satisfactory internal noise levels should be readily achievable provided facade glazing elements fronting the street are able to be kept closed. Further, it is also noted that existing residential receivers aligning Gauthorpe Street benefit from acoustic shielding afforded by solid fences at street level and balustrades on balconies.

Consideration of future noise levels associated with the operation of the bridge should be taken into account when assessing future residential developments aligning the bus lane. The range of at-dwelling noise mitigation options and applications is fully detailed in the RTA's Environmental Noise Management Manual (2001)[16].

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[16] http://www.rta.nsw.gov.au/environment/downloads/environmental_noise_management_manual_v1_0.pdf

Appendix A

Glossary

SOUND POWER AND SOUND PRESSURE

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

DECIBEL

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million : one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound level' (L) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside disco
90	Heavy lorries at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

'A'-WEIGHTED SOUND LEVEL dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. An increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise. A change of 2 to 3 dB is subjectively barely perceptible.

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

STATISTICAL NOISE LEVELS

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index that allows for this variation. 'A'-weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg. dB$L_{A10, 5min}$ or dB$L_{A90, 8hr}$.

$L_{A90(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 90% of the time interval (T) –i.e. measured noise levels were greater than this value for 90% of the time interval. This is also often referred to the background noise level.

$L_{A10(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 10% of the time interval (T). This is often referred to as the average maximum noise level and is frequently used to describe traffic noise.

$L_{A10(1hr)}$

For traffic noise, $L_{A10(1hr)}$ is the highest hourly L_{A10} noise level measured over each day of a measurement period. $L_{A10(1hr)}$ is the average maximum noise level resulting from the "worst hour" of the traffic flow.

$L_{A10(18hr)}$

$L_{A10(18hr)}$ refers to the arithmetic average of the eighteen 1-hour L_{A10} traffic noise levels over the time period from 6:00 am to midnight. $L_{A10(18hr)}$ is representative of the average maximum traffic noise level from each day of measurements.

$L_{A1(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement.

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{Aeq})

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

MAXIMUM SOUND LEVEL, L_{max}

The maximum sound level is the maximum weighted sound pressure level experienced during the measurement period.

FREQUENCY

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kilohertz (kHz), eg 2 kHz = 2000 Hz. Human hearing ranges from approximately 20 Hz to 20 kHz. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

VIBRATION

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structureborne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value eg $1mms^{-1}$ or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, L_V (dB) = $20 \log (V/V_{ref})$,

(where the preferred reference level, V_{ref}, for vibration velocity = 10^{-9} m/s).

The decibel approach has advantages for manipulation and comparison of data.

PEAK PARTICLE VELOCITY (PPV)

Peak Particle Velocity is the parameter most often used for the quantification of groundborne and structure-borne vibration. It is the maximum positive or negative magnitude of vibration in a defined direction caused by the passage of a wave front during a specified interval. Particle velocity is used in most cases because this parameter has been found to correlate best with the onset of structural damage. It can also be used to provide some guidance on disturbance to people and the sensitivity of equipment and processes to vibration.

Appendix B

Noise Survey Data

B1 Noise logger location 1 – 138 Lancaster Avenue, Melrose Park

Figure 4 Measured Noise Levels – Logger Location 1 – Monday 28 February 2011, dB re 20 µPa.

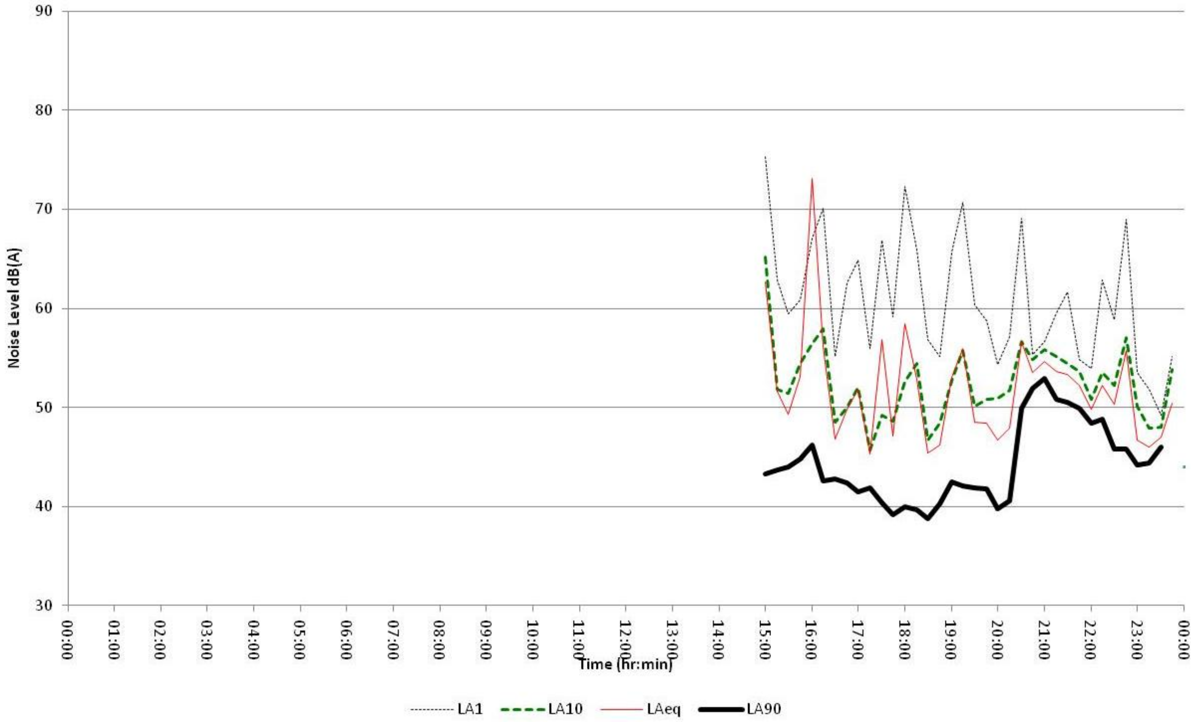


Figure 5 Measured Noise Levels – Logger Location 1 – Tuesday 1 March 2011, dB re 20 µPa.

