WOOD & GRIEVE ENGINEERS

Parkes Hospital Construction Noise and Vibration Management Plan

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Revision

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4	3/02/2014	Updated as per HI recommendations	ORFG

Contents

1. INTRODUCTION

Wood & Grieve Engineers have been engaged by the Appian Group (c/o Health Infrastructure) to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the construction of the new Parkes Hospital, located in Parkes NSW.

The objectives of the Lachlan Health Services Project, which includes the new build of Parkes Hospital, is to provide contemporary healthcare facilities suited to the current and future needs of the catchment population, and to provide capacity to support the agreed scope of clinical care in an environment that facilitates the delivery of contemporary health services.
Facility function should allow efficient bed utilisation and staffing to better meet the current and future needs of Parkes and the surrounding community.

The scope of the Parkes Hospital project is summarised as follows:

- Early Works including site preparation and bulk earthworks
- Construction of a new two-storey approx 9,000 sqm hospital building, including:
  - 28-bed inpatient unit;
  - Birthing unit;
  - Emergency Department;
    - Community and Ambulatory Care zone, including 6 chemotherapy chairs and 3 dental chairs;
    - Clinical Support Services, including Pharmacy; Pathology Laboratory and Medical Imaging; and
  - Non-clinical support services, including a Linen Distribution Centre for the district.
- Construction of single storey (approx 120 sqm) short-stay staff accommodation building.
- Access roads and circulation.
- On-grade car-parking for approximately 140 vehicles.
- Landscaping.
- Associated site infrastructure works.

The construction works for the Parkes Hospital was estimated to be 12 months for the purpose of the assessment.

This assessment discusses the predicted noise impact of construction noise and vibration of typical construction equipment on the nearest most-affected receivers whether residential or industrial.

This report provides:

- Noise and vibration criteria for construction stages
- Generic noise and vibration mitigation recommendations

The main purpose of the Construction Noise and Vibration Management Plan is to control and minimise the noise and vibration impact generated from construction activities on surrounding residents.

This construction noise impact assessment is based on the noise data collected from noise loggers installed at the nearest potentially affected receivers over a period of 7 days in August 2013.

The predicted noise levels are based on sound power levels of typical construction plant and equipment listed in this document and on a typical construction program. Nevertheless it is highly likely that this typical program will be modified by the successful tenderer for the project and therefore that the Construction Noise and Vibration Management Plan will require to be amended and updated once the successful tenderer is appointed.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore, this report shall not be relied upon as providing any warranties or guarantees.

