Noise and Vibration Assessment

Summary

The ambient noise environment at and near the proposed site ('North Penrith') has been analysed in order to accurately characterise the existing rail, traffic and industrial noise contributions in the absence of the proposed development.

Project-Specific Noise Limits (PSNL) were derived for habitable and other functional spaces within the proposed buildings with the necessary recommendations of noise and vibration mitigation measures where applicable.

Objectives

This report presents the methodology and results of the Noise and Vibration Assessment (the 'assessment') for the proposed mixed use development at North Penrith.

The assessment considered existing railway noise and vibration from the Penrith Railway Line Corridor flanked to the south of the subject site as well as noise from existing traffic movements and light industries along Coreen Avenue situated to the north of the proposed site.

Potential noise and vibration from the construction phase of the proposed development has also been taken into account.

Road traffic noise along Coreen Avenue and the Commuter Carpark Road for the assumed year of opening (2016) and ten years after opening (2026) has been assessed based on Parsons Brinckerhoff's *Forecast Traffic Conditions on Coreen Avenue* and National Project Consultants' *Commuters: Cars count at entry road* respectively.

Methods and findings

This assessment has been undertaken in accordance with relevant noise criteria as stated within the following policies and guidelines:

Rail Noise and Vibration

- State Environmental Planning Policy (Infrastructure) 2007;
- NSW Department of Planning's *Development Near Rail Corridors and Busy Roads – Interim Guideline*;
- Australian Standard AS 2377-2002: *Acoustics-Methods for the measurement of railbound vehicle noise*;
- Railcorp's *Interim Guidelines for Applicants - Consideration of Rail Noise and Vibration in the Planning Process*; and

- Existing vibration levels due to the Penrith railway line have been measured and evaluated against BS 6472 and AS 2670 (human response) and DIN 4150 (cosmetic damage).

Traffic Noise

- NSW DECCW's *Environmental Criteria for Road Traffic Noise* (ECRTN); and
- RTA's *Environmental Noise Management Manual* (ENMM).

Construction Noise and Vibration

- NSW DECCW's *Interim Construction Noise Guideline*; and
- Safe working distances during the construction phase of the project have been provided in accordance with BS 6472 (human response) and BS 7385 (cosmetic damage) to minimise potential vibration impacts from vibration intensive construction plant.

Industrial Noise

- NSW DECCW's *Industrial Noise Policy* (INP).

Building Design

- Building Code of Australia.

Conclusions

The assessment concludes that the proposed development is expected to comply with the project-specific noise and vibration objectives with the recommended acoustic considerations incorporated into the residential and commercial buildings proposed onsite.

These acoustic considerations are recommended to be incorporated during the design phase of the proposed development.

ESD principles demonstrated in the project

The following ESD principles were considered as part of this assessment:

- precautionary principle;
- reducing externalities;
- conservation of biological diversity; and
- preservation of intergenerational equity.

Recommendations

Concept Plan

This assessment recognises that acoustic considerations are required for residential and commercial buildings proposed onsite.

When proposing a development near a railway line, the NSW Department of Planning's *Development Near Rail Corridors and Busy Roads – Interim Guideline* suggests that commercial and industrial premises can often provide a valuable buffer between the (noise source) and adjacent residential and other noise sensitive uses. The Masterplan is a response to the site, and provides part of the foundation for the design response proposed by including buffer zones of industrial and mixed use areas both contiguous to the Penrith railway corridor and Coreen Avenue.

Guiding factors in terms of managing and ameliorating the issue of railway noise at the proposed residential, light residential and commercial premises proposed at North Penrith are outlined in the Building Design section of the report and are recommended to be incorporated into the built form.

Vibration impacts due to the Penrith railway operations have been assessed to account for human comfort and cosmetic damage to the proposed buildings onsite. The findings from this assessment indicate that the associated vibration levels comply with BS 6472 and AS 2670 (human response) and DIN 4150 (cosmetic damage). As such, no specific recommendations have been provided in this regard.

Stage 1 Project Application

During the construction phase of the proposed development at North Penrith, minimal noise impacts are predicted at the surrounding offsite receiver locations.

However, in response to the DGR, noise safeguards as well as safe working distances for vibration-intensive construction plant have been provided under the Assessment section of this report in order to minimise any undue noise and vibration impacts from the proposed construction works at the nearby offsite receivers.

Noise Mitigation

Appropriate noise mitigation measures and vibration safeguards have been detailed to address the existing noise and vibration levels from the Penrith rail line as well as during the proposed construction phase of the development.

Noise from the existing industries and road traffic along Coreen Avenue has been assessed and appropriate noise mitigation measures for the nearest onsite residences and commercial buildings recommended to be incorporated into the built form.

The commuter car park proposed offsite as well as the Commuter Carpark Road has been investigated to quantify any potential impacts at the onsite residential and commercial receivers at North Penrith. A similar suite of mitigation measures also apply.

The existing operations at the Penrith Training Depot has also been assessed and the results show that further acoustic considerations are not required.

Safeguards for construction noise and traffic noise have also been outlined.

Low frequency noise

The Ctr factor takes into account lower frequency noise levels and compensates for the poor performance of light weight walls and inter-tenancy partitions at low frequencies.

Although the Building Code of Australia (BCA 2010) specifies the Ctr factor for party walls to account for high bass frequency outputs of modern home theatre of music systems, it is worthy to take the Ctr factor into consideration when designing for external walls to mitigate against traffic and railway noise containing such frequencies typically below 100 Hz.

Sleep disturbance

A preliminary research of existing acceptable levels was undertaken by Benbow to devise an appropriate sleep disturbance criterion for the proposed development at North Penrith.

An internal noise limit of 45 dB LAmax has been applied in accordance with the recommendations set by the World Health Organisation.

This internal noise limit is an alternative to applying an external noise level and has been included in similar studies with the need to minimise sleep disturbance.

Contents

1. Objectives of assessment

At a glance

This Noise and Vibration Assessment has been prepared for Landcom in support of a Concept Plan application and a Stage 1 Project Application pursuant to Section 75F of the Environmental Planning and Assessment Act 1979.

A cross-sectional study of the subject site and its environs was carried out between 25 August 2010 and 1 September 2010. This study considered the site's exposure to railway noise and vibration as well as the existing road traffic noise levels and industrial noise along Coreen Avenue.

This commission involves the following:

- Review proposed site plans and environs;
- Analyse the existing ambient noise environment including railway noise from Penrith Railway Line Corridor, industrial noise from existing industries nearby, and traffic noise along Coreen Avenue;
- Collate appropriate sound power levels of the proposed noise sources onsite during the appropriate phases;
- Model potential noise impacts on the nearest potentially affected sensitive receivers;
- Assess potential noise impacts against relevant noise and vibration limits;
- Investigate ameliorative measures or control solutions (where required); and
- Compile a report containing a concise Statement of Potential Noise and Vibration Impact.

2. Site Analysis

At a glance

The subject site area covers 40.71ha in total as shown in Drawing #072-10 (Craig & Rhodes, 16 July 2010). The proposed development will accommodate mixed-use areas.

The eastern site boundary is contiguous with the Lemongrove residential subdivision identified as a conservation area in the Penrith LEP (Local Environmental Plan).

The site is exposed to railway noise from the Penrith Railway Line Corridor south of the site, and traffic and light industrial noise mainly along Coreen Avenue to the north of the site.

An indicative drawing showing the noise catchment areas (Figure 2-2) has been used to delineate the noise catchment areas and any acoustic refugia (areas of relative quiet, shielded from railway, traffic or industrial noise).

Existing ambient noise

The noise measurements were undertaken in accordance with the Australian Standard AS1055: *Acoustics – Description and measurement of environmental noise*.

Methodology: Long-term Unattended

Long-term (continuous) unattended monitoring was undertaken during a 7-day period between 25 August 2010 and 1 September 2010 at the representative locations shown in Figure 2-1:

- R01 – north-eastern site boundary;
- R02 – north-east of onsite oval;
- R03 - eastern site boundary representative of the Lemongrove residential precinct;
- R04 - south-eastern site boundary near residences on Macquarie Avenue;
- R06 - south-east of onsite oval;
- R07 - southern site boundary; and
- R10 - north of railway car park.

ARL Noise Loggers EL215 and EL316 were deployed. These precision environmental noise monitors are Type 2 and Type 1 respectively and comply with AS1259. They continuously record noise levels in assessment periods of 15-minute intervals and provide a statistical distribution of noise levels during the monitoring periods.

All instrumentation used for this assessment conforms to Australian Standards. Acoustically transparent microphone windscreens were fitted onto the microphones during the monitoring periods.

Continuous noise data loggers are influenced by all local sources of noise and therefore it is critical to record short-term noise levels (attended noise monitoring). A more accurate determination of the precise noise sources that are influencing the measured long-term values is thereby permitted.

Meteorological data was obtained from Bureau of Meteorology's nearest weather station in Penrith.

Results: Long-term Unattended

The analysed results from the long-term unattended monitoring are presented below. The measured background noise levels are summarised in the below tables and have been used to establish conservative project-specific noise criteria.

Table 2-1: Unattended Monitoring Levels – Location R01, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	-	-	-	-	-	-	-	-	-	-	-	-
26 August 2010	-	61	-	-	57	-	-	46	-	-	54	-
27 August 2010	-	58	58	-	54	52	-	44	40	-	52	51
28 August 2010	60	61	58	54	56	53	44	45	41	52	54	50
29 August 2010	59	55	55	53	51	50	42	38	37	51	48	47
30 August 2010	60	57	56	54	54	49	45	39	34	53	51	49
31 August 2010	61	59	56	55	56	50	46	45	34	53	53	50
1 September 2010	60	-	57	55	-	52	50	-	43	53	-	51
Average	60	58	57	54	55	51	*	*	*	*	*	*
Median	*	*	*	*	*	*	45	44	38	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	53	53	50

Monitoring periods affected by inclement weather, e.g. strong winds/rain, have been precluded from the data set in accordance with the NSW Industrial Noise Policy.

‘-‘ indicates periods of inclement weather and applies to all tables in this section of the report.

‘*’ Indicates ‘not applicable’ as only relevant values have been presented.

Table 2-2: Unattended Monitoring Levels – Location R02, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	-	-	-	-	-	-	-	-	-	-	-	-
26 August 2010	-	55	-	-	50	-	-	43	-	-	48	-
27 August 2010	-	52	53	-	47	47	-	40	39	-	45	46
28 August 2010	53	56	52	47	50	47	39	43	40	46	51	46
29 August 2010	51	47	48	46	42	43	37	36	34	44	42	43
30 August 2010	52	48	50	46	44	42	39	36	32	45	43	44
31 August 2010	52	52	51	47	49	45	40	42	33	45	47	45
1 September 2010	54	-	53	51	-	49	47	-	43	49	-	48
Average	53	52	51	47	47	46	*	*	*	*	*	*
Median	*	*	*	*	*	*	39	41	36	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	47	47	46

Table 2-3: Monitoring Levels – Location R03, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	-	-	-	-	-	-	-	-	-	-	-	-
26 August 2010	-	54	-	-	49	-	-	44	-	-	48	-
27 August 2010	-	52	52	-	47	47	-	42	40	-	47	47
28 August 2010	54	56	53	47	51	48	40	42	41	47	54	47
29 August 2010	54	46	48	47	42	44	39	37	35	46	41	44
30 August 2010	56	48	50	48	43	44	40	35	34	47	42	46
31 August 2010	56	53	49	49	49	44	41	42	32	48	47	45
1 September 2010	58	-	53	50	-	49	46	-	42	50	-	48
Average	56	51	51	48	47	46	*	*	*	*	*	*
Median	*	*	*	*	*	*	40	42	38	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	48	49	46

Table 2-4: Monitoring Levels – Location R04, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	54	-	-	51	-	-	45	-	-	49	-	-
26 August 2010	-	53	-	-	48	-	-	43	-	-	47	-
27 August 2010	-	52	52	-	47	46	-	41	38	-	46	45
28 August 2010	52	57	52	46	50	47	38	39	39	45	53	46
29 August 2010	52	47	48	45	41	43	37	35	35	44	40	44
30 August 2010	52	46	50	45	42	42	39	34	33	44	40	44
31 August 2010	52	53	48	46	47	42	40	42	31	45	46	43
1 September 2010	54	-	51	49	-	47	41	-	40	48	-	46
Average	53	51	50	47	46	44	*	*	*	*	*	*
Median	*	*	*	*	*	*	39	40	36	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	46	48	45

Table 2-5: Unattended Monitoring Levels – Location R06, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	-	-	-	-	-	-	-	-	-	-	-	-
26 August 2010	-	35	-	-	33	-	-	26	-	-	31	-
27 August 2010	-	32	34	-	28	30	-	24	24	-	27	29
28 August 2010	33	47	34	29	39	29	24	29	23	29	41	30
29 August 2010	38	36	38	33	33	34	28	28	28	37	31	33
30 August 2010	36	30	38	30	27	32	26	23	23	38	26	31
31 August 2010	34	33	32	29	30	27	25	26	22	28	29	31
1 September 2010	36	-	33	30	-	29	26	-	25	29	-	29
Average	35	35	35	30	31	30	*	*	*	*	*	*
Median	*	*	*	*	*	*	26	26	23	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	34	34	31

Table 2-6: Unattended Monitoring Levels – Location R07, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	-	-	-	-	-	-	-	-	-	-	-	-
26 August 2010	-	58	-	-	54	-	-	43	-	-	51	-
27 August 2010	-	59	56	-	53	50	-	43	40	-	51	49
28 August 2010	57	59	55	50	52	48	41	43	41	49	55	48
29 August 2010	54	52	51	48	45	44	40	37	36	46	44	45
30 August 2010	57	55	55	51	50	48	41	39	36	49	48	48
31 August 2010	58	57	55	53	52	48	44	43	36	51	50	49
1 September 2010	60	-	56	55	-	51	46	-	43	53	-	51
Average	57	56	55	51	51	48	*	*	*	*	*	*
Median	*	*	*	*	*	*	41	43	38	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	50	51	49

Table 2-7: Unattended Monitoring Levels – Location R10, values expressed in dB(A)

Date	Average L_1			Average L_{10}			ABL (L_{90})			Leq		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
25 August 2010	63	-	-	58	-	-	50	-	-	56	-	-
26 August 2010	-	63	-	-	58	-	-	47	-	-	55	-
27 August 2010	-	63	61	-	57	54	-	46	44	-	55	54
28 August 2010	60	61	58	52	54	52	43	44	44	51	56	52
29 August 2010	58	59	56	50	51	49	42	42	42	49	50	50
30 August 2010	60	62	61	52	56	53	41	42	41	52	54	53
31 August 2010	60	62	60	53	57	52	44	47	40	52	55	53
1 September 2010	61	-	61	55	-	54	45	-	45	54	-	54
Average	60	62	60	53	55	52	*	*	*	*	*	*
Median	*	*	*	*	*	*	43	45	43	*	*	*
Logarithmic Average	*	*	*	*	*	*	*	*	*	53	55	53

Methodology: Short-term Attended

Short-term monitoring (operator attended) was carried out on 25 August 2010 and 1 September 2010 by means of a Svantek SVAN957 sound level meter. The measurements were carried out at the representative locations:

- R01 – north-eastern site boundary;
- R02 – north-east of onsite oval;
- R03 – eastern site boundary representative of the Lemongrove residential precinct;
- R04 – south-eastern site boundary near residences on Macquarie Avenue;
- R06 – south-east of onsite oval;
- R07 – southern site boundary;
- R08 – near the Western Sydney Institute Nepean College
- R09 – west of onsite oval;
- R10 – north of railway car park; and
- R12 – north-western site boundary.

During these attended monitoring periods, the existing noise contributions from the following nearby noise sources were obtained:

- Railway noise from the Penrith Railway Line Corridor adjacent to the site;
- Industrial noise along Coombes Drive, Coreen Avenue north of the site; and
- Traffic noise along Coreen Avenue to the north of the site.

Further attended monitoring was undertaken with a SVAN957 along the Penrith Railway Line Corridor at four (4) reference locations 50m away from the rail line as shown in Figure 2-1, viz, Ref 1 to Ref 4. This methodology enables noise levels to be obtained at different lengths of the railway tracks. An approximate track length of 500m was chosen for this assessment from Ref 1 to Ref 4.

The sensitive receiver location at R05 represents a local hospital and the location of R11 is indicative of a nearby library. Although noise monitoring was not undertaken at these locations (as there were other sensitive receiver locations in closer proximity to the site), these receivers have been included in the assessment for information purposes. The receiver location at R13 has been included for modelling purposes only for a better gauge of the predicted noise impacts at that location. Similarly, R14 assumes the light industrial area north of the site.

An education facility is located at R08 and attended monitoring was undertaken at this location in order to quantify the existing ambient noise environment.

During the monitoring periods, there were no diesel passenger trains observed. CityRail has confirmed that there are no diesel trains travelling via Penrith. Therefore, this assessment refers to electric passenger trains and freight trains only.

All noise indices were measured in free-field conditions undertaken during suitable conditions in order to prevent weather bias.

A summary of the long-term unattended and short-term attended monitoring programmes are presented in Table 2-8.

Table 2-8: Summary of Long-term Unattended and Short-term Attended Noise Monitoring Programs (values expressed in dBA)

Logger Location	Distance to nearest railway track (m)	Distance to Coreen Ave	Period	Unattended Monitoring					Attended Monitoring									
									Overall Levels				Contribution from Rail Traffic (R)			Contribution from Road Traffic (T)	Contribution from Existing Industries (I)	Cumulative Noise (R+T+I)
				L_{A90} RBL	L_{Aeq} Overall	$L_{Aeq,Day}$ (1hr)	$L_{Aeq,night}$ (1hr)	L_{A1}	L_{A90}	L_{Aeq}	L_{Amax}	L_{A10}	L_{Aeq}	L_{Amax}	L_{AE}	L_{Aeq}	L_{Aeq}	L_{Aeq}
R01	522	77	**Day**	45	53	53		60	50	63	79	66	56[4]	-	-	64	65	68
			Evening	44	53			58	-	-	-	-	-	-	-	-	-	-
			Night	38	50		50	57	-	-	-	-	-	-	-	-	-	-
R02	340	258	**Day**	39	47	47		53	46	49	59	51	55	70	76	57	49	59
			Evening	41	47			52	-	-	-	-	-	-	-	-	-	-
			Night	36	46		46	51	-	-	-	-	-	-	-	-	-	-
R03	386	152	**Day**	40	48	48		56	42	48	78	48	62	76	81	58	51	64
			Evening	42	49			51	-	-	-	-	-	-	-	-	-	-
			Night	38	46		46	51	-	-	-	-	-	-	-	-	-	-
R04	182	332	**Day**	39	46	46		53	44	50	74	49	72	85	89	56	39	72
			Evening	40	48			51	-	-	-	-	-	-	-	-	-	-
			Night	36	45		45	50	-	-	-	-	-	-	-	-	-	-
R06	193	390	**Day**	26	34	36		35	44	54	74	55	71	84	88	56	51	71
			Evening	26	34			35	-	-	-	-	-	-	-	-	-	-
			Night	23	31		31	35	-	-	-	-	-	-	-	-	-	-
R07	106	513	**Day**	41	50	52		57	46	51	71	53	64	77	83	53	51	64
			Evening	43	51			56	-	-	-	-	-	-	-	-	-	-
			Night	38	49		48	55	-	-	-	-	-	-	-	-	-	-
R08	101	740	**Day**	-	-	-			46	56	79	59	79	87	94	68	64	79
			Evening	-	-				-	-	-	-	-	-	-	-	-	-
			Night	-	-		-		-	-	-	-	-	-	-	-	-	-
R09	247	391	**Day**	-	-	-			47	52	73	53	61	75	82	56	50	62
			Evening	-	-				-	-	-	-	-	-	-	-	-	-
			Night	-	-		-		-	-	-	-	-	-	-	-	-	-
R10	125	485	**Day**	43	53	54		60	44	55	82	56	68	80	87	54	59	69
			Evening	45	55			62	-	-	-	-	-	-	-	-	-	-
			Night	43	53		53	60	-	-	-	-	-	-	-	-	-	-
R12	242	353	**Day**	-	-	-			44	53	71	51	65	78	86	55	58	66
			Evening	-	-				-	-	-	-	-	-	-	-	-	-
			Night	-	-		-		-	-	-	-	-	-	-	-	-	-

Note:

1. $L_{Aeq(15hr)}$ refers to the daytime period, viz, 0700-2200 when assessing road traffic noise
2. $L_{Aeq(9hr)}$ refers to the night-time period, viz, 2200-0700 when assessing road traffic noise
3. '-' indicates monitoring was not undertaken at that location
4. Where rail or industrial noise was 'barely audible' and not registering on the sound level meter, then it was assumed that the noise contribution from the rail line or industrial area was 10 dB below the recorded L_{A10} level.

Attended L_{Aeq} and L_{Amax} levels presented in the above table have been logarithmically and numerically averaged respectively.

Attempts were made to record the noise contribution from the railway, traffic, industries in the absence of extraneous noise sources, viz, noise sources other than the aforementioned sources, during attended monitoring. A simple distance attenuation calculation has also been carried out (where possible) to verify the measured average noise levels at the nearby receiver locations. The associated standard deviations were within the acceptable range of 1-3dB.

$L_{Aeq(1hr)}$ daytime and night-time values from the unattended measurements were computed following judicious observations for any irregularities that could indicate that the noise sources recorded were not traffic noise, e.g. if traffic noise is the predominant noise source at the monitoring location, the L_{Aeq} noise levels due to traffic noise should not be appreciably higher than the L_{A10} levels and/or more similar to the even higher L_{Amax} levels.

The site boundary abutting the railway corridor is all within 50m from the nearest operational track and the proposed mixed use areas at the subject site indicate that 'other vibration sensitive buildings' would be more suited for this assessment.

Furthermore, the distance of the reference locations along the existing railway corridor (50m) comply with the Australian Standard AS 2377-2002: *Acoustics-Methods for the measurement of railbound vehicle noise*, which refers to monitoring locations situated within a 50m radius of the test rolling stock/locomotive.

Low Frequency Noise: dBC – dBA > x

When prominent low frequency noise components are present, viz, traffic/railway noise and some industrial processes, the dB(C) noise index should be considered as well as the dB(A).

Berglund et al (1999) have suggested that 'Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting.'

Kjelberg and co-workers (1997) have suggested that when x > 15 dB, an addition of 6 dB to the measured A-weighted level would address any potential undue disturbance to the local community.

1/3 octave frequency analysis of the recorded data showed presence of low frequency noise below 250Hz (although not considered tonal), specifically around 80Hz-125Hz.

During monitoring at the 50m reference locations (Ref 1 to Ref4), passenger and freight trains showed predominant frequencies at 80Hz, 100Hz and 125Hz. At the mid frequencies, 315Hz and 400Hz was dominant (rail horn) with a subsequent peak at 800Hz (second harmonic).

Therefore, design techniques employed in the final stages should apply a minimum of +6 dB correction for the overall noise intrusion or consider the 'Ctr' or correction factor in addition to the Rw values.

Noise sources considered

Railway

The predominant noise source existing adjacent to the proposed site is identified to be the Penrith Railway Line Corridor to the south of the subject site. Existing noise and vibration impacts from the following railway noise sources have been considered in this assessment:

- operational rail tracks during movement of rolling stock;
- stabling activities located to the west of the station;
- Penrith station car park; and
- rail brakes, horn sounding, wheel squeal, announcements, and doors opening/closing.

