ACOUSTICS AND AIR

BLOCK 5, BARANGAROO

DECLARATION AREA 21122
REMEDIATION DEVELOPMENT
APPLICATION SDD-6533-2014

CONSTRUCTION NOISE & VIBRATION ASSESSMENT

REPORT NO. 10232-B5
VERSION C

JULY 2015

PREPARED FOR

LEND LEASE (MILLERS POINT) PTY LTD
THE BOND, 30 HICKSON ROAD
MILLERS POINT NSW 2000

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GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10^{th} percentile (lowest 10^{th} percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period **–** daytime, evening and night time.

Block 4 Remediation Area – Portion of the Declaration Area situated within Barangaroo South.

Block 5 Remediation Area – Portion of the Declaration Area located within Barangaroo Central (including remediation of some land adjacent to the Declaration Area on the west)

EPA – Environment Protection Authority,

EPA Declaration Area – Remediation Site Declaration 21122

Hickson Road Remediation Area – Portion of the Declaration Area situated within the Hickson Road reserve,

Ex-situ Remediation Methodology – Excavation of contamination and off-site disposal (with off-site pre-treatment, where required)

LLMP – Lend Lease (Millers Point)

RAP – Remedial Action Plan

Site – area required for the purpose of the Block 5 Remediation Development Application identified as:

- Block 5 Remediation Area
- Any other areas of Barangaroo or Hickson Road required for staging and undertaking the remediation and stormwater diversion works.

Site Remediation Area – The Block 5 Remediation Area (including remediation of some land adjacent to the Declaration Area on the west).

VMP – Voluntary Management Proposal

1 INTRODUCTION

Wilkinson Murray has been engaged by Lend Lease Millers Point (Lend Lease) to prepare a construction noise and vibration impact assessment report to accompany a Development Application for Remediation of **Block 5** at Barangaroo Central to be submitted to the Minister for Planning and Environment pursuant to the Part 4 of the *Environmental Planning and Assessment Act, 1979*

The works proposed also include the temporary diversion of existing stormwater drainage infrastructure at the subject-site, involving decommissioning existing pipes, and construction of a new pipe network.

The noise and vibration assessment has been prepared to respond to the Director General's Requirements (DGR) issued in respect of SSD 6533-2014 Remediation and Land Forming Works dated 13 June 2014, specifically Item 9 as described below:

"*Noise*

The application must include an assessment of noise and vibration impacts, including construction, operation, traffic and cumulative noise. The assessment must also outline noise mitigation and monitoring procedures."

It is noted that the extent of these works do not include an operational component, therefore this element is not applicable to this project.

It is noted that this report is an update to a July 2014 report by Wilkinson Murray, submitted with the original DA. This updated report provides further information to respond to relevant authority submissions, and to update the cumulative impact assessment based on the latest, revised programme for Block 5 and concurrent works.

The potential cumulative noise impacts associated with Development Application SDD 6533-2014 and other projects on the site that are likely to occur concurrently with remediation works have been reviewed and include:

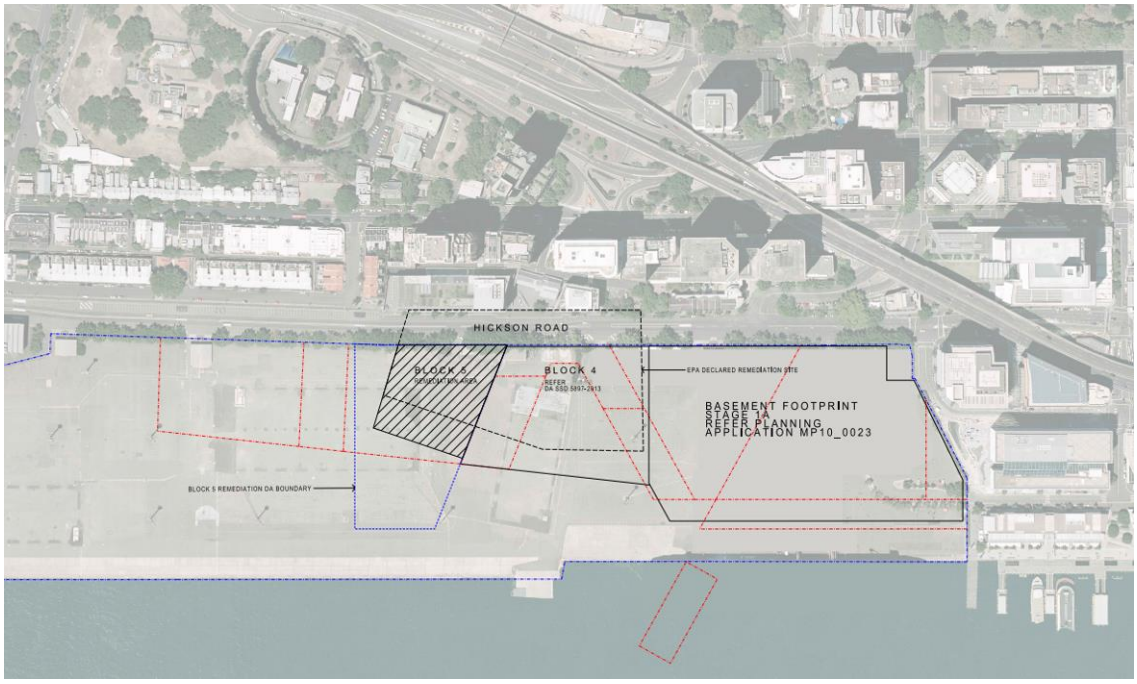
- Remediation Block 5,
- Remediation Block 4,
- C2 Construction, and;
- Stage 1C / Crown Works.

Other surrounding development works, such as Headland Park, Barangaroo Central temporary public domain and Wynyard Walk will have largely been completed before works on Block 5 have commenced.

Previous construction noise assessments for the Barangaroo South precinct have been submitted to DP&I and the EPA. These assessments included methodology and mitigation approaches adopted as a result of that consultation. Where relevant, the same principles have been applied in this current assessment.

Figure 1-1 shows an overview of the various areas of the subject site with Block 5 shown hatched.

Figure 1-1 Site Overview Diagram



2 PROJECT DESCRIPTION

2.1 The Barangaroo Site

Barangaroo is located on the north-western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded directly to the south by a range of new commercial development.

The 22 ha Barangaroo site is roughly rectangular in shape and has frontage to the harbour foreshore of 1.4km; Hickson Road delineates the eastern boundary.

2.2 Background

The NSW Government held an international urban design competition for the site in 2005 and the winning entry was used as the basis for the original Barangaroo Concept Plan which was approved in February 2007 and sets out the urban design and policy initiatives to be employed in the redevelopment of the site.

The Concept Plan (as modified) is the statutory planning approval to guide the urban renewal of Barangaroo and currently provides for the development of a mixed use precinct comprising commercial, retail, residential and community development and new public open space / public domain.

2.3 Lend Lease

In December 2009 Lend Lease (Millers Point) was appointed by the NSW Government as the preferred proponent to develop Barangaroo Stage 1 (otherwise known as Barangaroo South). Lend Lease has since been appointed as the Proponent to undertake the development for Barangaroo South.

2.4 Declaration Area N21122

In May 2009, the NSW Environment Protection Authority (EPA) determined (Declaration) that a portion of land at Millers Point (part of the Barangaroo Site and an adjacent portion of Hickson Road), was contaminated in such a way as to present a significant risk of harm (SROH) to human health and the environment. As a consequence the EPA declared the area to be a remediation site (Declaration Number 21122; Area Number 3221) under the Contaminated Land Management Act 1997.

The Remediation Site Declaration 21122 indicates that the area of the declaration coincides with the known footprint of the former Millers Point gasworks facilities. This area is located on part of the proposed Barangaroo Site and part of Hickson Road adjacent to the Barangaroo Site.

The Barangaroo Delivery Authority has entered into a Voluntary Management Proposal (VMP) with the EPA associated with the Declaration Area (Approval No. 20101719). Phase 1 of this VMP involves investigative works and undertaking remedial design to determine and obtain agreement on a proposed remediation methodology. Phase 2 of the VMP will involve the implementation of the agreed remediation works.

An independent EPA-accredited Site Auditor has been appointed to undertake review of proposed remediation works, and prepare statutory audit statements prior to and following completion of remediation.

2.5 Definition of Declaration Area Site

For the purposes of this report, the area of Remediation Site Declaration 21122 is referred to as the "**Declaration Area**".

In accordance with Declaration Number 21122, the Declaration Area comprises:

- Part Lot 101 DP1204946 and Part Lot 200 DP12049848 (Formerly known as Part Lot 5 and Part Lot 3 DP 876514), Hickson Road, Millers Point, NSW 2000;
- Part of Hickson Road adjacent to:
  - 30-34 Hickson Road (Lot 11, DP1065410)
  - 36 Hickson Road (Lot 5, DP873158)
  - 38 Hickson Road (SP72797) Millers Point

The location of the Declaration Area Site in the context of the surrounding area is illustrated at Figure 2-1.

Figure 2-1 Barangaroo Declaration Area Site (purple) and the SDD 6533-2014 Development Application Site

The Declaration Areas comprises three areas:

- Block 4 (Barangaroo South)
- Block 5 (Barangaroo Central)
- Hickson Road

The area of land requiring remediation associated with the Development Application referred to as the 'Site Remediation Area'. The extent of this application relates to remediation of Block 5 only.

2.6 Role of Lend Lease in the Remediation of the Declaration Area

Lend Lease has been appointed by the Barangaroo Delivery Authority to undertake remediation of the Declaration Area. Prior to commencement of these works, Lend Lease has committed to a process of detailed assessment and design in order to develop the proposed remediation strategy for the Declaration Area.

2.7 Planning Context

Approval for the works is being sought from the Minister for Planning under Part 4 of the Environmental Planning and Assessment Act, 1979.

2.8 Summary Site History and Key Contaminants

The Millers Point gasworks operated on the Declaration Area between 1840 and 1921. The Declaration Area has subsequently been used for various activities, but predominantly a commercial port facility and public road.

When the EPA declared parts of Barangaroo and Hickson Road a "Remediation Site", it described the nature of the contamination as gasworks waste, that is, waste tar resulting from the operation of a gasworks plant.

In particular, the EPA has identified the following substances as the contaminants on the Declaration Area: polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); total petroleum hydrocarbons (TPHs); ammonia; phenol and cyanide.

2.9 Construction / Remediation Hours

The proposed construction/remediation hours are between 7.00am and 6.00pm Monday to Friday and between 7.00am and 5.00pm on Saturdays.

It is noted that the proposed hours for Saturdays are outside EPA's standard hours of construction. However, this extended period of remediation hours will enable the major noise and vibration generating activities to be carried out in a more efficient manner, thereby shortening the overall construction period to which sensitive receptors will be exposed. This represents an approach already approved under Project Approval MP 10 0023.

No construction / remediation work is proposed to be undertaken outside the proposed Construction / Remediation hours, including on Sundays or Public Holidays, with the exception of the plant below which are discussed in more detail in Section 6.2.

- **Air Extraction and associated filtration plant and equipment** required to service the various proposed temporary soil treatment and remediation work area odour control structures.
- **Water treatment plant** required to dewater the site.
- **Temporary electrical generators** are proposed to supply the Development Application Site.
- **Potential Bentonite Plant (for retention system) –** At night, the plant will operate in a holding mode where only circulation pumps will be kept running to keep product viable**.**
- **Essential maintenance activities, road possessions and deliveries of oversize plant**

2.10 Hoardings / Site Fences

A 2.4 metre solid hoarding / noise barrier equivalent to a plywood barrier is proposed to be erected around the perimeter of the Development Application Site. This noise mitigation measure has been included for the purpose of this assessment.

2.11 Staging

Lend Lease has engaged ARUP to prepare a series of Staging Plans for the subject works to Block 5 that set out the indicative sequence and staging of works contemplated under SDD 6533-2014. These Staging Plans form part of Development Application SDD 6533-2014.

The following indicative time frames have been provided for the purposes of this construction noise and vibration assessment and have been utilised to inform this report. Appendix D shows the staging which will indicatively last 24 months.

It is likely that the remediation works contemplated in SDD 6533-2014 will occur concurrently with C2 , Crown and 1C site works along with remediation of Block 4. Accordingly, cumulative noise impacts from these concurrent have been assessed.

The timeframes described above are indicative only and subject to design development and the broader requirements of the development program.

2.12 Construction Traffic

Details regarding traffic movements associated with the works contemplated SDD 6533-2014 are detailed in the Construction Traffic Management Plan prepared by ARUP that accompanies the Project Application.

Indicative forecast truck movements from Block 5 are an average of 8 truck loads per hour (along Hickson Road)

Cumulative truck movements are also presented in the report, where maximum hourly truck movement of 37 in 2016 are predicted.

Where treatment of excavated contaminated material is required material will be transported directly off-site for off-site treatment at a licensed facility. If a change to the methodology is proposed in the future to include potential on-site treatment (e.g. a pug mill within the excavation enclosure), the Noise Assessment and Sub-plan will be updated to confirm any updated noise

predictions were within limits.

3 AMBIENT NOISE LEVELS & SURROUNDING RECEIVERS

Residential and commercial receivers surrounding the site that may be affected by construction noise and vibration have been identified in previous relevant project applications (including approved MP 10 0023) for the Barangaroo South site. These receivers are also relevant in assessing noise impacts from the Remediation Area and/or the broader Development Application Site. They are detailed in Table 3-1.

Table 3-1 Surrounding Receivers

Receivers	Comments
Commercial Receivers	
A - Napoleon St	Aon Australia Building Symantec Building Kent Street Serviced Apartments
B - 30 Hickson Rd	Top floor café Lend Lease offices
C - Lime St, (King Street Wharf)	Commercial office Retail including indoor / outdoor cafes
D - 37 High St, Millers Point	KU Lance Preschool and Children's Centre
F - Shelley St	Commercial on Cnr of Sussex and Shelley Sts Commercial on Cnr of Lime and Shelley Sts
Residential Receivers	
G - 38 Hickson Rd	Multi storey residential building
H - High St, Millers Point	Terrace residences – southern end of High St
I - Merriman St, Millers Point	Double storey unit blocks and single storey houses
J - Dalgety Rd, Millers Point	Double storey Community housing
K - Edward St and Little Edward St, Balmain East	Waterfront properties along Balmain peninsula
L - Northern end of Darling Island Rd and Wharf Cr, Darling Island	Multi storey high end apartments
M - Northern end Sydney Wharf Pirrama Rd, Pyrmont	Multi storey high end apartments
Q – Residential Building R8	Multi storey high end apartments
Heritage Receivers	
N - Former Grafton Bond Store, Hickson Rd, Millers Point	Former Grafton Bond Store Building
0 - 20-26 Sussex St , Sydney	The Sussex Hotel – Former Moreton's Hotel
P - 2-4 Jenkins St	Former MWS stores

In order to quantify the existing noise environment, long-term ambient noise levels were monitored at eight (8) locations surrounding the site, selected to cover the range of environments in the potentially affected areas.

The locations are presented in Table 3-2. The noise logger locations are shown in Table 3-1.

Table 3-2 Long-Term Noise Monitoring Locations

Logger	Location	Monitoring Period in 2010	Company*
1	Level 4, The Bond 30-38 Hickson Rd	14 – 29 April	ARUP
2	Middle of South Barangaroo Site	14 – 29 April	ARUP
3	South-west of site adjacent to Sussex St and Shelley St	14 – 29 April	ARUP
4	South of site adjacent to King Street Wharf Boulevard	14 – 29 April	ARUP
5	3 High St, Millers Point	31 August – 9 September	WM
6	18 Merriman St, Millers Point	31 August – 6 September	WM
7	25 Edward St, Balmain East	31 August – 9 September	WM
8	Adjacent to 3 Darling Island Rd, Darling Island	31 August – 9 September	WM

* Monitoring conducted by ARUP and Wilkinson Murray.

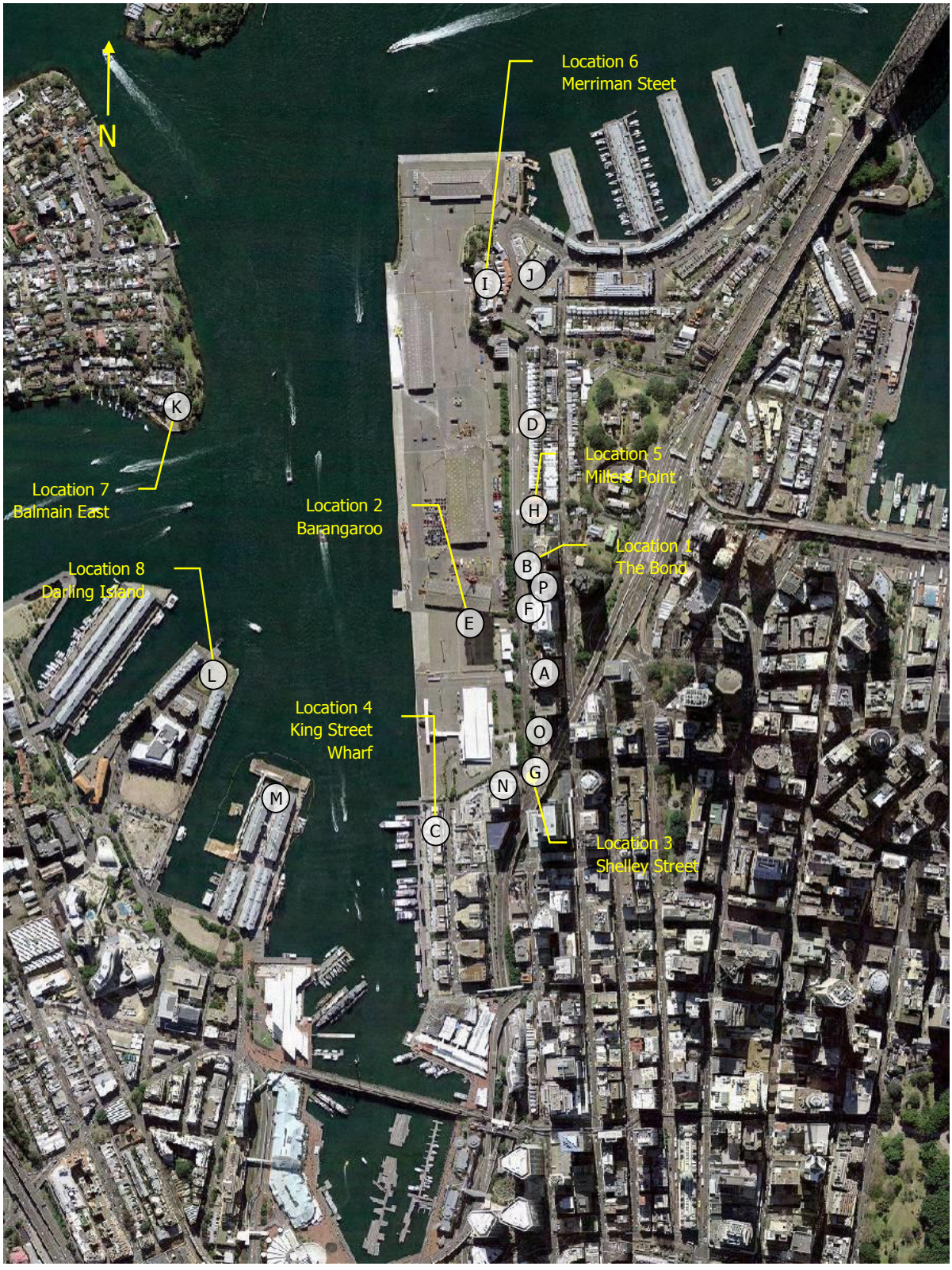
The noise monitoring equipment used for the Wilkinson Murray noise measurements consisted of ARL Type EL-215 environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

In the case of noise logging conducted by ARUP, the data was reviewed and is considered suitable to use for assessment purposes. The details of the noise measurement equipment and calibration can be referred to within the ARUP report.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1}, L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle. The L_{A90} level is normally taken as the background noise level during the relevant period.

Detailed results for each monitoring location are shown in graphical form in Appendix A. The graphs show measured values of L_{Aeq}, L_{A90}, L_{A10} and L_{A1} for each 15-minute monitoring period.

Figure 3-1 Aerial showing Noise Monitoring Locations



*Source Land and Property Management Authority

Table 3-3 summarises the noise results, for daytime, evening and night time periods as defined in the EPA's *Interim Construction Noise Guidelines* (*ICNG*). Additionally, noise monitoring results for Saturday (7.00am-5.00pm) has been included as Lend Lease proposes to operate outside standard *ICNG* hours during that time.

Table 3-3 Summary of Measured Noise Levels

Noise Logging Site	RBL (dBA)				$L_{Aeq,period}$ (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Saturday 7am-5pm	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Saturday 7am-5pm
1	53	53	49	51	62	61	57	60
2	52	50	45	50	56	54	50	56
3	60	59	49	57	67	66	62	66
4	52	60	46	48	60	62	60	60
5	47	44	41	45*	58	55	51	55
6	46	44	40	46*	58	55	50	56
7	49	45	40	46*	67	51	47	56
8	47	44	39	50*	54	49	46	56

* Determined from the afternoon on Saturday 4 September as the morning was affected by rain.

Background noise levels at all locations were free of the influence of extraneous noise sources such as plant or construction activities. Noise data measured during inclement weather was excluded in accordance with EPA procedures.

4 CONSTRUCTION NOISE & VIBRATION CRITERIA

The following sections detail the applicable site specific construction noise and vibration criteria based on the guidelines from EPA, being:

- *Interim Construction Noise Guideline*; and
- *Assessing Vibration: A Technical Guideline*.

4.1 Construction Noise Criteria

The EPA released the "*Interim Construction Noise Guideline*" *(ICNG)* in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq,\ 15min}$ noise level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am to 6.00pm, and Saturday 8.00am to 1.00pm. Outside the standard hours, where works can be justified the criterion would be background + 5dBA. Table 4-1 details the *ICNG* noise goals.

Table 4-1 Construction Noise Goals at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,,15min}$	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,,\ 15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. 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.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

In addition, the following construction noise management levels $L_{Aeq,15\ min}$ are recommended for other receivers and areas.