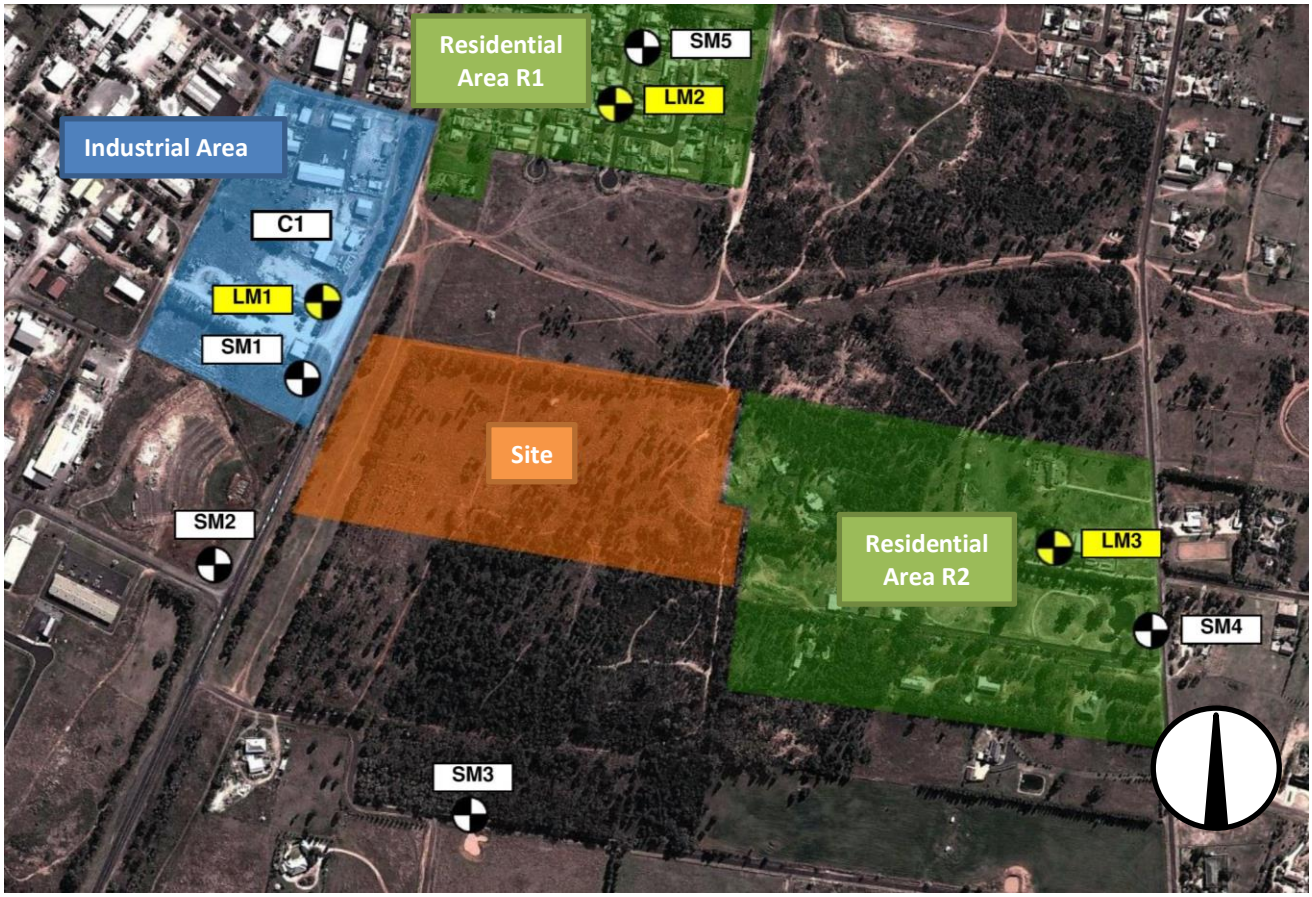
2. PROJECT DESCRIPTION

2.1 Site description

The site of the Parkes Hospital is bounded by Henderson St to the South, Newell Highway to the West and Back Yamma Road to the East, with Clancy Pl being one of the nearest roads north of the site. The nearest sensitive receivers have been identified as follows and are displayed in Figure 1:

- Location C1: Industrial receivers along the Newell Highway approximately 260m form the site (displayed in Blue)
- Location R1:Residential receivers to the North approximately 300m from the site (displayed in Green)
- Location R2: Residential receivers to the East approximately 320m from the site (displayed in Green)

Figure 1: Aerial Photo of the Area with Noise Measurement Locations



Source: Nearmap

2.2 Existing Noise Environment

The local ambient noise level is currently dominated by distant traffic noise, local traffic noise and general noise characteristic of a rural area. The background noise level varies over the course of 24-hour period, from a minimum level at night (from 10:00pm to 6:00am) to a maximum level during the day and evening which coincides with the area peak hours.

The NSW OEH Industrial Noise Policy (INP, Office of Environment & Heritage) defines background and ambient noise for the daytime, evening and night time periods. The NSW OEH INP defines these periods as follows:

Day: is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening: is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night: is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

Long term noise monitoring was undertaken during the day, evening and night at several locations around the proposed development for a period of 7 days in August 2013 to measure the background noise level of the site surroundings. The noise loggers were situated at a spot shielded from any mechanical plant or traffic noise in order to capture the typical background noise levels of the area.

The noise survey at the monitoring location was performed in the absence of intrusive mechanical plant (steady state noise) and is representative of the ambient noise of the areas surrounding the site. The results of short term noise measurement are summarized in Table 1.

These results have been used to establish the noise criteria at the boundary of the nearest residential premises so as to determine criteria for noise emission by construction activities for the proposed development.

Table 1 below shows a summary of the attended measurements results.

Table 1: Summary of short-term measurements

Measurement Location	Date/Start Time	$L_{Aeq,15min}$ dB(A)	$L_{A90,15min}$ dB(A)	Background Noise Description
SM1	27/08/2013 21:45	62	39	Traffic noise with approx. 90% trucks and 10% cars
SM2	27/08/2013 22:05	67	38	Traffic noise with approx. 90% trucks and 10% cars
SM3	27/08/2013 22:25	52	38	Ambient noise, distant traffic
SM4	27/08/2013 22:46	57	37	Ambient noise, distant traffic
SM1	10/09/2013 18:16	67	46	Traffic noise from Newell Highway dominating ambient noise
SM2	10/09/2013 17:48	71	53	Traffic noise from Newell Highway dominating ambient noise
SM3	10/09/2013 17:26	57	45	Ambient noise with some distant traffic
SM4	10/09/2013 17:03	61	42	Ambient noise with some distant traffic
SM5	10/09/2013 18:52	50	37	Ambient noise with some distant traffic

2.2.1 Long-term measurements

The three noise loggers (LM1, LM2 and LM3) were set to record statistical noise levels and continuously logged from Tuesday 28th August until Tuesday 10th September 2013. The data collected by the three noise loggers is also presented graphically in Appendix 1. The equipment recorded the noise levels over a 15-minute period and then determined the L_{A10}, L_{A90} and L_{Aeq} levels of the noise environment. Table 2 presents the results of the continuous averaged sound pressure levels (L_{Aeq}), and the rated background noise level (L_{A90}) see Appendix 2 for definitions.