Construction

The construction phase of the proposed development has been assessed for its potential noise and vibration impacts to the surrounding community. Construction works will include the following three (3) worst-case scenarios:

- site preparation/demolition (including concrete crushing);
- bulk earthworks; and
- construction of essential infrastructure (roads, services, open spaces etc) and a community building at the (former cricket) Oval.

Commercial/Industrial

The proposed site is bordered by existing commercial/industrial areas to the north, south and west. Existing light industries along Coombes Drive (north of the site) have been assessed, as well as those along Coreen Avenue. The Museum of Fire and SkillsWest Training Centre west of the site were observed to be inaudible during the attended monitoring periods at nearby identified locations.

Existing commercial/industrial noise contributions from these areas have been included in the predictive noise model in order to assess for the potential noise impact on North Penrith.

Penrith Training Depot

The Department of Defence has provided information on its current operations at the Penrith Training Depot.

The majority of the noise emanating from the Penrith Training Depot is due to various training activities including soldiers parading, drill practice, preparation of vehicles for movement outside the Penrith Training Depot as well as vehicle movements to and from the Depot. Minor maintenance of onsite equipment is also completed at the Depot.

From this existing situation, potential noise generating activities have been identified and included in the predictive model in order to assess for potential noise impacts at the proposed development at North Penrith.

Traffic

Coreen Avenue is situated along the north and north-east of the proposed site.

Existing traffic noise along Coreen Avenue (one lane each direction) has been considered in this assessment.

Information in terms of a potential increase in vehicle movements along Coreen Avenue due to the proposed development at North Penrith has been based on PB’s predicted 2016 traffic yield. A sensitivity analysis has been carried out for 10 years after the project opening based on PB’s predicted 2026 yield.

Vibration sources considered

Railway

Potential ground-borne vibration from the existing railway operations at Penrith rail line has been assessed to account for human comfort and structural damage.

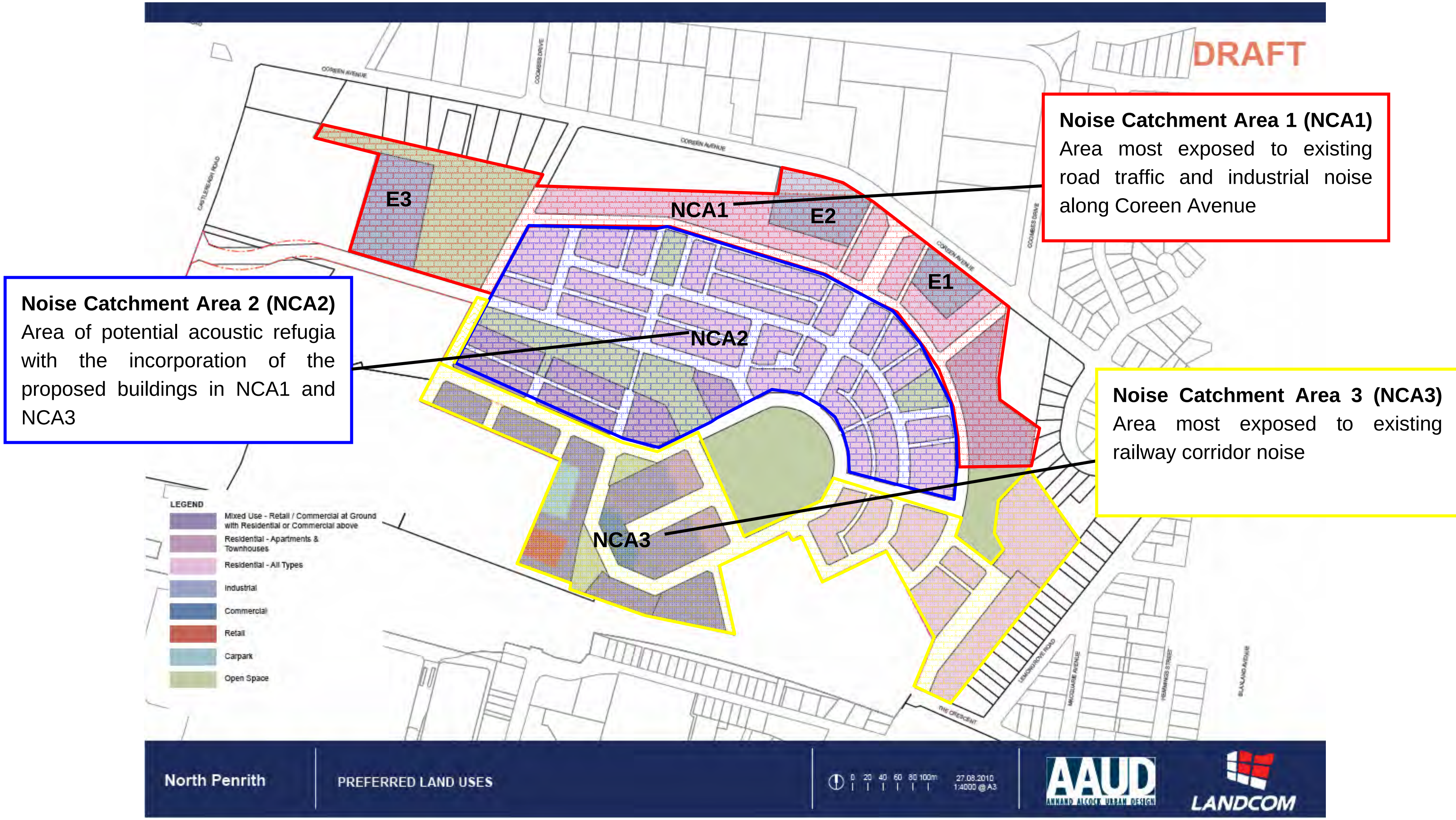
Construction

Potential impacts during the construction phase of the proposed development have been assessed based on an assumed schedule of construction activities and equipment types.

Indicative safe working distances for the most vibration intensive equipments have been quoted under the Construction Vibration Criteria section of this report.

Figure 2-1: Site Locality and Receiver Locations

Figure 2-2: Noise Catchment Areas According to the Preferred Land Uses



3. Regulatory context

At a glance

The Director-General's Requirements for the proposed development in terms of noise are:

1. Concept Plan: railway noise and vibration and details of how this will be managed and ameliorated through the design of buildings, in compliance with relevant Australian Standards and the Department's *Development near Rail Corridors and Busy Roads – Interim Guidelines.*

2. Stage 1 Project Application: construction noise and vibration and details of how this will be managed and ameliorated in compliance with relevant Australian Standards.

Noise criteria set out in these guidelines are not mandatory and therefore other factors such as economic consequences and the social worth of the development need to be taken into account.

It is prudent to also investigate other noise sources surrounding the site:

- Existing industrial noise along Coreen Avenue;
- Proposed industrial noise due to the proposed industrial areas at North Penrith;
- Existing road traffic noise along Coreen Avenue;
- Predicted road traffic noise along Coreen Avenue due to the proposed development at North Penrith
- Predicted road traffic noise due to the proposed multi-deck commuter car park offsite;
- Road traffic sensitivity analysis due to the proposed development at North Penrith;
- Predicted operational noise due to the proposed multi-deck commuter car park offsite; and
- Construction noise and vibration during the construction phase of the proposed development at North Penrith.

Railway Noise Criteria

At a glance

Recommended internal noise levels of 40 dB $L_{Aeq(15hr)}$ in sleeping areas and other habitable areas during the day (7am to 10pm) and 35 dB $L_{Aeq(9hr)}$ in sleeping areas during the night time (10pm to 7am) have been derived from the State Environmental Planning Policy Infrastructure 2007 (SEPP 2007).

External planning levels at one metre from the residential façade have been sourced from RailCorp's Environmental Protection Licence # 12208 and have been applied as the project-specific equivalent continuous noise limit of 55dB(A) $L_{Aeq,24hr}$ and a maximum passby level of 80dB(A) $L_{Amax,fast}$.

The *Environmental Planning and Assessment Act 1979* (EP&A Act) for new residential (and noise-sensitive) developments alongside rail lines will require the consideration and incorporation of noise and vibration mitigation measures.

The noise trigger levels for absolute levels of rail noise have been considered under both the L_{Aeq} and L_{Amax} noise parameters in order to more accurately address the average level of noise (L_{Aeq}) during the daytime and night-time periods and the maximum noise level (L_{Amax}) from 'passby' events. The L_{Aeq} noise metric refers to the equivalent continuous sound pressure level integrated over the assessment duration. The L_{Amax} represents the maximum sound pressure level measured over a period of time.

Generally, the L_{Aeq} descriptor alone does not adequately preserve the residential acoustic amenity from rail events and therefore a combination of the L_{Amax} and L_{Aeq} noise descriptors have been considered.

For other noise-sensitive land uses, the sole application of L_{Aeq} is acceptable to ensure satisfactory internal levels.

Current DECCW rail noise assessment trigger levels at one (1)metre from the façade of the nearest potentially affected residential property are based on RailCorp's Environmental Protection Licence (EPL) # 12208. These levels were applicable to the Auburn and Merrylands to Penrith line at the time of the *Line Based Noise Pollution Reduction Programme* (PRP) developed during the year 2000:

- Equivalent continuous level 60dB(A) $L_{Aeq,24hr}$; and
- Maximum passby level 85dB(A) $L_{Amax,fast}$.

The following planning goals at one (1) metre from the façade of the nearest potentially affected residential have been applied to this assessment (Ref: RailCorp EPL# 12208)

- Equivalent continuous level 55dB(A) $L_{Aeq,24hr}$; and
- Maximum passby level 80dB(A) $L_{Amax,fast}$.

For developments under Clause 87 (Rail) and 102 (Road) in accordance with the State Environmental Planning Policy Infrastructure 2007 (SEPP 2007), the following internal levels as shown in Table 3-1 are applicable. SEPP 2007 applies the internal L_{Aeq} levels 'if the development is for the purpose of a building for residential use'.

Table 3-1: Internal Railway Noise Criteria

Habitable Area	Time of Day	LAeq(period), dB(A)
Residential Buildings		
Sleeping areas Other habitable areas (excl. garages, kitchens, bathrooms & hallways)	Daytime	40
Sleeping areas	Night (2200 to 0700)	35

Note: LAeq(9h,night) and LAeq(15h,day)

When assessing the internal noise levels for commercial buildings, the *Interim Guidelines For Applicants – Consideration of Rail Noise and Vibration in the Planning Process* (Rail Infrastructure Corporation 2003) states that some guidance on internal noise levels may be obtained from the Australian Standard AS 2107:2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors.* Accordingly, an internal noise level of 45 dB(A) has been applied to the commercial/retail spaces proposed at North Penrith.

Road Traffic Noise Criteria

At a glance

Appropriate criteria pertinent to the road traffic along Coreen Avenue were referenced from the Environmental Criteria for Road Traffic Noise (ECRTN, DECCW). This assessment has Coreen Avenue classified as a 'collector road' and therefore the relevant development external criteria of $L_{Aeq(1hr)}$60 during the daytime (7am to 10pm) and $L_{Aeq(1hr)}$55 during the night-time period (10pm to 7am) has been applied under the development type of 'new residential developments affected by collector traffic noise'. Based on the forecast traffic conditions on Coreen Avenue (Parsons Brinckerhoff, 2010), the proposed development at North Penrith will 'potentially create additional traffic on the collector road', albeit insignificant in terms of noise.

The NSW DECCW's Environmental Criteria for Road Traffic Noise (ECRTN) has been referenced in deriving the traffic noise criteria as shown in Table 3-2. The ECRTN further states that where criteria are already exceeded, existing noise levels should be reduced to meet the noise criteria via judicious design and construction of the development (where feasible and reasonable). Locations, internal layouts, buildings materials and construction should be chosen so as to minimise noise impacts. These design considerations are discussed in detail under the Building Design section of this report.

For the purpose of this assessment, Coreen Avenue has been classified as a 'collector road' which ECRTN defines as roads 'which connect the sub-arterial roads to the local road system in developed areas'. The external traffic noise criteria for 'new residential developments affected by collector traffic noise' and 'land use developments with potential to create additional traffic on collector road' are both 60dB,$L_{Aeq(1hr)}$ during the daytime and 55dB,$L_{Aeq(1hr)}$ for the night-time and therefore these guideline values have been adopted for this project.

Practice Note IV of the RTA's Environmental Noise Management Manual (ENMM) provides guidance on 'selecting and designing *feasible and reasonable* treatment options for buildings affected by road traffic noise'. This Practice Note suggests that noise mitigation should be provided if noise levels are *acute*, viz, greater than or equal to 65dB $L_{Aeq,15hr}$(daytime) and 60dB $L_{Aeq,9hr}$(night-time).

These criteria are provided as guidelines only and may be subject to deliberations by the governing authority. They provide target design levels to apply where it is *feasible and reasonable*. ECRTN states that under some circumstances this may be achieved merely via 'long-term strategies such as improved planning; design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage'.

To address the reference to planning, a desktop review of the indicative Masterplan has been undertaken in terms of building orientation, layout and land use. The findings have been taken into consideration in this assessment.

The ECRTN further states that where criteria are already exceeded, existing noise levels should be reduced to meet the noise criteria via judicious design and construction of the development (where feasible and reasonable). Locations, internal layouts, buildings materials and construction should be chosen so as to minimise noise impacts. These design considerations are outlined under the Building Design section of this report.

Table 3-2: Road Traffic Noise Criteria (ECRTN) for Proposed Road or Residential Land Use Developments

Type of Development		Criteria	
		Day (7am-10pm) dB(A)	Night (10pm-7am) dB(A)
1	New residential developments affected by collector traffic noise	$L_{Aeq(1hr)}60$	$L_{Aeq(1hr)}55$
2	Land use developments with potential to create additional traffic on collector road	$L_{Aeq(1hr)}60$	$L_{Aeq(1hr)}55$

The ECRTN recommends that internal noise level criteria be set by the relevant planning or building authority in terms of residential premises. In the absence of local codes, the ECRTN recommends internal noise levels in the range 35 to 40 dB(A) for sleeping areas during the night-time period. For other living areas, internal noise levels of 10 dB below external levels are recommended on the basis of operable windows being opened sufficiently to provide adequate ventilation. For most residences, this equates to a minimum of 20% of the window area left open.

The ECRTN suggests that for commercial and industrial developments, information on desirable noise levels is contained in Australian Standard 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors.* An internal design level of 45 dB(A) L_{Aeq} has been applied to the commercial/retail spaces in accordance with the AS 2107. This internal level has been applied for the proposed commercial buildings located nearest to Coreen Avenue, and the Commuter Carpark Road.

For the North Penrith project, a conservative internal noise criteria of 35 dB(A) has been applied to the sleeping areas and 40 dB(A) for the other living areas in terms of the proposed residential developments onsite. This is consistent with the design values as stipulated in Australian/New Zealand Standard AS/NZS 2107:2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors.*

When referring to AS 2107, satisfactory internal noise levels for industrial buildings with packaging and delivery operations are 55 dB(A). However, this standard also states that a very wide range noise levels can occur in the occupied state in spaces housing manufacturing processes, and the levels are primarily subject to control as part of a noise management programme.

It further states that it is difficult to make generalised recommendations for desirable, or even maximum design levels for the unoccupied state, but one guiding principle may be that when the activity in one area of a manufacturing plant is halted, it is desirable that the local level should drop to 70 dB(A) or lower to permit speech communication without undue effort. Since the nature of the industrial operations pertaining to the proposed industrial areas are unclear at this stage, it is assumed that industrial buildings will not require any further acoustic consideration at this application stage.

Industrial Noise Criteria

At a glance

Industrial noise has been assessed against the DECCW's Industrial Noise Policy (2000) in terms of the intrusive noise impacts and the noise level amenity.

The lower limiting levels between the intrusive and amenity components have been derived and set as the project-specific noise limits at the nearest potentially affected receiver locations.

The assessment procedure for industrial noise sources provided in DECCW's Industrial Noise Policy (2000) has two components:

- Controlling intrusive noise impacts; and
- Maintaining the noise level amenity.

The project-specific noise goals reflect the most stringent noise levels derived from the intrusive and amenity criteria and are used to set the limiting level against which potential noise impacts are assessed.

Intrusive Noise Impacts

The Industrial Noise Policy (2000) states that:

> "The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the LAeq index) measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5dB."

The intrusiveness criterion can be summarised as:

$L_{Aeq,(15minute)} \leq$ rating background level (RBL) + 5 dB(A)

Maintaining the Noise Level Amenity

In the Industrial Noise Policy, it is stated that:

> "To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1"

Table 3-3 summarises the key information.

Table 3-3: NSW DECCW Amenity Criteria - Recommended L_{Aeq} noise levels from industrial noise sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended LAeq Noise Level dB(A)	
			Acceptable	Recommended Maximum
Residence	Urban	Day	60	65
		Evening	50	55
		Night	45	50
School classroom (internal)	All	Noisiest 1-hour period when in use	35*	40*
Hospital ward	All	Noisiest 1-hour period	50*	55*
Area specifically reserved for passive recreation	All	When in use	50	55
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

* $L_{Aeq(1hr)}$

When assessing under the 'school classroom' receiver type, the NSW INP states that where existing schools are affected by noise from existing industrial noise sources, the acceptable LAeq noise level may be increased to 40 dB LAeq(1hr). There are industries already existing within the immediate vicinity of R08 (Western Sydney Institute Nepean College) and therefore an acceptable noise limit (internal) of 40 dB(A) has been adopted for this location.

The existing industries along Coreen Avenue are assumed to operate during the daytime (7am – 6pm) only and therefore only the daytime criteria for residential receivers have been presented.

The existing noise levels are compared against the acceptable levels and are used to derive the amenity criteria.

Table 3-4: Modification to Acceptable Noise Level (ANL) to Account for Existing Levels of Stationary Noise

Total Existing LAeq Noise Level from Industrial Sources	Maximum L_{Aeq} Noise Level for Noise from New Sources Alone
≥ ANL + 2	If existing noise level is likely to decrease in future: ANL – 10 If existing noise level is unlikely to decrease in the future: Existing level – 10
ANL +1	ANL – 8
ANL	ANL – 8
ANL – 1	ANL – 6
ANL – 2	ANL – 4
ANL – 3	ANL – 3
ANL – 4	ANL – 2
ANL – 5	ANL – 2
ANL – 6	ANL – 1
< ANL – 6	ANL

Source: Table 2.2 NSW EPA INP

ANL is the recommended acceptable L_{Aeq} noise level for the specific receiver, area and time of day.

'Modifying Factor' Adjustments

Further to the above, where the character of the noise in question is assessed as particularly annoying (i.e. if it has an inherently tonal, low frequency, impulsive or intermittent character), then an adjustment of 5 dB(A) for each annoyance aspect, up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potential increase in annoyance.

Table 4.1 of Chapter 4 of the NSW INP provides definitive procedures for determining whether a penalty or adjustment should be applied for increased annoyance. Specifically for tonal noise, a one-third octave (or narrow band analysis) is required and a 5 dB(A) penalty is applied to the measured or predicted level when the level of one-third octave band exceeds the level of the adjacent bands on both sides by:

- 5 dB(A) or more if the centre frequency of the band containing the tone is above 400 Hz;
- 8 dB(A) or more if the centre frequency of the bank containing the tone is 160 to 400 Hz inclusive; and
- 15 dB(A) or more if the centre frequency of the band containing the tone is below 160 Hz.

Noise emissions from the existing industries along Coreen Avenue are determined not to be tonal or impulsive in character and therefore this penalty does not apply.

Project-specific Noise Limits

Noise limits for the development can now be established in accordance with the principles and methodologies of the NSW INP and the measured background noise levels.

According to the NSW INP, it is recommended that the more stringent noise limits be applied to protect the existing acoustic amenity from deteriorating. As such, the lower limits between the intrusive criterion and the amenity criterion have been applied to produce the project-specific noise criteria.

The selected criteria and calculated limits are presented below.

Table 3-5: Project-specific Noise Limits (PSNL) for existing industries on Coreen, dB(A)

Receiver	Indicative Noise Amenity Area	Time of Day	LAeq Noise Level, dB(A)			
			ANL	Intrusive Limit	Amenity Limit	PSNL
Residence	Urban	Day	60	50	55	**50**
School classroom (internal)	All	Noisiest 1-hour period when in use	40	N/A	54	**54**
Hospital ward (external)	All	Noisiest 1-hour period	50	N/A	50	**50**
Area specifically reserved for passive recreation	All	When in use	50	N/A	48	**48**
Commercial premises	All	When in use	65	N/A	65	**65**
Industrial premises	All	When in use	70	N/A	68	**68**

The nearest potentially affected receivers due to the existing industries along Coreen Avenue are considered to be R01 and R09. R01 represents both the nearest residential and industrial areas proposed on the subject site and R09 represents the nearest commercial premises on the subject site.

Potential industrial noise impacts due to the development within the industrial areas of the proposed site have also been assessed. The following nearest potentially affected receivers (onsite and offsite) have been included as part of this assessment:

- R01 – residential area proposed onsite;
- R02 – residential area proposed onsite;
- R03 – residential area proposed onsite and residences within the Lemongrove subdivision;
- R04 – residential area proposed onsite and residences within the Lemongrove subdivision;
- R05 – Governor Phillip Hospital;
- R08 - Western Sydney Institute Nepean College;
- R09 – residential area proposed onsite and commercial/retail area proposed onsite;
- R11 – Penrith Regional Library;
- R12 – Museum of Fire and SkillsWest Training Centre;
- R13 – residential area proposed onsite; and
- R14 – pre-existing industries along Coreen Avenue.

Similar to the selected PSNL for existing industries along Coreen Avenue as above the more stringent noise limits (between the Intrusive Limit and the Amenity Limit) has been applied to derive the project-specific noise criteria for the operation of the proposed commuter car park offsite.

The relative onsite receivers as well as the selected criteria and the calculated limits are shown in the table below.

Table 3-6: Project-specific Noise Limits (PSNL) for proposed commuter car park offsite, dB(A)

Receiver	Indicative Noise Amenity Area	Time of Day	LAeq Noise Level, dB(A)		
			Intrusive Limit	Amenity Limit	PSNL
Residence (R01)	Urban	Day	50	60	**50**
		Evening	49	50	**49**
		Night	43	45	**43**
Residence (R03)	Urban	Day	45	60	**45**
		Evening	47	50	**47**
		Night	43	45	**43**
Residence (R09)	Urban	Day	44	60	**44**
		Evening	45	50	**45**
		Night	41	45	**41**
Residence (R10)	Urban	Day	48	60	**48**
		Evening	50	50	**50**
		Night	48	45	**45**
Residence (R12)	Urban	Day	44	60	**44**
		Evening	45	50	**46**
		Night	41	45	**41**
Commercial premises	All	When in use	N/A	65	**65**
Industrial premises	All	When in use	N/A	68	**68**

The nearest identified receiver location to the offsite commuter car park is R12. Unattended long-term monitoring was not conducted at this location and therefore, background noise data from a similarly located receiver (R04) has been sourced to derive the Intrusive Limit.

The background noise data at R04 has also been applied to R09 (in the absence of unattended monitoring data at this location) which share a similar noise environment.