- Active recreation areas (such as parks): external $L_{Aeq,15\ min}$ 65dBA
- Industrial premises: external $L_{Aeq,15\ min}$ 75dBA
- Offices, retail outlets: external $L_{Aeq,15\ min}$ 70dBA
- Classrooms at schools and other educational institutions internal $L_{Aeq,15\ min}$ 45dBA

Based on the above, Table 4-2 presents the applicable noise management levels for construction activities at surrounding receivers.

Table 4-2 Site-Specific Construction Noise Management Levels

Location	Construction Noise Management Level, L_{Aeq} – dBA				Highly noise affected Noise Level, L_{Aeq} – dBA
	Day	Evening	Night	Saturday (extended)	
1 – Hickson Road Residences	63	58	54	55	75
5 – High Street Residences	57	49	46	50	75
6 – Merriman St Residences	56	49	45	51	75
7 – Balmain East Residences	59	50	45	51	75
8 – Darling Island Residences	57	49	44	55	75
9 – Sydney Wharf Residences	57	49	44	55	75
10- Building R8 Residences	63	58	54	56	75
All Commercial Properties	70				
Schools / Preschools	55*				
Parks / Outdoor Play Areas	65				

* The external NML of 55dBA is based on a 10dB reduction through an open window to meet an internal level of 45dBA.

4.2 Construction Vibration Criteria

The EPA document *Assessing Vibration: A Technical Guideline* (2006) is used to set criteria in relation to human comfort within buildings as well as potential damage to structures. This document refers to international standards.

4.2.1 Human Comfort within Buildings

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-2008. Methods and criteria in that Standard are used to set "preferred" and "maximum" vibration levels.

Acceptable values of human exposure to continuous vibration, such as that associated with underground drilling, are dependent on the time of day and the activity taking place in the occupied space (eg. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is set out in Table 4-3.

Table 4-3 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

In the case of intermittent vibration which is caused by plant such as rock breakers, the criteria are expressed as a Vibration Dose Value (VDV) and are presented in Table 4-4.

Table 4-4 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
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
Workshops	0.80	1.60	0.80	1.60

Calculation of VDV requires knowledge of the number of events in the relevant time period.

4.2.2 Building Damage

The British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings* sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) from BS 7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4-5.

Table 4-5 Transient Vibration Guide Values – Minimal Risk of Cosmetic Damage

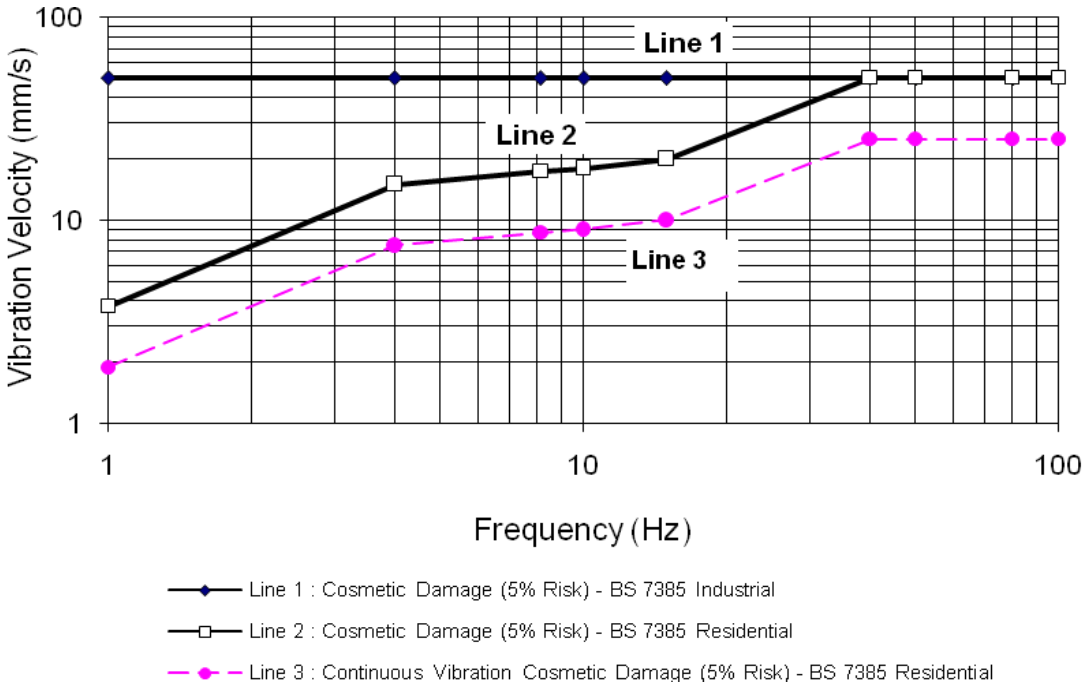
Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Un-reinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The Standard states that the guide values in Table 4-5 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Note that hydraulic hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

The British Standard goes on to state that "*Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity*". In addition, a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Figure 4-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



In addition to the British Standard, for the case of nearby heritage buildings, guidance for structural damage is derived from the German Standard DIN 4150 -3 *Structural Vibration Part 3 – Effects of Vibration on Structures*. The following Table 4-6 details these recommendations for heritage buildings.

Table 4-6 DIN 4150 recommend PPV vibration level for Heritage Buildings

Guideline Values for Velocity – mm/s		
1-10 Hz	10 to 15 Hz	40 to 50 Hz
3	3 to 8	8-10

5 CONSTRUCTION EQUIPMENT NOISE SOURCE LEVELS

Typical plant that may be used during the proposed works contemplated under Project Application SDD 6533-2014 Remediation and Land Forming are identified in Table 5-1. The table gives both L_{Aeq} Sound Power Level (SWL) and Sound Pressure Levels at 7m (SPL) for the equipment during a normal operating cycle. Sound Power Levels (SWL) is independent of measurement position. The SWLs shown have recently been measured at other similar construction sites.

Table 5-1 Typical General Construction Plant L_{Aeq} Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Bulldozer	114	89
Excavator	108	83
Excavator with Rocksaw	111	83
Concrete Truck / Truck and Dog	109	84
Concrete Pump - 120 mm diameter / 50 bar	112	87
Bentonite Plant	104	79
Concrete Crushing and Screening Plant	116	91
Concrete Saw	116	91
Crawler Cranes	98	73
Ground Water Pump, extraction and treatment plant	106	81
Mobile Crane	98	73
Site Cranes	104	79
Dump Truck	108	83
Front End Loader	112	87
Hydraulic Hammer	122	97
Auger Pile	110	85
Bored Pile Rig and Vibrating Sheet in Bentonite	114	89
Piling – Vibrating	108	83
Compressor	100	75
Bobcat	103	78
Hand Tools	90	65
Diesel Powered Air Extraction, handling and Filtration Units -Day	113	88
Night (running at low speed)	93	68
Grader	109	84
Compaction Roller	110	85
Electrical Generators	105	80
Concrete Batch Plant	110	85

6 CONSTRUCTION NOISE ASSESSMENT

Likely construction noise at surrounding commercial and residential receivers has been assessed for the remediation works contemplated under SDD 6533-2014 using scenarios that have been developed based on a review of the Staging plans. Staging is summarised in Table 6-1.

Table 6-1 Barangaroo Block 5 Remediation Works Stages

Stage	Indicative Duration	Summary Works
Stage 1	8 months	Temporary stormwater diversion. Install retention system.
Stage 2	2 months	Install & commission odour structures. Install Dewatering infrastructure.
Stage 3	6 months	Excavate and dispose soil/fill. Dewatering.
Stage 4	9 months	Backfill excavation. Decommission odour structures and dewatering infrastructure.

Site-related noise emissions were modeled with the "CadnaA" noise prediction program, using the ISO 9613 noise prediction algorithms. Factors that are addressed in the noise modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- a 2.4 metre high hoarding on the site boundary;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

The noise modelling has been conducted for the scenarios which are summarised in Table 6-2. These scenarios reference to the ARUP staging plans.

Table 6-2 Barangaroo Block 5 Remediation Works Construction Scenarios

Scenario	Description	Works
Stage 2	Retention Wall Construction	**Site Establishment - Piling** Retention wall construction (e.g. sheet piling in Bentonite trench) Remove surface pavement Services Diversion (including stormwater)
Stage 3	Block 5 Excavation Remediation and Dewatering	**Block 5 Excavation Works** Demolish caisson wall Excavate contaminated materials/fill Transfer materials from site Dewatering [Extracted groundwater treatment. Air Extraction, filtration and discharge plant and equipment servicing Block 5 Remediation Area running at normal speed during the day and low speed at night. Operation of all associated plant and equipment (generators, air handling, extraction, filtration, treatment and the like)]
Stage 4	Block 5 Backfill	**Block 5 Backfill Works** Backfill and compact excavations with suitable fill (either imported to site, or won from site, provided it satisfies HHERA criteria for the area) Remove temporary sheet piles and temporary ground anchors

Note that the scope of works table above is not exhaustive. The extent of proposed works commensurate with each stage is as indicated on the Staging Plans prepared by ARUP and as more broadly discussed in the specialist reports that accompany the SDD 6533-2014 Environmental Impact Statement.

Noise modelling has been conducted for each of the above scenarios based on equipment as listed in Appendix B. The equipment is located across the construction site as follows:

Area Noise Sources – General construction equipment that is distributed across the Stage 1A, 1B and Block 5 work sites has been modelled as an area source based on proposed equipment numbers and total noise levels.

Line Noise Source – Truck haulage routes are modelled as line noise sources with the number of trucks on the haulage route in a 15-minute period applied to these sources.

Point Noise Sources – Fixed plant and equipment that is located in one place (pumps or batching plant) or which has particular characteristics (rockbreakers) are modelled as point sources.

The *ICNG* requires predicted noise levels at receivers to be based on 15-minute periods. The modelling assumes a "typical worst-case" scenario whereby all the plant is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site specific noise criteria.

In addition to the above, the remediation works may occur at the same time as remediation of Block 4, C2 Construction and Stage 1C / Crown Works. Therefore, the following additional cumulative scenarios have been assessed to determine the cumulative noise impacts of the remediation works and other site construction works. Cumulative noise levels at surrounding receivers from the remediation works in combination the above works have been modelled as scenario C1.

Table 6-3 details the assessed cumulative construction scenario.

Table 6-3 Barangaroo Remediation Works Cumulative Construction Scenario C1

Scenario Description	Daytime Works
Remediation Block 5 – Stage 3 Remediation Block 4 C2 Construction Stage 1C / Crown Works	Represents periods where Block 5 remediation occurs concurrently with C2 and 1C / Crown works and Block 4 remediation, water treatment area and Dump Trucks delivering aggregate.

6.1 Out of Hours Operations

Predicted noise levels at residences at night are due to the following noise sources, which are included in the predictions:

Diesel /Electric Powered Filtration Plant – These operate at night at a reduced load, with noise levels in the night mode being 20dBA lower than daytime levels. If the fans are to be powered by mains power then lower noise emissions can expected.

Water Extraction and Treatment Area – This area contains pumps and treatment equipment. As this equipment is located away from residences, no noise mitigation is considered necessary.

Bentonite Plant – Circulation Pumps only operating to keep product fluid mobile.

Other works that are to be occasionally conducted outside normal hours are:

Diversion, cut over and commissioning of various authority infrastructure service diversions.

Local traffic diversion works which may be required by relevant authorities during localised cut over and commissioning of various services diversions.

Essential maintenance activities would be undertaken outside normal construction hours. Such essential maintenance activities would include, dust suppression, attendance and maintenance of environmental protection structures, emergency works and the like

In addition to the essential maintenance works described above, a number of trade work activities may be required to occur outside EPA standard construction hours. These include delivery of plant and equipment to the site out of hours where approved by police, the staging of existing building access ways and driveways to coordinate with the works, concrete finishing processes, materials handling/deliveries and other relatively quiet activities.

6.2 Construction Noise Levels at Residential Receivers

Predicted noise levels during day and evening / night operations at surrounding receivers are presented as follows:

- Table 6-4 Residential Receivers;
- Table 6-5 Commercial Receivers; and
- Table 6-6 Pre School.

Table 6-4 Predicted Noise Levels at Residential Receivers – $L_{Aeq,15min}$

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 1pm-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Block 5 – Stage 2														
1 – Hickson Road Residences	64	18	63	**1**	**NO**	58	0	YES	54	**0**	YES	55	**9**	**NO**
5 – High Street Residences	65	23	57	**8**	**NO**	49	0	YES	46	**0**	YES	50	**15**	**NO**
6 – Merriman Street Residences	47	7	56	0	YES	49	0	YES	45	**0**	YES	51	**0**	YES
7 – Balmain East Residences	44	6	59	0	YES	50	0	YES	45	**0**	YES	51	**0**	YES
8 – Darling Island Residences	47	6	57	0	YES	49	0	YES	44	**0**	YES	55	**0**	YES
9 – Sydney Wharf Residences	46	4	57	0	YES	49	0	YES	44	**0**	YES	55	**0**	YES
10 – R8 Residences	62	18	63	0	YES	58	0	YES	54	0	YES	56	**6**	**No**
Block 5 – Stage 3														
1 – Hickson Road Residences	67	27	63	**4**	**NO**	58	0	YES	54	0	YES	55	**12**	**NO**
5 – High Street Residences	66	27	57	**9**	**NO**	49	0	YES	46	0	YES	50	**16**	**NO**
6 – Merriman Street Residences	47	10	56	0	YES	49	0	YES	45	0	YES	51	**0**	YES
7 – Balmain East Residences	44	8	59	0	YES	50	0	YES	45	0	YES	51	**0**	YES
8 – Darling Island Residences	47	9	57	0	YES	49	0	YES	44	0	YES	55	**0**	YES
9 – Sydney Wharf Residences	45	8	57	0	YES	49	0	YES	44	0	YES	55	**0**	YES
10 – R8 Residences	62	24	63	0	YES	58	0	YES	54	0	YES	56	**6**	**No**

Table 6-4 continued

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 1pm-5pm)		
			Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance
Block 5 – Stage 4														
1 – Hickson Road Residences	67	20	63	**4**	**NO**	58	0	YES	54	0	YES	55	**12**	**NO**
5 – High Street Residences	66	23	57	**9**	**NO**	49	0	YES	46	0	YES	50	**16**	**NO**
6 – Merriman Street Residences	47	7	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	45	6	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	48	6	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	46	4	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	60	18	63	0	YES	58	0	YES	54	0	YES	56	4	**NO**
Block 5 – Cumulative C1														
1 – Hickson Road Residences	74	32	63	**11**	**NO**	58	0	YES	54	0	YES	55	**19**	**NO**
5 – High Street Residences	66	26	57	**9**	**NO**	49	0	YES	46	0	YES	50	**16**	**NO**
6 – Merriman Street Residences	51	10	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	50	8	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	54	11	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	56	10	57	0	YES	49	0	YES	44	0	YES	55	**1**	**NO**
10 – R8 Residences	71	28	63	**8**	**NO**	58	0	YES	54	0	YES	56	**15**	**NO**

Table 6-5 Predicted Noise Levels at Commercial Receivers – $L_{Aeq,15min}$

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 1pm-5pm)		
			Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance
Block 5 – Stage 2														
Lime Street, (King Street Wharf)	45	7	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	65	15	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	30	0	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	48	7	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Block 5 – Stage 3														
Lime Street, (King Street Wharf)	28	7	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	65	26	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	30	0	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	49	11	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Block 5 – Stage 4														
Lime Street, (King Street Wharf)	29	7	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	66	16	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	31	0	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	50	7	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Block 5 – Cumulative C1														
Lime Street, (King Street Wharf)	60	0	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	66	27	70	5	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	55	0	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	57	13	70	0	YES	70	0	YES	70	0	YES	70	0	YES

Table 6-6 Predicted Noise Levels at Pre School Receiver – $L_{Aeq,15min}$

Location	Predicted Noise Day/Night dBA		Day Playground			Day Internal Noise		
			Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance
Block 5 – Stage 2								
KU Lance Preschool	56	-	65	0	Yes	55	**1**	**No**
Block 5 – Stage 3								
KU Lance Preschool	57	-	65	0	Yes	55	**2**	**No**
Block 5 – Stage 4								
KU Lance Preschool	57	-	65	0	Yes	55	**2**	**No**
Block 5 – Cumulative C1								
KU Lance Preschool	66	-	65	1	Marginal	55	**11**	**No**

6.3 Discussions of Results

The following section relate to predicted noise levels from Block 5 construction noise predictions and cumulative noise levels.

6.3.1 Residential Receivers (Block 5 Works)

A review of the predicted noise levels due to the Block 5 remediation works contemplated under SDD 6533-2014 reveals predicted exceedances of relevant criteria at residences under all scenarios. The greatest exceedances are generally restricted to residences in Millers Point (Hickson Road, R8 and High Street) to the east and South of the site. The greatest potential exceedances of up to 16dBA on Saturdays are predicted for the residences at the southern end of High Street. This is due to the close proximity of these residences which overlook the Development Application Site.

At night time, noise levels are predicted to meet relevant criteria. This assumes that diesel generators are acoustically treated to reduce noise emissions on site. Therefore, the Noise and Vibration Management Sub Plan should include the requirement to ensure that generators are acoustically treated.

Noise control measures that can be adopted to reduce noise levels at surrounding receivers include:

- Acoustic containers on the generators or power supplied by the grid;
- Localised treatment such as barriers around fixed plant; and
- Selection of low noise equipment.

It is feasible that a combination of the above measures will be required to ensure the acoustic amenity of nearby properties is protected during the project. Details of noise mitigation will be determined at detailed design stage when actual equipment has been determined.

Note that the predicted noise levels in tables represent 'worst-case' values. It is likely that as the depth increases during excavation, the shielding effect of the perimeter excavation faces will act to diminish potential noise exceedances at Hickson Road and High Street residences.

6.3.2 Commercial Receivers (Block 5 Works)

General compliance with the 70dBA noise objective is indicated at surrounding commercial premises.

6.3.3 Preschool (Block 5 Works)

Construction noise levels in play areas of identified Preschools are predicted to generally comply with the 65dBA noise objective for active recreation area.

In the case of the internal areas, an exceedance of internal noise objectives by up to 2 dBA is expected, if windows are open which is considered marginal. To mitigate against predicted exceedances, the noise control measures as detailed in Section 8.1 will be employed.

It is further noted that when windows are closed no exceedance of internal objectives is

anticipated. Accordingly, windows could potentially be closed during intensive periods of construction, if required.

6.4 Cumulative Noise Impact with other Barangaroo Construction

Cumulative construction works Block 5, 4, C2 and Stage 1C / Crown has been modelled for this project application based on data provided for those applications under scenario C1.

The highest exceedance in this scenario is at Hickson Road residences where an exceedance of 19 dBA is predicted on Saturdays.

Table 6-7 illustrates the potential noise increases that will occur as a result of the cumulative assessment at residential receivers, being the most sensitive receiver locations.

Table 6-7 Cumulative Construction Noise Increases – dBA

Receiver	Construction Noise Level		Increase
	Remediation Works Only**	Block 4 Remediation Works and C2, and Crown / 1C*	
1 – Hickson Road Residences	67	74	8
5 – High Street Residences	66	66	0
6 – Merriman Street Residences	47	52	5
7 – Balmain East Residences	44	51	7
8 – Darling Island Residences	47	55	9
9 – Sydney Wharf Residences	45	55	10
10- R8 Receivers	62	71	9

*Includes operation of water treatment plant

** Block 5 Stage 3

Based on the above noise levels the following can be can be concluded:

- Noise from remediation of Block 5 will be the main contributor to Cumulative noise levels at residences on High Street.
- However other works, particularly Block 4 remediation will be the main contributors to noise levels at other receivers.
- Noise Levels at R8 residences will be dominated by Stage 1C and Crown excavation works.
- At surrounding commercial receivers (The Bond) a small exceedance 4 dBA of the 70dBA objective is predicted.

7 CONSTRUCTION VIBRATION ASSESSMENT

Operation of vibratory rollers and rock breakers and the like generate ground vibration that has the potential to transmit to nearby buildings.

Table 7-1 sets out the typical ground vibration levels at various distances for safe working distances (Extracted from the TfNSW Construction Noise Strategy).

Table 7-1 Recommended safe working distances for vibration intensive plant

Item	Description	Safe working Distance	
		Cosmetic Damage	Human Response
Vibratory Rollers	<50 kN (Typically 1-2 tonnes)	5 m	15-20 m
	<100 kN (Typically 2-4 tonnes)	6 m	20 m
	<200 kN (Typically 4-6 tonnes)	12 m	40 m
	<300 kN (Typically 7-13 tonnes)	15 m	100 m
	300 kN (Typically 13-18 tonnes)	20 m	100 m
	300 kN (>-18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Bored Piling	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

It is noted that these nearest receivers to the Block 5 site are:

- The Bond (Commercial) at 30 metres from the eastern site boundary;
- High Street Residences at 45 metres from the eastern site boundary; and
- Heritage Buildings South of the Bond at 50 metres from the eastern site boundary.

Based on the above distance and uses, it is concluded that cosmetic damage to buildings due to proposed construction techniques is unlikely.

In the case of larger vibratory rollers, human comfort objectives are likely to be exceeded when plant is working on the eastern side of the site. This is most likely to occur in The Bond, which happens to be Lend Leases Headquarters.

Options to minimise the impact of these activities consists of:

- Trial Vibration Monitoring to determine appropriate work distances and equipment types
- Notification of occupant's adjacent to the site of when these activities occur; and
- Utilise the smallest practicable size of vibratory roller.

It is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria.

Structural damage vibration criteria in commercial, heritage and residential buildings are much higher than human comfort criteria, and predicted vibration levels are within these criteria under all circumstances.

8 CONSTRUCTION NOISE & VIBRATION MANAGEMENT MEASURES

8.1 Construction Noise & Vibration Mitigation Measures

Without mitigation, noise levels from construction activities have been predicted to exceed the noise management levels nominated in the guidelines at some surrounding receivers. Therefore, noise control measures are recommended to ensure that noise is reduced where feasible.

It is noted that a Construction Noise and Vibration Management Sub Plan titled "*Noise & Vibration Management Sub-Plan Barangaroo South* has been prepared by Lend Lease for the Barangaroo South Site in its entirety. It is intended that this plan be a "live document" whereby project-specific noise and vibration control measures are incorporated into the noise and vibration sub plan. The following project specific mitigation measures are recommended:

- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures within the Block 5 remediation area and by "stepping down" the plant settings out of construction hours where able;
- Localised treatment, such as barriers, shrouds and the like around fixed plant such as pumps, crusher, screens, generators and groundwater extraction plant and by "stepping down" the plant settings out of construction hours where able. The detailed design of acoustic treatments will be undertaken during the detailed design phase; and
- It is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria is proposed.
- Extraction fans and generators should be acoustically treated. The treatment should achieve at least 20dBA. The details should be determined when equipment selection is made.