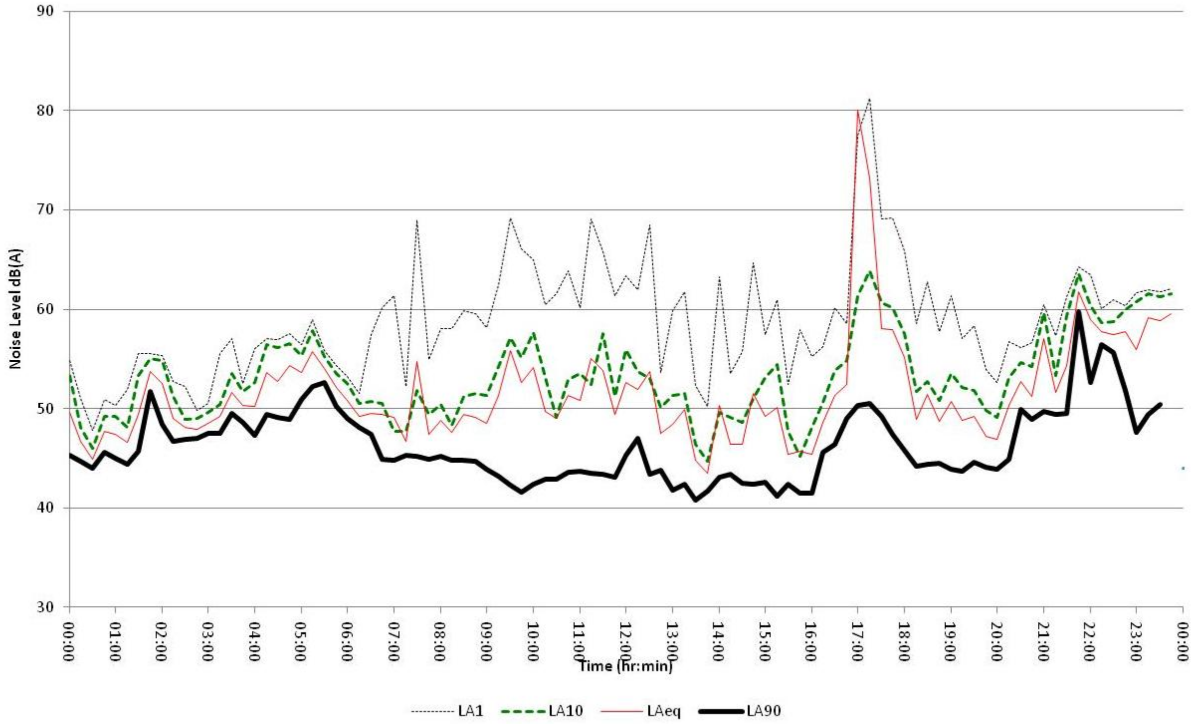


Figure 6 Measured Noise Levels – Logger Location 1 – Wednesday 2 March 2011, dB re 20 µPa.

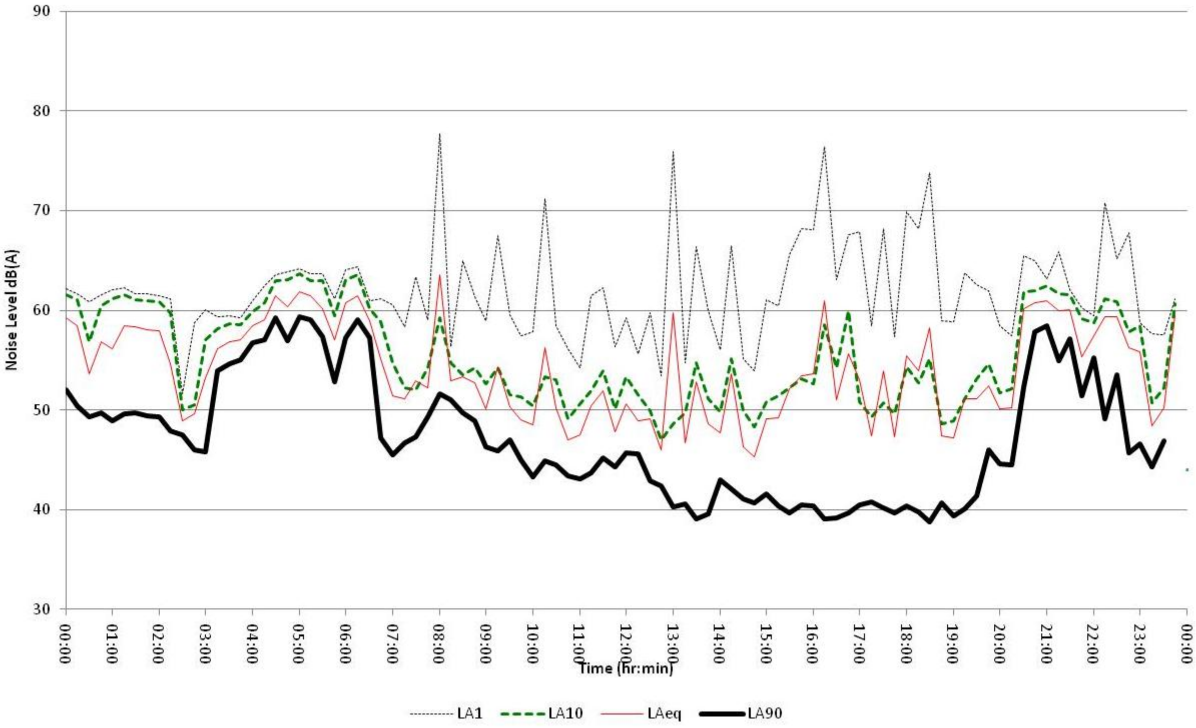


Figure 7 Measured Noise Levels – Logger Location 1 – Thursday 3 March 2011, dB re 20 µPa.