Construction Noise Criteria

At a glance

The NSW DECCW's Environmental Noise Control Manual (ENCM) has been superseded at large by the department's *Interim Construction Noise Guideline* (the 'Guideline'). Therefore management levels specified in the Guideline have been provided in lieu thereof the previous construction noise criteria as specified in the ENCM.

The Guideline recommends assessing noise at residences using a quantitative method under the management level of RBL (Rating Background Level) + 10 dB which may attract 'some community response to noise' at this level. At the highly noise affected management level of 75 dB(A), higher levels of community response may be expected.

Further to these management levels, construction noise safeguards have been outlined under the Construction Noise and Vibration Management section of this report to minimise the potential impacts at the nearby identified receivers.

The project-specific construction noise criteria are based on DECCW's *Interim Construction Noise Guideline* (the 'Guideline') which contains the noise management levels as shown in the excerpts in Table 3-6 and Table 3-7 below. The quantitative assessment method as per the Guideline has been referenced in order to assess for the airborne construction noise during standard hours.

Table 3-7: Noise at residences using quantitative assessment

Time of Day	Management Level, $L_{Aeq(15min)}$*
Recommended standard hours	Noise affected RBL + 10 dB
	Highly noise affected 75 dB(A)

* Noise levels apply at the property boundary that is most exposed to construction noise and at a height of 1.5m above ground level.

Table 3-8: Noise at sensitive land uses (other than residences) using quantitative assessment

Land Use	Management Level, $L_{Aeq(15min)}$ (applies when land uses are being utilised)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Classrooms at schools and other educations institutions	Internal noise level 45 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Industrial premises	External noise level 75 dB(A)

According to the Guideline, the recommended standard hours for ‘normal’ construction work are between:

- Monday to Friday 7am to 6pm;
- Saturday 8am to 1pm; and
- No work on Sundays or public holidays.

However, the relevant authority (consent, determining or regulatory) may impose more or less stringent construction hours. The construction hours for the proposed works are assumed to occur during standard hours.

A noise management level of RBL + 10dB applies at the receiver locations for construction work during standard hours which represents the point above. According to the Guideline, there may be ‘some community reaction’ to noise at this level.

Where the predicted levels exceed the nominated noise management level, all feasible and reasonable work practices should be applied to meet the noise management level. The proponent should also inform all potentially impacted residents of the nature of the proposed works, the predicted noise levels and duration, as well as contact details.

Where construction noise levels ($L_{Aeq,15min}$) are predicted to be above 75dB(A), the relevant authority (consent, determining or regulatory) may require restricted construction hours to be observed, taking the following into consideration:

- Times identified by the community when they are less sensitive to noise (e.g. before and after school for works near schools, or mid-morning or mid-afternoon for works near residences); and
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

There is no blasting expected for the proposed construction programme.

Railway Vibration Criteria

At a glance

Potential intermittent vibration impacts in terms of human comfort have been assessed in accordance with *Assessing vibration: A technical guideline* (DEC 2006). This guideline is based on British Standard BS6472: *Guide to Evaluation of human exposure to vibration in buildings (1Hz to 80Hz)*.

Australian Standard AS 2670.2 1990 *Evaluation of human exposure to whole-body vibration* has also been referenced in order to compare the outcomes with the BS6472.

German Standard DIN 4150, *Part 3: Structural Vibration in Buildings: Effects on Structures* and British Standard BS 7385 Part 2 1993 *Evaluation and measurement for vibration in buildings* form the basis on which the potential structural damage due to vibration was assessed. DIN 4150 addresses the 'human tactile perception of random motion'. This implies that an individual's response to the actual perception of motion (or vibration) is dependant on their previous experience and expectations.

Human comfort vibration has been derived from the NSW DECCW's *Assessing Vibration: a technical guideline* is based on the British Standard BS 6472:1992 – *Guide to evaluation of human exposure to vibration*.

The relevant guideline values have been reproduced below.

Table 3-9: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26

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

Furthermore, AS 2670.2 provides a 'base curve' when assessing vibration impacts in terms of human comfort. This base curve can be seen in Figure 4-1 of this report alongside the measured acceleration values.

In terms of structural vibration, the effects due to the existing vibration from the Penrith rail line on the 'structure' as a whole has been assessed in accordance with the German Standard DIN 4150-3 (1999-02): *Structural vibration – Effects of vibration on structures*.

This standard evaluates the maximum absolute value of the velocity signals, $|v|_{i,max}$ where i = x, y or z.

Table 3-10: Guideline vibration velocity values for evaluating the effects of short-term vibration on structures

Line	Type of Structure	Guideline Values for Velocity, v_{max} in mm/s Vibration at the foundation at a frequency of		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10

Construction Vibration Criteria

At a glance

Guideline limits as provided in BS 6472, AS 2670 (human comfort) and DIN 4150 (structural damage) should be complied with during the construction phase of the proposed development.

Further to this, typical safe working distances for vibration intensive plant have been provided in accordance with BS 6472 (human comfort) and BS 7385 (structural damage) as a guideline.

A guide of safe working distances for typical items of vibration-intensive equipments is quoted in Table 3-10 below. These safe working distances refer to both 'cosmetic' damage in accordance with BS 7385 and human comfort based on BS 6472.

The safe working distances are recommended to be complied with at all times, unless otherwise approved by the relevant authority.

Table 3-11: Recommended safe working distances for vibration intensive plant

Plant item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (BS 6472)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes) <100 kN (Typically 2-4 tonnes) <200 kN (Typically 4-6 tonnes) <300 kN (Typically 7-13 tonnes) >300 kN (Typically 13-18 tonnes) >300 kN (> 18 tonnes)	5 m 6 m 12 m 15 m 20 m 25 m	15 m to 20 m 20 m 40 m 100 m 100 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
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

The safe working distances listed in Table 3-10 above are indicative and may vary depending on the particular plant. These indicative distances apply to cosmetic damage of standard construction buildings under typical geotechnical conditions.

Sleep Disturbance Criteria

At a glance

An appropriate sleep disturbance criteria of 45 dB(A) L_{Amax} (internal) was applied to the proposed residential premises at the subject site.

The World Health Organisation states that individual noise events should occur below 45 dB(A) L_{Amax} inside the residential buildings and such occurrences should be less than 10-15 events per night to allow for a 'good night's sleep'.

This approach of setting an internal limit, as opposed to an external value, has been applied to similar areas that experience night time truck movements and has been accepted as a suitable management level.

ENCM

The emission of high noise levels for an instant or very short time period such as heavy items being dropped may cause sleep disturbance to residents during the night-time period. Chapter 19 of the Environmental Noise Control Manual (ENCM, originally developed by NSW SPCC) states:

> *"Noise control should be applied with the general intent to protect people from sleep arousal. To achieve this, the L_1 level of any specific noise source should not exceed the background noise level (L_{90}) by more than 15 dB(A) when measured outside the bedroom window."*

The manual is now superseded, but the sleep disturbance criterion is considered to be a valid guideline.

From this guideline, it can be said that sleep disturbance is probable when a sudden increase in the noise level above the existing background level occurs. Generally, this is when the L1 noise parameter is 15 dB(A) above the L90 noise level with the L90 noise level representative of the 15-minute period preceding a 'high noise' event (the potentially 'waking' event).

ECRTN

In accordance with the ECRTN, sleep disturbance is related to the number of 'waking events' during the night-time period.

The DECCW reviewed research on sleep disturbance in the ECRTN and concluded that current sleep disturbance criterion of an LA1(1minute) not exceeding the LA90(15minute) by more than 15 dB(A) is not 'ideal'. The relationship between the noise events causing awakenings and sleep disturbance is undefined at present however and therefore the DECCW continue to support the current guideline in assessing the likelihood of sleep disturbance.

The following factors are generally examined:

- Frequency of high noise events;
- Night time period (2200 to 0700); and
- Periods where there is a distinctive change in the noise environment (e.g. during early morning shoulder periods).

The ECRTN suggests that:

- the maximum internal noise levels contained under 50-55 dB(A) are unlikely to cause awakening reactions;
- one or two events per night, with maximum internal noise levels of 65-70 dB(A) are not likely to affect health and wellbeing significantly;
- At locations where road traffic is continuous rather than intermittent, the $LA_{eq,9hour}$ design noise level should sufficiently account for sleep disturbance impacts;
- However, where the emergence of maximum (LAmax) noise levels over the ambient (LAeq) is greater than 15 dB(A), the Leq,9hr criteria may not sufficiently account for sleep disturbance impacts.

Therefore, the ECRTN identifies that sleep disturbance on residents should be assessed under the consideration of the maximum noise levels exceedances occurring during the night-time period and the expected emergence of these exceedances above the ambient noise level.

World Health Organisation (WHO)

The World Health Organisation recommends individual noise events to be contained under 45dB L_{Amax} indoors (fast response) in order to minimise sleep disturbance. This value has been referenced in the NSW Department of Planning's *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects.* Generally, the number of such events should be less than 10-15 events per night for a 'good night's sleep'.

Project-specific Sleep Disturbance Criteria

In devising appropriate noise criteria, research was undertaken of what is generally accepted in terms of minimising sleep disturbance.

An internal noise limit of 45dB L_{Amax} has been considered (in accordance with the World Health Organisation) as an alternative to applying external noise levels as part of a management plan.

This approach has been included in studies for minimising sleep disturbance when night time truck movements associated with a specific industry occurs in an area.

Literature-based Research

At a glance

A review of the researched noise trigger values indicate that at above the L_{DN} (day-night) level of 60 dB(A), the community starts to become increasingly annoyed. This correlates to the trigger level of 60 dB(A) $L_{Aeq,24hr}$ as stipulated in RailCorp's EPL. Although the planning levels of 55dB(A) $L_{Aeq,24hr}$ has been applied to the railway noise in this assessment, it is worthy to compare the overarching trigger noise levels vs community response.

The importance of identifying the low frequency content of the noise sources has been addressed. From this research, it can be concluded that a correction is required when dealing with noise of high levels of low frequency noise. Therefore, a spectrum adaptation factor (Ctr) has been considered in the design techniques outlined in Building Design.

Noise trigger values

It is a well established fact in the acoustic literature that, for the same level of the noise indicator, individuals are more annoyed by road than by railway noise (Miedema and Oudshoorn, 2001). However, for the purpose of this assessment, both railway and traffic noise have been thoroughly investigated.

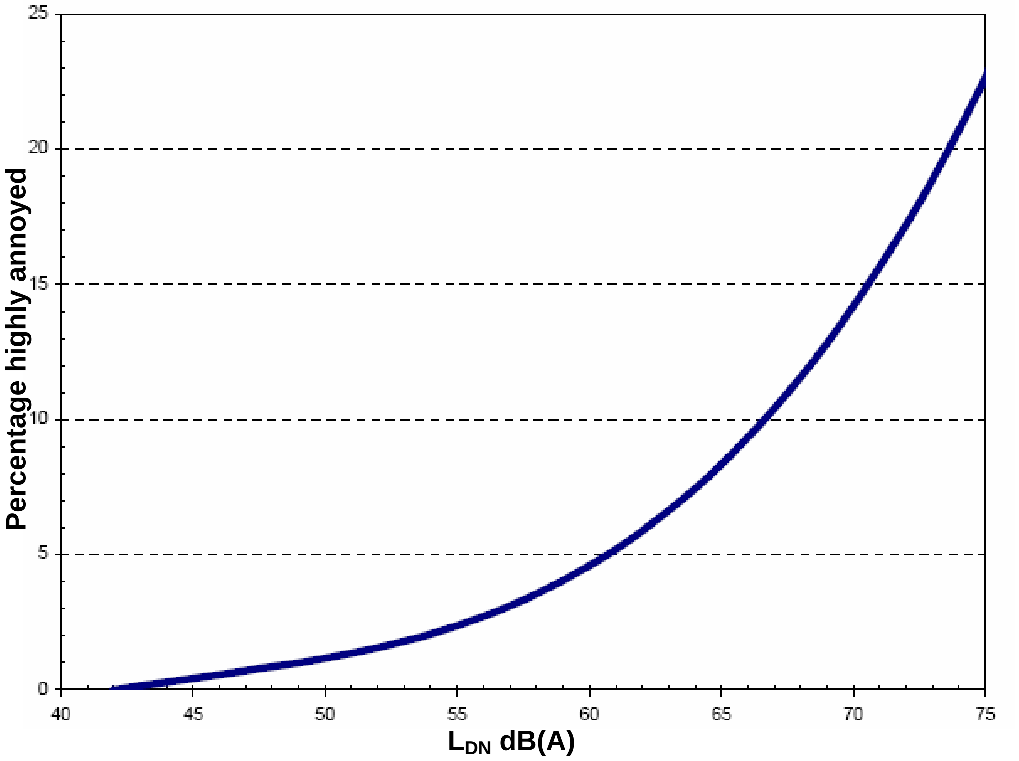
Research by Miedema and Oudshoorn shows L_{DN} (Day-Night) airborne noise trigger values as shown in Figure 3-1. These trigger values consider the levels at which community annoyance is apparent. It is observed that between L_{DN} levels of 65 and 70 dBA, the percentage of highly annoyed members of the community increases by approximately 6%, with a steep increase of 9% from 70 to 75 dBA L_{DN}.

The L_{DN} levels shown in Figure 3-1 are based on the L_{Aeq} noise parameter and are measured over a 24-hour period with a 10-dB penalty to night-time noise.

Low Frequency Noise

Leventhall's research (2004) states that an estimated 2.5% of the study population may have a low frequency threshold which is at least 12dB more sensitive than the average noise threshold. This corresponds to almost 1,000,000 persons in the 50-59 year old age group in the EU-15 countries. The age group mentioned in the research usually generates many complaints. Consequently, low frequency noise due to the identified noise sources has been carefully considered in this assessment.

Figure 3-1: Percentage highly annoyed vs L_{DN} for rail noise (Miedema and Oudshoorn, 2001)



4. Methods and results

At a glance

Modelling software comprises SoundPLAN for railway, industrial and construction noise and TNoise for traffic noise. Both of these software programs invoke the widely accepted algorithms applicable for each relevant area of assessment.

The Masterplan was imported into SoundPLAN from AutoCAD in order to accurately define the site area and its proposed constituents.

Railway noise was modelled employing the Nordic Rail Prediction Method which is preferred over the Calculation of Railway Noise (CRN, UK) as it predicts both the L_{Aeq} and L_{Amax} noise indices. Exceedances are predicted at all representative receiver locations onsite.

Industrial and construction noise was predicted under the relevant 15-minute assessment periods. An exceedance of 15 dB(A) (and 17 dB(A) under noise enhancing meteorological conditions) due to existing light industries along Coreen Avenue are expected at the nearest proposed residential location onsite (R01).

During the operational phase of the proposed industrial areas onsite (E1, E2 and E3), compliance is expected to be achieved at the representative onsite and offsite receiver locations (R01, R02, R03, R04, R05, R08, R09, R11, R12, R13 and R14) with the implementation of appropriate recommendations as outlined within this report.

The activities of the proposed industrial operations onsite were assumed based on a warehousing/manufacturing facility.

Exceedances are expected at the representative onsite locations nearest to Coreen Avenue (R01, R13) based on existing traffic volumes along Coreen Avenue. Furthermore, the potential road traffic noise levels at project opening (2016) due to the traffic yield of the 2016 base and the proposed development at North Penrith has been assessed. Under this scenario, the expected noise level increase is 0.6 dB(A) during the daytime and 0.9 dB(A) during the night-time period. Therefore the proposed development is not predicted to increase the existing levels on Coreen Avenue by more than 2 dB(A) according to CoRTN procedures.

During the construction phase, noise levels are predicted to comply at the nearest sensitive receivers which include the existing light industries to the north of the site, residences to the east, a hospital to the south-east, an educational institution to the south, a library to the south-west and a museum located to the west of the site.

At the northern site boundary, the cumulative noise levels from the existing road traffic along Coreen Avenue and the existing light industries will need to be considered in the design and the specification of the built form for the proposed residences. The most affected residences proposed onsite are considered to be within the immediate area of the entry into The Boulevard as the residential buildings at this location will be subject to the road traffic noise along Coreen Avenue and The Boulevard.

The predominant noise sources along the southern site boundary consist of the operations at Penrith railway line.

Ameliorative design measures such as building layouts and construction requirements for the most exposed facades along the northern and southern site boundary will need to be considered in the built form for residential and commercial buildings.

Vibration generated by train passbys along the Penrith railway line adjacent to the proposed development will not potentially generate structure borne vibration when assessing the measured vibration levels within 75m of the nearest operating railway track. The low levels of structure borne vibration is not expected to radiate noise at an appreciable level and therefore complies with the internal noise goals for structure borne noise set out in Table 3 of the NSW DECCW's Interim Guidelines for the Assessment of Noise from Rail Infrastructure Projects (2007).

Construction vibration is deemed to be manageable if construction activities are carried out in accordance with the typical safe working distances for vibration intensive plant as listed in Table 3-10 of this report. Guide values for human response and cosmetic damage provided in Table 3-8, Figure 4-1 and Table 3-9 should be complied with during the construction phase.

Rail Noise Methodology

The employed model was the Nordic Rail Prediction Method, which predicts both L_{Aeq} and L_{Amax} noise levels.

Each model has been developed from measurement data compiled in the country of origin based on their specific rolling stock fleet and track constructions and therefore have been validated for this assessment based on existing rail noise measurements.

Rail noise was separately calculated based on the number of worst-case passenger train movements during peak hours. This includes four (4) Oscar services which stop at Penrith on a typical weekday under the current timetable.

The number of freight trains was assumed to be half of the number of the passenger trains during each time period.

The cumulative LAeq(T) for rail noise was determined from the following formula:

$LAeq(T) = 10\log_{10}(1/T(\sum \cdot n_i \cdot 10^{0.1 \cdot SEL_i}))$

where:
T is the total time in the relevant period in seconds (viz, hours x 60 x 60)

n_i is the number of each type of event

SEL_i is the representative event SEL of each type of event as measured at the most-affected receiver and is summed over the different type of events occurring at the site.

∴ Passenger Train LAeq(24hr) = 74.6dB at 50m from railway tracks;
Freight Train LAeq(24hr) = 78.6 dB at 50m from railway tracks.

By instead applying a 15-minute integration based on the unattended and attended assessment periods, a difference of approximately 1 dB was found:

Passenger Train LAeq(24hr) = 75.5dB at 50m from railway tracks;
Freight Train LAeq(24hr) = 79.5 dB at 50m from railway tracks.

Although the difference based on the integration period is not substantial, the latter cumulative LAeq values based on the 15-minute integration period was applied to the predictive model as a conservative measure.

These levels have been validated within +/-1 dB when compared to the measured noise levels at the reference locations located 50m from the nearest operational railway tracks. This calibration procedure provides a more accurate data set.

Rail Noise Assumptions

Façade Correction

For neighbouring residential receivers, educational institutions, hospitals and other sensitive receiver locations, external noise levels are assessed at a distance of one (1) metre from the window of the receiver that is most exposed to noise from the rail corridor, at a height of 1.5 metres above floor level.

Due to access restrictions, most of the noise measurements were undertaken at or near the proposed site boundaries. Consequently, prediction of external noise levels at free-field receiver locations (in the absence of reflective surfaces), has been adjusted by +2.5dB to account for reflections from the building facades.

This will ensure that the comparison of measured and predicted noise levels against the noise criteria is consistent.

Modelling Assumptions

Conservative modelling factors have been adopted for the railway noise prediction.

The receivers were modelled at various heights to show any variances in noise levels at different elevations. Minor variances were observed, however once buildings are constructed onsite, structural shielding will be provided for certain levels or sections of buildings and therefore the resulting noise levels at one (1) metre from the window of the respective receiver may vary.

The following worst-case assumptions have been made:

- Hard ground between the railway and noise sensitive receivers.
- Noise-enhancing meteorological conditions, viz, 3m/s wind source to receiver and 2m/s drainage wind source to receiver with F stability class temperature inversion.
- An average hourly number of passenger trains were derived from the peak hour movements (0600 to 0800 and 1600 to 1800) and assumed for the daytime (15hour).
- The average hourly night-time (9hour) number of passenger trains was derived from train movements during the time period from 2200 to 0000.
- The number of freight trains was assumed to be half of the number of the passenger trains during each time period.
- Horn noise was excluded from the model during the night-time period, viz, 2200 to 0700 as trains do not usually sound the horn during this period.
- Rail vehicles modelled at a height of 3.5m (reference AS 2377-2002).
- Receiver heights (assuming a ceiling height of 2.5m and no ceiling space): 1.5m (level 1), 4m (level 2), 6.5m (level 3), 9m (level 4), 11.5m (level 5), 14m (level 6).
- Rail air brake release at a height of 1.0m.
- Train carriage length of 20m and a standard of 8 carriages.
- Chosen track of 500m to carry out reference monitoring 50m from the nearest operational track was extrapolated to a calibrated model with a target track length of 1000m.

Train Movements

Table 4-1: Passenger Trains at Penrith Railway Station during the Peak and Night time periods

Departure Times at Penrith for Emu Plains/Richmond to Chatswood Line			Arrival Times at Penrith for Chatswood to Emu Plains/Richmond Line		
Peak - Day (0600 to 0800)	**Peak - Evening (1600 to 1800)**	**Night (2200 to 0000)**	**Peak - Day (0600 to 0800)**	**Peak - Evening (1600 to 1800)**	**Night (2200 to 0000)**
0605	1600	2209	0602	1617	2201
0612	1613	2235	0619	1620	2223
0615	1631	2239	0627	1626	2253
0626	1638	2308	0654	1646	2312
0629	1643	2334	0713	1655	2327
0640	1659	2337	0725	1702	2342
0643	1713	-	0729	1713	2358
0647	1723	-	0750	1723	-
0654	1734	-	-	1726	-
0700	1740	-	-	1735	-
0709	1743	-	-	1743	-
0712	-	-	-	1751	-
0716	-	-	-	1755	-
0730	-	-	-	-	-
0741	-	-	-	-	-
0746	-	-	-	-	-
0754	-	-	-	-	-
0800	-	-	-	-	-

'-' No service

Table 4-2: Passenger Trains at Penrith Railway Station during the Peak and Night time periods

Departure Times at Penrith for Lithgow to Central Line			Arrival Times at Penrith for Central to Lithgow Line		
Peak - Day (0600 to 0800)	**Peak - Evening (1600 to 1800)**	**Night (2200 to 0000)**	**Peak - Day (0600 to 0800)**	**Peak - Evening (1600 to 1800)**	**Night (2200 to 0000)**
0605	1638	2334	0619	1620	2201
0640	1723	-	0627	1646	2312
0654	1734	-	0713	1713	-
0709	-	-	0729	1735	-
0741	-	-	-	1743	-
0754	-	-	-	1758	-

'-' No service

Table 4-3: Total number of Passenger Train Movements at Penrith Railway Station

Passenger train movements per assessment period	Peak – Day 0600 to 0800	Peak – Evening 1600 to 1800	Night 2200 to 0000
Hourly ($n_{i,hourly}$)	16	16	8

Train Speeds

An upward gradient of approximately 10m has been observed along the 1000m target track from the western point to the south-eastern point. Therefore, different train speeds have been assumed as shown in Table 4-4 below.