In addition, the following measures are included in the Noise and Vibration Management Sub Plan.

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service. To this end, testing should be established with the contractor.
- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.
- *Equipment Selection* – All fixed plant at the work sites should be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures in order to ensure that the total noise emission from each work site complies with EPA guidelines.
- *Site Noise Planning* – Where practicable, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.

- Use rocksaws and rippers where feasible.
- Install a noise barrier between the site and street frontages. This should be a minimum 17mm thick structural plywood or equivalent panel.

The adoption of the above measures and application of the procedures in the Project Noise and Vibration Management Sub Plan are aimed at working towards achieving the noise management levels established at surrounding receivers.

8.2 Community Liaison & General Approaches to Mitigation

An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected appraised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with surrounding tenants, etc) of any anticipated changes in noise and vibration emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms. This programme will be included in Lend Lease's *Community and Stakeholder Engagement Strategy* that has been specifically developed for the Barangaroo Project.

Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

8.3 Noise & Vibration Management Plan

Lend Lease have prepared a construction Noise and Vibration Management Sub-Plan for the Barangaroo South site in its entirety. The sub-plan is revised as needed for additional assessments and planning approvals. Measures required by this assessment and any subsequent planning approval requirements, will be incorporated into a revised version of the sub-plan. Areas that have been addressed in plan include:

- noise and vibration monitoring
- response to complaints**;**
- responsibilities;
- monitoring of noise emissions from plant items;
- reporting and record keeping;
- non-compliance and corrective action; and
- Community consultation and complaint handling.

Details of monitoring procedures are shown in Table 8.1 extracted from the Sub Plan:

Table 8.1 Sub- Plan Monitoring Procedures

Detail	Frequency	Standards	Reporting	Action if non-complying	Responsibility
Continuous unattended noise monitoring at locations shown in Appendix 1, both L_{eq} and L_{eq} 1000Hz, (the web-based monitoring system used for Barangaroo South is shown in Appendix 4).	Real-time monitoring using a web-based system.	NMLs in Appendix 1, Table 4.	Monthly	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
Construction equipment monitoring (noise audit) to assess compliance with expected noise levels, and to allow any increase in noise levels to be detected and addressed.	If equipment is perceived as being noisy or noisier than other similar equipment, or in response to complaints.	Levels in Appendix 1, Table 2 – Typical Plant & Equipment Noise Levels. AS 2012	N/A	Assess equipment and undertake remedial action such as repair, noise-proofing, redeployment or removal.	EHS Co-ordinator Noise Specialist
Attended noise monitoring: • in response to complaints, as per table 1 below, • to refine construction methods to minimise noise, • to differentiate between construction noise sources and other sources (eg. road traffic or Headland Park works), • to assess internal construction noise levels at commercial premises, if needed, or • as needed during site establishment.	As required.	NMLs in Appendix 1, Table 4. AS 1055	As required Monthly	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
Attended vibration monitoring at locations shown in Appendix 1.	Initial two weeks of significant vibratory activity. Frequency to be reassessed following data interpretation. As required for changes in works or complaints.	EPA guidelines BS6472 DIN4150 Part 3	Monthly	Cease relevant activities, and/or implement additional measures. Seek professional vibration input if required.	EHS Manager (Environment) Vibration Specialist
Integrity of site hoarding.	Weekly.	Hoarding intact.	Weekly Site Checklist	Construction Manager to repair or replace	Foreman

Table 8.2 Additional Noise Mitigation Procedures

Scenario	Mitigation measures LAeq(15 minute) noise level above NML	
	0 to 10 dBA Noticeable	**>10 dBA** Clearly audible – potentially intrusive
Approved hours, no complaints received		• Review noise data and current work practices.
Approved hours, complaint(s) received	• Respond to complainant • CRM entry indicating additional reasonable and feasible measures (see Appendix 5)	• Respond to complainant • CRM entry indicating additional reasonable and feasible measures (see Appendix 5)
Planned out of approved hours, no complaints received	• Letter box drops prior to works • Inform relevant authorities prior to works	• Letter box drops prior to works • Inform relevant authorities prior to works • Briefing of residents via CCLG • CRM entry indicating close out actions
Planned out of approved hours, complaint(s) received	• Letter box drops prior to works • Inform relevant authorities prior to works • Respond to complainant • CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.	• Letter box drops prior to works • Inform relevant authorities prior to works • Respond to complainant • CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.

9 CONSTRUCTION TRAFFIC

9.1 Traffic Noise Criteria

Criteria for assessment of road traffic noise are set out in the NSW Government's *NSW Road Noise Policy (RNP)*. Table 9-1 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use.

These are normally applied to developments which result in indefinite increases in road traffic noise rather than temporary increases associated with construction projects. Nevertheless the RNP provides a process to assess potential noise impacts.

Table 9-1 Traffic Noise Criteria extracted from the NSW *RNP*

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq,\ (15\ hour)}$ 55 (external)	$L_{Aeq,\ (9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,\ (15\ hour)}$ 60 (external)	$L_{Aeq,\ (9\ hour)}$ 55 (external)
Local roads	4. Existing residences affected by noise from **new** local road corridors 5. Existing residences affected by noise from **redevelopment** of existing local roads 6. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq,\ (1\ hour)}$ 55 (external)	$L_{Aeq,\ (1\ hour)}$ 50 (external)

Hickson Road would be classified as a sub arterial road. In summary the noise level goals at the residential receivers, for this project, based on the *RNP* are:

- $L_{Aeq,15hr}$ day 55dBA; and
- $L_{Aeq,9hr}$ night 50dBA

In addition, where the above criteria are already exceeded as a result of existing traffic the policy notes:

> *For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.*

Based on a review of noise levels at The Bond on Hickson Road it has been determined that existing noise levels in the hours of proposed construction already exceed the daytime objective of 55 dBA. Therefore the already exceeded objective of not increasing existing noise levels by more than 2 dB is applicate for this development.

Data is not available for existing traffic volumes over the 15 hour day and 9 hour night. Morning peak traffic flows are presented in Table 9-2 based on information provided by ARUP, the traffic consultants, report titled "*Block 5 Remediation Construction Traffic Impact Assessment Dated 17 July 2015*".

Table 9-2 AM Traffic Flows on Hickson Road

Condition	South Bound AM Peak hour	North Bound AM Peak hour
Existing 2013	254	621
December 2016 Operational Traffic	329	806
December 2016 with Block 5 Construction	333	810
December 2016 Total Operational and All Construction	342	830

AM peak hour traffic noise levels at the nearest residences on Hickson Road have been predicted using the *Calculation of Road Traffic Noise (CORTN)* traffic noise prediction technique based on a "worst-case" assumption that all construction traffic travels south.

The point in time where the maximum impact of traffic noise from Block 5 is around December 2015. At this point, there will be operational traffic from some of the Barangaroo South projects and these have been included in traffic figures.

Table 9-3 details predicted peak hour traffic noise levels with and without the Block 5 construction traffic.

Table 9-3 Predicted AM peak Traffic Noise Levels at Hickson Road Residences – $L_{Aeq,1hr}$ – dBA

Construction Traffic	Calculated Traffic Noise Level
Existing 2013	67.1 (measured)
December 2016 Operational Traffic	68.9
December 2016 with Block 5 Construction	69.0
December 2016 Total Operational and All Construction	69.7

A review of predictions indicates the following;

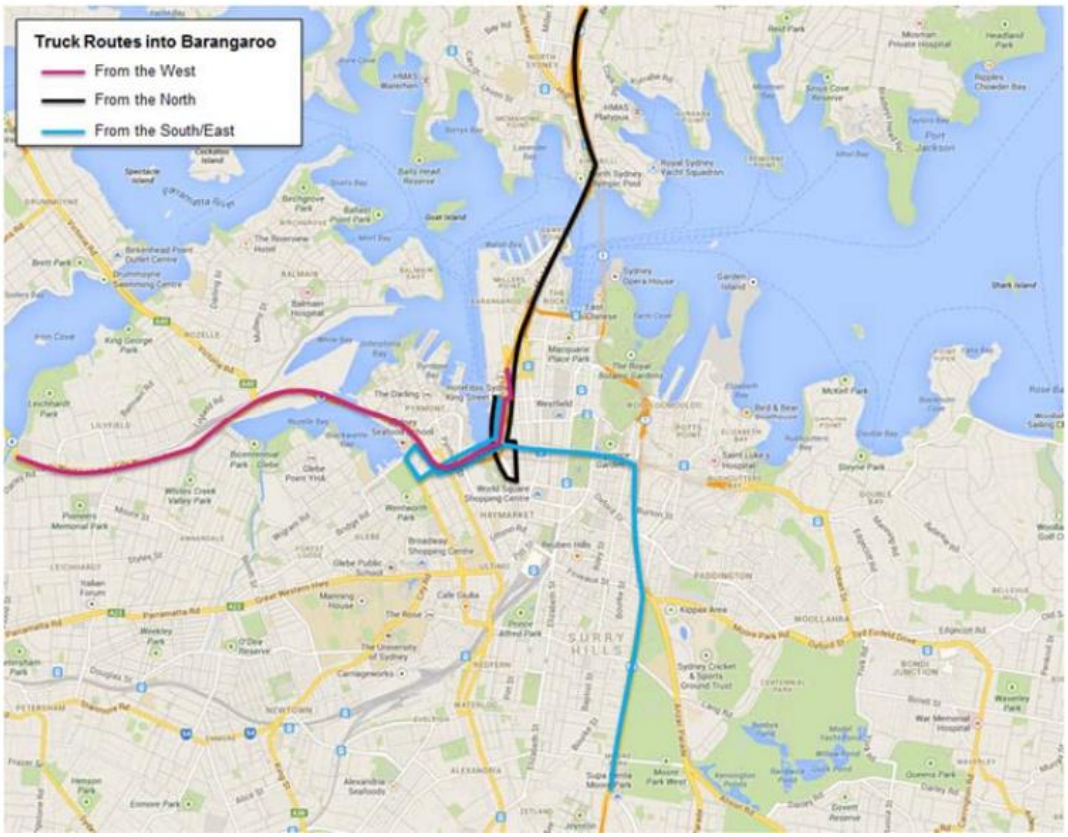
- Block 5 traffic will increase traffic noise levels at Hickson Road residences by approximately 0.1 dBA;
- When Block 5 and all Barangaroo South operational traffic is included an increase of 1.1dBA is predicted. Traffic noise levels are therefore not predicted to exceed the 2dBA objective due

to construction and operational traffic in December 2016; and

- The predicted changes in hourly peak hour flow are considered representative of the changes over a 15 hour daytime period.

A review of the proposed truck routes (Figure 9.1) to and from the site are through major roads in the CBD. It is not envisaged that traffic from construction will use local streets thereby avoiding any potential traffic noise impact at residences.

Figure 9-1 Construction Traffic Routes through the CBD



10 SUMMARY & RECOMMENDATIONS

The noise and vibration assessment has been prepared to accompany a Development Application for SSD 6533-2014 for remediation Block 5 part of the EPA declared area at Barangaroo and some adjoining land (referred to throughout this report as the Remediation Site). It specifically addresses Block 5 remediation to determine the potential for noise and vibration impact at surrounding receivers.

The assessment allows the area of risk to be identified and appropriately responsive measures to be adopted to mitigate or minimise any potential noise and vibration issues.

Based on our investigations of the proposed remediation works, the following findings have been determined.

10.1 Construction Noise Management Levels

Noise objectives for construction have been established based on EPA guidelines. The Noise Management Levels should be adopted as objectives to work toward in minimising any noise impact at surrounding residences.

Table 10-1 presents applicable noise criteria at residential and non-residential receivers in the vicinity of the site.

Table 10-1 Site Specific Construction Noise Management Levels – dBA

Location	"Affected" Noise Management Level, L_{Aeq} – dBA				Highly Affected Noise Level, L_{Aeq} – dBA
	Day	Evening	Night	Saturday (extended)	
Hickson Road Residences	63	58	54	55	75
High Street Residences	57	49	46	50	75
Merriman Street Residences	56	49	45	51	75
Balmain East Residences	59	50	45	51	75
Darling Island and Sydney Wharf Residences	57	49	44	55	75
Building R8 Residences	63	58	54	56	75
All Commercial Properties	70				75
Schools / Preschools	55*				75
Parks / Outdoor Play Areas	65				75

* The external noise goal of 55dBA is based on a 10dB reduction through an open window.

10.2 Construction Noise & Vibration

It has been determined that noise from construction activities during the day evening and night periods will potentially exceed the established construction noise management levels. Therefore, the planning and management of construction activities must take into account the sensitivities of surrounding residents so as to minimise the impact of construction activities at these receivers where feasible and reasonable.

Management and mitigation measures to reduce noise impact at receivers have been identified which are consistent with those recommended as part of the approved project application MP 10 0023 and which include:

- Localised treatment of fixed plant;
- A 2.4 metre noise barrier to be installed on the eastern and western boundaries of the site;
- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures;
- Localised treatment such as barriers, shrouds and the like around fixed plant such as pumps, generators and groundwater extraction plant and by "stepping down" the plant settings out of construction hours where able. The detailed design of acoustic treatments will be undertaken during the detailed design phase; and
- Provision of respite from noise producing activities during extended hours operations where practicable;
- Selection and maintenance of low vibration equipment where practicable;
- Selection and maintenance of "quiet" type equipment where practicable; and
- Effective community consultation and complaints management.

Vibration associated with excavation activities is predicted to exceed established human comfort criteria at properties along Hickson Road when on the eastern side of the site within 20 metres from residences. Therefore, it is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria is proposed.

The control of construction noise and vibration is addressed in Lend Lease's Noise and Vibration Management Sub-Plan for Barangaroo South. The sub-plan would be updated to detail reasonable and feasible management measures (see Appendix A) and community consultation as discussed in this assessment.

The following measures are recommended (noting many are existing measures already being implemented at Barangaroo South for construction works):

- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures within the Block 5 remediation area;
- Audit plant to select equipment that generates the lowest practical commercially available noise levels.
- Plan the construction activities so that respite is provide to residences when noise activities occur. This is particularly important during extended Saturday hours (7.00am to 5.00pm);

- Continue to implement an effective complaints and community consultation program, which informs the construction manager about appropriate mitigation measures to protect the acoustic amenity of surrounding residences;
- Select vibration generating plant a small as possible given site constraints and practicability.

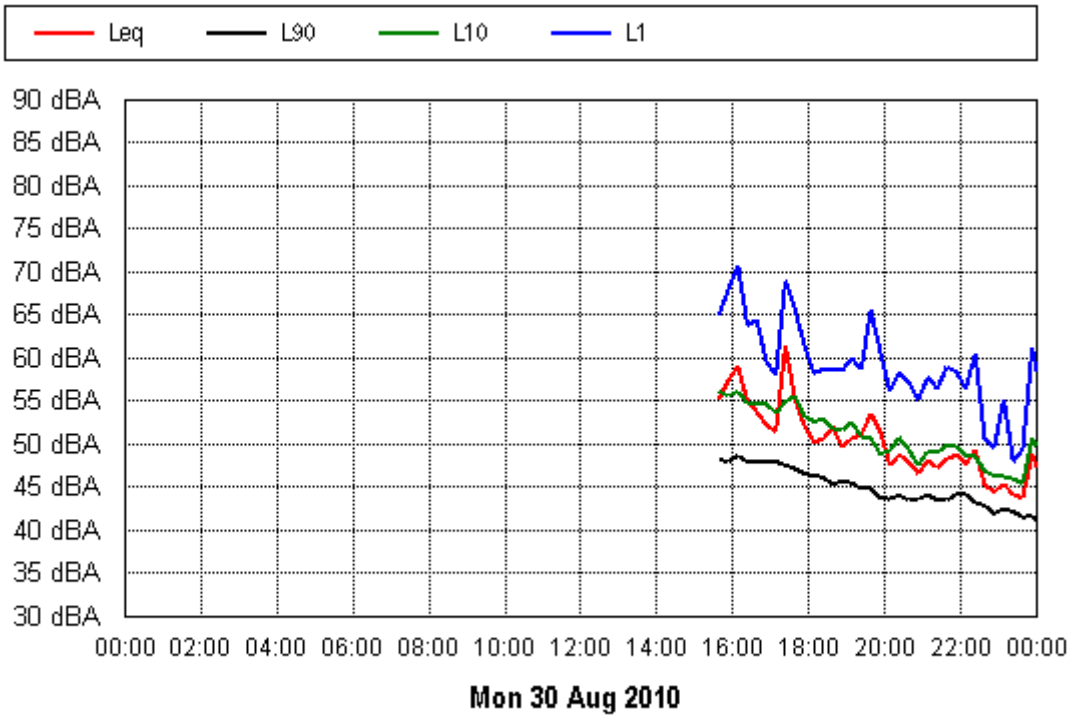
In addition, a review of increased noise associated with temporary off-site truck and car movements is consistent with the requirements of the EPA *Road Noise Policy*.

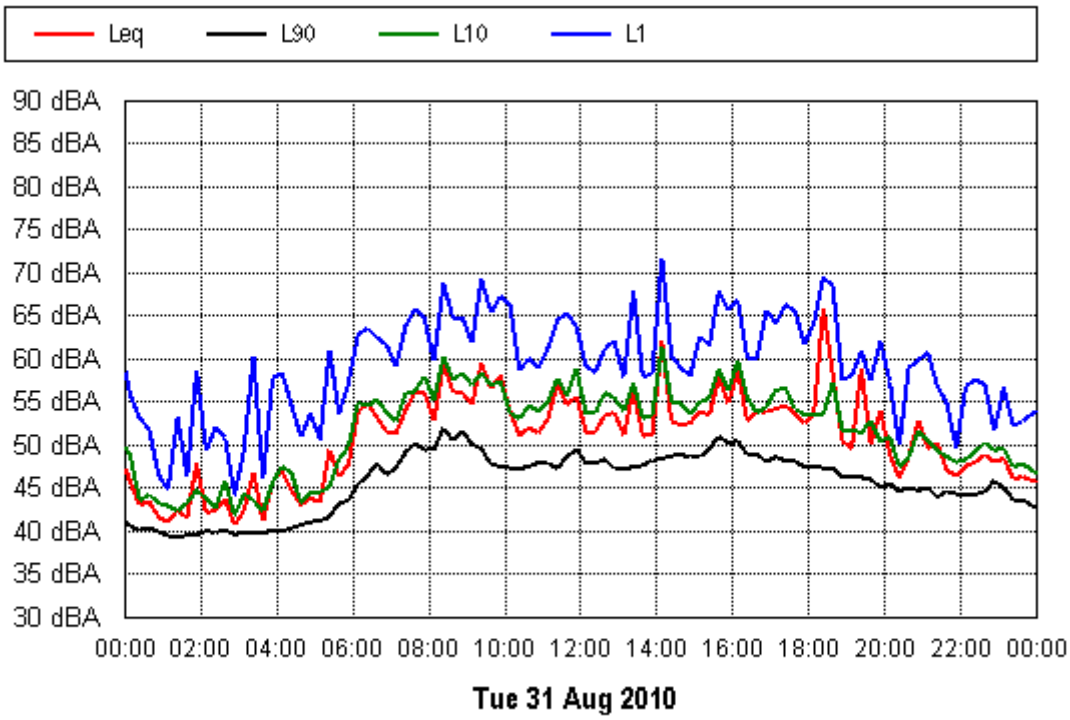
It is concluded that the noise management measures identified in this assessment and the current construction noise and vibration management measures will minimise any potential impact on surrounding receivers to manageable levels

APPENDIX A

NOISE MEASUREMENT RESULTS

Location: 5 – 37 High St





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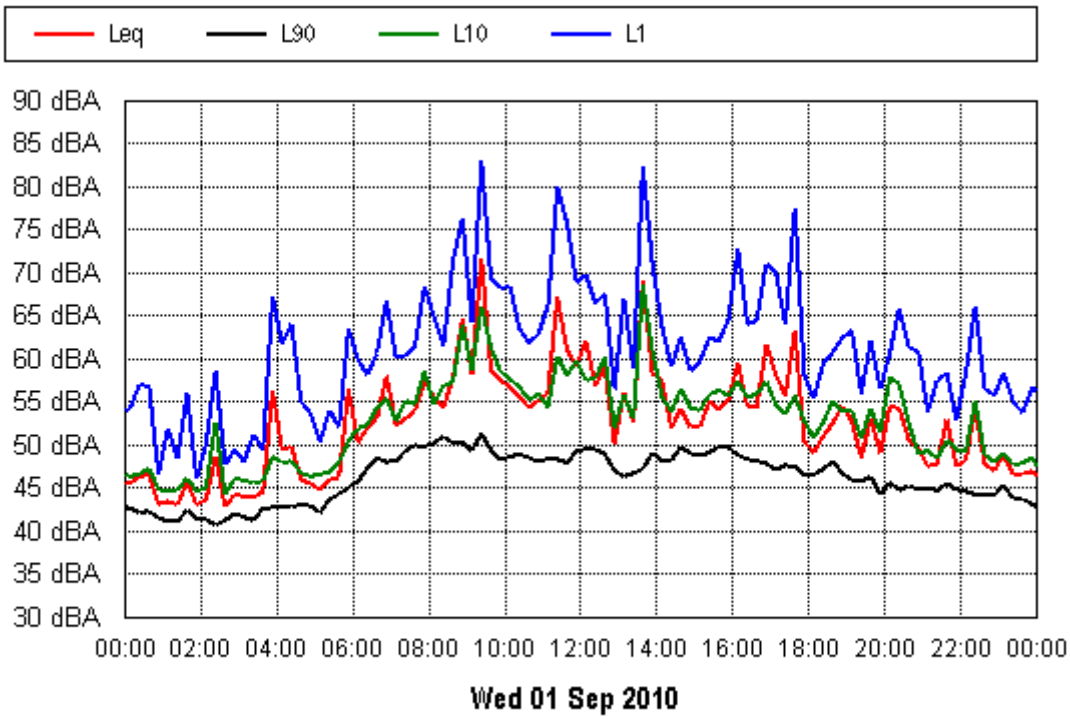