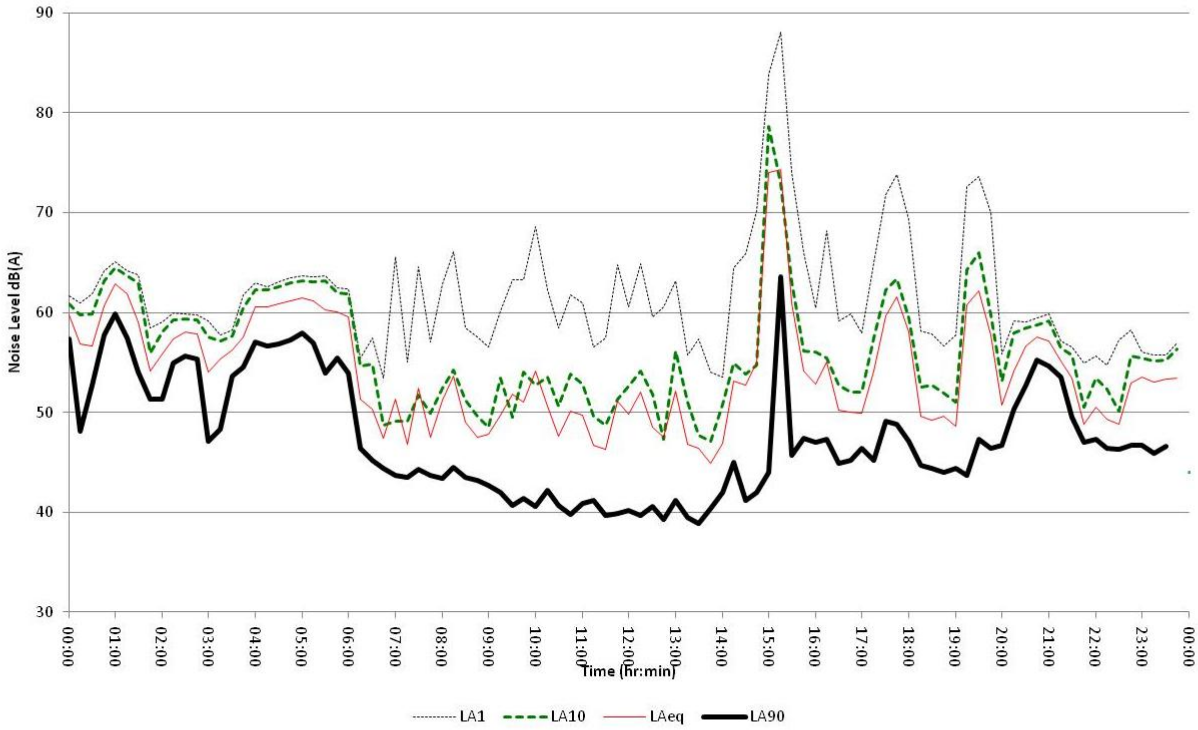


Figure 8 Measured Noise Levels – Logger Location 1 – Friday 4 March 2011, dB re 20 µPa.

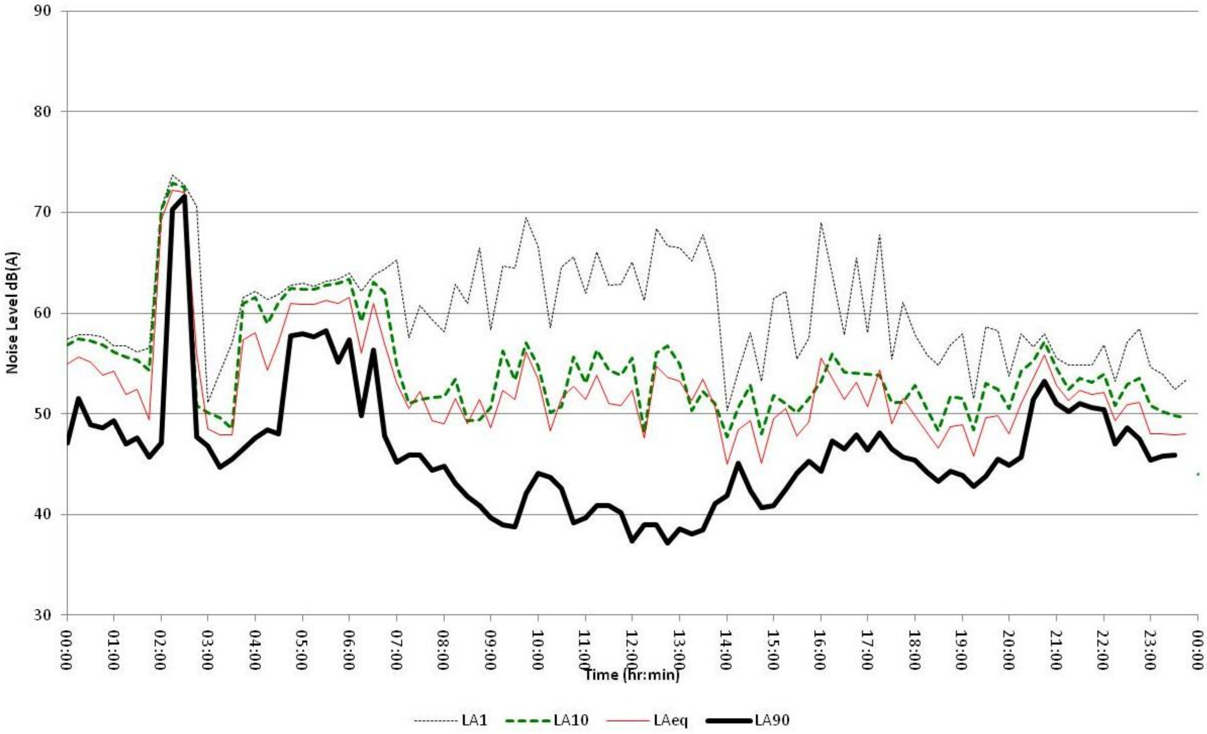


Figure 9 Measured Noise Levels – Logger Location 1 – Saturday 5 March 2011, dB re 20 µPa.

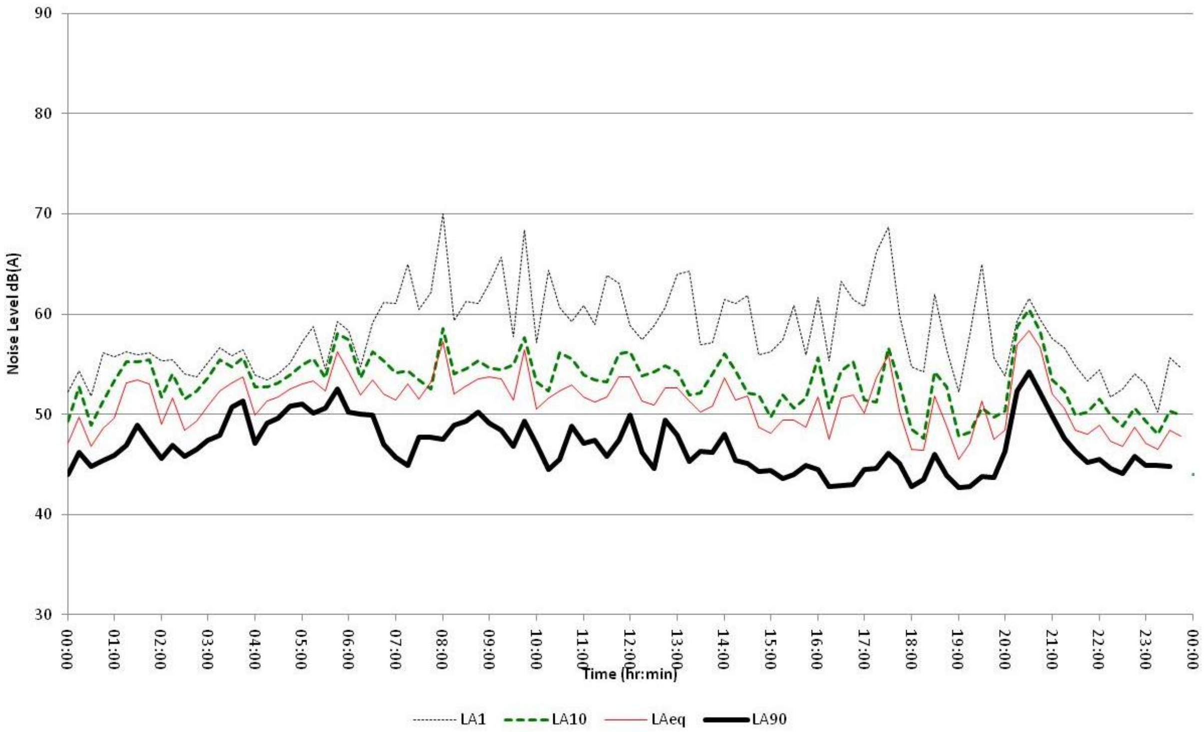


Figure 10 Measured Noise Levels – Logger Location 1 – Sunday 6 March 2011, dB re 20 µPa.