Table 4-4: Maximum Assumed Train Speeds at Penrith Railway Station

Train type	Down	Up
Electric Passenger	80	80
Freight	70	80

These speeds are comparable to maximum train speeds at similar NSW train stations.

The model scenario was configured to provide a worst-case assessment of the potential site-related noise emissions. The model configurations were used to calculate noise levels at the nearest potentially affected receivers under the existing maximum operations. The scenarios are detailed in Table 4-5 below.

Table 4-5: Modelled Noise Scenarios Considered

Scenario	Description	Sources Included	Source Locations
Maximum Operations			
1	All rail noise sources	Passenger Train (4 pass-bys per 15min) Freight Train (2 pass-bys per 15 min) Train horn sounding and brake release	Along the 1000m target track length adjacent to the subject site and the Penrith Training Depot

Note: It is unlikely that trains will ever operate continuously at a rate similar to a peak period for an entire daytime/night-time period. A scenario where the number of trains are similar to the peak hour period provides a stringent assessment of potential off-site noise impact.

There was minimal activity observed in the railway car park and the stabling yard during the attended monitoring periods (daytime).

The following meteorological conditions were applied to Scenario 1:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

Existing Rail Noise Prediction

Table 4-6: Modelled Existing Rail Noise Impacts

Scenario		Receiver Location									
		R01	R02	R03	R04	R06	R07	R09	R10	R12	R13
Design Criteria External (LAeq,24hr)		**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
Scenario 1 (LAeq,24hr)	Condition A	59.0	61.8	60.7	65.2	65.4	68.9	65.1	69.1	65.1	60.8
	Condition B	63.2	65.8	64.8	68.8	69.1	72.0	68.7	71.9	68.5	64.8
Design Criteria (LAmax,fast)		**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**
Scenario 1 (LAmax)	Condition A	65.4	68.6	68.7	76.4	73.9	78.9	72.7	77.8	73.5	68.3
	Condition B	65.4	68.6	68.7	76.4	73.9	78.9	72.7	77.8	73.5	68.3

Potential exceedance

The following receiver locations were precluded from the existing railway noise assessment as they are pertinent to the construction stage of the proposed development:

- R05 represents a local hospital existing to the south-east of the site;
- R08 represents an educational institution;
- R11 represents a local library; and
- R14 is a central receiver location for the light industries to the north of the site.

Under light wind in Condition B, there is an increase of 4.3 to 5dB when compared to Condition A.

The existing rail noise levels exceed the design criteria for residences at all locations as shown in Table 4-6 above.

Under Condition A, the exceedances range from 4 dB to 14.1 dB at all of the representative receiver locations onsite. During light winds (source to receiver) under Condition B, exceedances between 8.2 dB to 17 dB are expected due to existing rail noise. The design of the residential and commercial buildings closest to the railway line will need to consider these exceedances as outlined in the Building Design section of this report.

During the night-time period, the predicted LAmax values are predicted to be contained below the design criteria of 55 dB,L_{Amax} at R01, R02, R03, R04, AND R13 on the general basis that a façade with a partly open window will provide a 10 dB(A) noise reduction therefore resulting in an internal noise level of 45 dB,L_{Amax}.

In order to minimise sleep disturbance, the recommended internal noise levels are 45 dB,L_{Amax} indoors (fast response) as recommended by the World Health Organisation (WHO). Where exceedances are predicted at R06, R07, R09, R10 and R12 during the night-time period, ameliorative measures are recommended to be incorporated into the built form as outlined in the Building Design section of this report.

Rail Vibration Methodology

A potential vibration impact assessment due to the existing Penrith Railway Line Corridor was carried out under the British Standard BS6472:1992 and Australian Standard 2670.2 in order to ascertain the likelihood of undue vibratory disturbance for occupants at the proposed site.

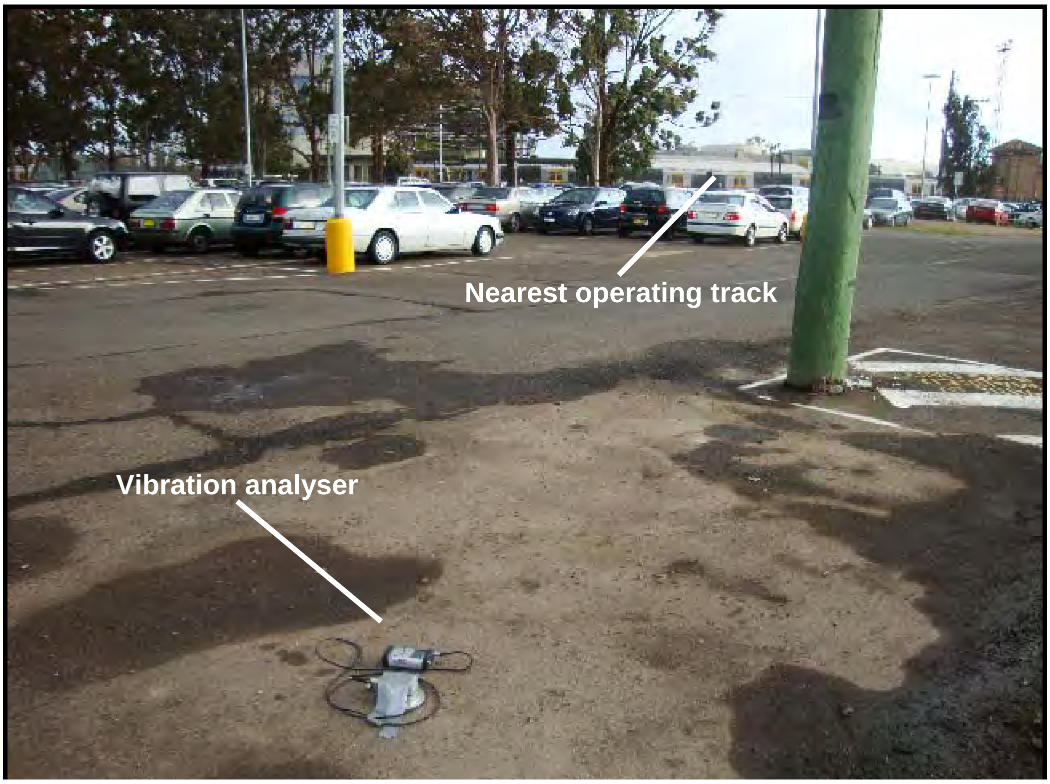
A Svantek SVAN958 four-channel sound vibration analyser (as shown in the photograph below) was utilised to measure the existing vibration levels from the Penrith rail line at a location approximately 75m away from the nearest operating railway track.

The comparative analysis undertaken between the above standards show that the existing rail vibration impacts will not adversely affect human comfort when measured in the region of 75m from the nearest operating railway tracks.

There are proposed mixed use and residential buildings at North Penrith located within a closer proximity to the railway line. Based on the extremely low levels of measured vibration levels at the 75m reference locations, the nearest mixed use and residential buildings to the railway line will not experience unacceptable levels of railway induced building vibration.

When considering the potential impacts from the railway line on structural vibration, the assessment was undertaken in accordance with the German Standard DIN 4150.3. The measured velocities were in compliance with the guideline values.

The human comfort limits are more stringent when compared with building damage and therefore if compliance with human comfort is achieved then it is known that compliance will be achieved with the building damage objectives.



According to the Geotechnical and Groundwater Assessment (Geotechnique Pty Ltd, 22 September 2010), the site geology of its western portion (close to the Nepean River) is known to generally be underlain by sand and gravel river deposits. The eastern portion which encompasses the Lemongrove residences offsite, is underlain by heavy clays derived from weathering of the underlying shale bedrock (Wianamatta Shales).

It is generally understood that ground-borne vibration is more readily transmitted via continuous rock beds.

The findings from the Geotechnical and Groundwater Assessment suggest there are no continuous rock strata between the railway line and the proposed development at North Penrith. Therefore, any correlation between continuous rock strata affecting the rate at which ground-borne vibration would occur at North Penrith is negated.

The type of vibration pertaining to railway activities is considered 'intermittent' and therefore the standards were applied accordingly.

Human Comfort Vibration

During the night-time, the number of trains was assumed to be 8 per hour, which is half the number of trains assumed for the daytime. Each train was assigned an approximate duration of 5 minutes to cause the vibration on the railway tracks during a 5-hour night-time period when the trains usually operate on the Penrith rail line, viz, 5am, 6am, 10:00pm, 11:00 pm and 12:00am.

Table 4-7: Vibration dose values obtained for the daytime and night-time in the x-axis ($m/s^{1.75}$)

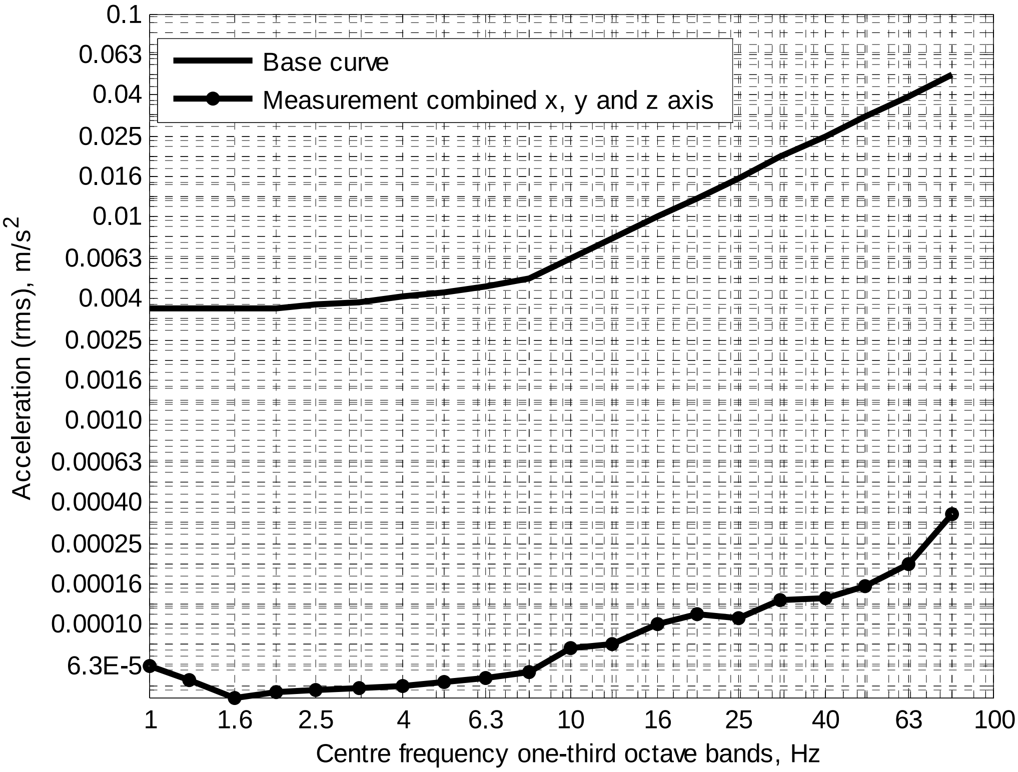
Location	eVDV Daytime				eVDV Night-time			
	x-axis	y-axis	z-axis	Preferred value	x-axis	y-axis	z-axis	Preferred value
Residences	0.0026	0.0027	0.0040	0.20	0.0023	0.0024	0.0036	0.13

Both the day and night-time eVDV values are under the 'preferred value' for residences.

The resultant vibration dose values when evaluated under the BS6472 standard as above can be compared to an alternative standard, viz, Australian Standard AS2670.2: 1990 – *Evaluation of Human Exposure to Whole Body Vibration – Continuous and shock-induced vibration in buildings (1 to 80 Hz)* to ascertain the status of compliance in terms of human comfort.

AS2670.2 provides a 'base curve' when assessing vibration impacts in terms of human comfort. The measured acceleration values have been plotted against the base curve according to AS2670.2:1990 and presented in the figure below.

Figure 4-1: X, y, z axes base curve (rms, m/s²) vs x, y, z axes measurement (rms, m/s²)



The measured rms values (m/s²) are under the base curve under all frequencies in the x, y and z axes and therefore, human comfort due to rail vibration is deemed to be satisfactory.

Structural Vibration

The signal envelope presented a similar trend between the x, y, and z axes. However, the most energy was found to be in the z-axis.

The measured V_{max} values are significantly lower than the (DIN4150) lines 1, 2 and 3 and therefore vibration isolation is not deemed to be required for the proposed onsite premises at this stage of assessment.

The guideline values in Figure 4-1 account for frequencies of up to 100 Hz which indicates that higher frequency vibration has less potential to cause damage than lower frequencies.

Figure 4-2: Guideline values vs measured velocities in the x-axis (mm/s)

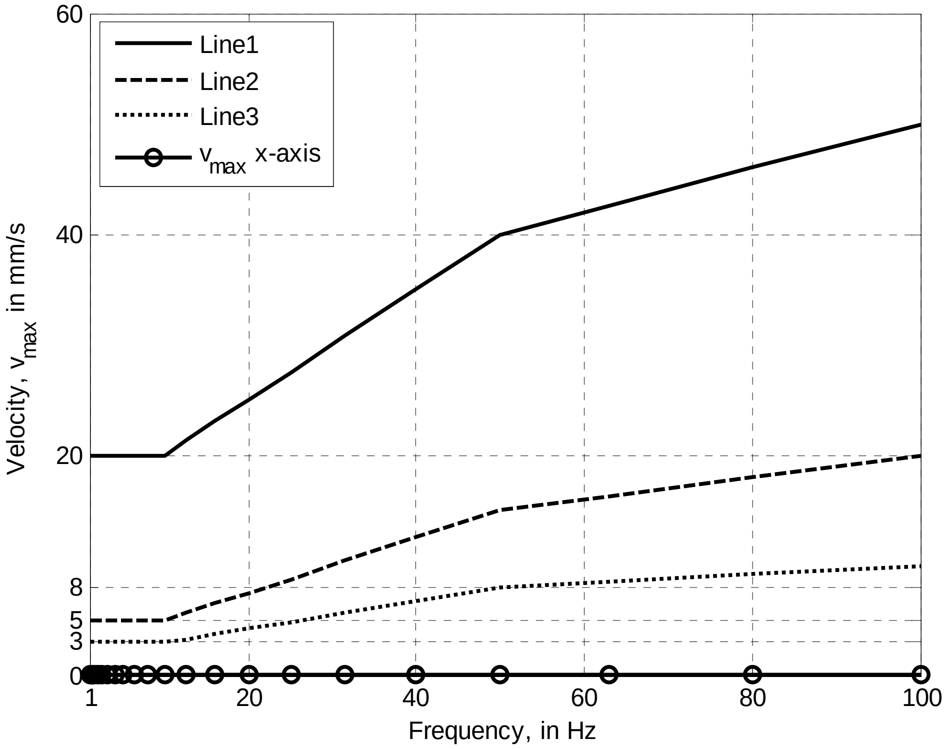


Figure 4-3: Guideline values vs measured velocities in the y-axis (mm/s)

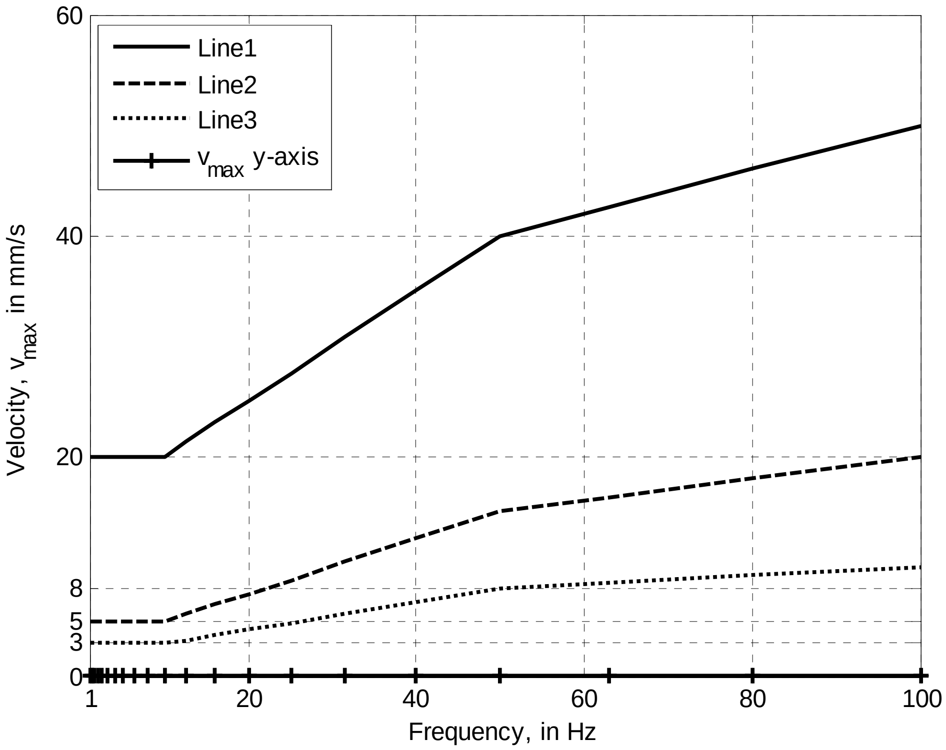
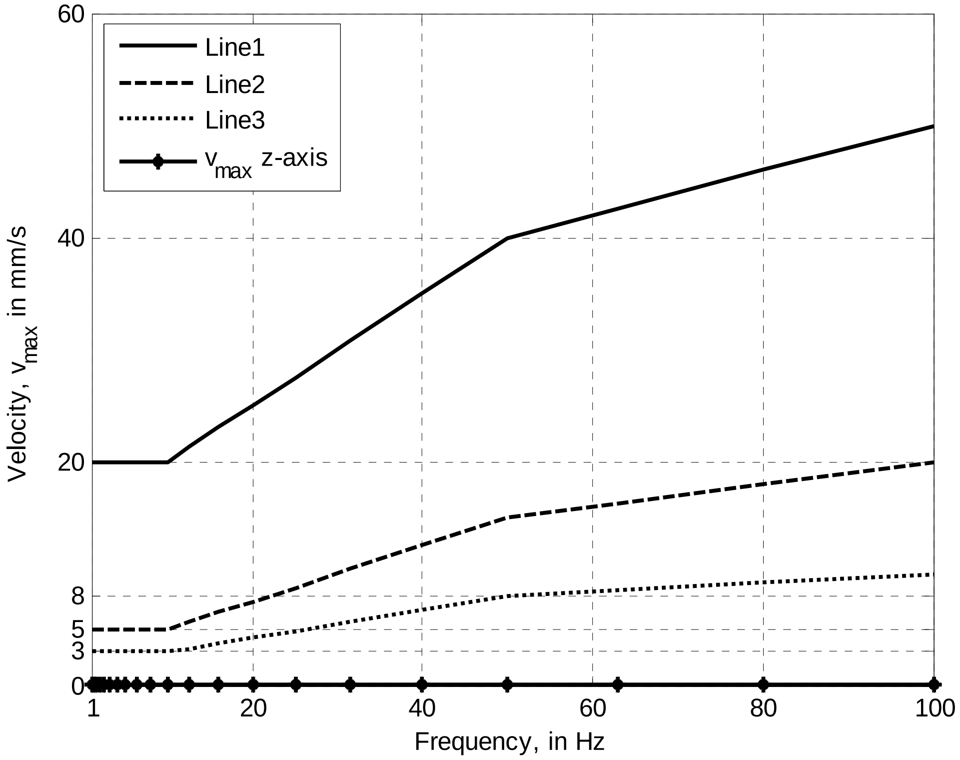


Figure 4-4: Guideline values vs measured velocities in the z-axis (mm/s)



Traffic Noise Methodology

Noise levels from the existing Coreen Avenue traffic were calculated following the CoRTN prediction algorithms in order to assess the current impacts potentially affecting the residences within the study area.

The modelled road segment for this assessment is from Coreen Avenue (east of Commuter Carpark Road) to Coreen Avenue (west of Coombes Drive). This road segment represents generally consistent characteristics when considering the speed zone (50km/h), pavement type and grade.

A computer modelling program, TNOISE was used. TNOISE calculates traffic noise following the method described in the book: "Calculation of Road Traffic Noise" (CoRTN) issued by the U.K. Department of Transport in 1988. This program predicts the $L_{A10(1hr)}$ noise levels, then calculates $L_{Aeq(1hr)}$ noise levels for every hour in a day (24 hours) by applying a correction of – 3 dB(A). TNOISE does not account for meteorological conditions and therefore the road traffic noise along Coreen Avenue has been modelled under 'neutral' meteorological conditions.

The final noise modelling was performed in SoundPLAN v7.0 to further validate the noise levels and to consolidate the various noise sources of interest (including industrial, railway etc).

For an accurate assessment, the model was compared with the attended monitoring results near Coreen Avenue. Upon comparison, existing traffic noise levels were predicted at each assessment location, and the levels were assessed against the established traffic noise criteria.

The traffic composition shown in the table below is based on a traffic survey undertaken by Parsons Brinckerhoff on 29 July 2010. Parsons Brinckerhoff has adjusted the count values according to seasonal RTA data.

The peak periods (as indicated by Parsons Brinckerhoff) of 8am to 9am and 4pm to 5pm during a weekday were modelled as a worst-case assessment. Assuming that the vehicle count during the night-time period (10pm-7am) is equivalent to 10% of the 24-hour figure (Parsons Brinckerhoff), a representative value for the night-time hour of 10pm has been applied for modelling purposes.

Proposed night-time road traffic volumes for year 2016 (project opening) and 2026 (10-year horizon) are based on Parsons Brinckerhoff's *Forecast Traffic Conditions on Coreen Avenue* (8 October 2010). The applied data in this report pertains to the 2016 Base and the predicted traffic yield due to the North Penrith project.

The respective traffic volumes for the existing and future operational scenarios are provided in the following tables.

Table 4-8: Coreen Avenue Traffic Composition - Existing 2010		
	Weekday	
Hour beginning	**Existing total vehicles**	**Percentage heavy vehicles**
8	998	3.1
16	1174	3.3
22	140	3.0
Total	**2172**	

Table 4-9: Coreen Avenue Traffic Composition – 2016 Base + North Penrith Project		
	Weekday	
Hour beginning	**Predicted total vehicles**	**Percentage heavy vehicles**
8	1118	3.1
16	1326	3.3
22	205	3.0
Total	**2172**	

Traffic Noise Assumptions

The road traffic noise assessment applies to Coreen Avenue only.

A comparative analyse was carried out between the predicted TNoise model of the existing traffic along Coreen Avenue and the measured noise levels at 10 monitoring locations.

The resultant calibration factors were:

- 1.3dB to -1.3dB.

These calibration factors were taken into account in the final modelling process.

The calculation of existing road traffic noise levels has been undertaken using the following assumptions:

- Road surface: Bituminous;
- Road gradient: 1.1%;
- Absorbing ground: 0 % between the road and the receivers (worst-case scenario);
- An angle of 180 degrees at the receivers;
- Average source height: 1.5m to account for both light and heavy vehicles;
- Receiver heights (assuming a ceiling height of 2.5m and no ceiling space): 1.5m (level 1), 4m (level 2), 6.5m (level 3), 9m (level 4), 11.5m (level 5), 14m (level 6); and
- A conservative assumption of '7 mm Bituminous Spray Seal' has been made with a respective correction factor of +3dB. In terms of noise, this is synonymous with dense graded asphalt.