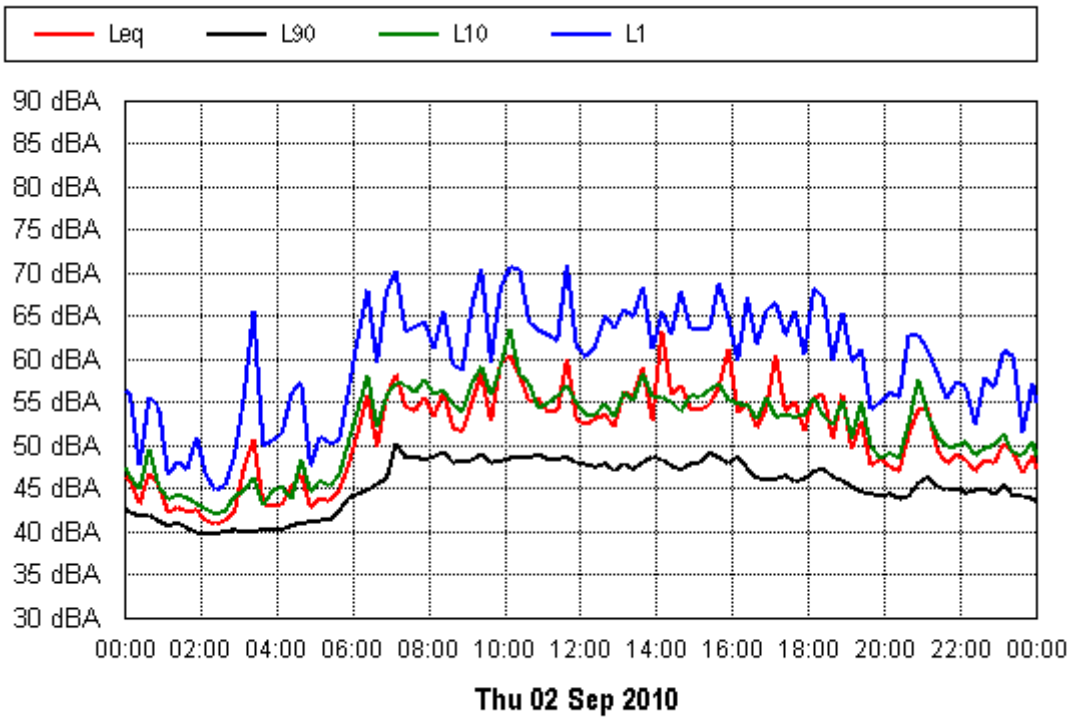

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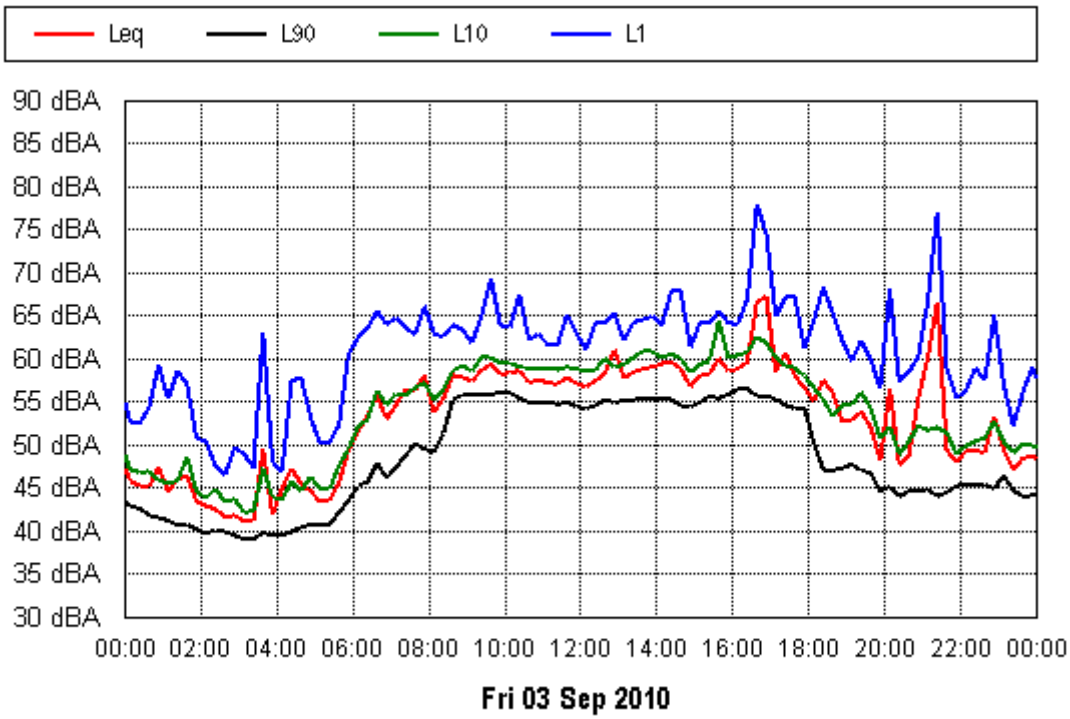

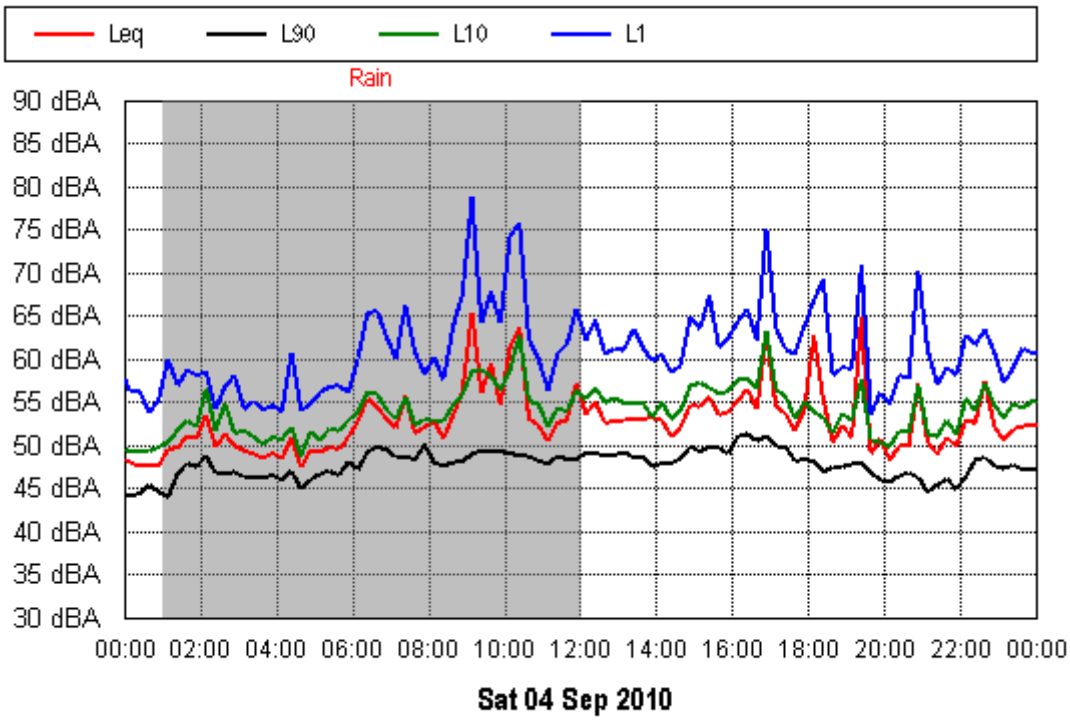

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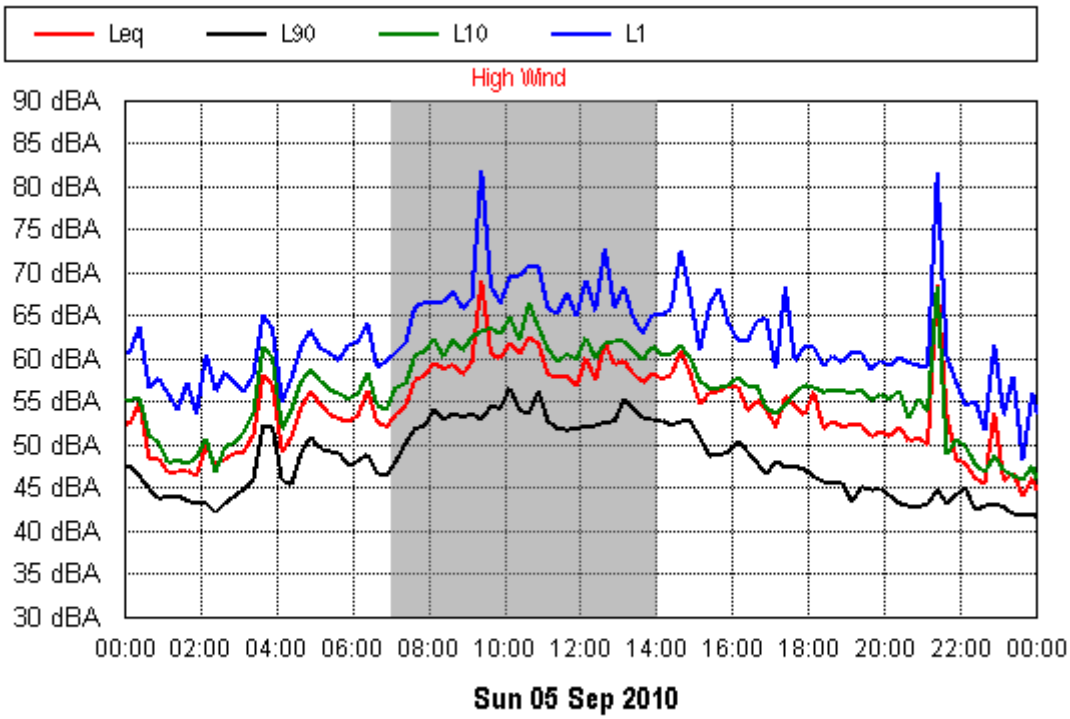

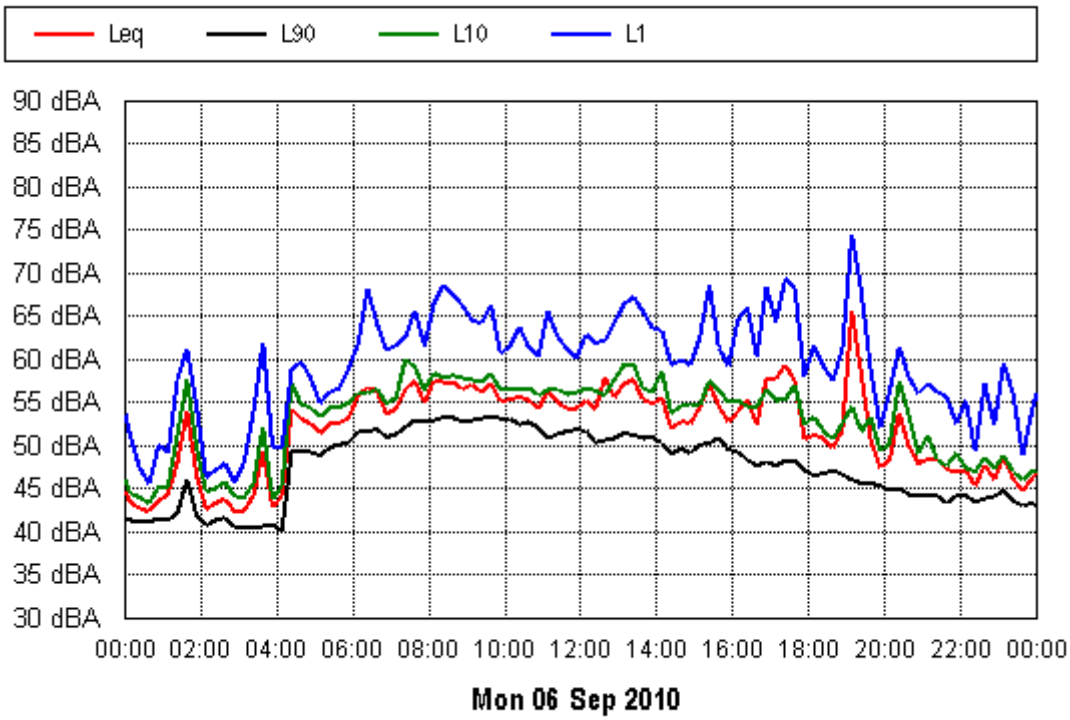

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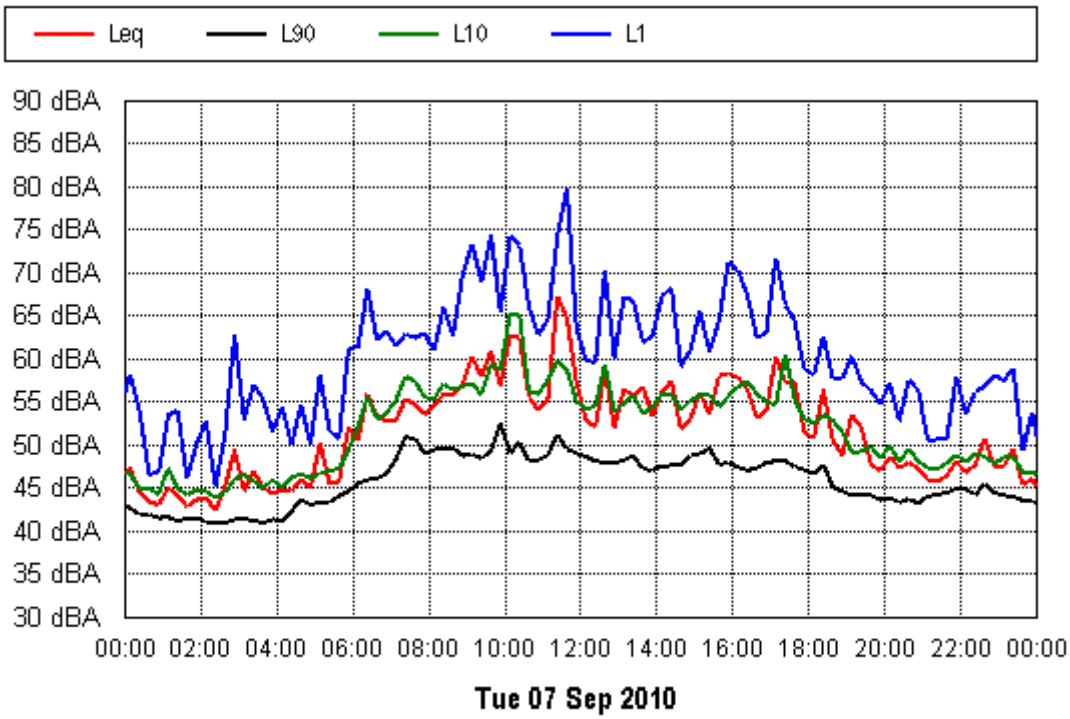

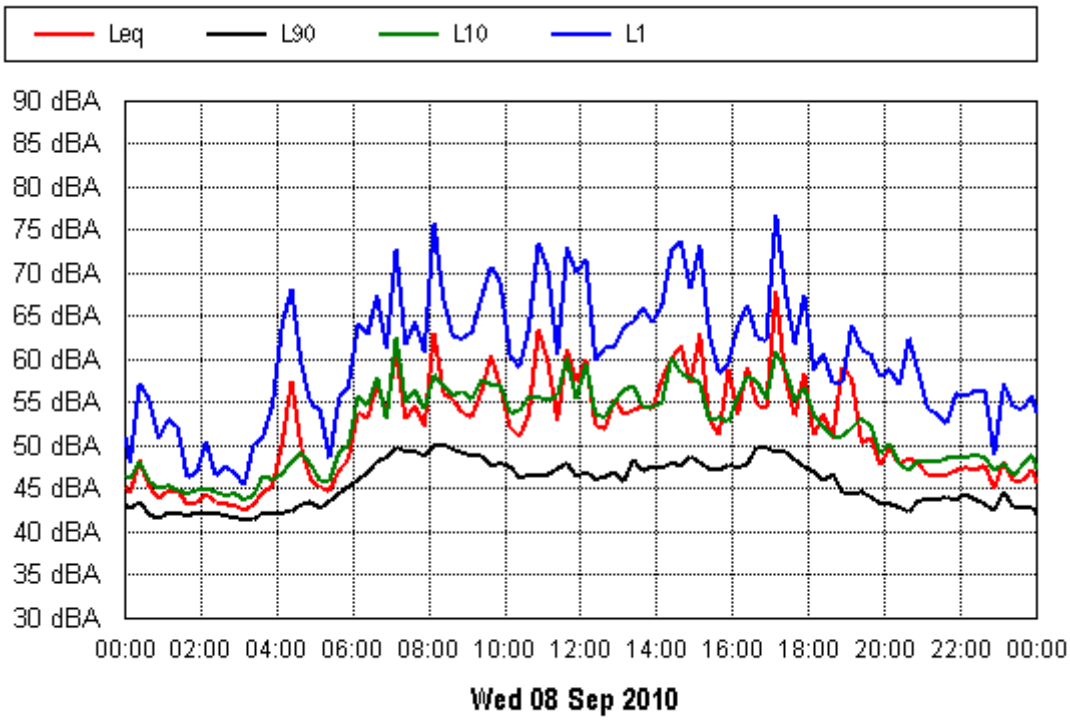

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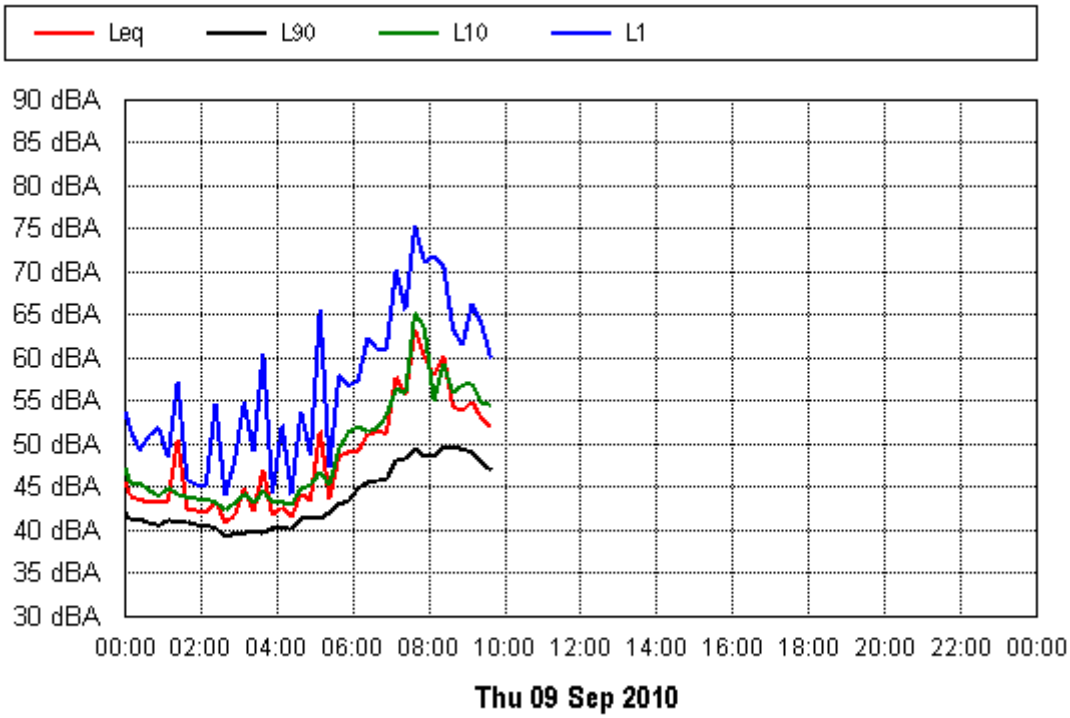
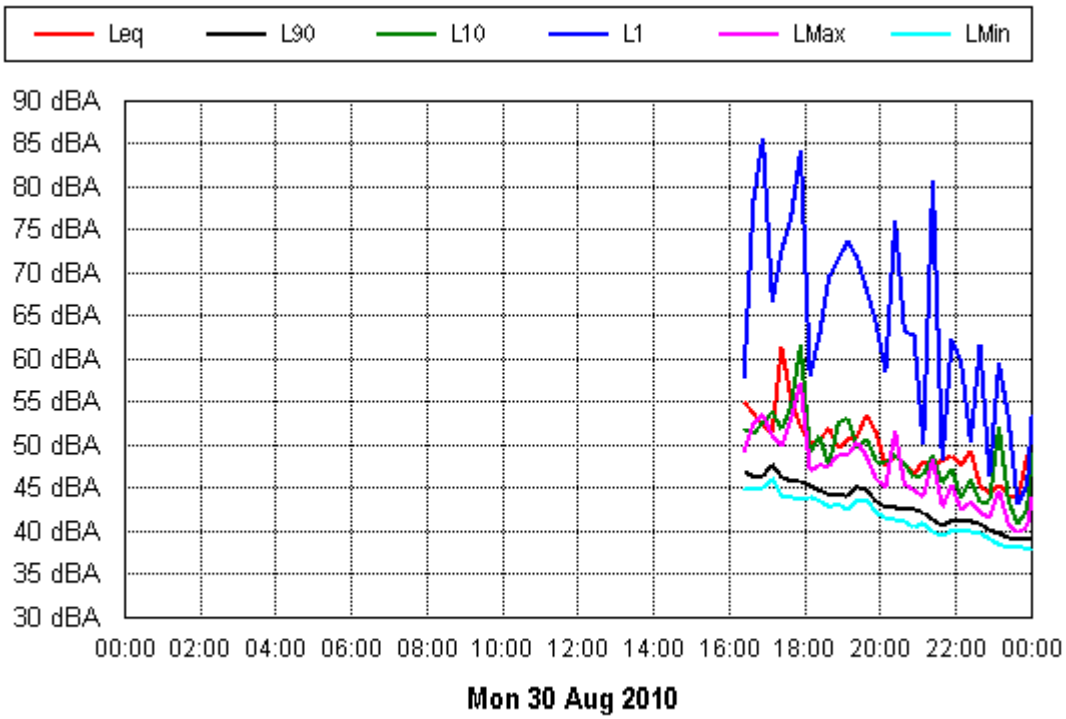
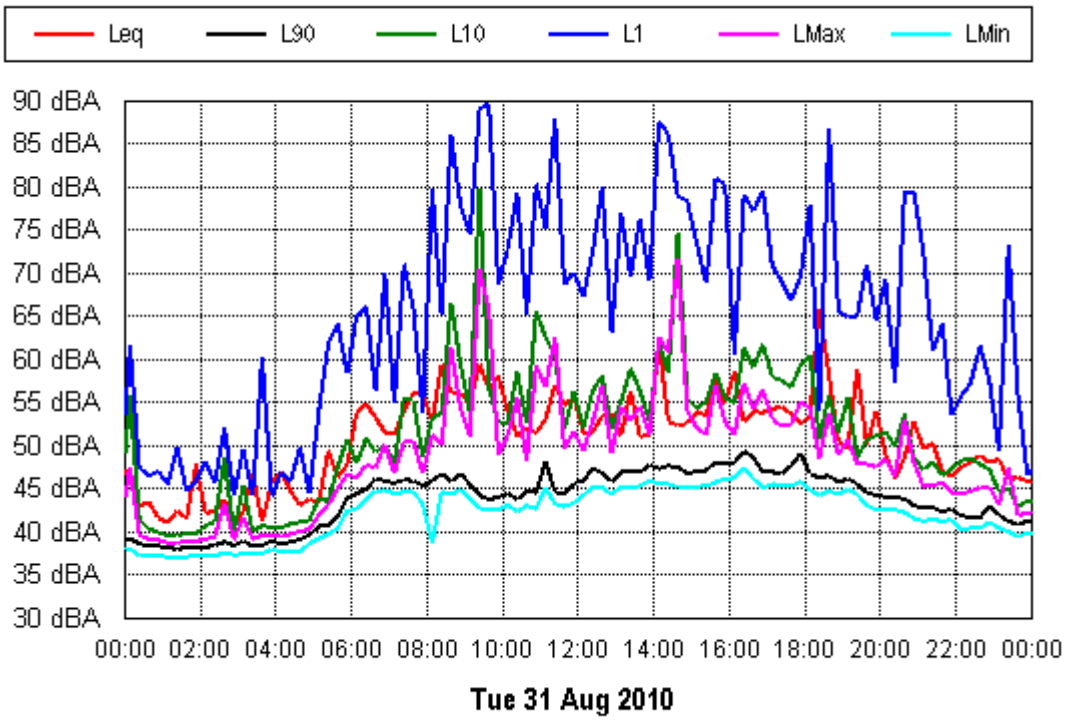