Table 2: Summary of existing and background noise levels

Location	Rated background noise level RBL			$L_{Aeq,period}$		
	Day	Evening	Night	Day	Evening	Night
LM1	40	33	28	63	60	57
LM2	35	36	31	53	48	45
LM3	35	36	31	52	45	46

The noise loggers' detailed data is shown in Appendix 1.

2.2.2 Traffic Noise

The noise environment at SM2 for the day period was consistently dominated by the traffic noise during our attended measurements; therefore the measurement was extrapolated to a one hour period.
Table 3 presents the worst case scenario traffic noise level that will be used for the acoustic traffic assessment. .

Table 3: Road traffic noise levels from attended measurements

Measurement Location	Period	$L_{Aeq,60min}$ dB(A)	$L_{A10,60min}$ dB(A)
SM2	Day	71	75
SM2	Night	67	66

3. CONSTRUCTION NOISE AND VIBRATION CRITERIA

3.1 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the NSW Office of Environment and Heritage. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW OEH ICNG (July 2009) were specifically referenced. The limits presented in Table 4 apply.

Table 4: NSW OEH ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (7am – 4pm) No work on Sunday & Public Holidays	Noise Affected RBL + 10dB	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 meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	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 relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: • 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) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	• 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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

Note: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Source: Chapter 4 (Table 2 Sec 4.1.1) of NSW OEH ICNG.

3.2 Construction Noise Project Specific Levels

The noise levels presented in Table 5 are the construction noise criteria adopted for the project. These values are adopted from our long term noise loggers' results (LM2 and LM3).

Table 5: Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (7am – 4pm) No work on Sunday & Public Holidays	Noise Affected 45 dB	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 meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	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 relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: • 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) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected 40 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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

3.2.1 Construction Vibration Criteria

The OEH has developed a document, "Assessing vibration: A technical Guideline" in February 2006 to assist in preventing people from excessive vibration levels within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects.
Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

3.2.2 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 6. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 6: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
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 place of worship	Day or night time	0.020	0.014	0.040	0.028
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.014
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072

3.2.3 Human Comfort – Intermittent Vibration Criteria

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 7: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	**Daytime** (7:00am to 10:00pm)		**Night-time** (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.40
Critical areas	0.10	0.20	0.10	0.20

3.2.4 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure.

Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings".

Table 8 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 8: Guideline value of vibration velocity, vi for evaluating the effects of short term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		< 10Hz	10 - 50Hz	50 -100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20-40	40-50	40
2	Dwellings and buildings of similar design and/or use	5	5-15	15-20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3-8	8-10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 9 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 9: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
Residential or light commercial type buildings	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

3.3 Construction Vibration Project Specific Levels

Table 10 indicates the construction vibration criteria applicable to residential properties and schools located adjacent to the development site.

Table 10: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives					Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $m/s^{1.75}$ (VDV)	Impulsive vibration m/s^2 (RMS)		
		z-axis	x- and y-axis		z-axis	x- and y-axis	
Residential	Daytime	10-20	7.1-14	0.2-0.4	0.3-0.6	0.21-0.42	5
	Night time	7-14	5-10	0.13-0.26	0.1-0.2	0.071-0.14	5
Critical areas	Daytime or Night time	5-10	3.6-7.2	0.1-0.2	5-10 mm/s	3.6-7.2 mm/s	3

4. PROPOSED CONSTRUCTION ACTIVITIES

4.1 Proposed Works

A description of works and program is detailed below including the staging and nature of each construction stage (program).

Construction would generally be carried out between the hours of 7:00 am to 7:00 pm from Monday to Friday. However work may also be conducted on a Saturday between 7:00 am and 4:00 pm. On Sundays and Public Holidays there will be no work undertaken.

4.1.1 STAGE A – Site Establishment

The noisy equipment used during the site establishment works is assumed to be:

- Cordless screw drivers, hand held non-power tools.
- Other hand tools such as hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills
- Diesel power generator
- Trucks
- Vehicle (light commercial e.g. 4WD)

4.1.2 STAGE B – Earthworks

The noisy equipment used during the site establishment works is assumed to be:

- Bulldozer
- Scraper
- Excavator
- Compactor
- Roller (vibratory)
- Trucks (dump)
- Trucks
- Vehicle (light commercial e.g. 4WD)

4.1.3 STAGE C – Construction (Structure works)

The noisy equipment used during the site establishment works is assumed to be:

- Bobcat
- Excavator
- Piling (bored)
- Cordless screw drivers, reciprocating saw, hand held non-power tools
- Crane (mobile)
- Crane (tower)

- Hand held jackhammers, hammer drills (pneumatic)
- Other hand tools such as hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills
- Concrete agitator truck
- Concrete pump truck
- Concrete pencil vibrator
- Concrete vibrator screed
- Trucks (dump)
- Trucks
- Vehicle (light commercial e.g. 4WD)