With the presence of existing buildings (structural barriers) surrounding the subject site, hard ground has been assumed in accordance with the CoRTN procedures.

Assuming the receivers are positioned at a building façade, a +2.5dB correction has been applied to the model under the CoRTN procedures. This accounts for sound reflections from the façade surface.

Existing Traffic Noise Prediction

The ECRTN states that where criteria are already exceeded, the development should be designed so as not to increase existing noise levels by more than 2 dB. It also states that all feasible and reasonable noise mitigation opportunities should still be explored, to endeavour to reduce noise levels towards the ECRTN noise criteria before applying a 2 dB allowance.

In many instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

RTA's Environmental Noise Management Manual (ENMM) provides guidelines in selecting and designing 'feasible and reasonable' treatment options as follows:

'Feasibility' relates to engineering considerations (what can be practically built). These engineering considerations may include:

- The inherent limitation of different techniques to reduce noise emissions from road traffic noise sources;
- Safety issues, such as restrictions on road vision;
- Road corridor site constraints such as space limitation;
- Floodway and stormwater flow obstruction;
- Access requirements;
- Maintenance requirements; and
- The suitability of building conditions for architectural treatments.

'Reasonableness' relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected;
- The cost of mitigation, including the total cost and cost variations with different benefits provided;
- Community views and wishes;
- Visual impacts;
- Existing and future noise levels, including changes in noise levels; and
- The benefits arising from the proposed road or road redevelopment.

Considering the growing development areas in Penrith overall, and the increased number of vehicles frequenting Coreen Avenue as a result, any potential increases in traffic movements along Coreen Avenue due to the proposed development at North Penrith is predicted to be insignificant. When compared with the existing 2010 results, the predicted noise levels along Coreen Avenue in year 2016 (including the contribution due to North Penrith) range between 0.6 to 0.7 dB(A) during the daytime and 1.6 to 1.7 dB(A) during the night-time.

It is therefore considered that the proposed development at North Penrith will not increase the existing road traffic levels by more than 2 dB. As such, a 2 dB increase allowance has been considered for receiver location R01 where existing road traffic noise levels from Coreen Avenue are already exceeded. The predicted existing noise levels have incorporated both eastbound and westbound traffic volumes.

Predicted Road Traffic

Table 4-10: Existing Road Traffic Noise Levels dB(A), Weekday - Coreen Ave 2010

Receiver	Existing Noise Level		ECRTN Criteria		Exceedance	
	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day	Night
R01	68.4	57.4	62[1]	57[1]	6.4	0.4
R02	55.8	44.8	60	55	0	0
R03	54.7	43.7	60	55	0	0
R04	48.7	37.7	60	55	0	0
R06	51.5	40.5	60	55	0	0
R07	49.8	38.8	60	55	0	0
R09	52.3	41.3	60	55	0	0
R10	49.6	38.6	60	55	0	0
R12	50.7	39.7	60	55	0	0
R13	58.4	47.4	60	55	0	0

Note:

1. After applying a 2 dB-increase allowance to existing levels as the existing noise levels already exceed the criteria.

Table 4-11: Predicted Road Traffic Noise Levels dB(A), Weekday - Coreen Ave 2016

Receiver	Predicted Noise Level		ECRTN Criteria		Exceedance	
	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day	Night
R01	69.0	58.3	62[1]	57[1]	7.0	1.3
R02	56.4	45.7	60	55	0	0
R03	55.3	44.6	60	55	0	0
R04	49.3	38.6	60	55	0	0
R06	52.1	41.5	60	55	0	0
R07	50.4	39.7	60	55	0	0
R09	52.9	42.2	60	55	0	0
R10	50.2	39.5	60	55	0	0
R12	51.3	40.6	60	55	0	0
R13	59.1	48.4	60	55	0	0

Note:

1. After applying a 2 dB-increase allowance to existing levels as the existing noise levels already exceed the criteria.

It can be seen from these modelling results that compliance is predicted to be achieved at all receiver locations with the exception of R01. R01 represents the nearest proposed residential premises to Coreen Avenue on the Masterplan. At this location, suitable noise mitigation measures for the proposed residential and commercial buildings as documented within the Building Design section of this report are recommended for the proposed residential buildings at North Penrith.

Road Traffic Sensitivity Analysis

A sensitivity analysis has been performed in order to show any variations in road traffic noise levels along Coreen Avenue ten years after opening (2026).

The traffic volumes over the 10-year operational horizon have been derived from Parsons Brinckerhoff's predicted 2026 base counts and the traffic volume contribution due to the proposed development at North Penrith.

Similar to the 2010 and 2016 assessments above, a weekday scenario was applied as part of a worst-case assessment since traffic volumes are generally higher during the week compared to the weekend.

At the façade of the nearest residential receiver to Coreen Avenue, a noise level increase of 1 dB(A) is expected during the daytime when compared with the predicted 2016 results above. Similarly, an increase of 0.5 dB(A) is expected during the night-time period. A minor exceedance is predicted during the daytime at R13 which is deemed negligible.

Table 4-12: Predicted Road Traffic Noise Levels dB(A), Weekday - Coreen Ave 2026

Receiver	Existing Noise Level		ECRTN Criteria		Exceedance	
	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day	Night
R01	70.0	58.8	62[1]	57[1]	8.0	1.8
R02	57.4	46.2	60	55	0	0
R03	56.3	45.2	60	55	0	0
R04	50.3	39.2	60	55	0	0
R06	53.2	42.0	60	55	0	0
R07	51.4	40.2	60	55	0	0
R09	53.9	42.7	60	55	0	0
R10	51.2	51.2	60	55	0	0
R12	52.3	41.1	60	55	0	0
R13	60.1	48.9	60	55	0.1	0

Note:

1. After applying a 2 dB-increase allowance to existing levels as the existing noise levels already exceed the criteria.

Construction Noise Methodology

The construction works within the Stage 1 Application include taking out concrete slabs, earthworks, and constructing essential infrastructure. Any crushing of concrete will be undertaken at a later stage.

The purpose of the proposed earthmoving and site beautification works is to demolish existing buildings and construct essential infrastructure (such as roads, services, and open spaces) and a community building at the Oval.

The construction activity schedule will depend on the contractor undertaking the works. Therefore, assumptions of activities and equipment (pertinent to this stage of the application) have been made for each construction phase of the project.

Table 4-13: Summary of Activities for each Construction Scenario

Scenario	Activities
1	Site clearing and bulk earthworks
2	Construct access routes/internal roads
3	Excavation and installation of drainage
4	Installation of underground electrical cables
5	Construction of community building and open spaces

In order to quantify the potential construction noise levels from the proposed works, the anticipated noise sources have been modelled in the DECCW-recognised SoundPLAN software program to predict the $L_{Aeq(15min)}$ noise levels at the nearest potentially affected receivers.

Typical LAeq sound power levels for the anticipated equipment assumed are shown below. The sound power levels reflect the assumption that the equipment will be selected for this project with the intent of minimising noise.

The sound power levels for the construction plant has been obtained from Benbow Environmental's extensive noise database and also compared with Table 2 in TIDC's *Construction Noise Strategy (Rail Projects)* for a higher confidence level of the data.

Construction noise levels have been predicted at the nearest potentially affected receiver locations:

- North – R14 (central location to represent existing industries along Coreen Avenue);
- East – near R03, R04 (residences along the Lemongrove subdivision);
- South – R08 (Western Sydney Institute Nepean College);
- Southeast - R05 (Governor Phillip Hospital);
- Southwest – R11 (Penrith Regional Library); and
- West – near R12 (Museum of Fire and SkillsWest Training Centre).

Table 4-14: Summary of Sound Power Levels used	
Plant Item	**L_{Aeq} Sound Power Level, dB(A)**
Dump truck (approx. 50 tonne)	108
Excavator	105
Scraper	108
Dozer	114
Water cart (approx. 20,000 litre)	105
Grader	102
Roller	104
Trench compactor	104
Crusher and screens	112
Concrete truck	105
Concrete pump	105
Concrete saw	110
Front end loader	111
Semi-trailer	102
Hand tools	92
Generator	96
Truck air brake release	110

The construction hours are assumed to occur during the recommended standard hours for 'normal' construction work and therefore this assessment covers the daytime period only:

- Monday to Friday 7am to 6pm;
- Saturday 8am to 1pm; and
- No work on Sundays or public holidays.

N/A Not applicable

The background noise levels were derived from the unattended L_{A90} (RBL) values presented in Table 2-8 of this report.

Based on site inspections, the background noise levels applied to the receiver locations are deemed representative of each respective area.

The following meteorological conditions were applied to each modelling scenario:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

Where internal noise limits are specified, the predicted noise levels are taken to be 10 dB(A) less inside the receiver building to account for a typical façade reduction with windows slightly open for ventilation.

Under Scenario 1, the predicted noise level of 50 dB(A) at R03 under Condition B and 60 dB(A) at R12 under Condition B coincides with the noise management level also of 60 dB(A) at this location and therefore safeguards outlined within the Construction Noise and Vibration Management section of this report are recommended to be implemented during the operations of the proposed works.

Under Scenario 5, Condition B compliance is predicted within 1 dB(A) of the noise management level at R03 and therefore it is appropriate to recommend the abovementioned safeguards during the associated works.

Compliance is expected to be achieved at the remaining receivers under the outstanding scenarios and meteorological conditions.

Table 4-15: Predicted Construction Noise Levels – Scenario 1, Daytime

Scenario	Most Potentially Affected Receiver	Background Noise Level L_{A90}, dB(A) RBL	$L_{Aeq(15min)}$ Noise Level, dB(A)			
			Noise Management Level	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance
1 - Site clearing and bulk earthworks (including concrete crushing)	R03 – residence (near eastern site boundary)	40	50 (external)	46	50	None predicted
	R04 – residence (near south-eastern boundary)	39	49 (external)	42	47	None predicted
	R05 – hospital	N/A	45 (internal)	33	38	None predicted
	R08 – college	N/A	45 (internal)	45	49	None predicted
	R11 – library	N/A	45 (internal)	39	44	None predicted
	R12 – museum	N/A	60 (external)	58	60	None predicted
	R14 – existing industries	N/A	75 (external)	51	55	None predicted

Table 4-16: Predicted Construction Noise Levels – Scenario 2, Daytime

Scenario	Most Potentially Affected Receiver	Background Noise Level L_{A90}, dB(A) RBL	$L_{Aeq(15min)}$ Noise Level, dB(A)			
			Noise Management Level	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance
2 – Construct access routes/internal roads	R03 – residence (near eastern site boundary)	40	50 (external)	29	34	None predicted
	R04 – residence (near south-eastern boundary)	39	49 (external)	27	31	None predicted
	R05 – hospital	N/A	45 (internal)	18	23	None predicted
	R08 – college	N/A	45 (internal)	30	34	None predicted
	R11 – library	N/A	45 (internal)	25	30	None predicted
	R12 – museum	N/A	60 (external)	44	47	None predicted
	R14 – existing industries	N/A	75 (external)	36	40	None predicted

Table 4-17: Predicted Construction Noise Levels – Scenario 3, Daytime

Scenario	Most Potentially Affected Receiver	Background Noise Level L_{A90}, dB(A) RBL	$L_{Aeq(15min)}$ Noise Level, dB(A)			
			Noise Management Level	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance
3 – Excavation and installation of drainage	R03 – residence (near eastern site boundary)	40	50 (external)	42	47	None predicted
	R04 – residence (near south-eastern boundary)	39	49 (external)	39	44	None predicted
	R05 – hospital	N/A	45 (internal)	30	36	None predicted
	R08 – college	N/A	45 (internal)	41	46	None predicted
	R11 – library	N/A	45 (internal)	36	41	None predicted
	R12 – museum	N/A	60 (external)	50	54	None predicted
	R14 – existing industries	N/A	75 (external)	47	52	None predicted

Table 4-18: Predicted Construction Noise Levels – Scenario 4, Daytime

Scenario	Most Potentially Affected Receiver	Background Noise Level L_{A90}, dB(A) RBL	$L_{Aeq(15min)}$ Noise Level, dB(A)			
			Noise Management Level	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance
4 – Installation of underground electrical cables	R03 – residence (near eastern site boundary)	40	50 (external)	42	47	None predicted
	R04 – residence (near south-eastern boundary)	39	49 (external)	39	44	None predicted
	R05 – hospital	N/A	45 (internal)	30	35	None predicted
	R08 – college	N/A	45 (internal)	41	46	None predicted
	R11 – library	N/A	45 (internal)	36	41	None predicted
	R12 – museum	N/A	60 (external)	50	54	None predicted
	R14 – existing industries	N/A	75 (external)	47	52	None predicted

Table 4-19: Predicted Construction Noise Levels – Scenario 5, Daytime

Scenario	Most Potentially Affected Receiver	Background Noise Level L_{A90}, dB(A) RBL	$L_{Aeq(15min)}$ Noise Level, dB(A)			
			Noise Management Level	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance
5 – Construction of community building	R03 – residence (near eastern site boundary)	40	50 (external)	44	49	None predicted
	R04 – residence (near south-eastern boundary)	39	49 (external)	40	45	None predicted
	R05 – hospital	N/A	45 (internal)	27	32	None predicted
	R08 – college	N/A	45 (internal)	41	46	None predicted
	R11 – library	N/A	45 (internal)	30	35	None predicted
	R12 – museum	N/A	60 (external)	41	46	None predicted
	R14 – existing industries	N/A	75 (external)	42	47	None predicted

Industrial Noise Methodology

The existing industries along the northern boundary of the subject site are mainly observed to be light industrial.

The predominant industrial noise source along Coreen Avenue was located approximately 90m north of R01. During the attended monitoring periods, industrial noise contribution at R01 was recorded at 65 dB(A), $L_{Aeq(15min)}$. The model was calibrated to reflect this value at this receiver location. Third-octave spectral data recorded in the absence of traffic movements along Coreen Avenue (where possible) was applied to represent the existing industrial noise profile.

At R01, the indicative Masterplan shows 1-2 storey buildings with 3-6 storeys at R09. As such, the receiver heights have been adjusted accordingly and presented together with the predicted noise levels below.

The DECCW-recognised SoundPLAN v7.0 model software was used to model each scenario with noise enhancing meteorological conditions, in accordance with the INP:

- Condition A: Calm, isothermal weather conditions; and
- Condition B: 3 m/s wind from source to receiver.

Table 4-20: Predicted Industrial Noise Levels (existing), dB(A) NO CONTROLS

PSNL dB(A),L_{Aeq}	Receiver Location		
	R01 (1.5m, 4.0m high)		R09 (1.5m, 6.5m, 14.0m high)
	Residence 50	Industrial 68	Commercial 65
Condition A	65	65	40
Condition B	67	67	45

A potential exceedance of 15 dB(A) and 17 dB(A) is expected at R01 under Condition A and Condition B respectively when considering residential premises. Therefore, the most exposed façades of the residential premises are recommended to be acoustically treated as outlined in the Building Design section of this report.

The onsite industrial and commercial receivers nearest to the existing industries along Coreen Avenue are R01 and R09 respectively as marked on the Masterplan. Compliance is expected at both of these onsite locations.

The existing industries along Coreen Avenue is assumed to operate during the daytime (7am – 6pm) only and therefore the design criteria and modelling results apply to the respective time of day.

Penrith Training Depot

The following predictive noise modelling scenarios have been derived from information received from the Department of Defence. The model scenarios account for the existing training (outdoor) and other outdoor activities at the Penrith Training Depot (PTD).

Table 4-21: Modelled Noise Scenarios Considered – Existing Operations

Scenario	Description	Sources Included	Source Location
Maximum Operations			
1	All operations in Scenarios 2 to 5	All sources	Distributed throughout PTD
Regular Operations			
2	Onsite training west During evening period (6.30pm to 10.00pm)	1 raised voice for the full duration of training	Near western boundary of PTD
3	Onsite training east (6.30pm to 3.00pm*)	1 raised voice for the full duration of training	Near eastern boundary of PTD
4	Onsite tool and vehicle maintenance During daytime period (15 mins during 7.00am to 6.00pm)	Hand tools Idling engine Handheld welder	Distributed throughout PTD
5	Onsite vehicle movements 6.30pm to 10.00pm	15 heavy vehicles, 1 hour 1 forklift, 1 hour 100 light vehicles, dropping off at 6.30pm and picking up at 10.00pm	Distributed throughout PTD

* Training occurs throughout the weekend so a conservative assessment during a 20.5-hour training session has been assumed from 6.30pm Friday to 3.00pm Saturday.

The sound power levels for the outdoor PTD activities as shown in the table below have been obtained from Benbow Environmental's inhouse noise database.

Table 4-22: Summary of Sound Power Levels used

Plant Item	L_{Aeq} Sound Power Level, dB(A)
Raised voice	83.0
Hand tools	92.0
Idling engine	99.0
Handheld welder	103.9
Truck manoeuvring	102.5
Forklift	101.8
Car	75.7

The following meteorological conditions were applied to each modelling scenario:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

The predictive noise modelling results of the existing PTD operations are shown below. These activities are deemed to be the main noise-generating activities onsite and thus represent the worst-case operational scenarios.

The nearest onsite potentially affected residence considered is R07 for Scenario 2, R06a for Scenario 3 with the nearest onsite commercial receiver represented also by R07. The nearest potentially affected industrial receiver considered onsite is R01.

R06a is a representative onsite receiver location immediately to the east of the eastern PTD boundary and south of R06. This location would share a similar ambient noise environment as R07 and therefore the same noise criteria have been applied at R06a.

Table 4-23: Scenario 1 - Predicted PTD Maximum Operations Noise Levels (existing), dB(A)

	Receiver Location							
	R01	**R06a**			**R07**			**R07**
	Industrial	**Residence**			**Residence**			**Commercial**
	When in use	Day	Even	Night	Day	Even	Night	When in use
PSNL dB(A),L_{Aeq}	68	46	48	43	46	48	43	65
Condition A	24	40	43	N/A	34	36	N/A	34
Condition B	29	42	44	N/A	37	39	N/A	37

Under Scenario 1 maximum operations, compliance is predicted at the receiver locations during Conditions A and B.

Table 4-24: Scenario 2 - Predicted PTD Evening Training (West) Noise Levels (existing), dB(A)

	Receiver Location				
	R01	**R07**			**R07**
	Industrial	**Residence**			**Commercial**
	When in use	Day	Even	Night	When in use
PSNL dB(A),L_{Aeq}	68	46	48	43	65
Condition A	17	N/A	34	N/A	34
Condition B	22	N/A	36	N/A	36

N/A Not Applicable

During Scenario 2, compliance is predicted to be achieved at R01 and R07 under Conditions A and B.

Table 4-25: Scenario 3 - Predicted PTD Evening Training (East) Noise Levels (existing), dB(A)

	Receiver Location				
	R01	R06a			R07
	Industrial	Residence			Commercial
	When in use	Day	Even	Night	When in use
PSNL dB(A),L_{Aeq}	68	46	48	43	65
Condition A	19	N/A	35	N/A	26
Condition B	24	N/A	36	N/A	30

N/A Not Applicable

Compliance is expected during Scenario 3 at R01, R06 and R07 under Conditions A and B.

Table 4-26: Scenario 4 - Predicted PTD Daytime Tool and Vehicle Maintenance Noise Levels (existing), dB(A)

	Receiver Location							
	R01	R06a			R07			R07
	Industrial	Residence			Residence			Commercial
	When in use	Day	Even	Night	Day	Even	Night	When in use
PSNL dB(A),L_{Aeq}	68	46	48	43	46	48	43	65
Condition A	23	40	N/A	N/A	34	N/A	N/A	34
Condition B	28	42	N/A	N/A	37	N/A	N/A	37

During Scenario 4, tool and vehicle maintenance activities have been assumed to occur for 15 minutes during the daytime, i.e. 7am to 6pm. Under this scenario, PTD onsite activities are predicted to be inaudible at the receiver locations under Conditions A and B as shown in the table above.

Table 4-27: Scenario 5 - Predicted PTD Evening Vehicle Movement Noise Levels (existing), dB(A)

	Receiver Location							
	R01	R06a			R07			R07
	Industrial	Residence			Residence			Commercial
	When in use	Day	Even	Night	Day	Even	Night	When in use
PSNL dB(A),L_{Aeq}	68	46	48	43	46	48	43	65
Condition A	21	N/A	42	N/A	N/A	32	N/A	32
Condition B	26	N/A	43	N/A	N/A	35	N/A	35

Compliance is predicted under Scenario 4 at the receiver locations during Conditions A and B.

Future Industrial Developments Onsite

Development within the industrial areas of the proposed site marked as E1, E2 and E3 in Figure 2-2 is expected to be a mixture of light industrial units with operations similar to warehousing and ancillary uses.

The following operating hours were assumed based on similar facilities:

- 7.00am to 6.00pm Monday to Friday; and
- 7.00am to 4.00pm Saturdays.

As such, only daytime operations have been taken into account.

According to the NSW INP, onsite road traffic is classified as industrial noise and therefore the onsite vehicle movements have been assessed in this way.

The NSW Roads and Traffic Authority's *Guidelines for Traffic Generating Development* (2002) suggests Daily Vehicle Trips (DVT) as follows:

- Industrial Units :5 vehicle trips per day per 100 square metres gross floor space; and
- Warehousing :4 vehicle trips per day per 100 square metres gross floor space.

Based on these guideline values, an average DVT of 4.5 per 100 square metres gross floor space has been adopted for the purposes of this assessment. The gross floor space has been assumed to be 50% of each industrial area based on a similar warehousing facility.

The resultant estimated yield is shown in the table below.

Table 4-28: Estimated Daily Vehicle Trips – Proposed Industrial Areas Onsite

Proposed Industrial Area	Total Site Area (sqm)	Gross Floor Space (sqm)	Total DVT
E1	4800	2400	108
E2	7000	3500	158
E3	10800	5400	243
TOTAL			**509**

From the total estimated yield for each proposed industrial area, the breakdown of light and heavy vehicles have been based on a similar warehousing facility and presented in the following table.

The light vehicle movements are assumed to be a mixture of staff vehicles, customers/visitors, and light commercial vehicles transporting goods. The heavy vehicles are assumed to be for the purpose of deliveries and despatches.

The total DVT has been assumed to include return vehicle trips.

Table 4-29: Estimated Daily Vehicle Trips by Vehicle Type – Proposed Industrial Areas Onsite			
Proposed Industrial Area	**Total DVT**	**Type of Vehicle**	**Total DVT (Return trips)**
E1	120	Light	95
		Heavy	14
E2	175	Light	139
		Heavy	18
E3	270	Light	215
		Heavy	28
TOTAL			**509**

In addition to the vehicle movements, measured noise levels from a similar warehousing/manufacturing building has been applied to industrial areas E1, E2, E3. The representative sound power levels used to model the onsite industrial areas are provided in Table 4-21.

Table 4-30: Summary of Sound Power Levels used	
Plant Item	**L_{Aeq} Sound Power Level, dB(A)**
Semi trailer manoeuvring onsite	102
Engine compression brake	110
Light vehicle manoeuvring onsite	76
Warehousing and manufacturing building	79
Forklift (approx. 3 tonne)	102

Four (4) operating scenarios were established for the model so as to provide an estimate of the potential noise impacts due to the proposed industrial areas onsite. Each scenario is detailed in the table below.