Location: 6 – 18 Merriman Street





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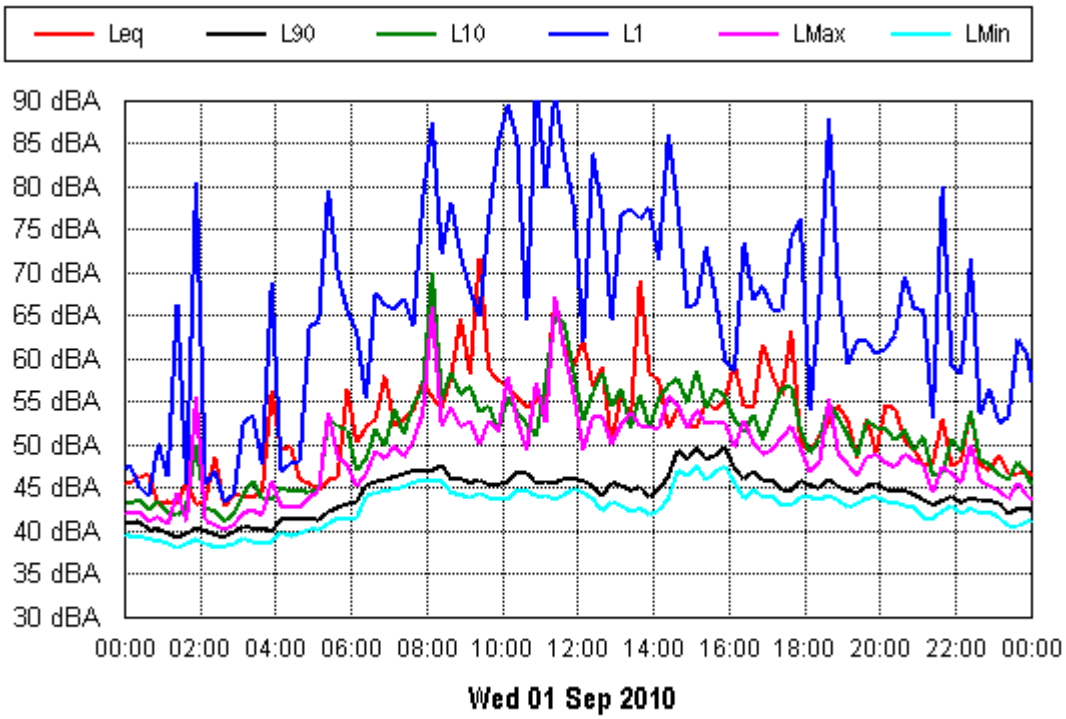

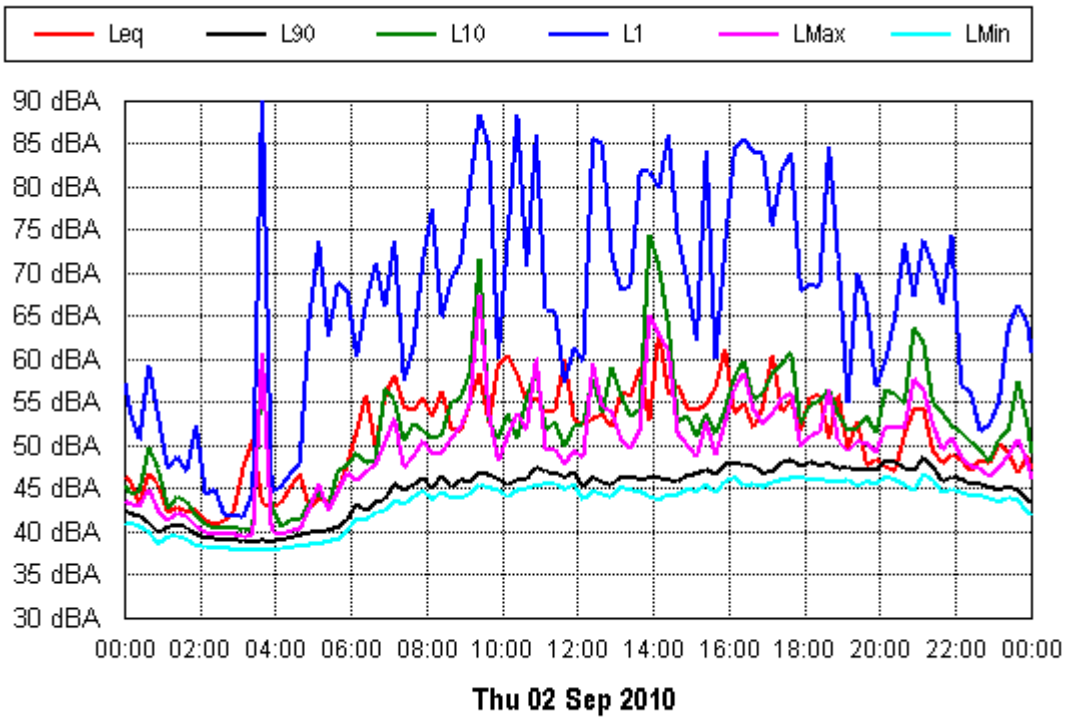

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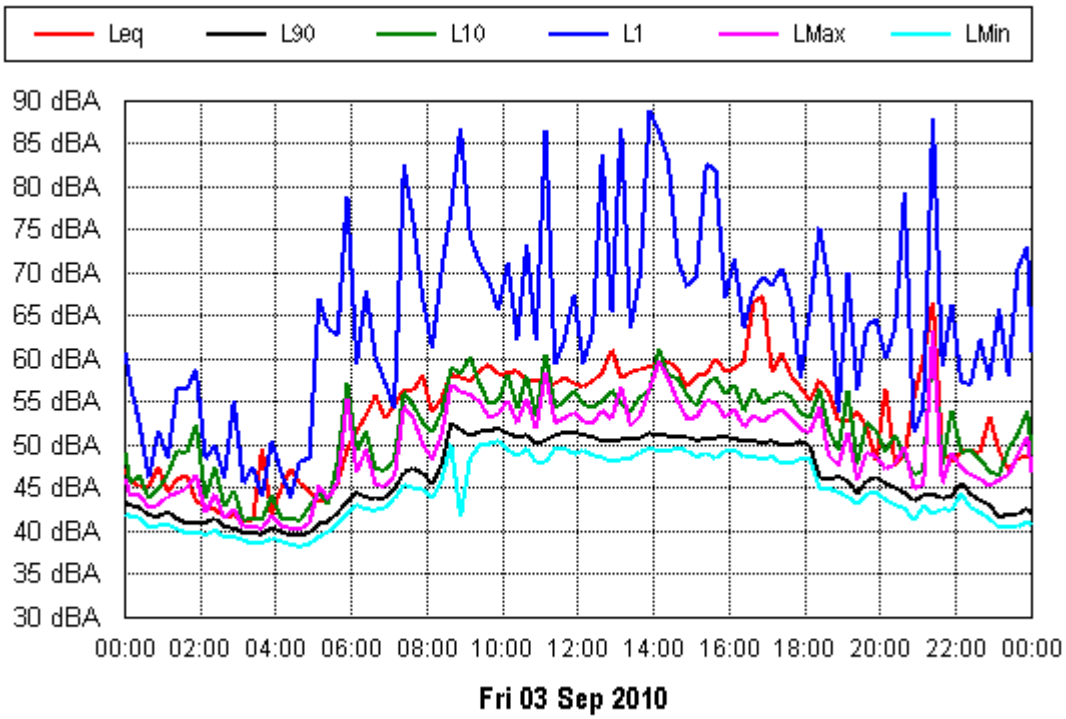

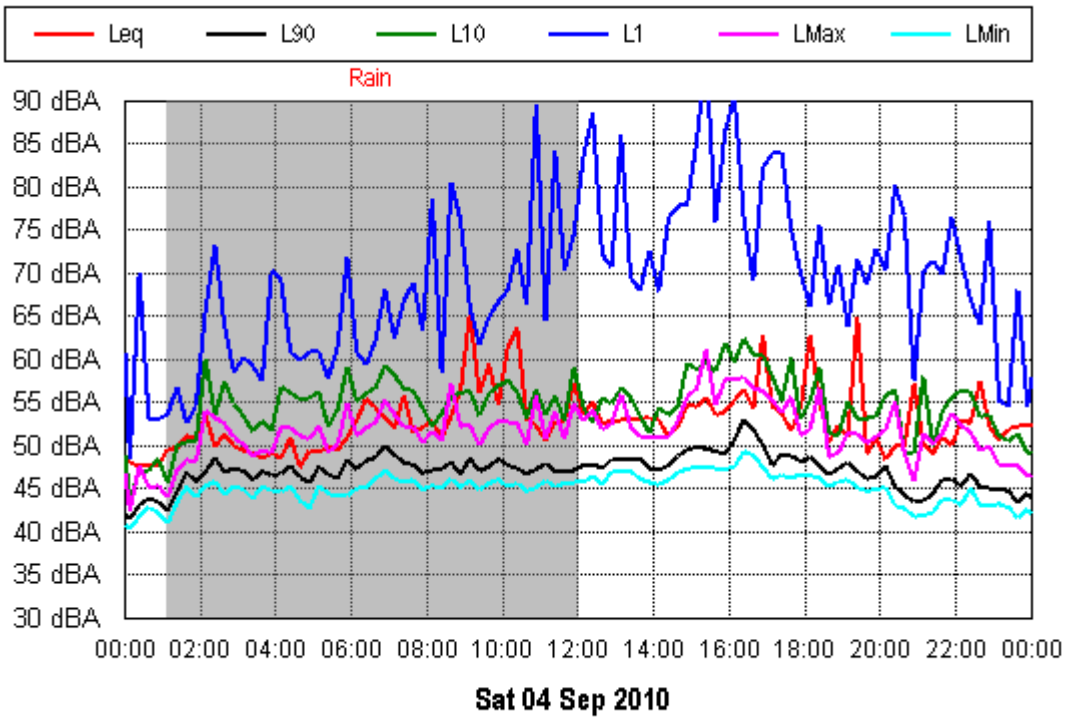

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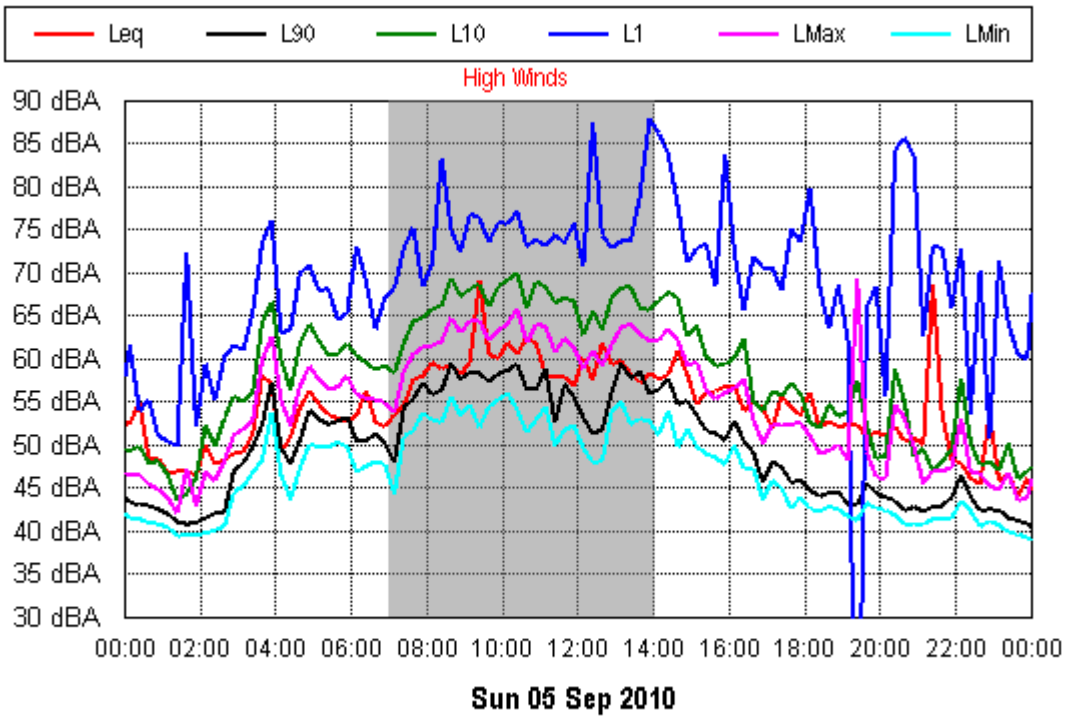

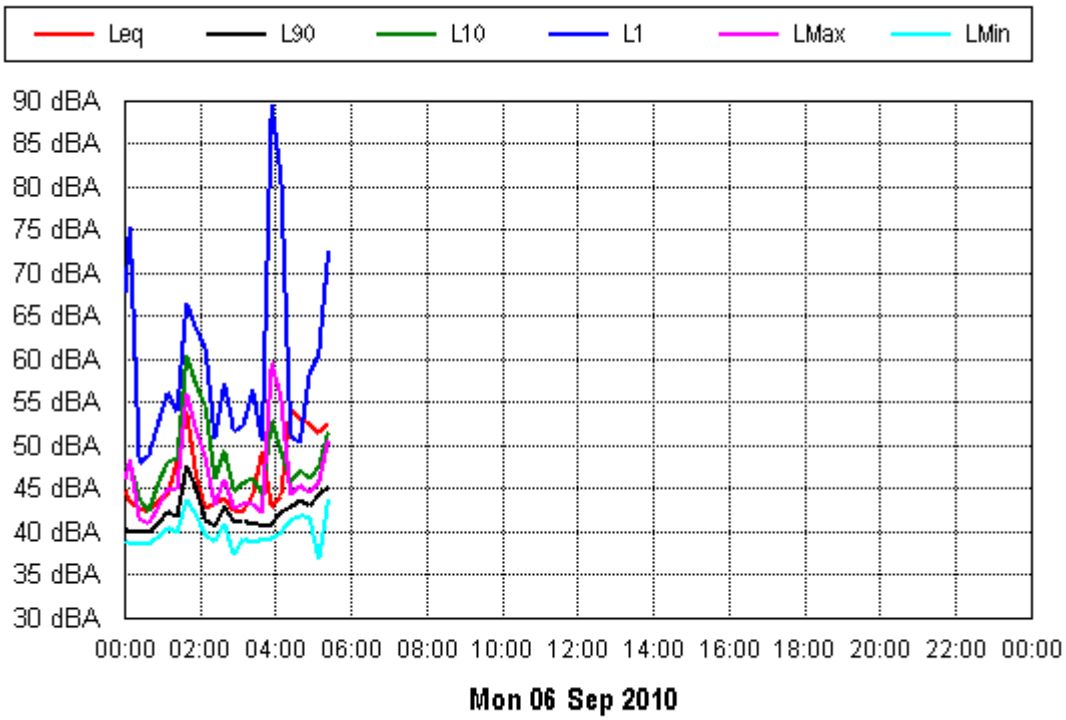

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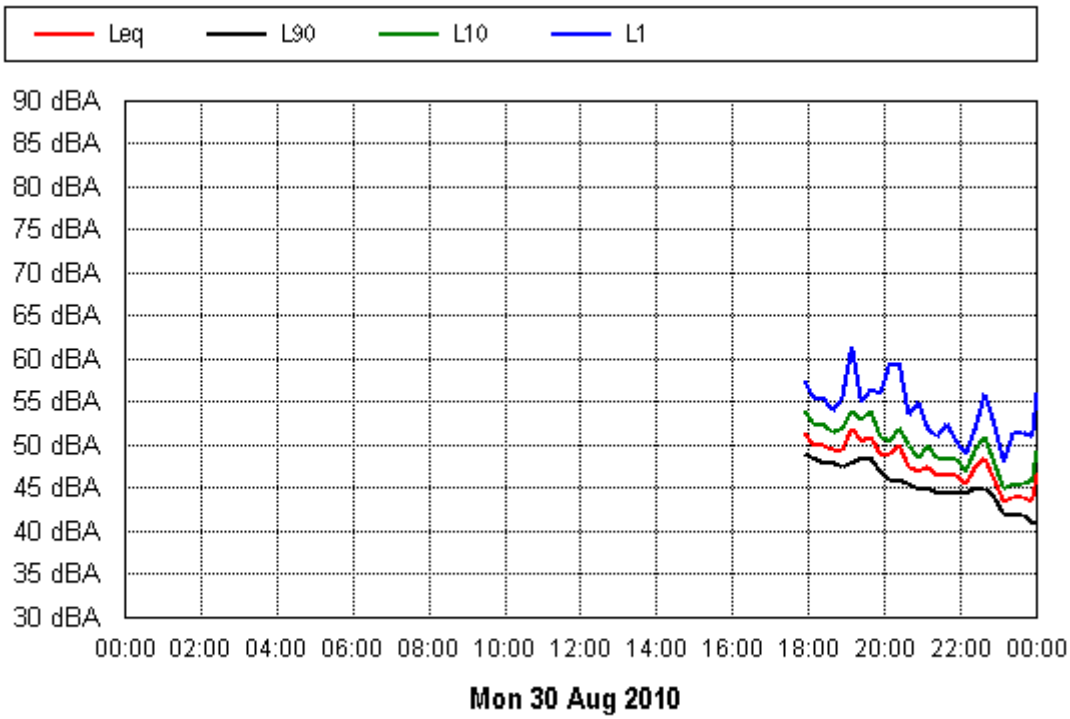