4.1.4 STAGE D – Construction (Façade, Roof and internal Partitions)

The noisy equipment used during the site establishment works is assumed to be:

- Cordless screw drivers, reciprocating saw, hand held non-power tools
- Crane (mobile, lifting)
- Crane (tower)
- Hand held jackhammers, hammer drills (pneumatic)
- Other hand tools such as hammers, hand held hydraulic breakers, impact drivers, rattle drills
- Concrete agitator truck
- Trucks (dump)
- Trucks
- Vehicle (light commercial e.g. 4WD)

Once this stage is complete most of the works are primarily taking place within the building and therefore should not significantly impact the nearby residents due to the attenuation provided by the facades and the distance separating these facades from the nearest sensitive receivers.

4.1.5 STAGE E – Construction (Internal Building Services and Finishes)

The noisy equipment used during the site establishment works is assumed to be:

- Cordless screw drivers, reciprocating saw, hand held non-power tools.
- Hand held jackhammers, hammer drills (pneumatic)
- Other hand tools such as hammers, impact drivers, rattle drills
- Trucks (dump)
- Trucks
- Vehicle (light commercial e.g. 4WD)

4.1.6 STAGE F – External Works (Including landscaping)

The noisy equipment used during the site establishment works is assumed to be:

- Bobcat
- Excavator
- Cordless screw drivers, reciprocating saw, hand held non-power tools.
- Hand held hammer drills
- Other hand tools such as hammers, impact drivers, rattle drills
- Cherry picker

4.1.7 STAGE G – Certification / Completion of Works

The noisy equipment used during the site establishment works is assumed to be:

- Cordless screw drivers, reciprocating saw, hand held non-power tools.
- Hand held hammer drills
- Other hand tools such as hammers, impact drivers, rattle drills
- Cherry picker

5. CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

5.1 Plant Sound Level

The noise sources likely to be associated with demolition and construction are presented in the following section.

In order to assess the magnitude of potential noise and vibration impacts during construction, a number of typical scenarios using various type of equipment have been used. These scenarios are summarized in Table 11. The equipment noise levels are extracted from AS2436:2010 “Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites”.

Table 11: Construction Equipment List

Equipment	dB(A) SWL	dB(A) SPL (10 m)	Assumed No. hours / day
Hand tools such as hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	74	11
Hand held jackhammers, hammer drills (pneumatic)	116	88	8
Bulldozer	108	80	11
Cherry picker	105	77	8
Compactor	113	85	8
Concrete agitator truck	109	76	7
Concrete pencil vibrator	103	75	10
Concrete pump truck	108	80	8
Concrete vibrator screed	115	87	10
Crane (mobile)	104	76	6
Crane (tower)	105	77	9
Excavator	107	79	11
Forklift	106	78	7
Generator (diesel)	99	71	10
Jack hammer	121	93	8
Roller (vibratory)	108	80	10
Piling (bored)	125	97	10
Scraper	116	88	10
Truck (dump)	117	89	1
Truck	107	79	6
Vehicles (light commercial e.g. 4WD)	106	78	3

5.2 Predicted Noise Levels

The predicted noise levels at surrounding residential and industrial receivers have been assessed for construction.

The criteria specified in Table 5 are in accordance with Interim Construction Noise Guideline (ICNG July 2009) by the NSW Office of Environment and Heritage.

5.2.1 Assumptions for the predicted noise calculations

A minimum of 6mm single façade glazing system is assumed for the noise predictions at the boundary of the most sensitive receivers. This glazing system achieves the following sound transmission loss.

Table 12: Glass sound reduction index

Material	Octave band centered frequencies (R values) [dB]						
	63 Hz	125 Hz	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz
6mm single glazing	15	19	24	28	33	31	37

The predicted noise levels at the nearest receivers on Paterson Street (Residential – R1) and Back Yamma Road (Residential R2) are summarized in Table 13 and Table 14.

The following predictions assume all the listed equipment is running simultaneously for a period of 15-minute during each stage as a worst case scenario.

5.2.2 Predicted Noise Levels surrounding residential receivers

The predicted noise levels for the nearest residential receivers are as follows.

Table 13: Residential Predicted Noise Levels (R1)

Description	$L_{A,av,max}$ at Receiver (dB A)	Criteria (dB A)	Exceedance (dB A)	Compliance
STAGE A – Site Establishment	29	45	-	YES
STAGE B – Earthworks	37		-	YES
STAGE C – Construction (Structure works)	44		-	YES
STAGE D – Construction (Façade, roof and internal partitions)	36		-	YES
STAGE E – Construction (Internal Building Services and Finishes)	35		-	YES
STAGE F – External Works (including gardening)	33		-	YES
STAGE G – Certification / Completion of Works	27		-	YES

Table 14: Residential Predicted Noise Levels (R2)

Description	$L_{A,av,max}$ at Receiver (dB A)	Criteria (dB A)	Exceedance (dB A)	Compliance
STAGE A – Site Establishment	30	45	-	YES
STAGE B – Earthworks	35		-	YES
STAGE C – Construction (Structure works)	41		-	YES
STAGE D – Construction (Façade, roof and internal partitions)	35		-	YES
STAGE E – Construction (Internal Building Services and Finishes)	34		-	YES
STAGE F – External Works (including gardening)	31		-	YES
STAGE G – Certification / Completion of Works	26		-	YES

The predicted construction noise levels in Table and Table indicate that the required criteria will be met for all the potential scenarios with the implementation of some noise control measures.