The warehousing and manufacturing building has been based on a typical effective height of 4 m to represent a typical height of a roller shutter door in similar facilities.

The following meteorological conditions were applied to each modelling scenario:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

Table 4-31: Modelled Noise Scenarios Considered – Proposed Operations

Scenario	Description	Sources Included	Source Location
Maximum Operations			
	All vehicles	449 light vehicle trips	From site ingress to designated
		60 semi trailer trips	industrial areas E1, E2, E3.
1*		Compression brake	Egress via the same route.
	Operations	3 warehouse buildings	E1, E2, E3
		3 forklifts	E1, E2, E3
	All vehicles – E1	94 light vehicle trips	From site ingress to designated
		14 semi trailer trips	industrial area E1.
2		Compression brake	Egress via the same route.
	Operations	1 warehouse building	North-western corner of E1
		1 forklift	Within E1
	All vehicles – E2	139 light vehicle trips	From site ingress to designated
		18 semi trailer trips	industrial area E2.
3		Compression brake	Egress via the same route.
		1 warehouse building	North-western corner of E2
		1 forklift	Within E2
	All vehicles – E3	215 light vehicle trips	From site ingress to designated
		28 semi trailer trips	industrial area E3.
4		Compression brake	Egress via the same route.
		1 warehouse building	North-western corner of E3
		1 forklift	Within E3

* A scenario where all vehicles are arriving onsite simultaneously provides a stringent assessment of the potential off-site noise impact.

Engine compression brakes were modelled according to the number of heavy vehicles arriving at each designated industrial area, viz, E1, E2, E3 proposed onsite.

At varying receiver heights of 1.5m, 4m, 6.5m and 14m (for proposed premises onsite), an average deviation of +/- 1.2 dB(A) was observed.

It is generally considered that changes of up to 3 dB(A) in sound levels are not readily discernible to the human auditory system. Therefore the specified deviation is deemed negligible.

The predicted industrial noise levels for the proposed development are shown in the following tables.

Table 4-32: Predicted Industrial Noise Levels (proposed) – Scenario 1, dB(A) NO CONTROLS

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
1 - All vehicles and operations E1, E2, E3	R01 (residence)	50	68	69	18	19
	R02 (residence)	50	52	56	2	6
	R03 (residence)	50	50	54	None predicted	4
	R04 (residence)	50	40	45	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	30	35	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	36	41	None predicted	None predicted
	R09 (residence)	50	45	50	None predicted	None predicted
	R09 (commercial)	65	45	50	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	34	39	None predicted	None predicted
	R12 (Museum of Fire)	48	48	52	None predicted	4
	R13 (residence)	50	52	54	2	4
	R14 (existing industry)	68	59	61	None predicted	None predicted

Exceedances of 18 dB(A) and 19 dB(A) are predicted at R01 under Scenario 1 during Conditions A and B respectively.

A minor exceedance of 2 dB(A) is predicted at R02 under Condition A with Condition B resulting in an expected exceedance of 6 dB(A).

A 4 dB(A) exceedance is expected at R03 under Condition B.

At R12, a marginal exceedance of 4 dB(A) is predicted under light winds of 3m/s source to receiver.

The proposed onsite industrial areas are expected to be audible at R13 with an exceedance of 2 dB(A) and 4 dB(A) under Conditions A and B respectively.

Compliance is expected to be achieved at the remaining onsite and offsite receiver locations under the corresponding meteorological conditions.

Table 4-33: Predicted Industrial Noise Levels (proposed) – Scenario 2, dB(A) NO CONTROLS

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
2 - All vehicles and operations E1 only	R01 (residence)	50	68	69	18	19
	R02 (residence)	50	51	55	1	5
	R03 (residence)	50	49	53	None predicted	3
	R04 (residence)	50	39	43	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	28	33	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	32	37	None predicted	None predicted
	R09 (residence)	50	41	45	None predicted	None predicted
	R09 (commercial)	65	41	45	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	24	29	None predicted	None predicted
	R12 (Museum of Fire)	48	33	38	None predicted	None predicted
	R13 (residence)	50	38	43	None predicted	None predicted
	R14 (existing industry)	68	45	50	None predicted	None predicted

A potential noise impact of 18 dB(A) is expected at R01 under Scenario 2 during Condition A with a similar exceedance of 19 dB(A) under Condition B.

An exceedance of 1 dB(A) is expected at R02 during calm, isothermal conditions with a further exceedance of 5 dB(A) during light winds of 3m/s source to receiver.

At R03, the proposed E1 industrial operations are expected to be audible with an exceedance of 3 dB(A) under Condition B.

It is predicted that compliance will be achieved at all other receiver locations and meteorological conditions.

Table 4-34: Predicted Industrial Noise Levels (proposed) – Scenario 3, dB(A) NO CONTROLS

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
3 - All vehicles and operations E2 only	R01 (residence)	50	52	55	2	5
	R02 (residence)	50	47	51	None predicted	1
	R03 (residence)	50	40	45	None predicted	None predicted
	R04 (residence)	50	34	39	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	25	29	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	32	36	None predicted	None predicted
	R09 (residence)	50	42	47	None predicted	None predicted
	R09 (commercial)	65	42	47	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	26	30	None predicted	None predicted
	R12 (Museum of Fire)	48	37	42	None predicted	None predicted
	R13 (residence)	50	51	53	1	3
	R14 (existing industry)	68	59	60	None predicted	None predicted

The assessment of potential noise impacts under scenario 3 predicts exceedances of 2 dB(A) and 5 dB(A) under Conditions A and B respectively.

At R02, a marginal exceedance of 1 dB(A) has been observed under Condition B.

A similar exceedance of 1 dB(A) is expected at R14 during Condition A with an exceedance of 3 dB(A) under Condition B.

Compliance is predicted to be achieved at the remaining receiver locations under the corresponding meteorological conditions.

Table 4-35: Predicted Industrial Noise Levels (proposed) – Scenario 4, dB(A) NO CONTROLS

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
4 - All vehicles and operations E3 only	R01 (residence)	50	30	34	None predicted	None predicted
	R02 (residence)	50	26	30	None predicted	None predicted
	R03 (residence)	50	22	26	None predicted	None predicted
	R04 (residence)	50	25	30	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	16	21	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	30	35	None predicted	None predicted
	R09 (residence)	50	36	41	None predicted	None predicted
	R09 (commercial)	65	36	41	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	33	38	None predicted	None predicted
	R12 (Museum of Fire)	48	47	51	None predicted	3
	R13 (residence)	50	36	40	None predicted	None predicted
	R14 (existing industry)	68	35	40	None predicted	None predicted

Under Scenario 4, a potential exceedance of 3 dB(A) can be observed at R12 under light winds of 3m/s source to receiver.

The predicted industrial noise levels from the proposed E3 industrial operations onsite is expected to comply with the Project-Specific Noise Levels at all other receiver locations and meteorological conditions.

The main source contribution was observed to be engine compression braking which is generally known to be the main noise contributor from a heavy vehicle. The National Transport Commission's (NTC) *Engine Brake Noise – Final Proposal and Regulatory Impact Statement* (2007) state that 'noise from engine brakes is the greatest source of community complaint against the heavy vehicle industry.'

Judicious management of the use of exhaust, engine compression brakes or any similar auxiliary braking devices (sometimes known as secondary retarders) would lower the potential impacts from the proposed industrial operations onsite. Engine brakes are an important safety device however, and any recommendations presented in this report should be implemented in conjunction with reasonable measures that would not compromise safety.

Such measures may include optimising driving habits by preventing unnecessary use of auxiliary braking devices or fitting mufflers with reduced modulation. The NTC, along with several transport/road agencies, carried out an extensive research program and suggested a proposed in-service standard that has a modulated Root Mean Square (RMS) value of three (3). Furthermore, it is important to ensure that the muffler or any other similar quiet technology products are not defective and is well maintained to minimise degradation.

Under these safeguards, the four (4) modelling scenarios were remodelled with a reduced number of hourly braking events to account for 25% of the heavy vehicles arriving onsite.

The results are shown in the following tables.

Table 4-36: Predicted Industrial Noise Levels (proposed) – Scenario 1, dB(A) LIMITED COMPRESSION BRAKES

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance *Condition A*	Exceedance *Condition B*
1 - All vehicles and operations E1, E2, E3	R01 (residence)	50	59	60	9	10
	R02 (residence)	50	45	49	None predicted	None predicted
	R03 (residence)	50	44	47	None predicted	None predicted
	R04 (residence)	50	35	39	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	26	31	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	31	36	None predicted	None predicted
	R09 (residence)	50	39	43	None predicted	None predicted
	R09 (commercial)	65	39	43	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	30	35	None predicted	None predicted
	R12 (Museum of Fire)	48	43	47	None predicted	None predicted
	R13 (residence)	50	50	51	None predicted	1
	R14 (existing industry)	68	51	53	None predicted	None predicted

Under Scenario 1 (Limited Compression Braking), a reduction of approximately 9 dB(A) and 10 dB(A) is predicted under Conditions A and B when compared to Scenario 1 (No Controls) as shown in Table 4-23 above. The latest exceedances at R01 as shown in Table 4-29 are appreciably more manageable when compared with Scenario 1 (No Controls) in Table 4-25.

A marginal exceedance of 1 dB(A) is expected at the proposed onsite residential area, R13. There are also marginal compliances predicted at R02, R03 and R12 under Condition B where compliance is expected to be achieved by a marginal value ranging between 1 dB(A) to 3 dB(A).

Table 4-37: Predicted Industrial Noise Levels (proposed) – Scenario 2, dB(A) LIMITED COMPRESSION BRAKES

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
2 - All vehicles and operations E1 only	R01 (residence)	50	59	60	9	10
	R02 (residence)	50	44	46	None predicted	None predicted
	R03 (residence)	50	44	47	None predicted	None predicted
	R04 (residence)	50	34	38	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	24	29	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	27	31	None predicted	None predicted
	R09 (residence)	50	36	39	None predicted	None predicted
	R09 (commercial)	65	36	39	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	20	25	None predicted	None predicted
	R12 (Museum of Fire)	48	28	33	None predicted	None predicted
	R13 (residence)	50	32	36	None predicted	None predicted
	R14 (existing industry)	68	39	43	None predicted	None predicted

Exceedances of 9 dB(A) and 10 dB(A) are predicted at R01 under Scenario 2 (Limited Compression Braking) during Condition A and B respectively.

A comparison with Scenario 2 (No Controls) indicates a reduction of approximately 8 dB(A) and 9 dB(A) at R01 during Conditions A and B respectively when the number of compression braking events have been reduced to account for 25% of the heavy vehicles arriving at industrial area E1.

Compliance is predicted at the remaining receiver locations.

Table 4-38: Predicted Industrial Noise Levels (proposed) – Scenario 3, dB(A) LIMITED COMPRESSION BRAKES

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
3 - All vehicles and operations E2 only	R01 (residence)	50	47	50	None predicted	None predicted
	R02 (residence)	50	40	44	None predicted	None predicted
	R03 (residence)	50	35	39	None predicted	None predicted
	R04 (residence)	50	29	34	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	21	26	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	27	31	None predicted	None predicted
	R09 (residence)	50	36	40	None predicted	None predicted
	R09 (commercial)	65	36	40	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	21	26	None predicted	None predicted
	R12 (Museum of Fire)	48	32	36	None predicted	None predicted
	R13 (residence)	50	50	51	None predicted	1
	R14 (existing industry)	68	50	52	None predicted	None predicted

Compliance is predicted at all receiver locations under all meteorological conditions under Scenario 3 (Limited Compression Braking) with the exception of R13 where a marginal exceedance of 1 dB(A) is expected under Condition B.

An approximate reduction of 5 dB(A) is predicted at R01 during Conditions A and B when compared with Scenario 3 (No Controls).

Marginal compliances can be observed under Scenario 3 (Limited Compression Braking).

Table 4-39: Predicted Industrial Noise Levels (proposed) – Scenario 4, dB(A) LIMITED COMPRESSION BRAKES

Scenario	Most Potentially Affected Receiver	$L_{Aeq(15min)}$ Noise Level, dB(A)				
		PSNL	Predicted Noise Level *Condition A*	Predicted Noise Level *Condition B*	Exceedance	
					Condition A	*Condition B*
4 - All vehicles and operations E3 only	R01 (residence)	50	25	28	None predicted	None predicted
	R02 (residence)	50	23	27	None predicted	None predicted
	R03 (residence)	50	18	23	None predicted	None predicted
	R04 (residence)	50	20	24	None predicted	None predicted
	R05 (Governor Phillip Hospital)	50	12	16	None predicted	None predicted
	R08 (Western Sydney Institute)	54 (Internal)	26	31	None predicted	None predicted
	R09 (residence)	50	30	35	None predicted	None predicted
	R09 (commercial)	65	30	35	None predicted	None predicted
	R11 (Penrith Regional Library)	54 (Internal)	29	33	None predicted	None predicted
	R12 (Museum of Fire)	48	42	46	None predicted	None predicted
	R13 (residence)	50	31	35	None predicted	None predicted
	R14 (existing industry)	68	30	33	None predicted	None predicted

Compliance is predicted at all receiver locations and meteorological conditions under Scenario 4 (Limited Compression Brakes).

Future Industrial Developments Offsite

An offsite multi-deck commuter car park is expected to be constructed near the south-western boundary of North Penrith. The commuter car park will accommodate approximately 1000 spaces in total with 500 spaces at-grade and two decked levels of 500 spaces.

The proposed car park will function as per the existing car park where it is evident that most of the inflow of commuter traffic occurs in tidal movements based on the peak commuter times as listed in Table 4-33.

There is negligible commuter traffic movement outside of these hours.

An assessment of the commuter car park has been undertaken in an effort to quantify the potential noise impacts due to the operation of the car park at the proposed premises within North Penrith.

The vehicle count data as well as the peak travel periods have been sourced from NPC (National Project Consultants). NPC carried out a traffic count near the entry to the Commuter Carpark Road (west of R13) on Tuesday, 6 July 2010 between the hours of 5am and 9am. Therefore, this assessment is based on weekday operations considering that traffic volumes are typically higher during the week as opposed to the weekend.

NPC has estimated that the current temporary commuter car park accommodates approximately 725 vehicles. This is approximately 275 vehicles less than what the proposed multi-deck commuter car park will accommodate and therefore the assumed trip generation values for the proposed multi-deck car park are applied pro-rata, based on this difference (of 275 vehicles).

Table 4-40: Assumed Trip Generation Values for the Proposed Commuter Car Park

Peak period	Total Trips	At Grade Level		First Deck		Second Deck	
		In	Out	In	Out	In	Out
Day							
7am to 8am	509	257	0*	128	0*	128	0*
5pm to 7pm	509	0*	257	0*	128	0*	128
Night							
6am to 7am	401	212	0*	106	0*	106	0*

Note: Day is 7am to 10pm and Night is 10pm to 7am

* The onsite traffic movements have been based on incoming/outgoing vehicles only as the inflow/outflow traffic during this time has been assumed to be due to kiss and ride or other non-commuter vehicles.

The onsite traffic pertain to movements within the actual car park area and not the public Commuter Carpark Road which is discussed later in this section. Kiss and ride would occur along the Commuter Carpark Road and not within the proposed car park area.

The NSW INP states that road traffic noise from vehicles while onsite is considered industrial noise and therefore onsite vehicle movements at the commuter car park are subject to the noise criteria presented in Table 3-5.

The predictive noise model included conservative atmospheric conditions of 15°C and 70% humidity.

A scenario with the maximum predicted operations was established for the model so as to provide an estimate of the potential noise impacts due under the worst-case operations at the proposed commuter car park.

The following meteorological conditions were applied to the modelling scenario:

Condition A: Calm, isothermal conditions; and
Condition B: Equivalent to 3m/s wind from source to receiver.

The scenario is detailed in Table 4-33 below.

Table 4-41: Modelled Noise Scenarios Considered – Proposed Operations

Scenario	Description	Sources Included	Source Location
Maximum Operations			
1	All vehicles	All vehicles Car door closure	At grade level First deck Second deck

The number of car park spaces at each level and the hourly vehicle movements as specified in Table 4-33 above have been input to the predictive noise model to account for a conservative scenario of peak hour movements.

The following effective ceiling heights were applied to the car park building:

- 2.2 m at grade based on a typical range of 1.9 m to 2.1 m maximum height for cars within car parks; and
- 6.2 m for the first deck.

The representative sound power levels used to model the offsite commuter car park are provided in Table 4-34.

Table 4-42: Summary of Sound Power Levels used

Plant Item	L_{Aeq} Sound Power Level, dB(A)
Light vehicle manoeuvring within car park	76
Car door closure	97

The results of the predictive noise model are presented in 4-35 below.

The modelling results below predict that the highest noise levels due to the onsite vehicle movements at the proposed offsite commuter car park would occur at the representative onsite residential locations R09 (3-6 storey apartments), R10 (mixed use) and R12 (single storey and 3 storey apartments). Appropriate acoustic considerations as outlined under the Building Design section are recommended to be incorporated into the residential buildings in order to achieve acceptable internal noise levels at these locations.

Different receiver heights have been included for the receiver locations to show any predicted noise variations at different building heights. An insignificant variance within the range of 1 to 3 dB(A) was observed between the different receiver heights.

Table 4-43: Predicted Industrial Noise Levels (proposed commuter car park offsite) – Scenario 1, dB(A)

Scenario	Most Potentially Affected Receiver Onsite	Noise Level, dB(A)										
		PSNL		Sleep Disturbance	Predicted Noise Level L_{Aeq}	Sleep Disturbance L_{Amax}	Predicted Noise Level L_{Aeq}	Sleep Disturbance L_{Amax}	Exceedance			
		Time of Day	L_{Aeq}	L_{Amax} (internal)	Condition A		Condition B		L_{Aeq} Condition A	L_{Amax}* Condition A	L_{Aeq} Condition B	L_{Amax}* Condition B
1 - All vehicles - at grade level, first deck, second deck	R01 (residence) 1.5m height	Day	50	N/A	45	N/A	50	N/A	0	N/A	0	N/A
		Evening	49	N/A	45	N/A	50	N/A	0	N/A	1	N/A
		Night	43	45	44	42	48	46	1	0	5	0
	R01 (residence) 4.0m height	Day	50	N/A	46	N/A	50	N/A	0	N/A	0	N/A
		Evening	49	N/A	45	N/A	50	N/A	0	N/A	1	N/A
		Night	43	45	44	43	48	46	1	0	5	0
	R03 (residence) 1.5m height	Day	45	N/A	45	N/A	49	N/A	0	N/A	4	N/A
		Evening	47	N/A	45	N/A	49	N/A	0	N/A	2	N/A
		Night	43	45	43	42	48	46	0	0	5	0
	R03 (residence) 6.5m height	Day	45	N/A	46	N/A	50	N/A	1	N/A	5	N/A
		Evening	47	N/A	46	N/A	49	N/A	0	N/A	2	N/A
		Night	43	45	44	43	48	46	1	0	5	0
	R07 (retail) 1.5m height	When in use	65	N/A	56	N/A	59	N/A	0	N/A	0	N/A
	R07 (retail) 6.5m height	When in use	65	N/A	58	N/A	60	N/A	0	N/A	0	N/A
	R07 (retail) 14.0m height	When in use	65	N/A	59	N/A	60	N/A	0	N/A	0	N/A
	R09 (residence) 1.5m height	Day	44	N/A	57	N/A	60	N/A	13	N/A	16	N/A
		Evening	45	N/A	57	N/A	60	N/A	12	N/A	15	N/A
		Night	41	45	56	55	58	57	15	0	17	2

Table 4-44: Predicted Industrial Noise Levels (proposed commuter car park offsite) – Scenario 1, dB(A)

Scenario	Most Potentially Affected Receiver Onsite	Noise Level, dB(A)											
		PSNL		Sleep Disturbance	Predicted Noise Level L_{Aeq}	Sleep Disturbance L_{Amax}	Predicted Noise Level L_{Aeq}	Sleep Disturbance L_{Amax}	Exceedance			
				L_{Amax} (internal)					L_{Aeq}	L_{Amax}*	L_{Aeq}	L_{Amax}*
		Time of Day	L_{Aeq}		*Condition A*		*Condition B*		*Condition A*		*Condition B*	
	R09 (residence) 6.5m height	Day	44	N/A	59	N/A	61	N/A	15	N/A	17	N/A
		Evening	45	N/A	58	N/A	60	N/A	13	N/A	15	N/A
		Night	41	45	57	57	59	57	16	2	18	2
	R09 (residence) 14.0m height	Day	44	N/A	60	N/A	61	N/A	16	N/A	17	N/A
		Evening	45	N/A	60	N/A	61	N/A	15	N/A	16	N/A
		Night	41	45	58	58	59	58	17	3	18	3
	R09 (retail) 1.5m height	When in use	65	N/A	57	N/A	60	N/A	0	N/A	0	N/A
	R09 (retail) 6.5m height	When in use	65	N/A	59	N/A	61	N/A	0	N/A	0	N/A
	R09 (retail) 14.0m height	When in use	65	N/A	60	N/A	61	N/A	0	N/A	0	N/A
	R10 (residence) 1.5m height	Day	48	N/A	71	N/A	71	N/A	23	N/A	23	N/A
		Evening	50	N/A	70	N/A	71	N/A	20	N/A	21	N/A
		Night	45	45	69	69	69	69	24	14	24	14
	R10 (residence) 6.5m height	Day	48	N/A	71	N/A	71	N/A	23	N/A	23	N/A
		Evening	50	N/A	70	N/A	71	N/A	20	N/A	21	N/A
		Night	45	45	69	69	70	69	24	14	25	14

Table 4-45: Predicted Industrial Noise Levels (proposed commuter car park offsite) – Scenario 1, dB(A)

Scenario	Most Potentially Affected Receiver Onsite	Noise Level, dB(A)										
		PSNL		Sleep Disturbance	Predicted Noise Level	Sleep Disturbance	Predicted Noise Level	Sleep Disturbance	Exceedance			
				L_{Amax} (internal)	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}*	L_{Aeq}	L_{Amax}*
		Time of Day	L_{Aeq}		*Condition A*		*Condition B*		*Condition A*		*Condition B*	
	R10 (residence) 14.0m height	Day	48	N/A	72	N/A	72	N/A	24	N/A	24	N/A
		Evening	50	N/A	72	N/A	72	N/A	22	N/A	22	N/A
		Night	45	45	70	71	70	71	25	16	25	16
	R10 (retail) 1.5m height	When in use	65	N/A	71	N/A	71	N/A	6	N/A	6	N/A
	R10 (retail) 6.5m height	When in use	65	N/A	71	N/A	71	N/A	6	N/A	6	N/A
	R10 (retail) 14.0m height	When in use	65	N/A	72	N/A	72	N/A	7	N/A	7	N/A
	R12 (residence) 1.5m height	Day	44	N/A	62	N/A	65	N/A	18	N/A	21	N/A
		Evening	46	N/A	62	N/A	64	N/A	16	N/A	18	N/A
		Night	41	45	60	61	63	63	19	6	22	8
	R12 (residence) 6.5m height	Day	44	N/A	63	N/A	65	N/A	19	N/A	21	N/A
		Evening	46	N/A	63	N/A	65	N/A	17	N/A	19	N/A
		Night	41	45	61	61	63	63	20	6	22	8

* Assuming a typical 10 dB(A) reduction due to a standard building construction with windows slightly open for ventilation. Where internal noise levels are exceeded under this assumption, special acoustic considerations are recommended as outlined within this report.