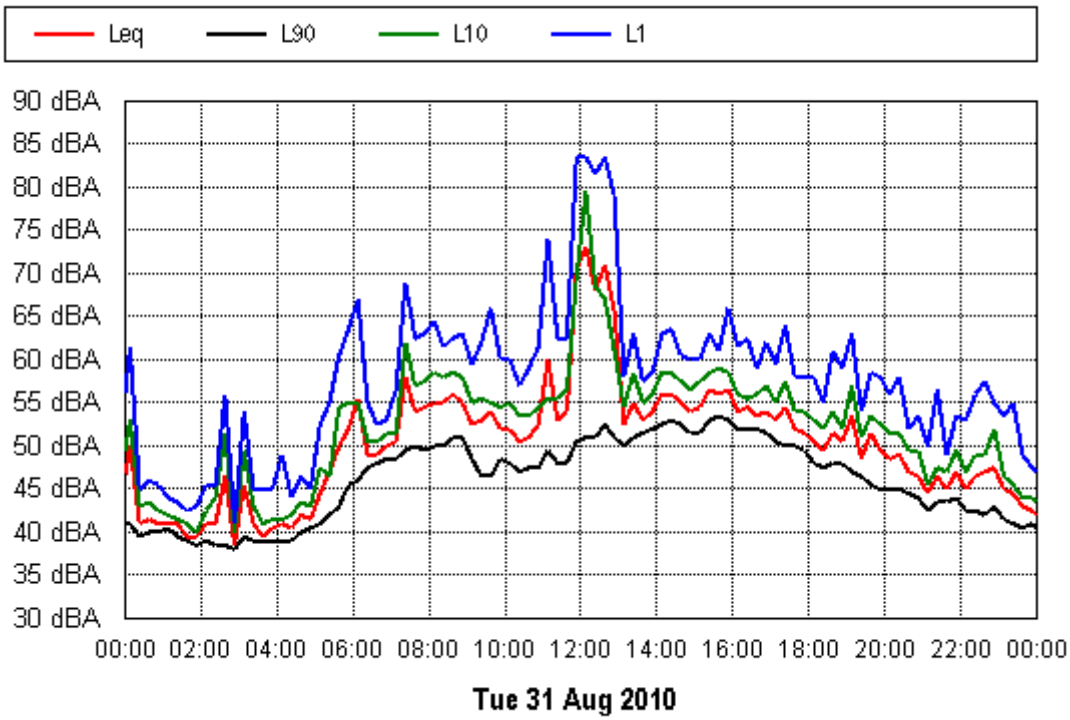

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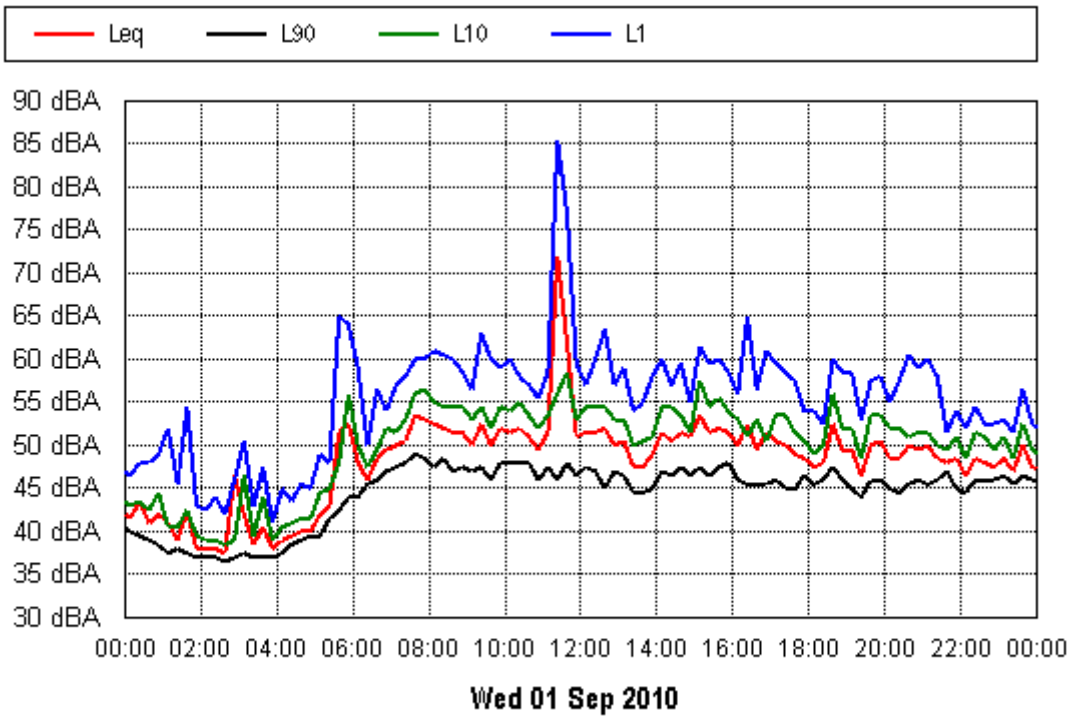

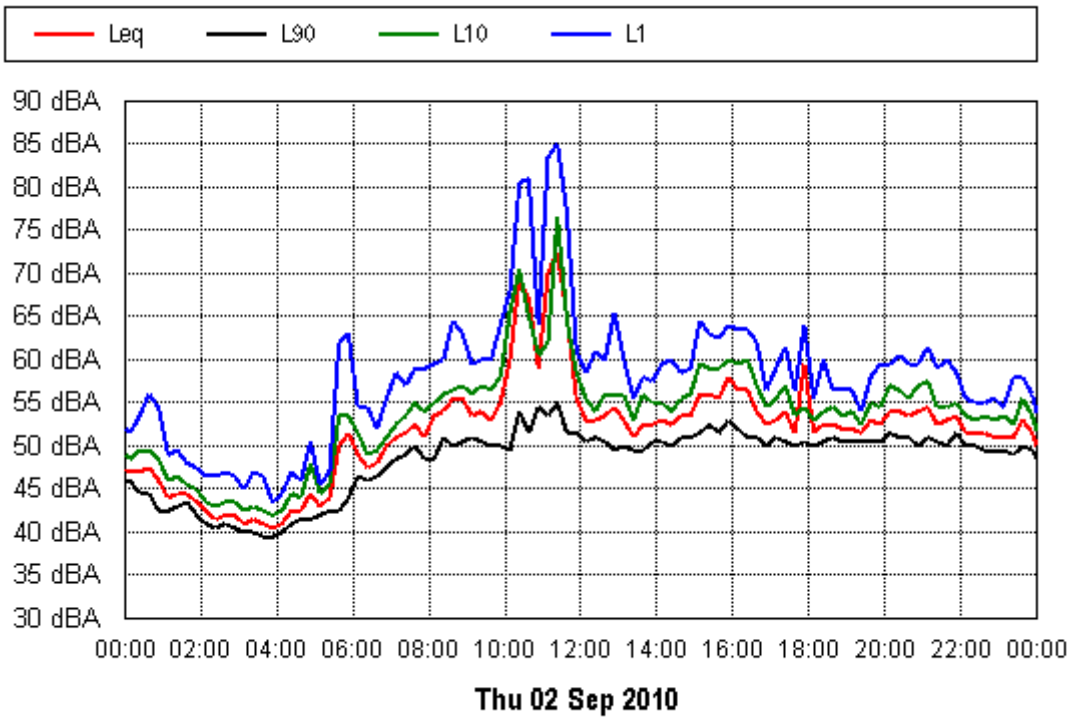

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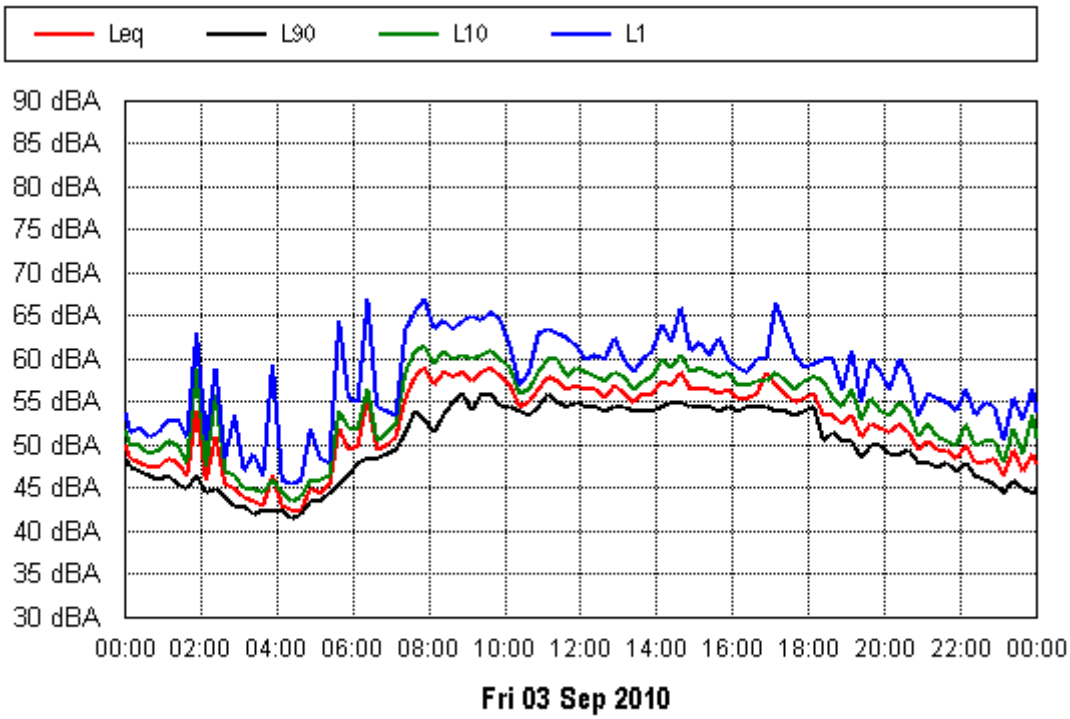

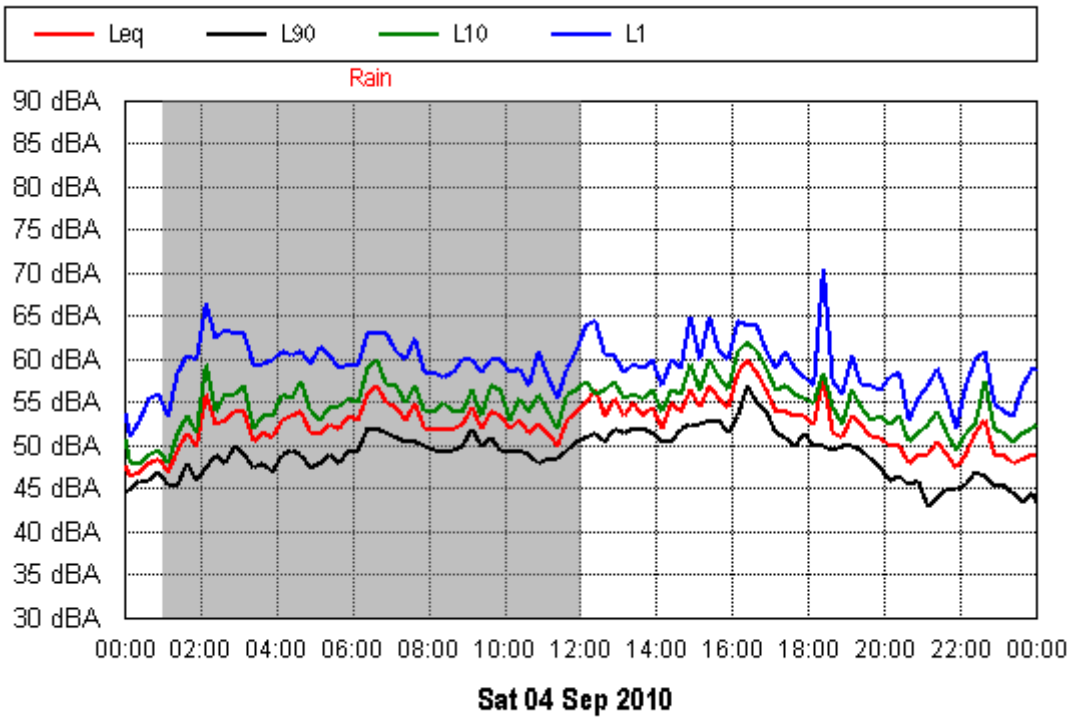

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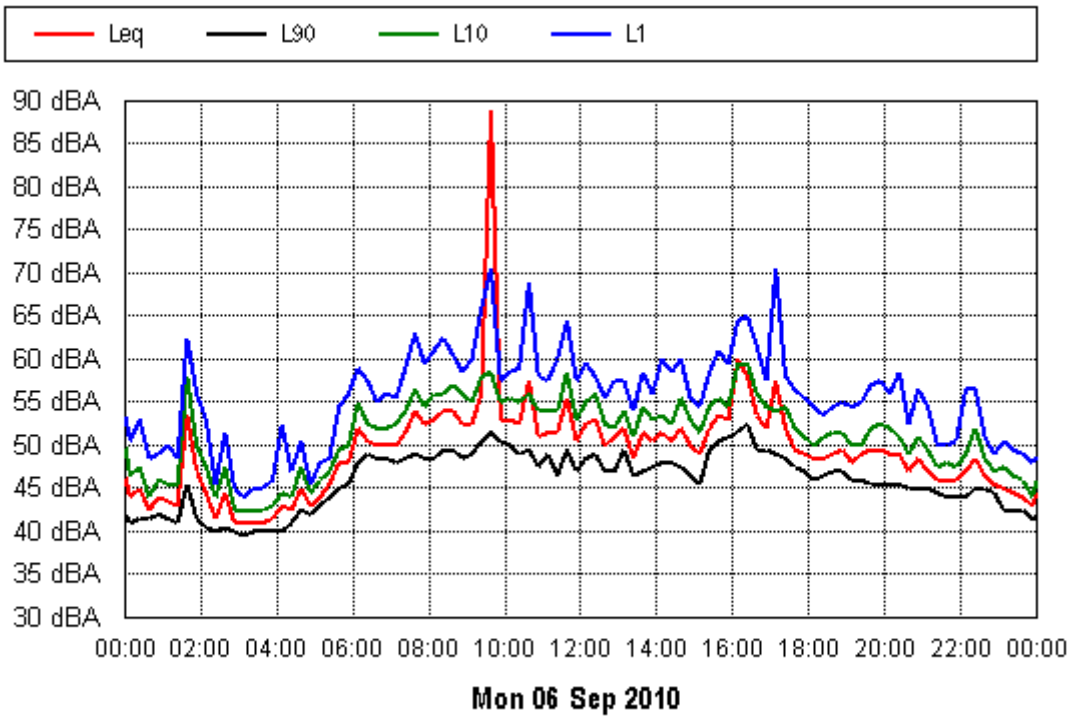

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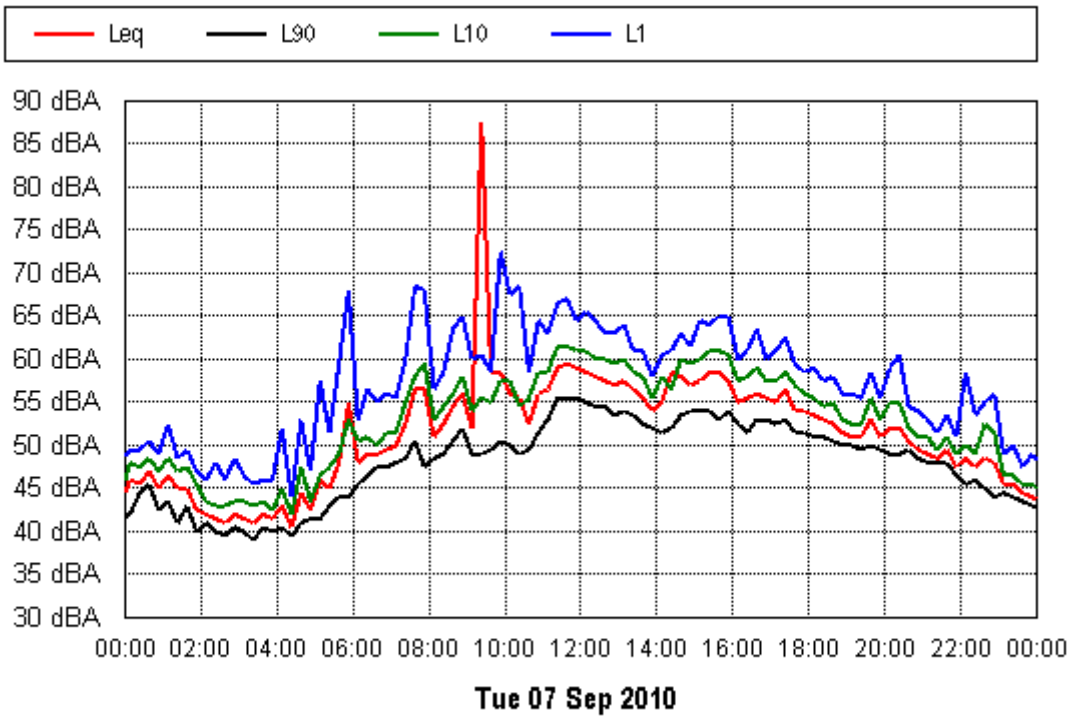

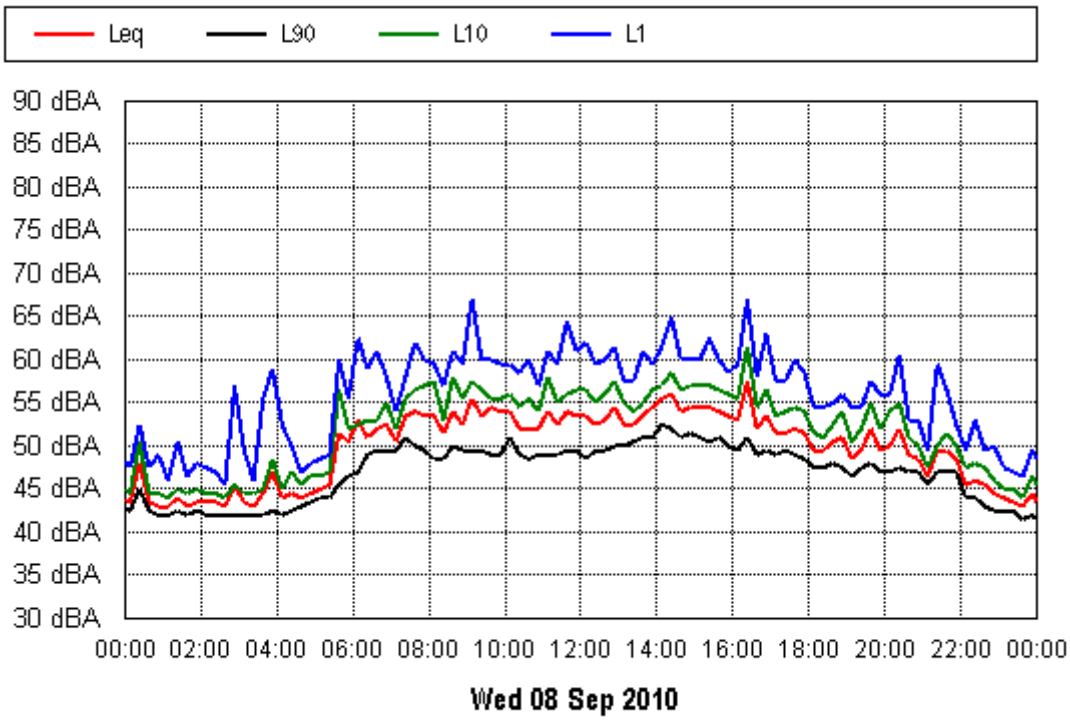

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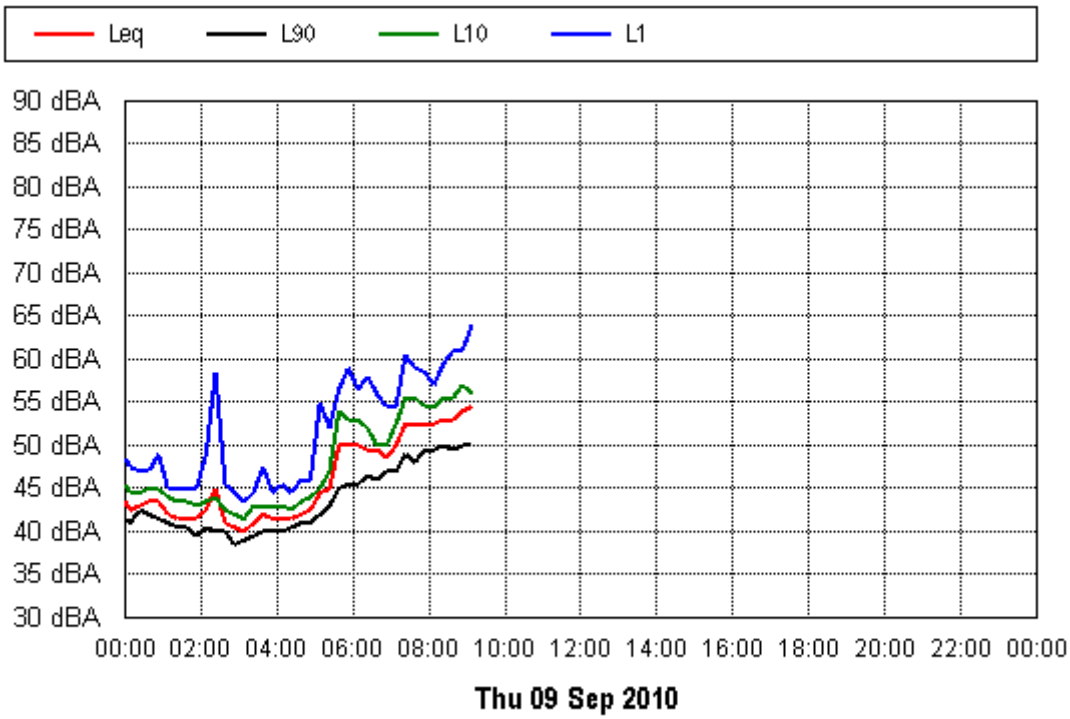

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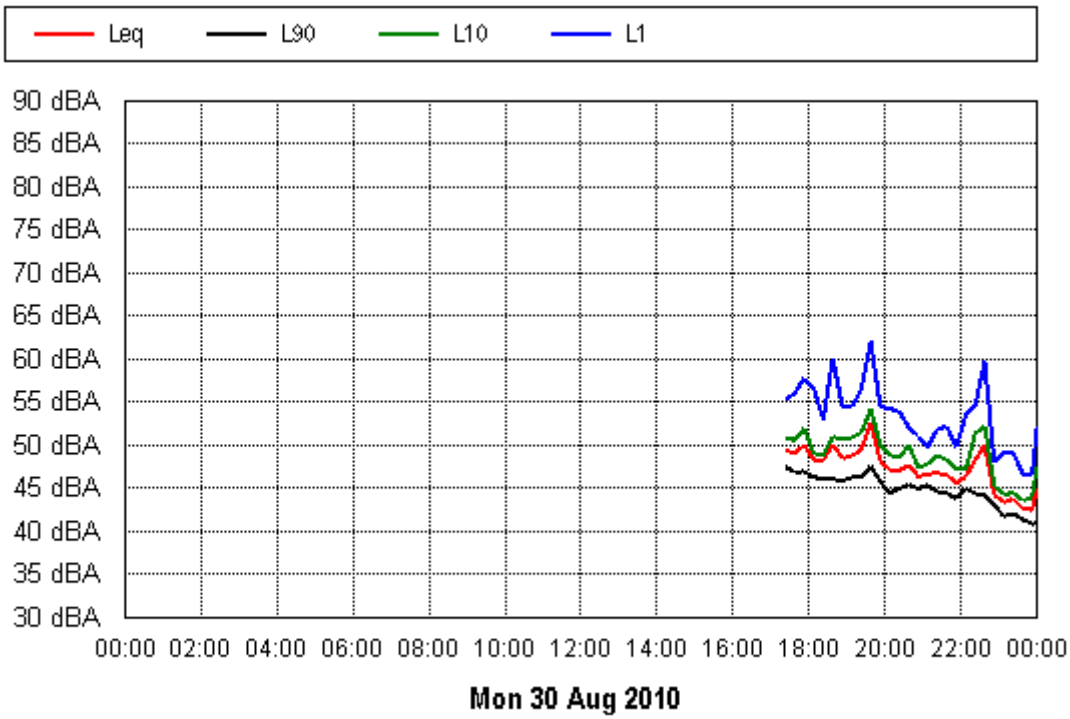