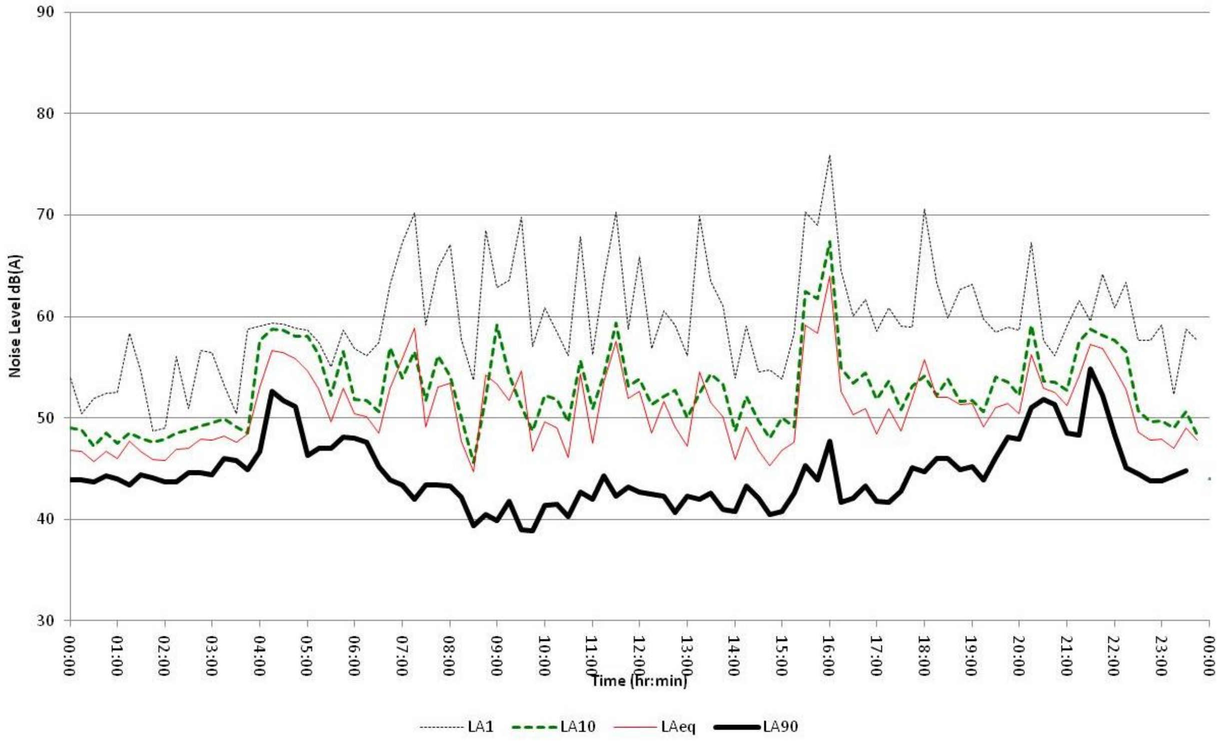
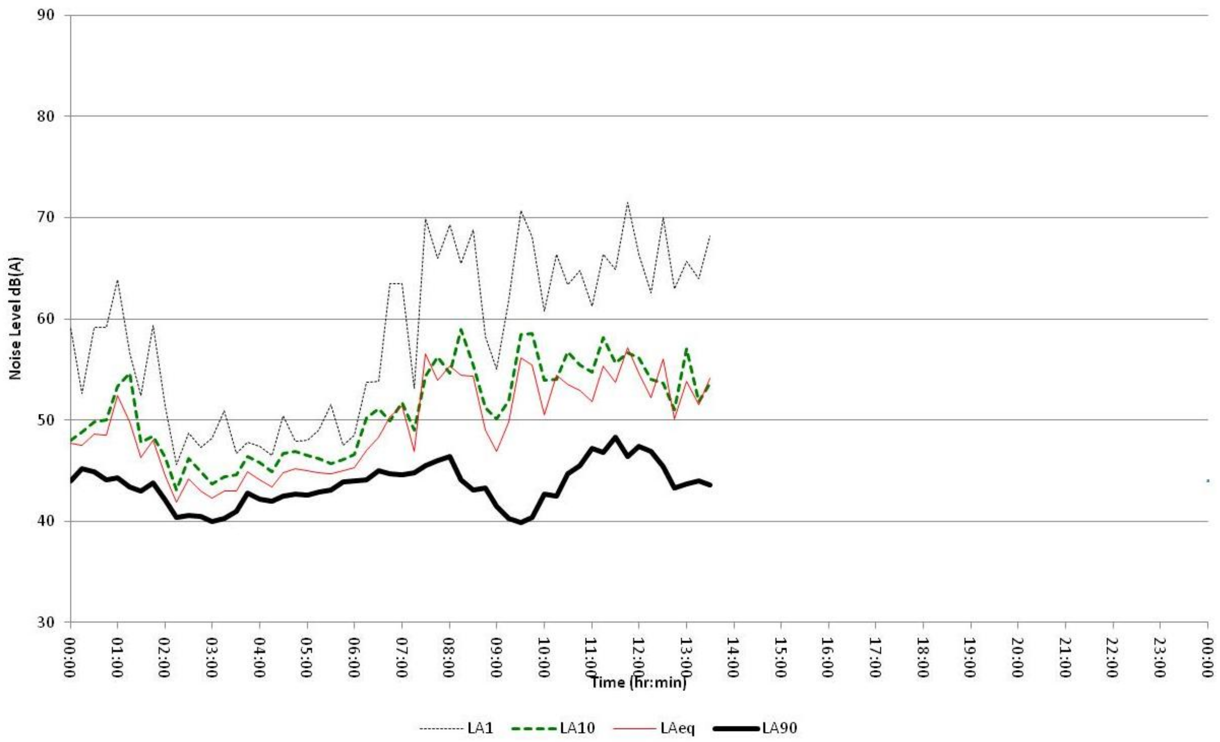


Figure 11 Measured Noise Levels – Logger Location 1 – Monday 7 March 2011, dB re 20 µPa.