N/A Not Applicable

Road traffic noise from vehicles while traversing the Commuter Carpark Road and along Coreen Avenue will be assessed in accordance with ECRTN noise criteria discussed in Table 4-36 below.

Table 4-46: Traffic Noise Criteria (ECRTN)

Type of Development		Criteria	
		Day (7am-10pm) dB(A)	Night (10pm-7am) dB(A)
1	Land use developments with potential to create additional traffic on local roads	$L_{Aeq(1hr)}$55	$L_{Aeq(1hr)}$50

The predicted road traffic noise levels along the Commuter Carpark Road as well as Coreen Avenue are presented below.

Table 4-47: Predicted Existing Road Traffic Noise Levels, Weekday – Commuter Carpark Road and Coreen Avenue

Receiver	Existing Noise Level1		ECRTN Criteria		Exceedance	
	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day $L_{Aeq(1hr)}$	Night $L_{Aeq(1hr)}$	Day	Night
R01 (residence) 1.5m height	48	46	55	50	None predicted	None predicted
R01 (residence) 4.0m height	48	46	55	50	None predicted	None predicted
R03 (residence) 1.5m height	37	35	55	50	None predicted	None predicted
R03 (residence) 6.5m height	37	35	55	50	None predicted	None predicted
R09 (residence) 1.5m height	35	33	55	50	None predicted	None predicted
R09 (residence) 6.5m height	35	33	55	50	None predicted	None predicted
R09 (residence) 14.0m height	35	33	55	50	None predicted	None predicted
R12 (residence) 1.5m height	51	49	55	50	None predicted	None predicted
R12 (residence) 6.5m height	51	49	55	50	None predicted	None predicted

From the above predictive road traffic noise model results, it can be seen that the area containing the residential premises near R12 is most critical with a predicted compliance within 1 dB(A) during the night-time.

Although the remaining receiver locations indicate compliance with the ECRTN Criteria, it is important to address the low frequency content of road traffic noise which may cause the noise levels to fluctuate.

Therefore, acoustic considerations as outlined within the Building Design section of this report are recommended to be incorporated into the design and specification of the residential buildings abutting the Commuter Carpark Road.

5. Assessment

At a glance

The following noise and vibration sources have been assessed against the appropriate guidelines and standards:

- existing railway noise and vibration impacts from the railway corridor on the development;
- existing road traffic noise impacts along Coreen Avenue on the development;
- noise impacts from existing industries on Coreen Avenue, and the Museum of Fire and SkillsWest Training Centre on the western site boundary on the development;
- potential noise impacts from the proposed commuter car park to the south-west of the subject site at the proposed onsite premises; and,
- potential offsite construction noise and vibration impacts during the construction of the development.

Various recommendations are made for consideration in the design of the future built forms in the NCA 1 and NCA 3 areas.

Noise and vibration amelioration measures for inclusion in the CEMP are listed.

Figure 2-2 indicates the locations designated for residential and commercial uses where acoustical considerations and treatments are recommended for inclusion in the design of the ultimate built form.

The proposed buildings within NCA1 and NCA3 will shield the proposed buildings within NCA2. The effectiveness of the shielding will depend on there being no clear line of sight between the sensitive buildings in NCA2 and the noise source/s.

In summary:

- the most exposed facades of commercial and residential buildings to the railway corridor will require acoustic design considerations to obtain acceptable internal noise levels
- the most exposed facades of residential dwellings in the vicinity of Coreen Avenue will require acoustical treatment due to the road traffic noise and industrial noise along Coreen Avenue.
- the proposed industrial areas within the development will potentially impact on onsite and offsite land uses near R01, R02, R03, R12, R13. Appropriate ameliorative measures in the design of the industrial buildings is required
- the road traffic noise and operational noise assessment of the Commuter Car Park indicates acoustical treatment is required for the residential dwellings near R12 as well as the residential dwellings on the road accessing the Commuter Car Park from Coreen Avenue.

Building Design

Recommendations

These noise amelioration recommendations generally are to be considered in the design of the future built form for the residential and commercial buildings within the locations identified in Figure 2-2.

The recommendations are:

- non-critical areas such as courtyards, laundry spaces, bathrooms or garages might be oriented near the noise sources. In terms of courtyards at the most exposed facades, a solid courtyard wall is better.

- critical areas for residential dwellings, such as balconies, large glazing areas, sleeping and living areas, might be placed behind the buffering non-critical areas and as far from the dominant noise source, whether the railway corridor or Coreen Avenue, as is practicable.

- a residential tower above a retail/ commercial space might be set back so that the commercial space/ podium on the ground level acts to provide an increased distance from the railway corridor thereby effectively shielding the lower residential floor.

- where balconies are required to face the noise source, an enclosed balcony might be provided with appropriate ventilation measures. This may require the consideration of acoustic louvres for flexibility of ventilation while being able to control the internal noise levels, i.e., louvres partly open for natural ventilation will allow some noise penetration).

- solid balustrades with sound absorption material added to the balcony soffits will typically reduce the noise entering the dwelling when compared to the typical jutting balcony.

- windows and doors generally present the weakest areas when considering the noise transmission loss of a composite wall. At the most exposed façades to traffic and industrial noise along the northern site boundary, and railway corridor noise along the site boundary, any windows might have to be double glazed and the doors acoustically sealed. The walls at the most exposed facades will have to consist of a double brick wall with cavity insulation (minimum 30 kg/ m3 density).

- where anticipated internal noise levels with windows or doors open will exceed the criteria by more than 10dBA, light-weight materials such as fibrous cement or large glazing areas are to be avoided.

- appropriately sited, partially enclosed carports will act as a partial noise barrier for ground floor dwelling spaces.

Construction Noise and Vibration Management

During the construction of the development, statutory compliance is predicted at all offsite receiver locations provided best practice amelioration measures are adopted. The most sensitive receivers will be the residents in the Lemongrove precinct to the east of the site.

It is appropriate these measures are documented in the Construction Environmental Management Plan (CEMP) to enable that level of implementation necessary to maintain the local acoustic amenity at an acceptable level.

To the extent applicable to the location of the construction works within the site relative to the sensitive receivers, and the nature of the construction task, the following construction noise measures or safeguards should be implemented:

- trucks transporting materials to and from the site to avoid local roads. It is understood this will be 100% achieved by virtue of the Construction Traffic Management Plan.

- use of silenced equipment where feasible, with appropriate mufflers fitted and maintained on construction and earth-moving equipment.

- consideration given to noise impact in the selection of piling systems for the built form, e.g., specifying non-displacement type piles such as bored piles in lieu of driven piles. Bored piles are generally known to be installed with little or no vibration, and with lower noise levels than driven piles.

- use of a broadband style 'quacker' alarm or flashing lights instead of the conventional 'beeper' style reversing alarms.

- advance notification to nearby residents and business owners of construction activities that are likely to occur.

- Set up and maintain a complaints and feedback hotline or equivalent and promptly address all complaints pertaining to noise and vibration.

Depending on the plant selection of the contractor, vibration monitoring on the northern boundary (next the Mobil site and its underground tanks) and on the eastern boundary (next the residences and the heritage significant Thornton Hall) might be considered to validate the safe working distances.

The safe working distances in Table 3-10 apply to continuous vibration. However, most construction activities emit intermittent vibration and therefore BS 6472-1 discusses higher allowable vibration levels occurring over shorter periods of time.

The distance to the underground tanks and some of the residences may occur below the safe working distance in terms of 'Cosmetic damage' for heavier equipment types. In this case, attended vibration monitoring may be appropriate at the commencement of any vibration intensive activities in order to ensure compliance with BS 7385.

In terms of 'Human response', the safe working distances may not be met in some cases. As a general guide, humans are more sensitive to vibration from construction activities than that of earthquakes.

Generally, one's tolerance to vibration levels from an 'unusual source' will be improved provided that the origin of the vibrations is known in advance and there is no resultant damage. It may be appropriate to offer nearby potentially affected sensitive receivers a form of 'onsite induction' to familiarise them with the proposed improvements and the type of activities likely to occur.

The nature of vibration from excavation and construction equipment causes the vibratory disturbances to arrive at different parts of large nearby structures. Furthermore, they usually arrive out-of-phase which reduces its potential to excite in-phase motions of the low order modes of vibration in large nearby structures.

In addition to complying with the guideline values provided in BS 6472, AS 2670.2 and DIN 4150-3, the following measures are recommended to minimise potential undue impacts from any vibration intensive plant:

- restrict any heavily loaded trucks to the main road system and away from any local residential streets.
- place operating plant on the construction site as far as possible from the identified receivers.
- phase demolition, earthmoving and ground-impacting operations so as not to occur in the same time frame. Dissimilar to noise, the total vibration level produced can be appreciably less when each vibration source operates during separate time periods.
- schedule vibration-causing activities during periods when residences are likely to be away from their homes, e.g. mid-morning or early afternoon.
- Inform the public about the exact work hours, type of work, type of equipment and the expected nuisance duration.

Similar guidance is available from TIDC's website www.tidc.nsw.gov.au under *Construction Noise Strategy (Rail Projects)* which provides a similar suite of standard mitigation measures as presented in this report.

These measures are examples of feasible and reasonable practices applied on similar construction projects.

'Feasibility' relates to acoustic considerations in terms of what can be practically built or modified based on the opportunities and constraints of the site.

'Reasonableness' pertains to judgement which takes into account the following factors:

- noise mitigation benefits – noise reduction provided, number of people protected;
- cost of mitigation – total cost and cost variation with level of benefit provided;
- community views;
- aesthetic impacts; and
- noise levels for affected land uses – existing and future levels, and expected changes in noise levels.

6. ESD (Ecologically Sustainable Design)

Sustainability aspects of the North Penrith project may be impacted by the acoustics and noise control design.

Acoustic impacts on sustainability aspects in many ways, not all are obvious but are obtuse – hidden from first perspectives until analysed more deeply.

These are discussed below as quality objectives.

- The health and comfort of residents can be protected by achieving a quality of living space noise levels that enhance the living experiences. Deliberately providing for quiet zones within the living spaces when designing the building locations and the internal layouts. A number of criteria are provided further along in this discussion to assist in achieving these quality objectives.
- Productivity benefits result if the acoustics are of high quality for commercial work spaces.
- Aim to reduce reverberation within the quiet zones of residential apartments and in the "thinking areas" of commercial buildings, e.g. board rooms, meeting rooms.
- Consider the cross advantages of window noise control and thermal efficiencies when selecting glazing.

A number of design criteria can be applied to achieve these quality objectives:

- Orientation of building to place sleeping areas away from dominant sources of noise.
- Create landscaped areas that will enable earth berms to provide acoustic shielding to traffic and mobile equipment movements at industrial sites.
- Include in the design of landscaped areas quiet areas where urban noise is limited.
- Design traffic flow on the project site to achieve "calming" of the movement of vehicles, avoiding acceleration noise emissions of vans, large 4WDs and trucks.
- Select location of car parks to avoid door slamming impacting on sleeping areas.
- Avoid creating noise sinks where the multiple reflection of noise causes noise levels to be increased. Further consider the potential to reduce the reflected sound of balconies causing increase noise intrusion into the living spaces of residential buildings.
- Consider at the design stage construction techniques that allow building walls designed for noise reduction to also serve as passive solar energy collectors.

Precautionary Principle

Worst-case scenarios (as discussed within the body of this report) have been sought in order to provide a precautionary assessment of the proposed development.

Specialised building design recommendations as well as a thorough investigation into the potential noise and vibration impacts at the surrounding local community provide overarched guidelines based on conservative assumptions. These acoustic considerations have been outlined to minimise the associated impacts of the proposed development to the potentially affected receivers.

Reducing Externalities

Noise mitigation measures have been recommended to minimise the noise impacts due to the proposed development. These measures would be incorporated during design prediction and commissioning and therefore reduce noise externalities and permitting an improved valuation of environmental resources.

Acoustic considerations and preserving the visual amenity are usually a conjoined effort. Landscaping will positively enhance the quality of the ambient noise environment.

Conservation of Biological Diversity

The management of the potential noise impact on local fauna is at present an inexact science due to the limited research undertaken.

However, initiatives were implemented at the Sydney Olympic Park during two 3-day open air music concert events ('The Great Escape') held at a heritage site in Newington known as The Newington Armoury. An ecological acoustic study was conducted before, during and after The Great Escape 2006. A further similar study was conducted during the following year's The Great Escape involving a team comprising a Sydney Olympic Park Authority (SOPA) Ecologist, Epacris Environmental Consultants and Acoustic Consultants employed by the event promoter but reporting to the SOPA.

The acoustic study involved unattended noise logging at four (4) sensitive ecological areas. It also involved attended noise monitoring at a nesting colony of bats, wharf pond, Wanngal wetland and Wanngal woodland during the main events.

These studies found no measurable relationship between the noise levels that occurred and disturbance to the species inhabiting the sensitive ecological areas.

Preservation of Intergenerational Equity

The concept of real resource costs to an individual corresponds to the duration of disturbances of optimally chosen human activities and is measured in units of time.[5] Implementation of the recommended noise and vibration mitigation measures and safeguards would enable the preservation of the acoustic amenity for the potentially affected individuals.

7. Conclusion

Benbow Environmental has conducted a detailed assessment of the following potential noise and vibration impacts on the proposed mix-use residential, commercial and industrial development at North Penrith:

- Railway noise and vibration existing due to the Penrith Railway Line;
- Existing industrial noise along Coreen Avenue;
- Proposed industrial noise due to the proposed industrial areas at North Penrith;
- Existing road traffic noise along Coreen Avenue;
- Predicted road traffic noise due to the proposed multi-deck commuter car park offsite;
- Road traffic sensitivity analysis due to the proposed development at North Penrith;
- Existing operations at the Penrith Training Depot;
- Predicted operational noise due to the proposed multi-deck commuter car park offsite; and
- Construction noise and vibration during the construction phase of the proposed development at North Penrith.

The nearest potentially affected receiver locations were strategically identified onsite and offsite during the relevant assessment scenarios.

Regenerated railway noise levels are expected to exceed the NSW Department of Planning's *Development Near Rail Corridors and Busy Roads - Interim Guideline*'s internal LAeq noise levels and the external noise limits as stipulated in RailCorp's EPL# 12208.

Results of the measured vibration levels due to the rolling stock and locomotive pass-bys demonstrated compliance at the nearest identified potentially affected receivers under the criteria as defined in standards BS 6472 and AS 2670 for residential dwellings and were within the acceptable vibration dose levels and base acceleration values respectively. The analysed velocity values also showed compliance with standard DIN 4150.

Safe working distances for vibration-intensive construction plant have been provided in accordance with standards BS 6472 (human response) and BS 7385 (structural damage) to minimise any undue vibratory disturbances to nearby receivers.

Similarly, exceedances are predicted due to the industrial noise existing along Coreen Avenue when assessed against the PSNL derived from the NSW INP.

The existing road traffic noise levels along Coreen Avenue assessed in accordance with the ECRTN and minor exceedances have been predicted. Strategic building layouts and construction details will enable the mitigation especially against heavy vehicle noise, vehicle acceleration and braking which tend to be higher in noise levels.

Ameliorative measures have been provided accordingly.

This concludes the report.

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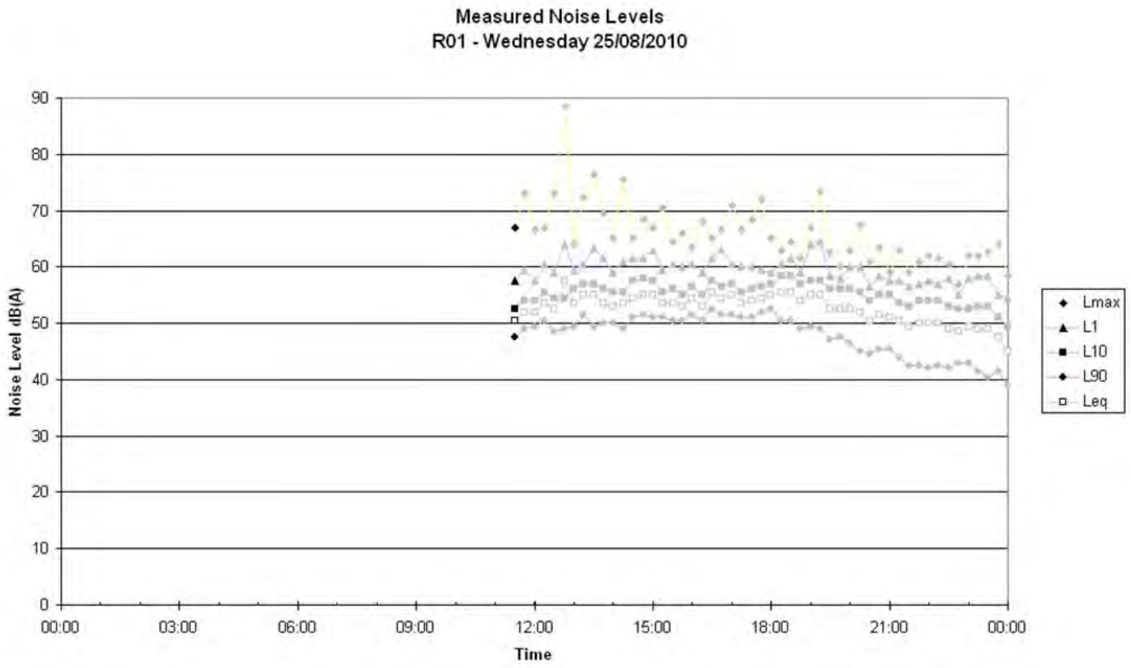
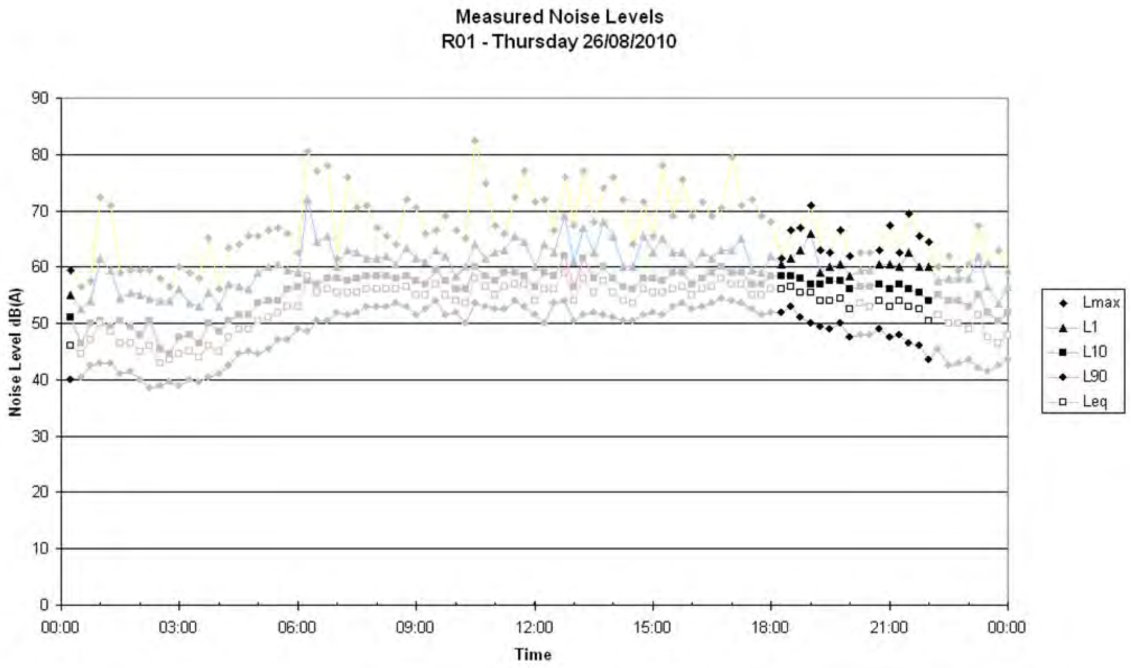
Appendix 1: Glossary of Acoustic Terminology

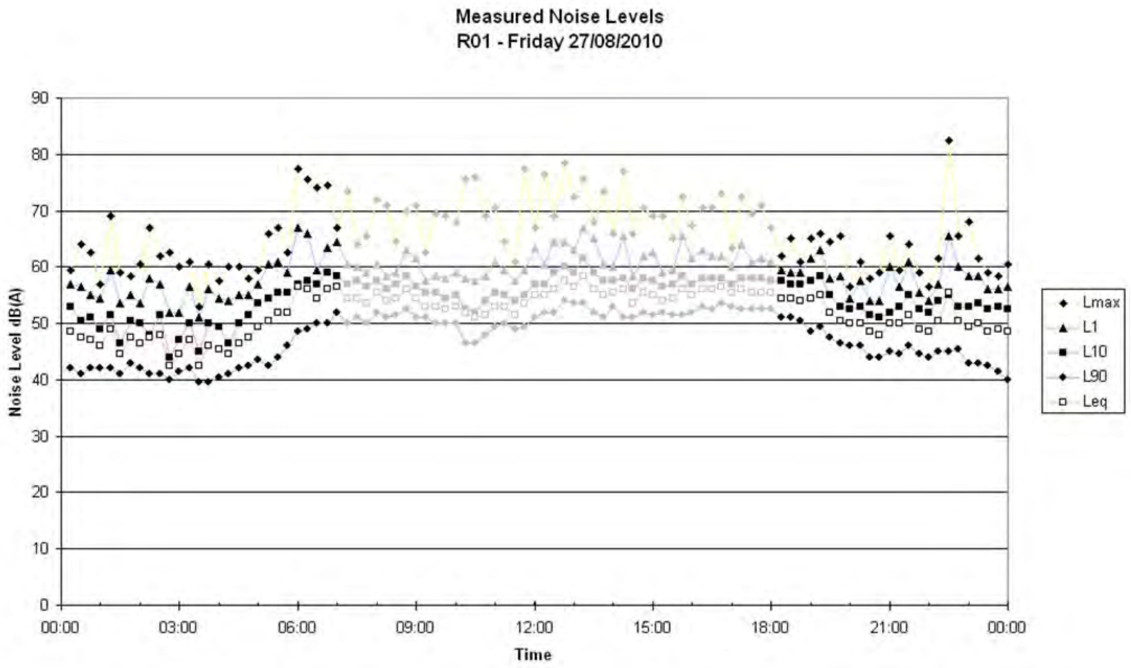
Acceptable Noise Level	The acceptable L_{Aeq} noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Acoustic Barrier	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.
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).
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. This is represented as the $\mathbf{L_{eq}}$ noise level.
Assessment Period	The period in a day over which assessments are made.
Assessment Point	A 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.
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.
$\mathbf{L_{A10}}$	The sound pressure level that is exceeded for 10% of the time for which the sound is measured.
$\mathbf{L_{A90}}$	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).
$\mathbf{L_{Aeq}}$	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.