The noise control measures that can be used, in order to reduce the noise levels at the boundary of the surrounding receivers, can include but are not limited to the following:

- Installation of temporary noise barriers (in the event that the attenuation performance of the exiting facade differs from our predictions).
- The use of quieter or silenced machinery (if feasible).
- Manage when the equipment is to be used such that all the equipment is not simultaneously being operated.

5.3 Construction Vibration Assessment

We are of the opinion that vibration emerging from the construction works is unlikely to cause any issue as the nearest residential are relatively far from the site and are not rigidly linked to site by any road ways.

5.4 Construction Traffic Assessment

It is our understanding that the maximum of traffic movements associated with the construction works is limited to 2 truck movement at any one time. We do not anticipate that this increase in traffic movements would cause any issues in terms of noise impact due to existing number of truck movements on the Newel highway and streets surrounding the site.

6. CONSTRUCTION NOISE AND VIBRATION MANAGEMENT

6.1 Management Plan

Earth works, Structure, Façade and Roof works

These four construction stages are predicted to produce the highest noise levels of all of the construction phases. It was assumed that the façade of the receiver's houses has an approximate Rw of 31 (see Table 12), this assumption is typical form country town residential building not located close to main transportation areas. In the event that the current attenuation is significantly lower than the one used in the predictions, alternative attenuation methods should be sought to manage the emanating noise from the construction site to the surrounding residents e.g. a sound proof hoarding or alternatively a temporary sound barrier could be erected around the site perimeter. The barrier should be impervious of gaps and cracks, which would compromise its performance. The barrier should be build out of acoustically suitable materials such as plasterboard, plywood, particleboard, or some other materials having equivalent or better acoustic performance.

Sporadic attended and unattended monitoring should be conducted during these stages of construction which represent the highest risk in terms of noise and vibration exposure for the surrounding community. This monitoring would include 15 minute measurements using a type 1 sound level meter, vibration analyzer and noise and vibration loggers. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

Other construction works

The remaining phases of construction are predicted to have a lower overall noise and vibration impact on the surrounding residents. Some of the internal works also will be completed after the façade will be installed minimizing even more the predicted noise levels.

Sporadic attended monitoring could also be conducted during this construction stage. This monitoring would include 15 minute measurements using a type 1 sound level meter and vibration analysis. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

The following flow chart (See Figure 2) can be used to assist with noise mitigation and management measures in order to comply with the standards as aforementioned.

6.1.1 Generic

According to AS 2436 – 2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* the following techniques could be applied to minimize noise and vibrations exposure of the potential most affected receivers.

NOISE

If noisy processes cannot be avoided, then the amount of noise reaching the receiver should be minimized. There are two ways of achieving this, either in increasing the distance between the noise source and the receiver or in introducing noise reduction measures such as screens.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. Practices that will reduce noise from the site include:

(a) Increasing the distance between noise sources and sensitive receivers.
(b) Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
(c) Constructing barriers that are part of the project design early in the project to provide mitigation against site noise.
(d) Installing purpose built noise barriers, acoustic sheds and enclosures.

Screening

On site where distance source-receiver is limited, the screening of noise may be of benefit and this should be taken into account at the planning stage.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, then sound insulation measures may be necessary to protect workers occupying them.

A hoarding that includes a site office on an elevated structure offers a superior noise reduction when compared with a standard (simple) hoarding. This performance is further enhanced when the hoarding is a continuous barrier.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. Noisy stationary plant can be put in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficient running.

Where such noise barriers are not practicable, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen the plant from any noise-sensitive areas. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant and equipment that operate on a 24-hour basis may not be a source of noise nuisance by day but can create problems at night. They should therefore be effectively screened either by being sited behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

In many cases it will not be practicable to screen earthmoving operations effectively, but it may be possible to partially shield construction plant or to build-in at the early stages protective features ultimately required to screen traffic noise.

Where earth noise barriers are not a practical proposition because of lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any of the materials suggested in

Appendix D of AS2436:2010 “Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites”.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the listener, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (in case it is a diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from it.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternatives capable of providing a safe system of work that are equal to or better than the traditional ‘beeper’, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

(a) Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal-frequency ‘beep’) are less intrusive when heard in the neighbourhood.
(b) Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
(c) Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, providing safety considerations, are not compromised.
(d) Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
(e) Spotters or observers.