B2 Noise logger location 2 – 9 Jean Wailes Avenue, Rhodes

Figure 12 Measured Noise Levels – Logger Location 2 – Monday 28 February 2011, dB re 20 μPa.

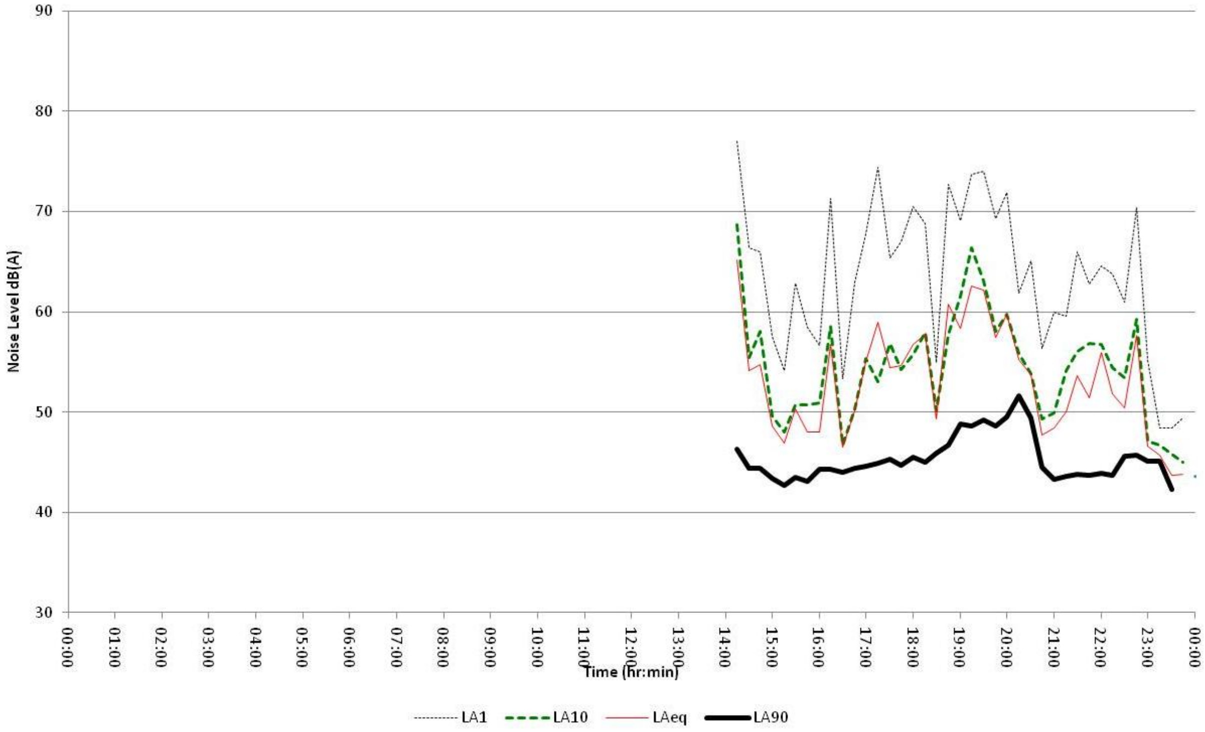


Figure 13 Measured Noise Levels – Logger Location 2 – Tuesday 1 March 2011, dB re 20 μPa.

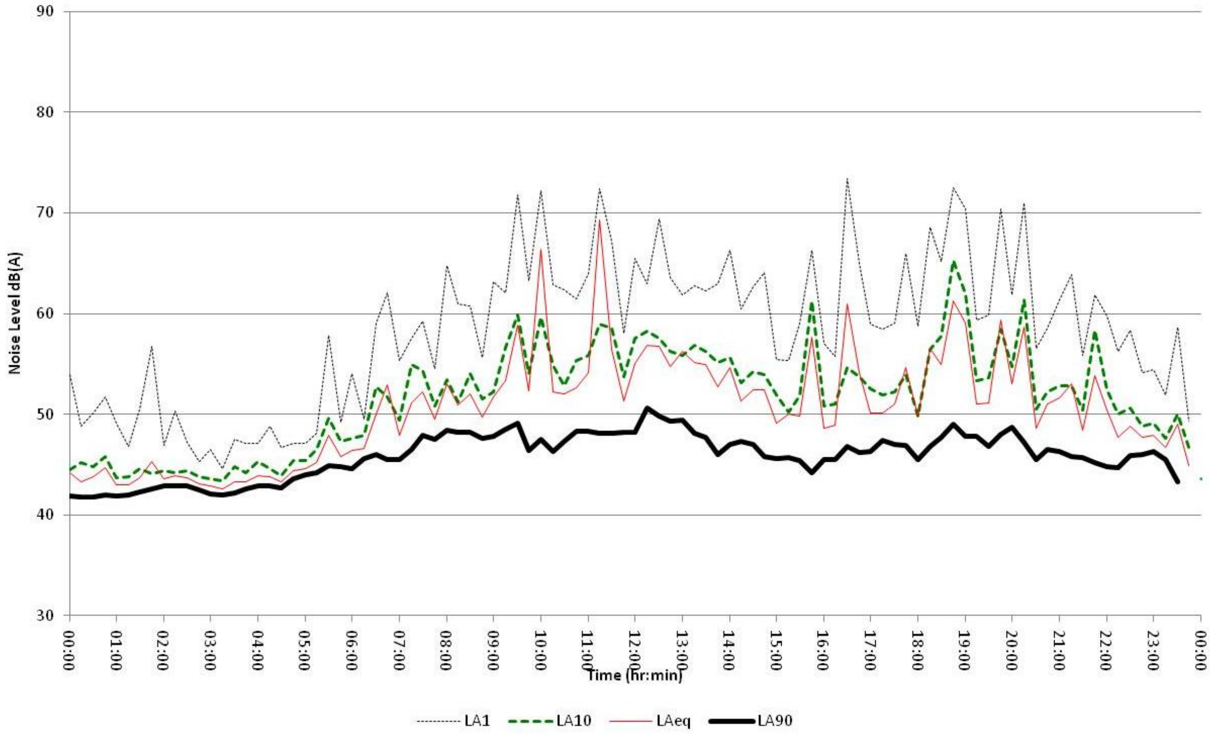


Figure 14 Measured Noise Levels – Logger Location 2 – Wednesday 2 March 2011, dB re 20 µPa.