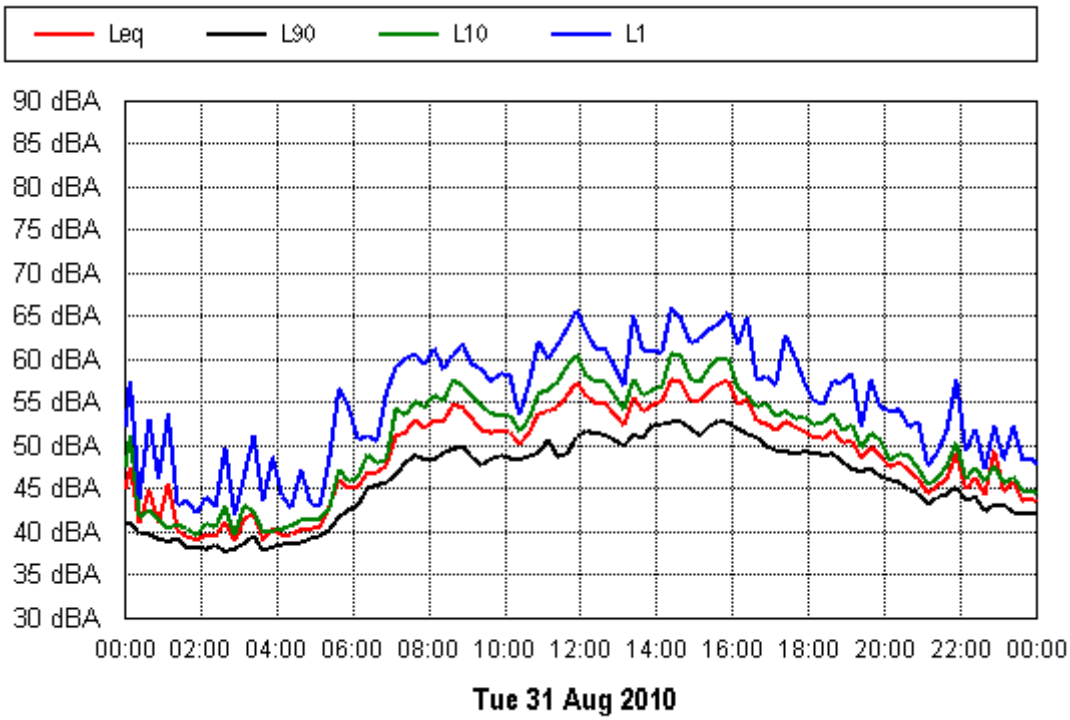

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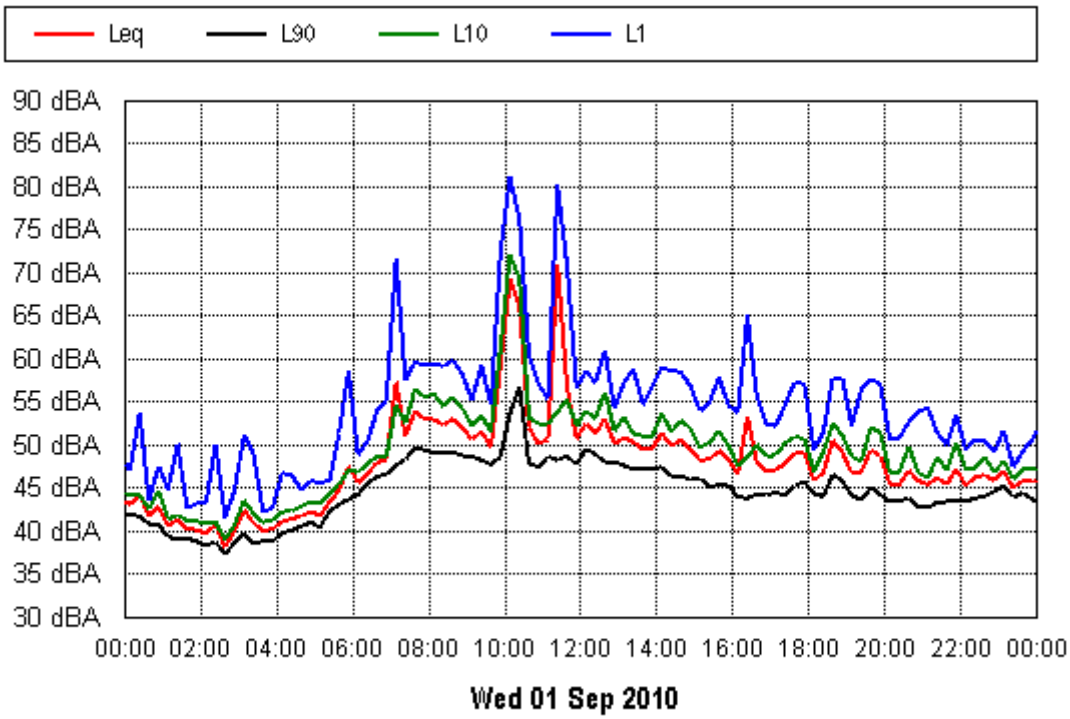

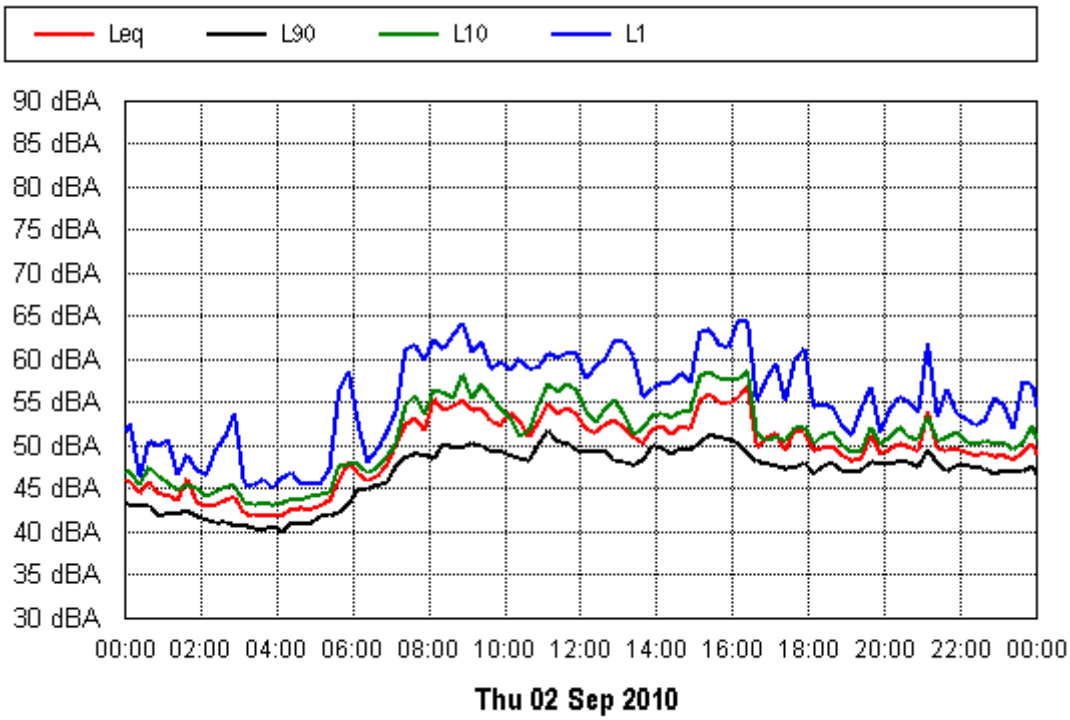

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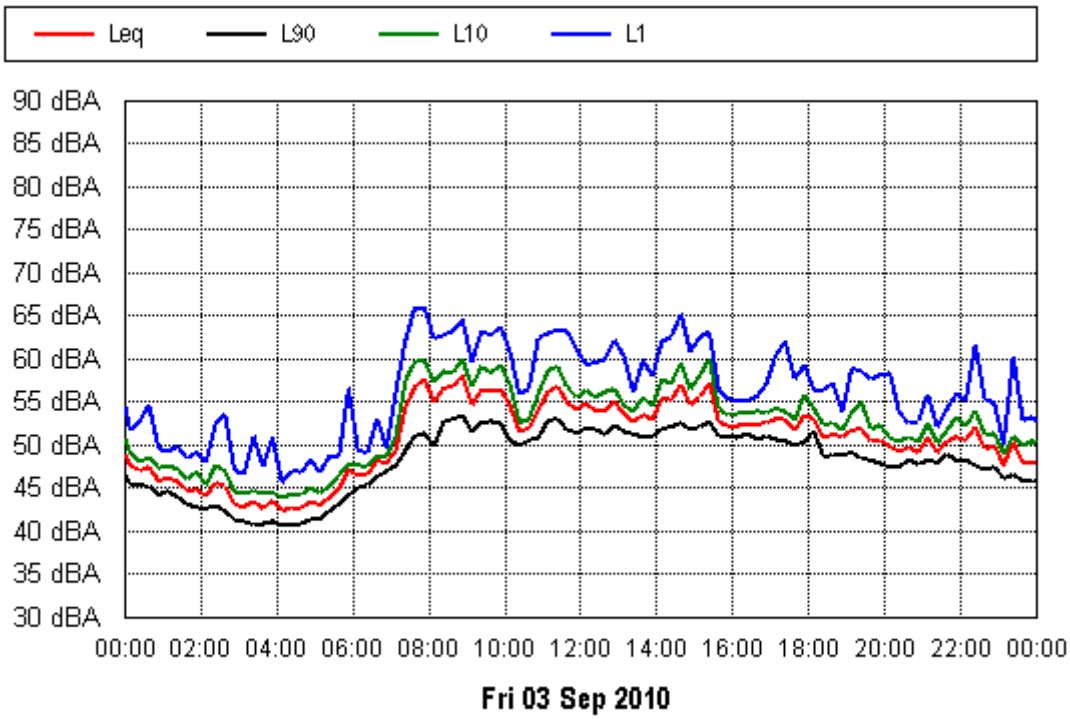

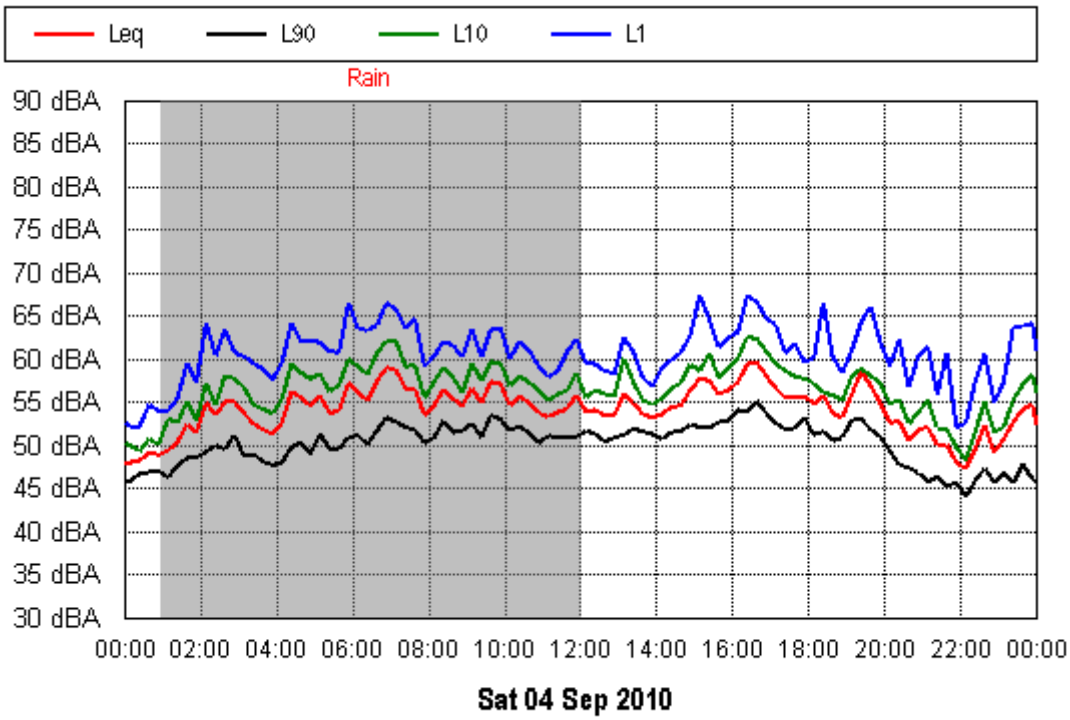

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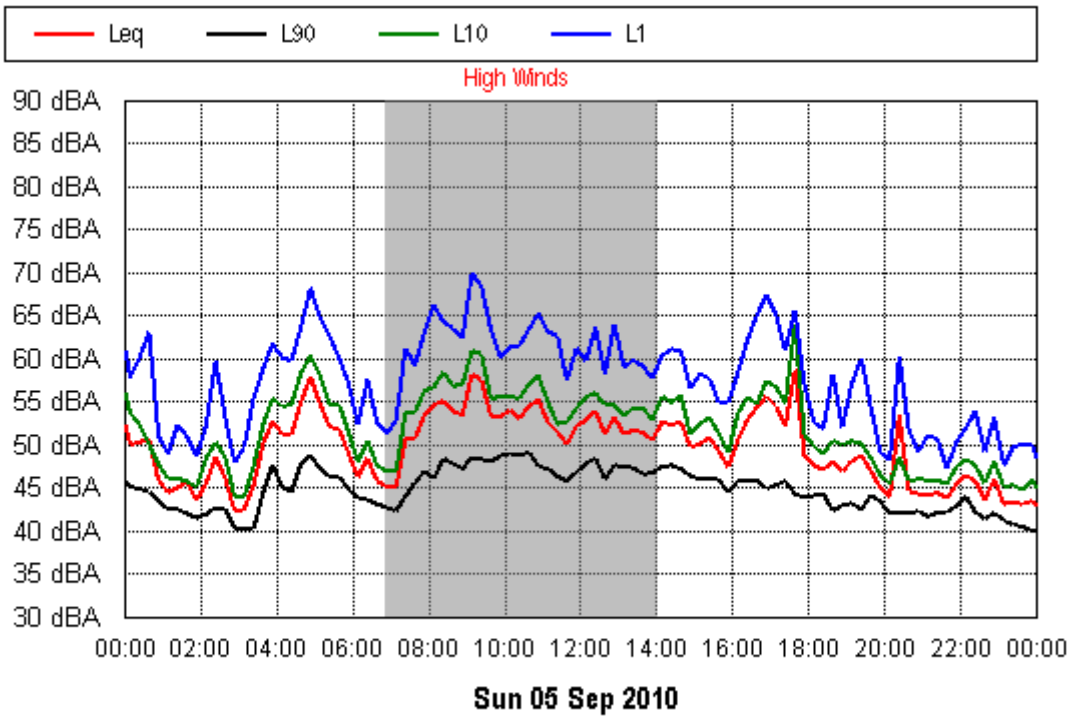

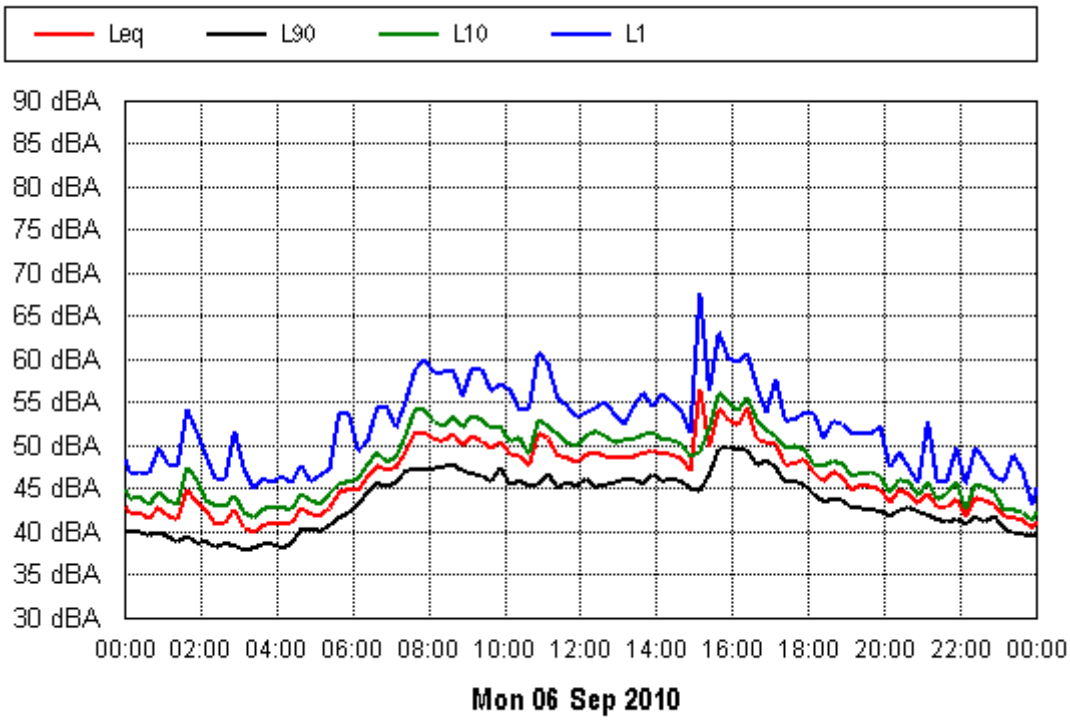

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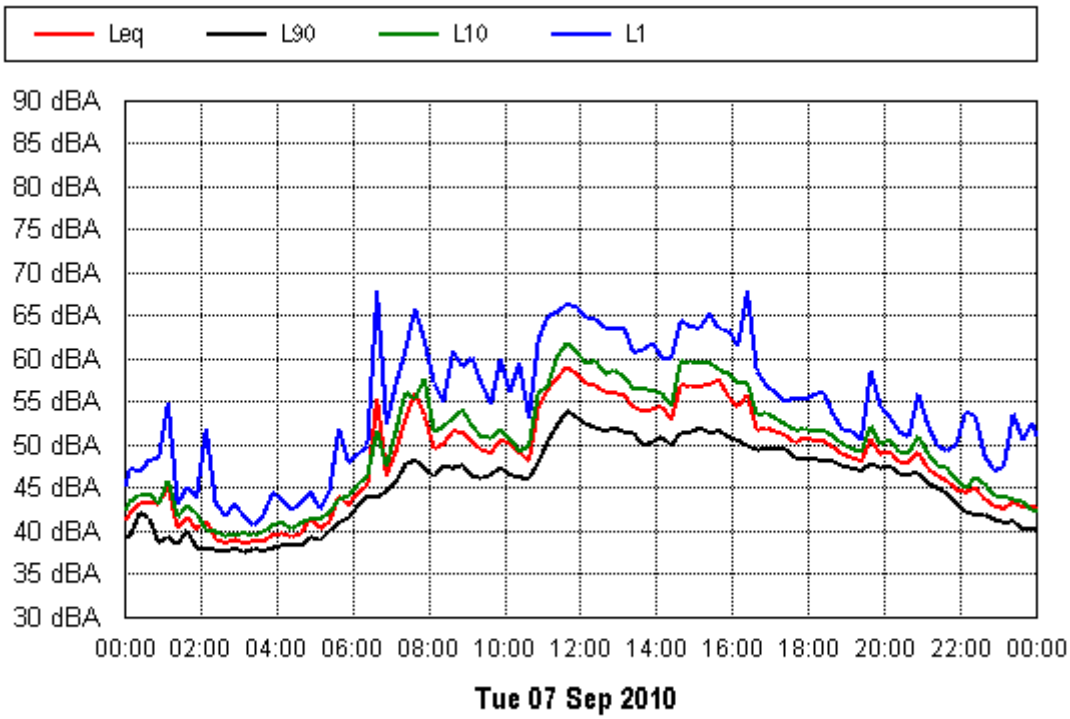