The above methods should be combined, where appropriate.

VIBRATIONS

Vibration can be more difficult to control than noise, and there are few generalizations that can be made about its control. It should be kept in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement. Impulsive vibration can, in some cases, provide a trigger mechanism that could result in the failure of some building component that had previously been in a stable state.

During the demolition works some vibrations (transmitted through the structure from the demolition sites) are expected, being more of a concern for the surrounding sensitive receivers.

It can also trigger annoyance being elevated into action by occupants of exposed buildings, and should therefore be included in planning of communication with impacted communities. It should be remembered

that failures, sometimes catastrophic, can occur as a result of conditions not directly connected with the transmission of vibrations, e.g. the removal of supports from retaining structures to facilitate site access. BS 7385-2 provides information on managing ground borne vibration and its potential effects on buildings.

Where site activities may affect existing structures, a thorough engineering appraisal should be made at the planning stage.

General principles of seeking minimal vibration at receiving structures should be followed in the first instance. Predictions of vibration levels likely to occur at sensitive receivers is recommended when these are relatively close, depending on the magnitude of source of the vibration or the distance involved. Relatively simple prediction methods are available in texts, codes of practice or other standards, however it is preferable to measure and assess site transmission and propagation characteristics between source and receiver locations.

Comparison of predicted levels of vibration with preferred or regulatory levels will indicate when either more detailed predictions are required or mitigation of transmitted vibration is advisable or necessary. Guidance in measures available for mitigation of vibration transmitted can be sought in more detailed standards, such as BS 5228-2 or policy documents, such as the NSW DEC Assessing Vibration: A technical guideline.

Identifying the strategy best suited to controlling vibration follows a similar approach to that of noise—of avoidance, control at the source, control along the propagation path, control at the receiver, or a combination of these. It is noted that vibration sources can include stationary plant (pumps and compressors), portable plant (jackhammers and pavement vibrators), mobile plant, pile-drivers, tunneling machines and activities, and blasting, amongst others. Unusual ground conditions, such as a high water-table, can also cause a difference to expected or predicted results, especially with piling.

Figure 2: Noise Mitigation Management Flow Chart

6.2 Complaint Handling Procedures and Community Liaison

It is recommended that the builder directly contact adjacent noise sensitive receivers and provide them with the following information:

a. The contact details for a nominated representative in order to make noise / vibration complaints.
b. Explain the timeframe for the works and the proposed activities, i.e the proposed start / stop dates of work, and a description of what noise producing works will take place.
c. Notify the noise sensitive receivers and Parkes Shire Council in a timely manner should there need be any extension to the proposed arrangements.
d. Provide them with a copy of this report as approved by the Parkes Shire Council.
e. The Parkes Shire Council should be notified of the nature and details of complaints received (time, complainant etc) and what remedial action has taken place, if any.

f. Where noise is demonstrated as being compliant with criteria, this should not limit the proponent in undertaking further additional reasonable and feasible steps to reduce noise emissions.

To assist in the management of noise and vibration complaints various procedures are to be followed, these include:

- Clearly visible signage identifying any key personnel along with their contact details is to be erected along the perimeter of the building site including;
    - A 24 hour contact name, phone number and email address provided for the resident to address any complaint. The signage will declare; “For any enquiry, complaint or emergency relating to this site at any time please contact…”
- Give complaints a fair hearing
- Have a documented complaints process, including an escalation procedure so that if a complaint is not satisfied there is a clear path to follow
- Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night time only if requested by the complainant to avoid further disturbance
- Implement all feasible and reasonable measures to address the source of the complaint
- A register is to be kept by the contractor to keep a record of complaints and detail any information associated with them. The contents of the register will include:
    - The name and the address of the complaint
    - Time and date of the complaint
    - The nature of the complaint (Noise/Vibration)
    - Subsequent details
    - Remedial action undertaken

The contents of the register will be maintained and updated with any new complaint without delay. The report will be reported to both Parkes Shire Council and Wood & Grieve Engineers. The investigation of the complaint and any remedial actions will be performed by the builder projects and/or Wood & Grieve Engineers.

In the event of noise works, the builder will notify residents 3-7 days in advance.

7. CONCLUSION

This report presents the results of a study of operational noise emission from the proposed new development of the Parkes Hospital located in Parkes NSW. This report forms a part of the documentation package to be submitted to the authority (Department of Planning and Infrastructure) as part of the State Significant Development Application for the proposed Parkes Hospital redevelopment.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed development have been established based on Parkes Shire Council requirements and state policy guidelines. The establishment of the noise criteria was based on our noise survey which monitored ambient and background noise levels using both hand held sound level meters and long-term noise loggers at the boundary of the potentially most-affected receivers.

Road traffic noise criteria intrusion was also established based on the requirements of Parkes Shire Council and state policy guidelines.