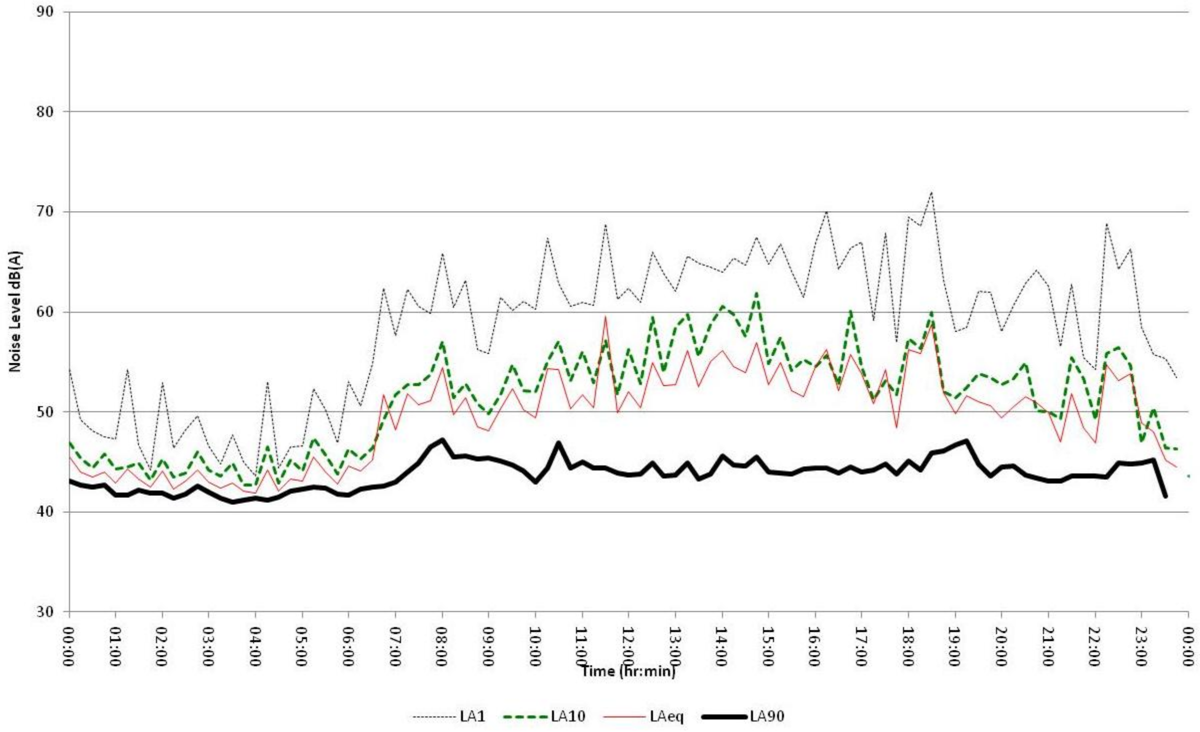


Figure 15 Measured Noise Levels – Logger Location 2 – Thursday 3 March 2011, dB re 20 µPa.

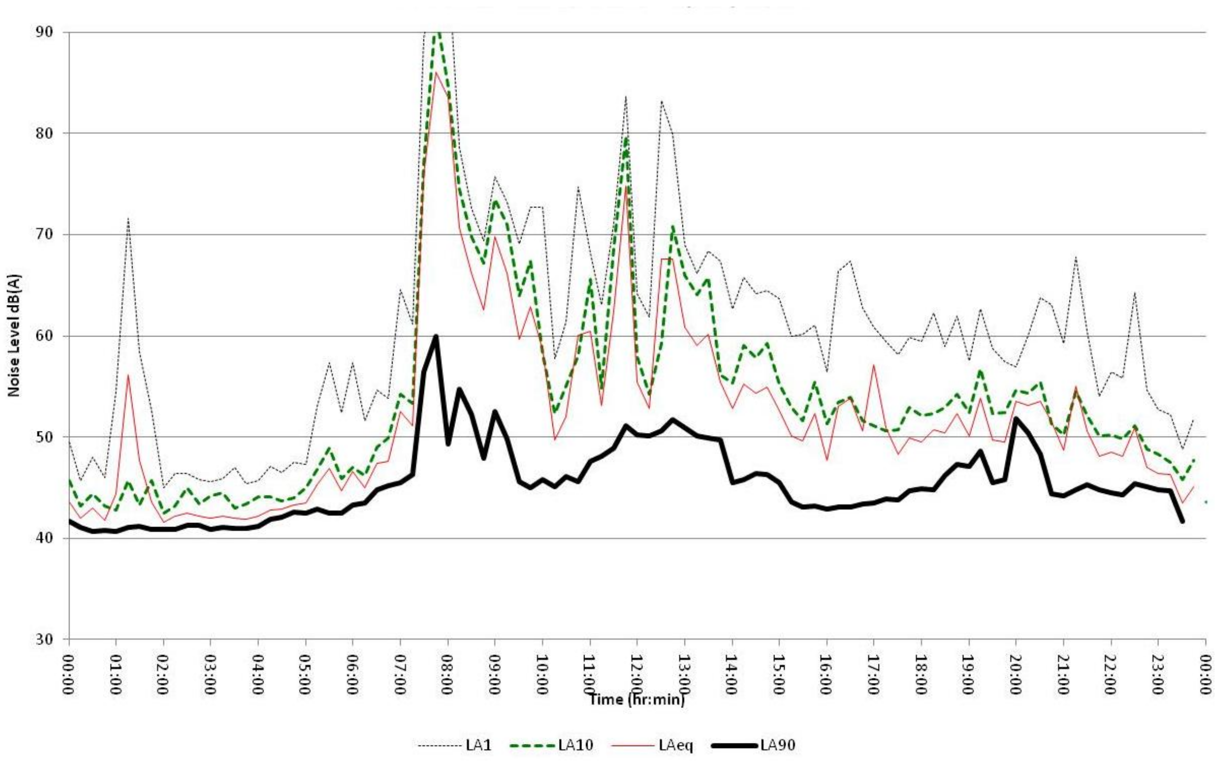


Figure 16 Measured Noise Levels – Logger Location 2 – Friday 4 March 2011, dB re 20 µPa.