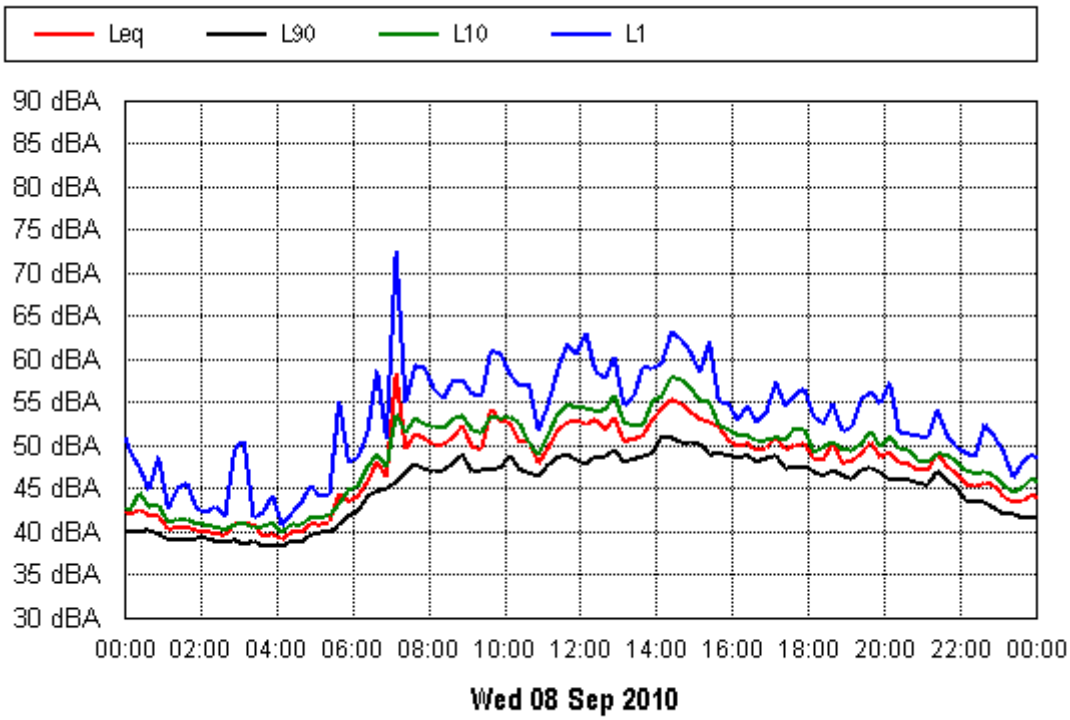

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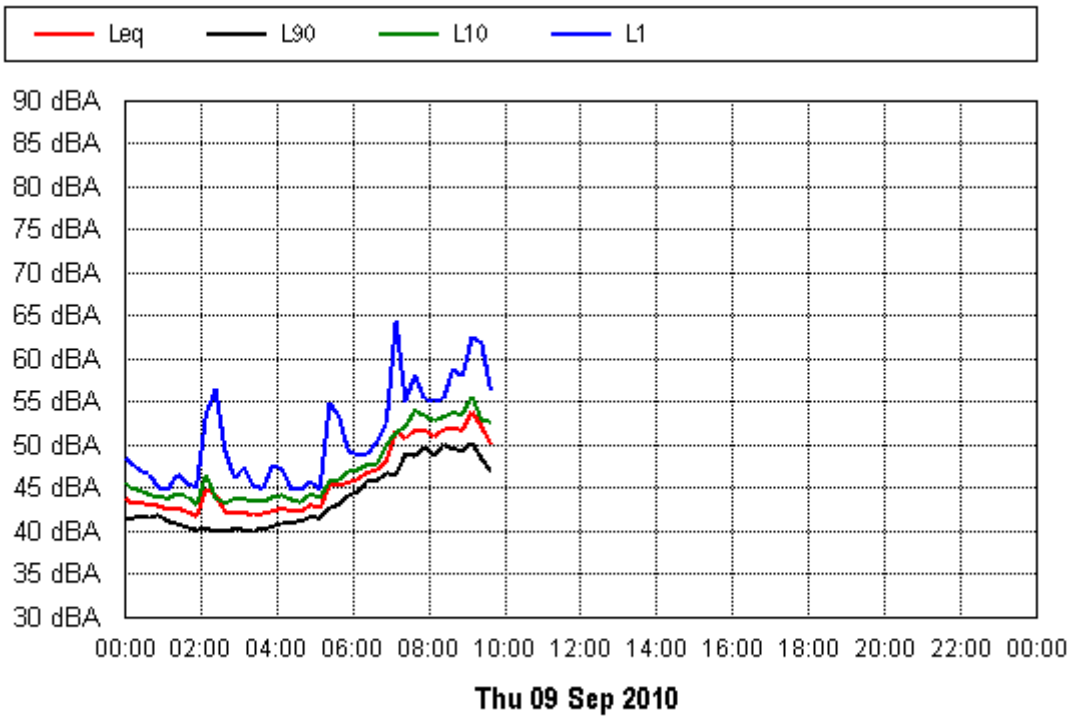


APPENDIX B

Estimated Plant and Truck Movements

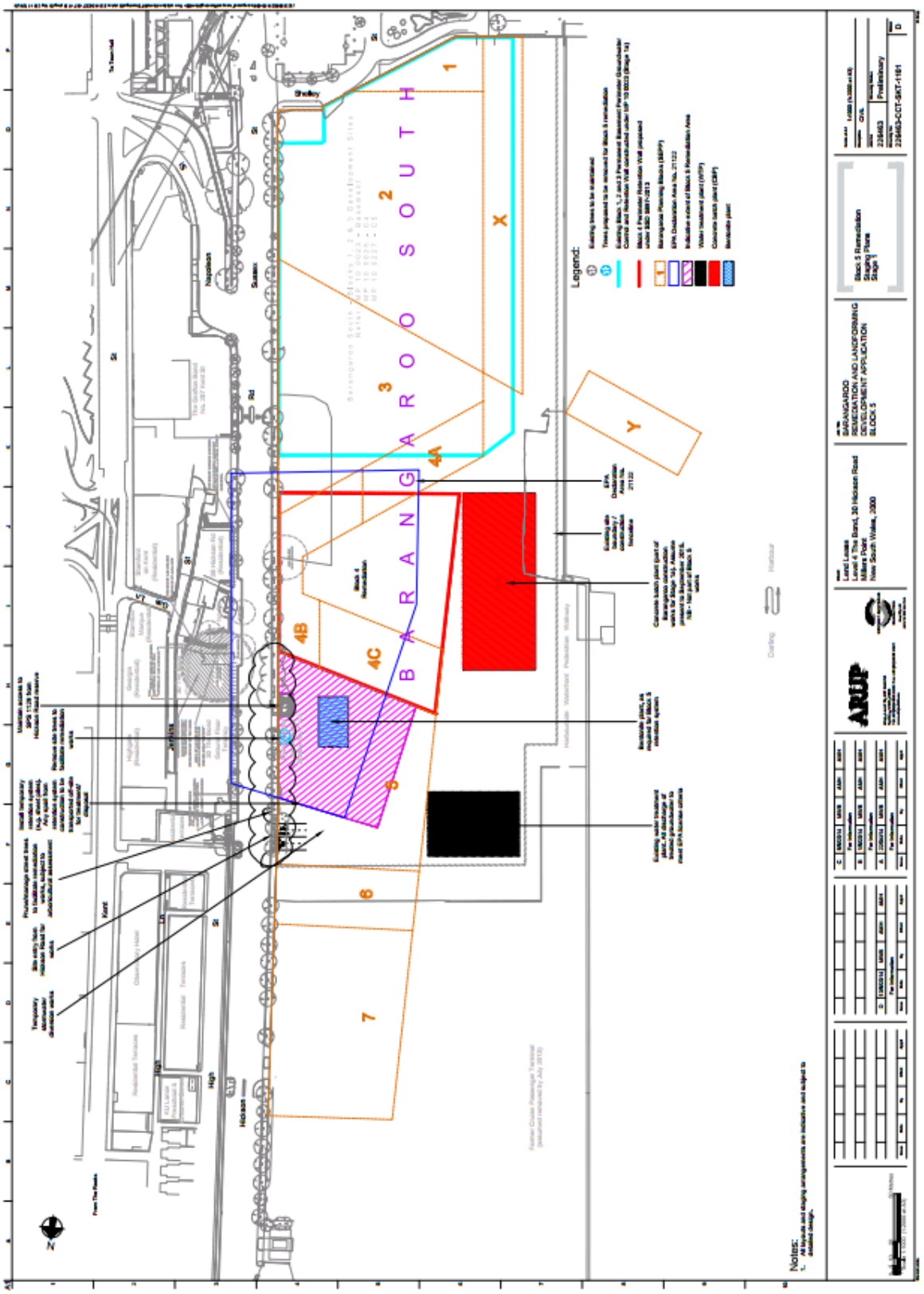
Equipment in Scenarios

		Stage 1	Stage 2	Stage 3	Stage 4
Block 5	Works	Remove site trees Install temporary retention Stormwater diversion	Dewatering / Install odour structures	Excavation - Remove surface pavement - Excavate contaminated materials - Transfer materials direct for off-site disposal - Dewatering	Backfilling Import fill Backfill / compact Remove temp. shoring
	Typical plant	Excavation Crane x 2 30 t excavator x 1 20t excavator x 1 Franna crane x 1 Bentonite plant (as req for retention system)	mobile cranes x2 boom lifts x3 40 tonne piling rig x1 Submersible water pumps x6 Watercart x1 Tip Truck x1	30 tonne excavators x2 20 tonne excavators x1 Front end loader x1 D7 or equivalent dozer x1 Submersible water pumps x3 Skid Steer Bobcat x1 Watercart x1 Tip Truck x1 Powerscreen x1 Crusher x1 Air extraction fans Generators Small piling / anchor rig x 2	Vibrating Roller x2 Bulldozer (D7) x1 Watercart x1 Grader 14ft x1 Tip trucks x2
	Est truck movements / day	10	20 (one-way)	50 off-site (one-way)	15 (one-way, import fill)
Other (Water Treat Plant)	Works	None	Water treatment	Water treatment	Water treatment
	Typical plant	None	Per current	Per current	Per current

APPENDIX C

STAGING PLANS

Stage 1



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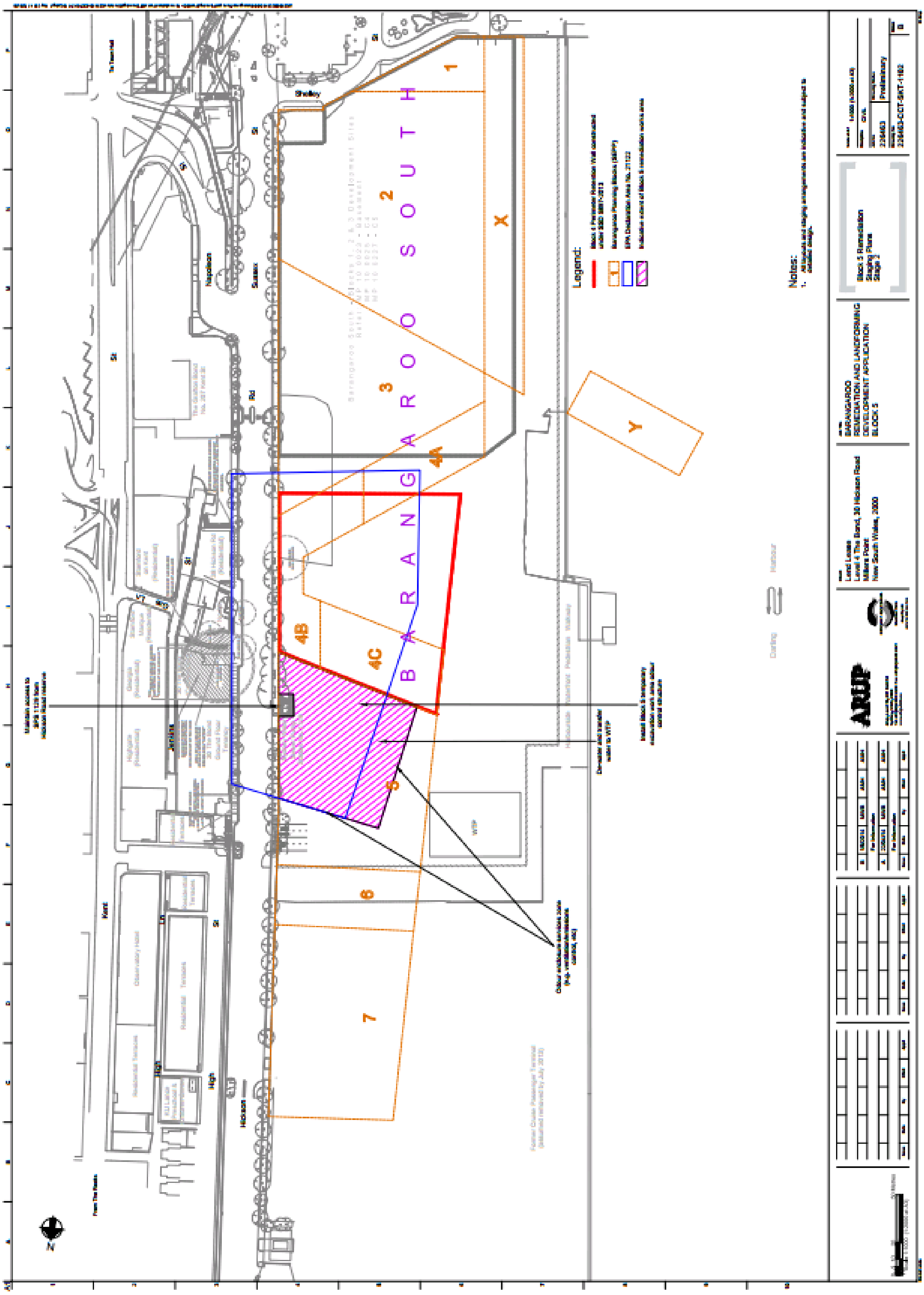
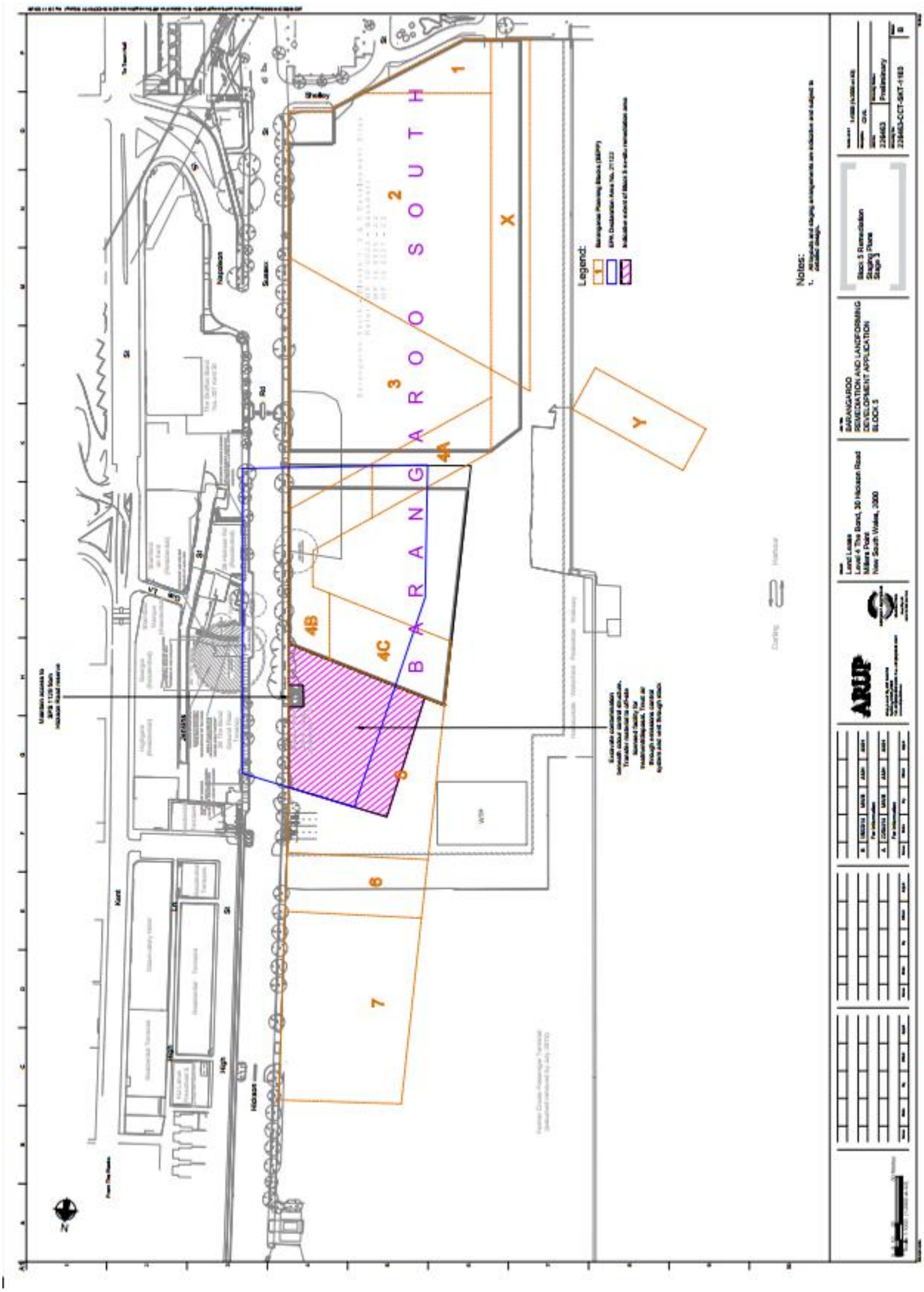
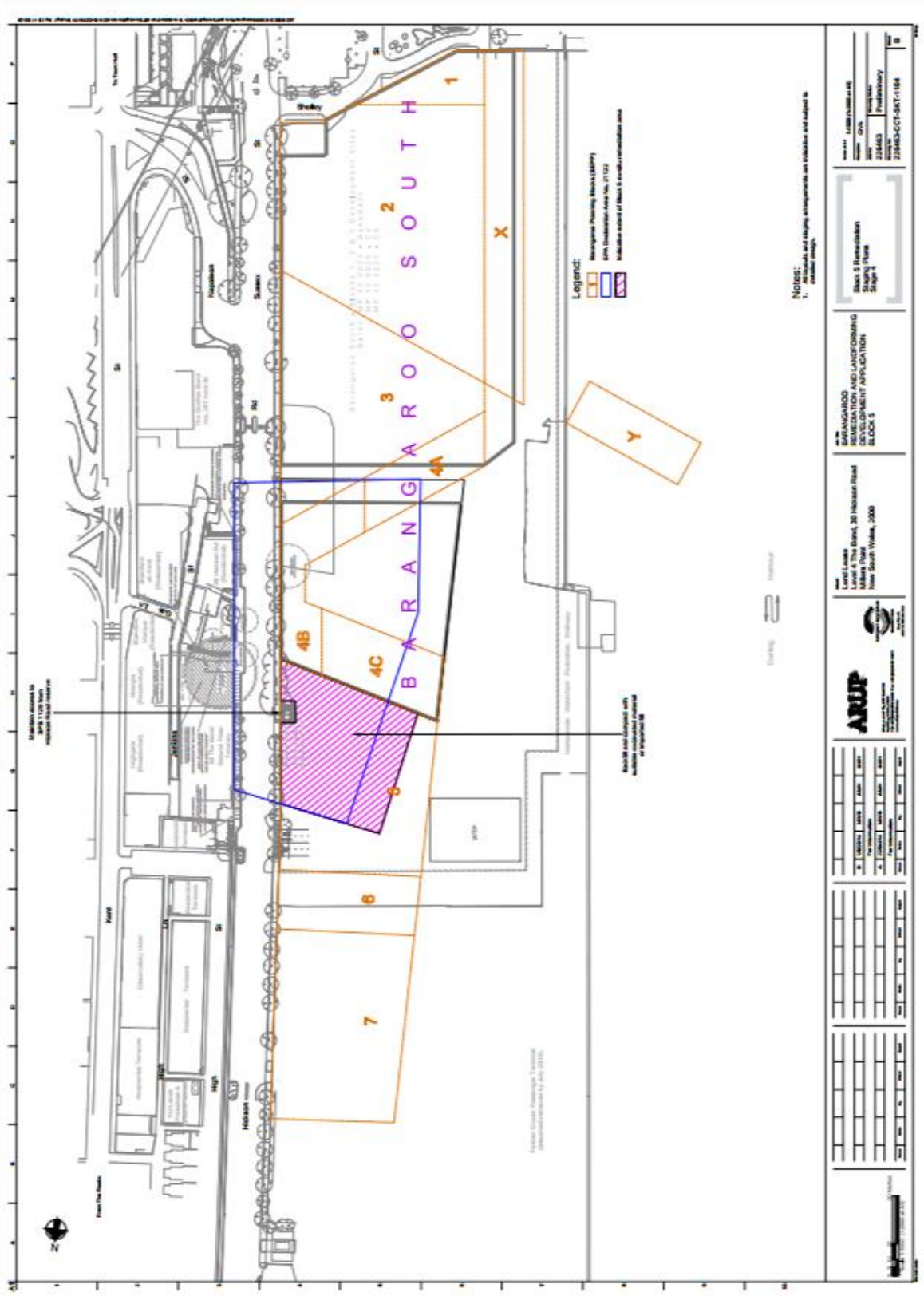


Stage 3



Stage 4


BARANGAROO SOUTH
1
2
3
4A
4B
4C
5
6
7
X
Y
Legend:
Notes:
ARUP
Level 4 The Bond, 30 Hickson Road
Millers Point
New South Wales, 2000
BARANGAROO
REMEDIATION AND LANDFORMING
DEVELOPMENT APPLICATION
BLOCK 5
Block 5 Remediation
Staging Plans
Stage 4
224463
Preliminary
224463-CCT-SKT-1164
N

APPENDIX D

ANALYSIS OF POSSIBLE NOISE REDUCTION MEASURES

Analysis of reasonable and feasible noise reduction measures

The following table provides an evaluation of whether measures are reasonable and feasible to implement.

Noise Reduction Measure	Measure type	Source	Day or Night	Reasonable and feasible?
In previous documents				
Encapsulate engine chambers and fit silencers to equipment. This typically provides 5dBattenuation, but can achieve attenuation up to 10dB(A) .	Quiet equipment		Day & night	Yes – install on equipment operating long term on-site.
Minimise equipment use especially during off peak hours.	Procedure		Night	Yes – reduce equipment used whenever practical.
Use temporary barriers or berms to shield construction equipment. Examples include: – Stacking containers around noisy equipment; – Constructing a shield around operation equipment such as dewatering pumps.	Shielding		Day & night	Yes – provide hoardings around the site, and barriers for pumps and static plant if needed. Provide barriers during permanent stormwater works.
Restricting times when noisy work is carried out (respite periods).	Procedure		Day	Yes – provide periods of relief when practical during noise intensive activities such as rock breaking.
Placement of work compounds, parking areas, equipment and material stockpile sites away from noise-sensitive locations.	Design		Day & night	Yes – current location of these facilities is away from noise-sensitive receivers.
Where noise barriers/walls are to be constructed, program this as early as possible to reduce noise impacts on neighbouring residents.	Procedure		Day & night	Yes – hoardings will be built at the commencement of construction.
Ensure that least noisy construction methods, vehicles, plant and equipment are used, and adopting alternative construction measures.	Quiet equipment		Day & night	Yes – bored piling preferred. Otherwise generally not feasible due to specialised construction equipment required.
Consider alternatives to, or curtailing of reversing alarms.	Quiet equipment		Day & night	Yes – non-tonal alarms for on-site equipment.
Prevent vehicles and plant queuing and idling outside construction hours.	Procedure		Day & night	Yes – procedural.
Identify measures to be implemented to ensure that where movement alarms are fitted to vehicles, plant or equipment entering or operating on the site, such alarms are of a type that minimised noise at noise sensitive receivers.	Quiet equipment		Day & night	Yes – non-tonal alarms.

Noise Reduction Measure	Measure type	Source	Day or Night	Reasonable and feasible?
Minimise use of impact piling techniques.	Quiet equipment / design		Day	Yes, bored piling preferred. Dependant on piling equipment used.
Based on current construction methods				
Silenced generators.	Quiet equipment		Day & night	Yes
Quiet compressors & pumps.	Quiet equipment		Day & night	Yes
Notify community two days in advance of noisy or planned out of hours activities.	Procedure		Day & night	Yes
Verification of noise model by monitoring equipment.	Procedure		Day & night	Yes, when operating as per predicted scenarios.