The predicted noise levels presented in this report show that the most stringent noise criterion will be met for all the construction stages at the nearest residential receivers. Regardless, we recommend the implementation of generic mitigation measures for external noise sources. Nevertheless it is highly likely that this typical program will be modified by the successful tenderer for the project and therefore that the Construction Noise and Vibration Management Plan will require to be amended and updated once the successful tenderer is appointed.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the proposed development should not be refused on the grounds of excessive noise generation.

Appendix 1: Noise Logger Results

Figure 3: Long term measurement location LM1

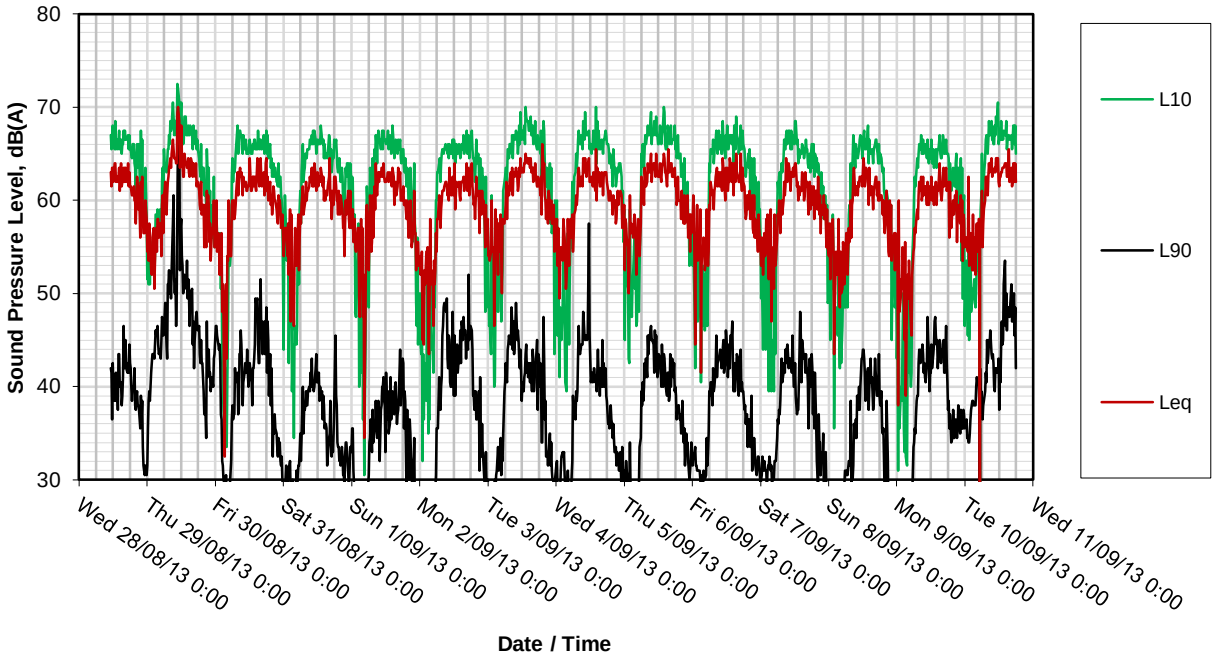


Figure 4: Long term measurement location LM2

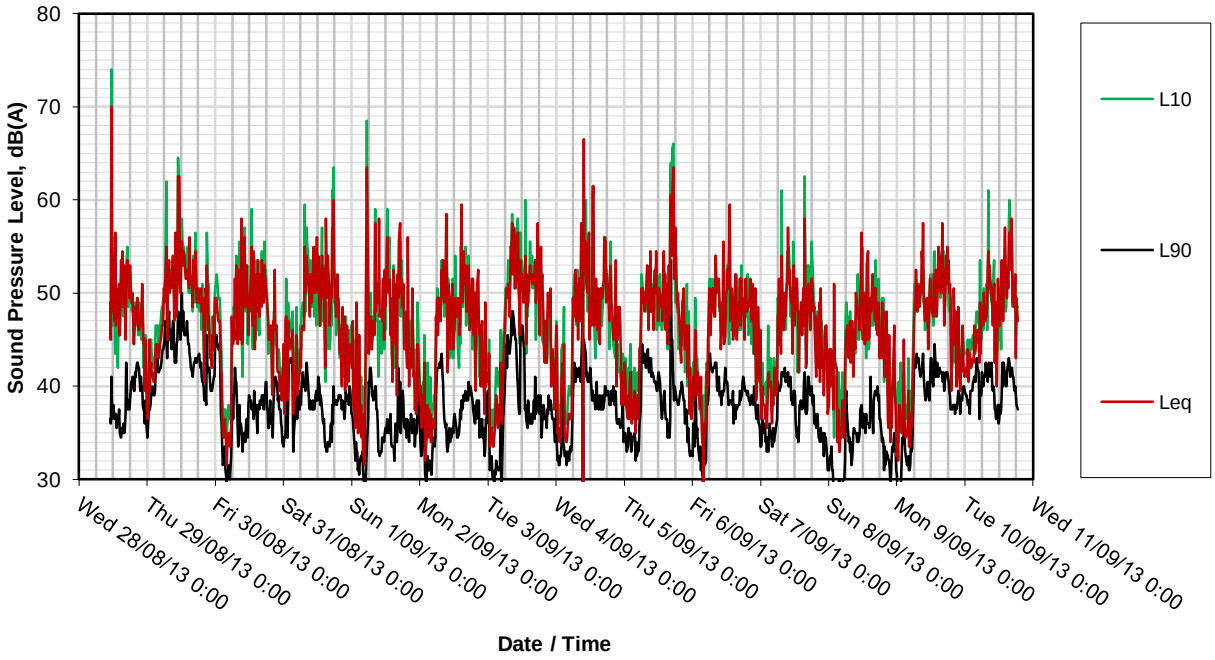
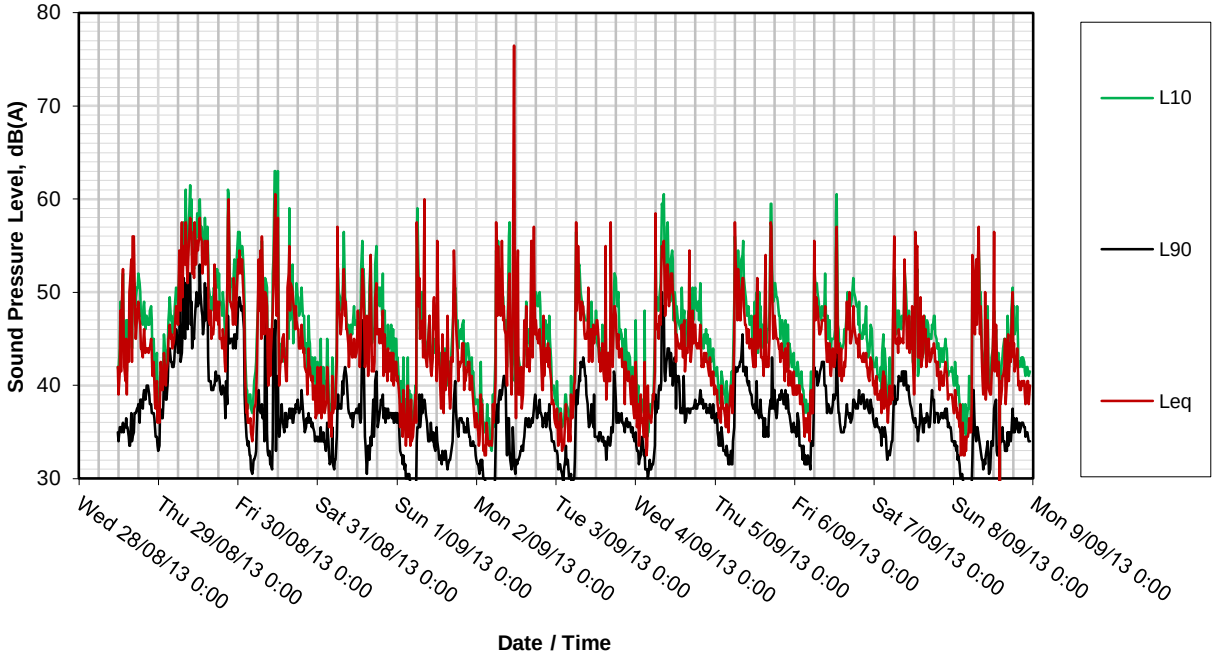


Figure 5: Long term measurement location LM3



Appendix 2: Glossary of Acoustic Terms

Acceptable Noise Level: The acceptable L_{Aeq} noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.

Adverse Weather: Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).

Acoustic Barrier: Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.

Ambient Noise: The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.

Assessment Period: The period in a day over which assessments are made.

Assessment Location: The position at which noise measurements are undertaken or estimated.

Background Noise: Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the $\mathbf{L_{90}}$ noise level.

Decibel [dB]: The units of sound pressure level.

dB(A): A-weighted decibels. Noise measured using the A filter.

Extraneous Noise: Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.

Free Field: An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.

Frequency: Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).

Impulsive Noise: Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.

Intermittent Noise: Level that drops to the background noise level several times during the period of observation.

$\mathbf{L_{Amax}}$ The maximum sound pressure level measured over a period.

$\mathbf{L_{Amin}}$ The minimum sound pressure level measured over a period.

$\mathbf{L_{A1}}$ The sound pressure level that is exceeded for 1% of the time for which the sound is measured.

L_{A10}	The sound pressure level that is exceeded for 10% of the time for which the sound is measured.
L_{A90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{Aeq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection:	Sound wave changed in direction of propagation due to a solid object meets on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.