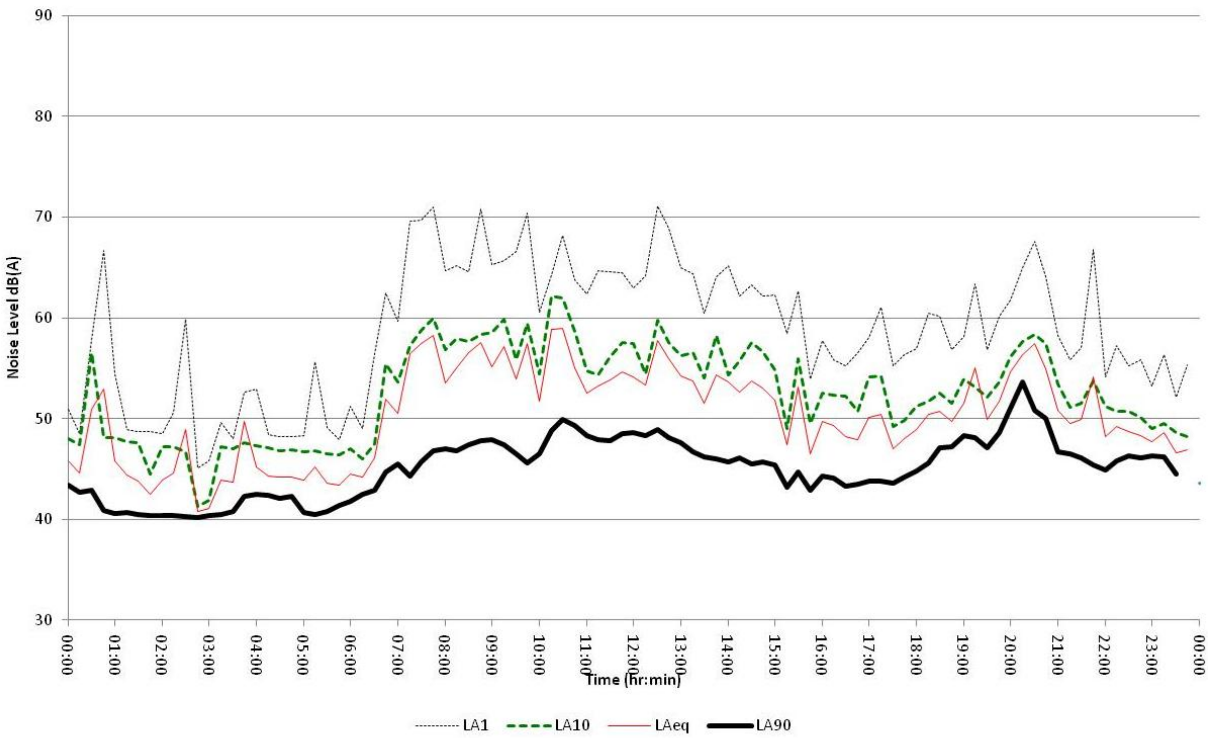


Figure 17 Measured Noise Levels – Logger Location 2 – Saturday 5 March 2011, dB re 20 µPa.

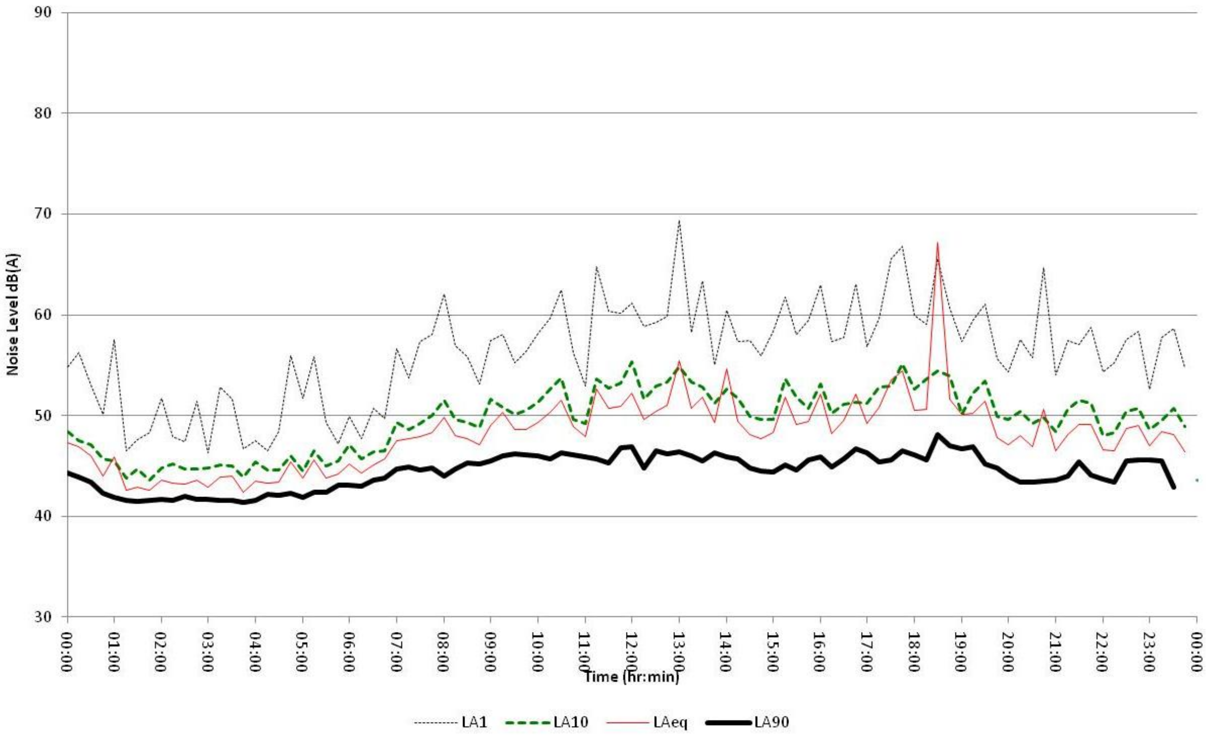


Figure 18 Measured Noise Levels – Logger Location 2 – Sunday 6 March 2011, dB re 20 µPa.

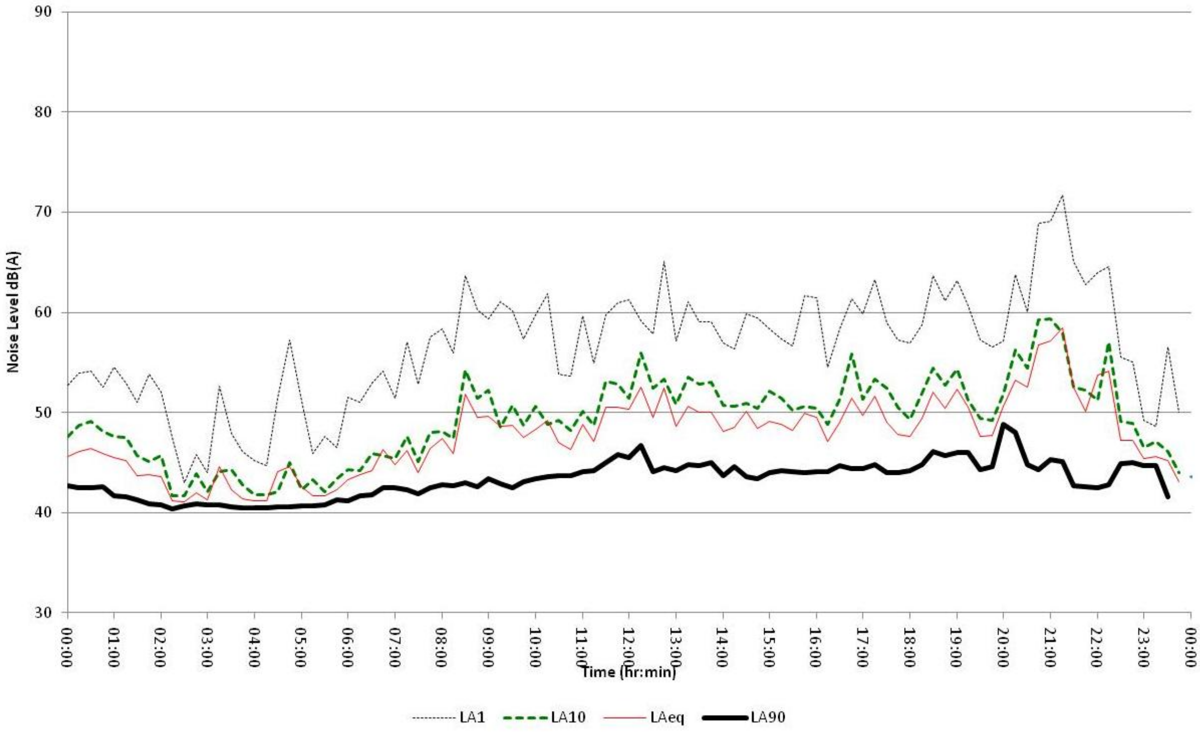
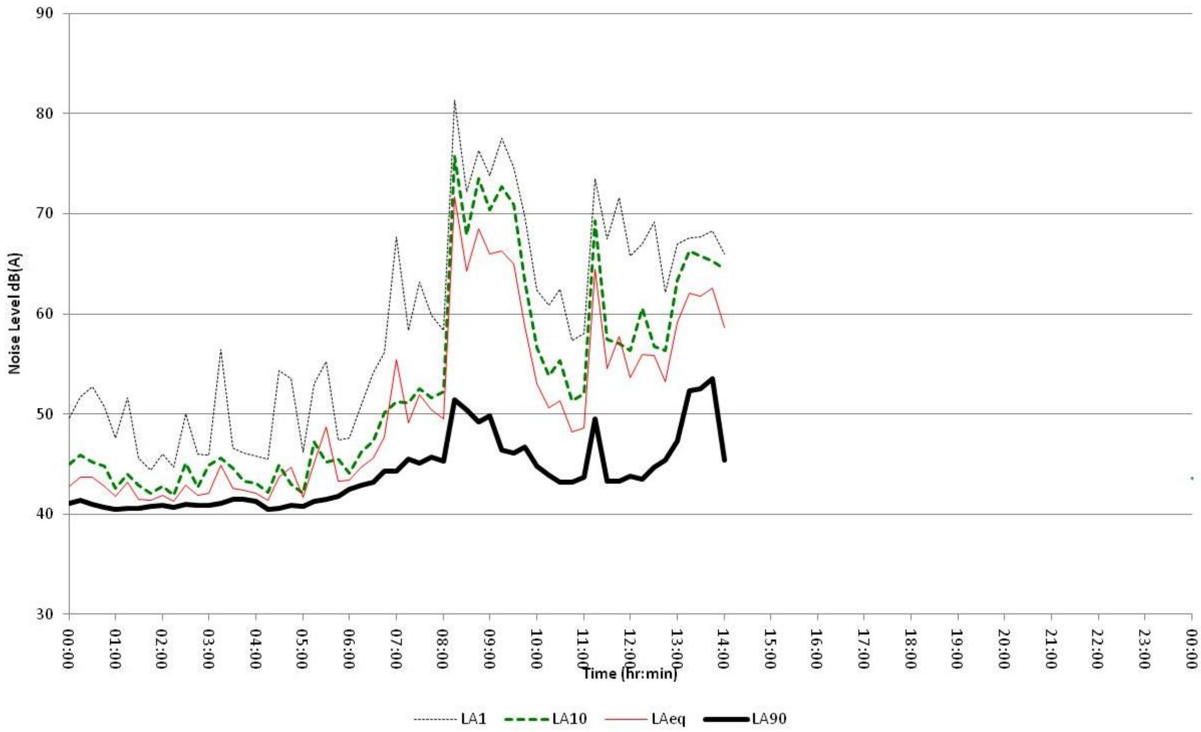


Figure 19 Measured Noise Levels – Logger Location 2 – Monday 7 March 2011, dB re 20 µPa.



Appendix C

Construction Plant Source Noise Levels

Table 22 Construction plant and equipment source noise levels as defined in DEFRA[17].

Item of Plant	Octave Band Centre Frequency (Hz)								Overall dBA
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
Tracked excavator	80	83	76	73	72	70	69	66	78
Tracked excavator (idling)	59	49	45	45	49	46	39	31	52
Pneumatic breaker	83	83	81	74	73	76	78	77	83
Dozer	85	74	76	73	72	78	62	56	81
Wheeled backhoe loader	74	66	64	64	63	60	59	50	68
Wheeled backhoe loader (idling)	60	53	49	52	51	48	43	33	55
Articulated dump truck	80	76	73	70	69	66	63	58	74
Vibratory roller (L_{max})	88	83	69	68	67	65	62	59	74
Hydraulic vibratory compactor	81	76	72	73	72	72	68	63	78
Water pump	73	68	62	62	61	56	53	41	65
Hydraulic hammer rig	82	82	82	89	83	78	75	70	89
Tracked mobile crane	81	77	66	62	59	57	51	46	67
Hand-welder	67	68	69	68	69	66	61	56	73
Welding Generator	75	72	67	68	70	66	62	60	74
Gas cutter	74	74	72	61	60	58	56	56	68
Road planer	81	87	79	77	77	74	70	67	82
Bulldozer	85	74	76	73	72	78	62	56	81
Cement mixer Truck (Discharging)	85	73	67	61	72	69	63	56	76
Cement mixer Truck (Idling)	71	62	57	59	63	60	54	46	66
Concrete pump	84	76	70	71	73	73	66	58	78
Diesel generator	75	72	76	70	69	65	56	47	74

17 Department for Environment Food and Rural Affairs (United Kingdom) (2006), *Update of noise database for prediction of noise on construction and open sites*