Appendix 2: Unattended Noise Monitoring Profile



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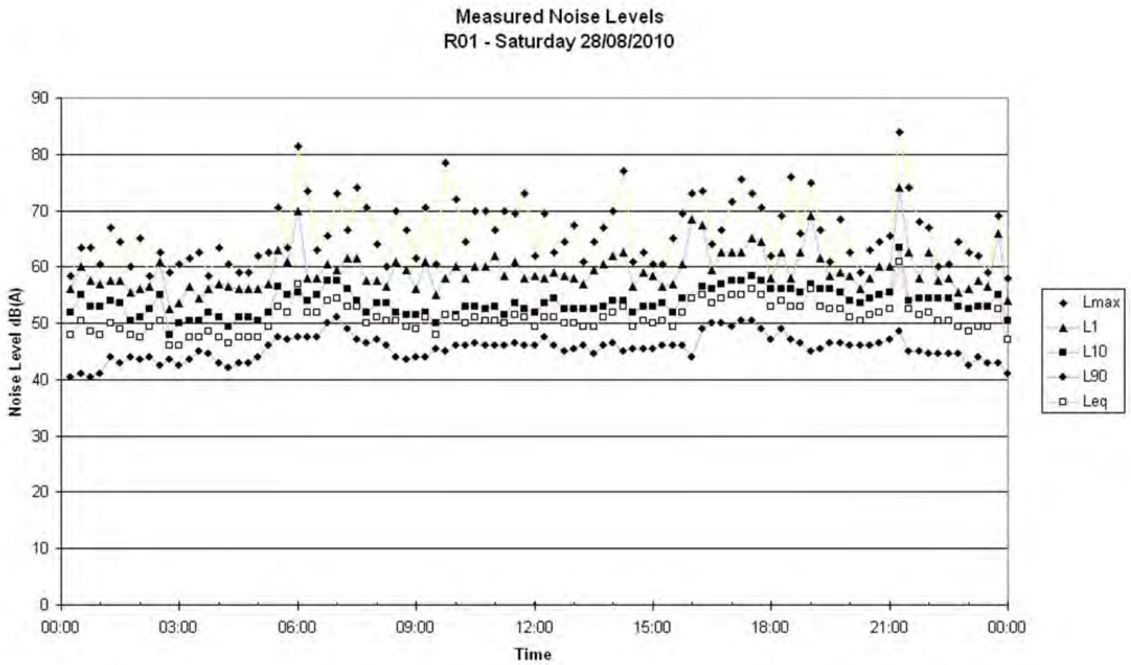
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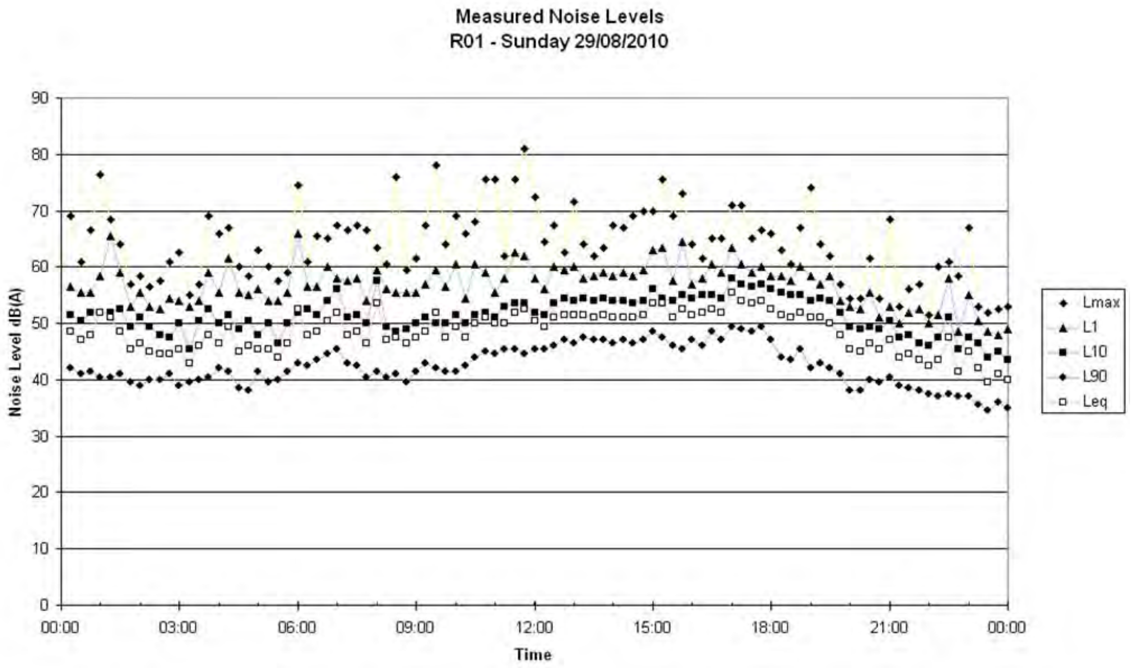
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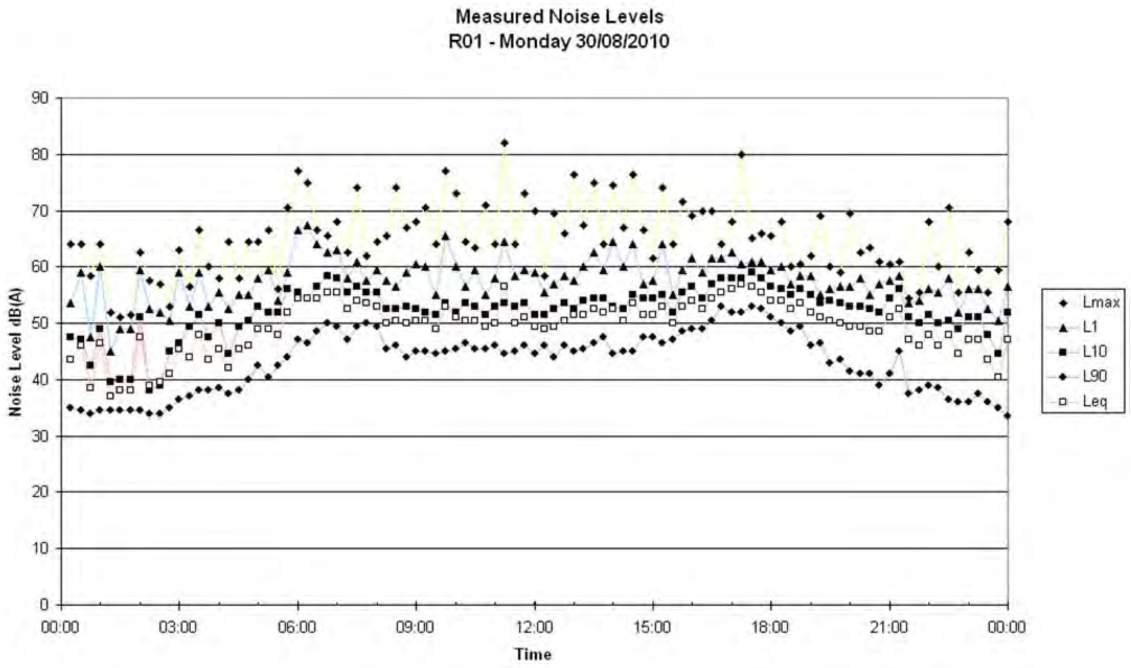
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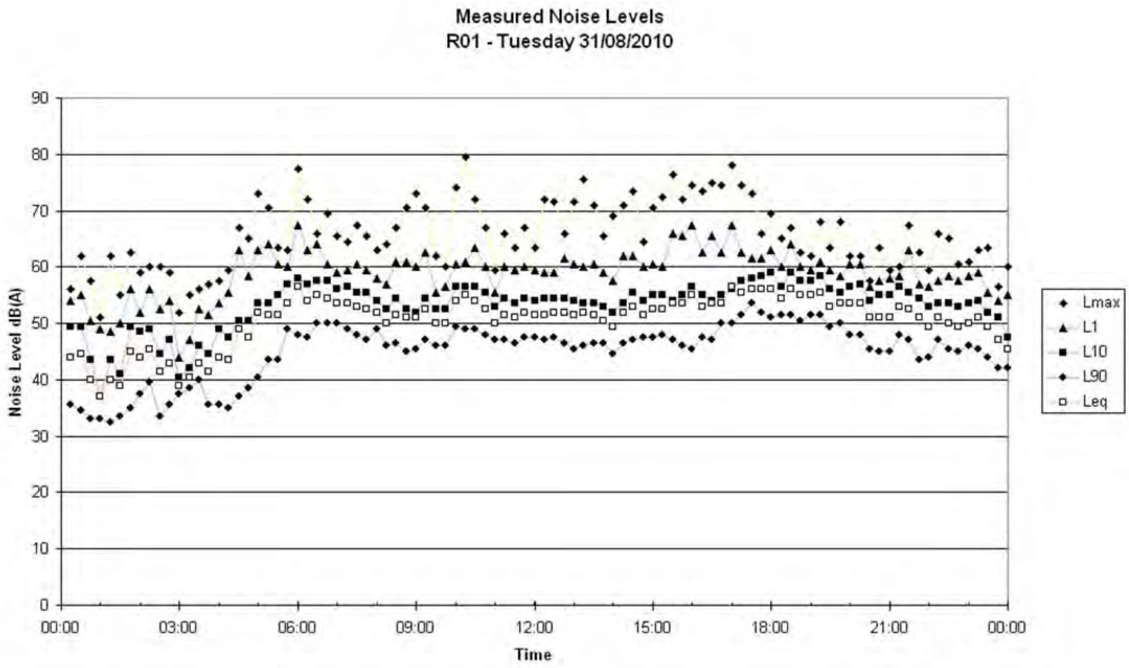
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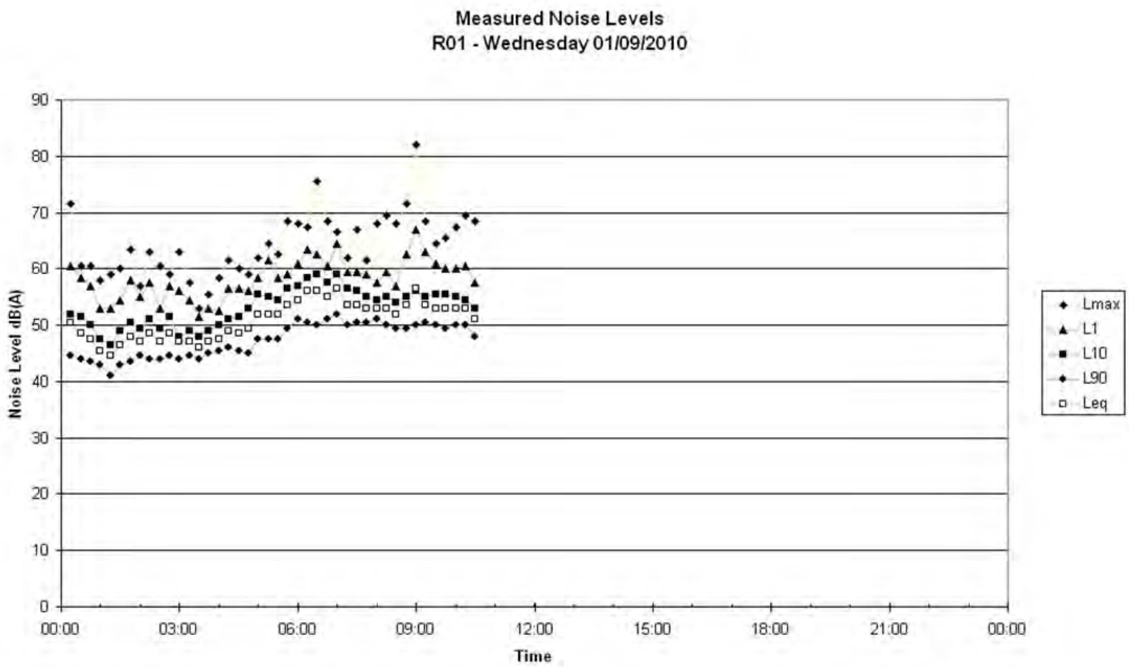
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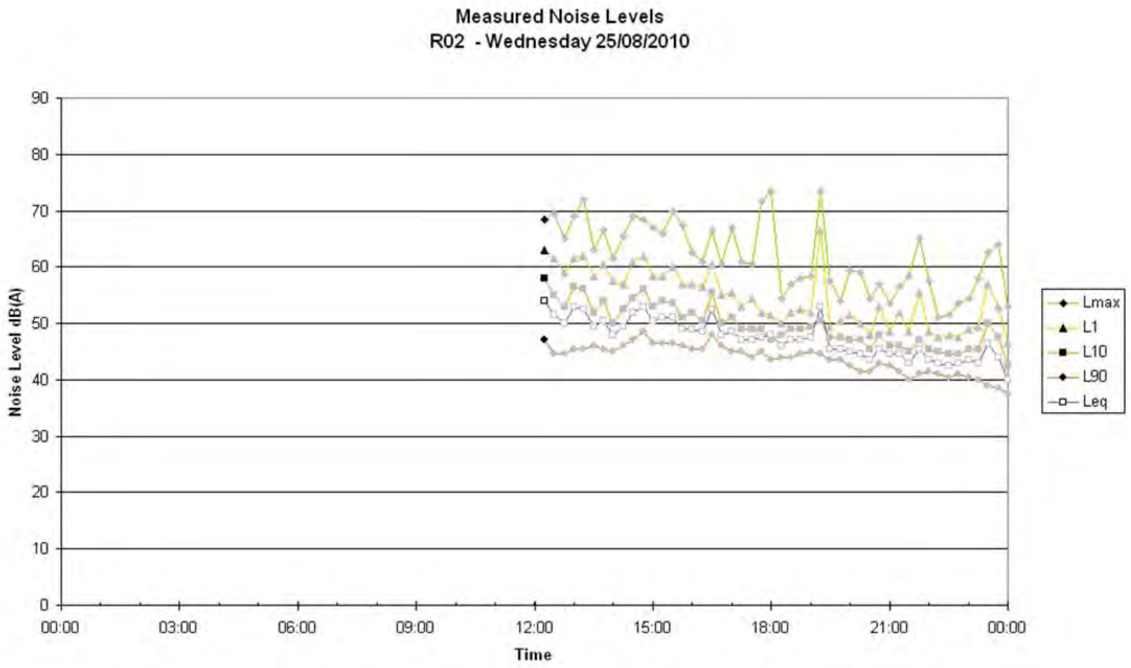
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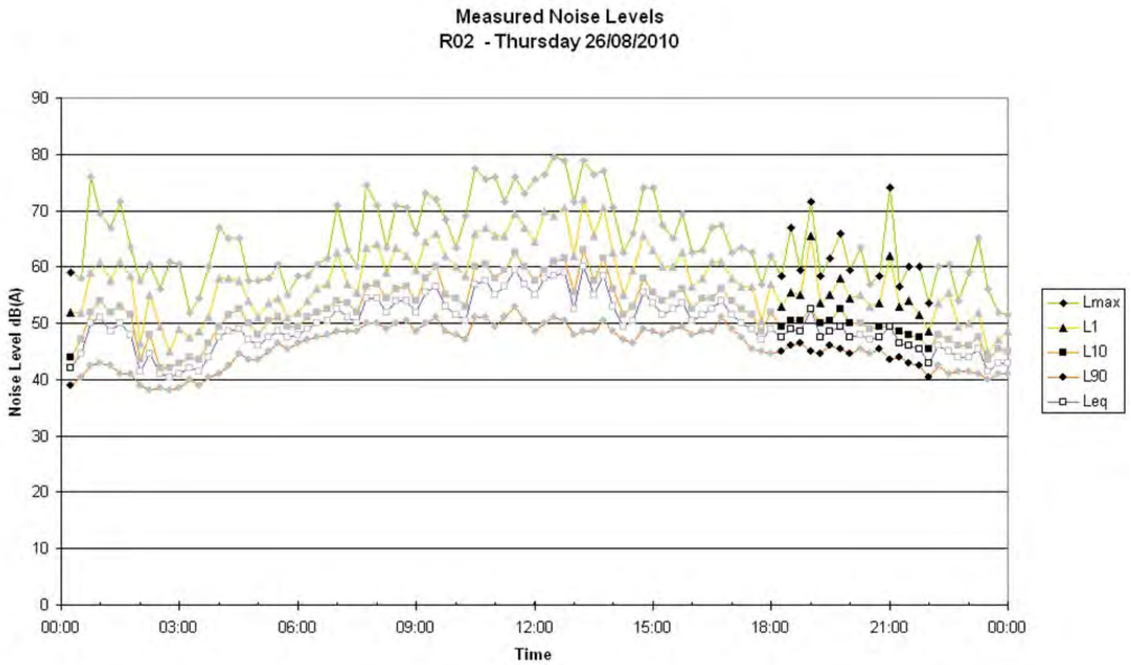
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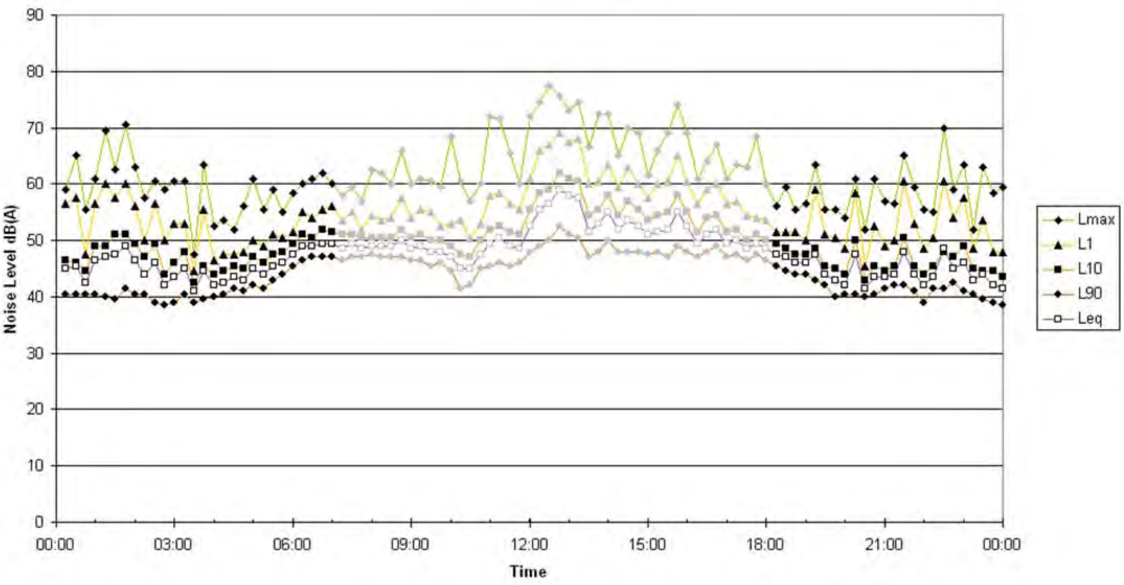

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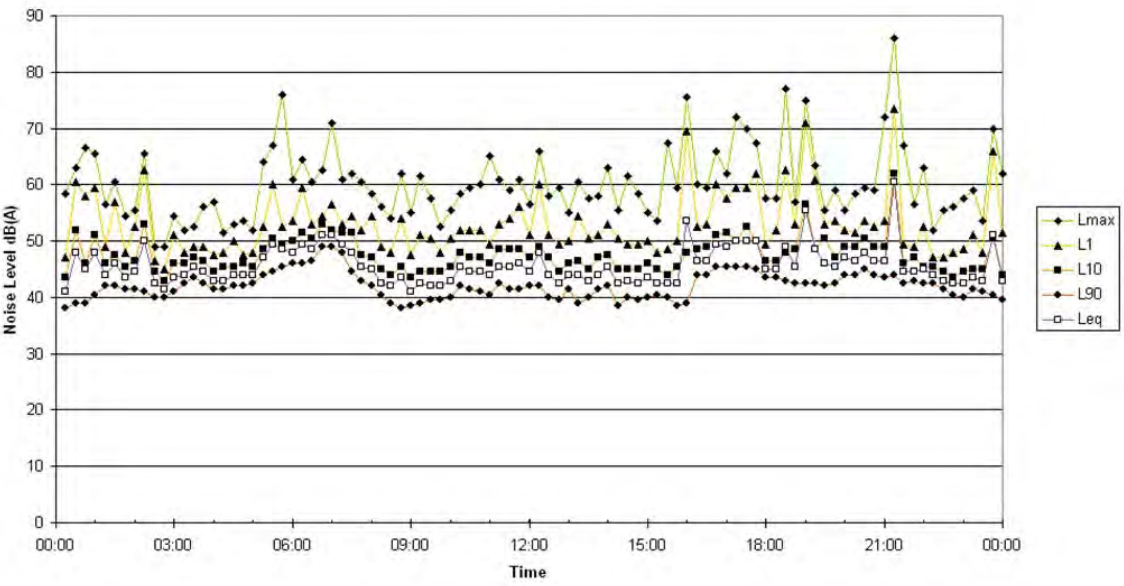

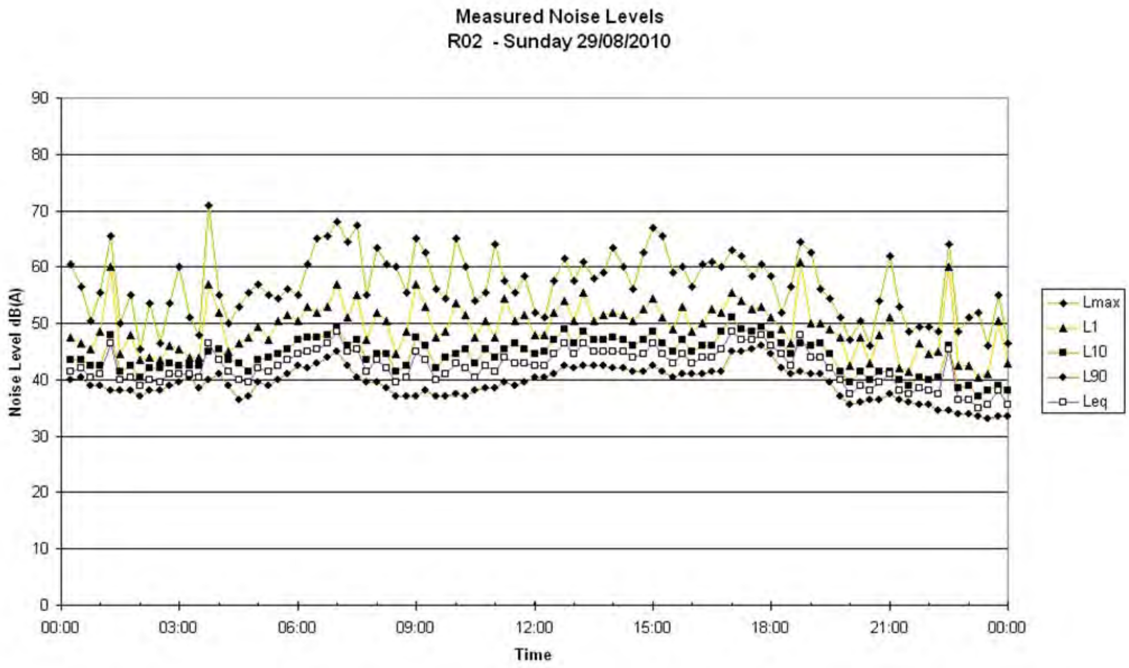

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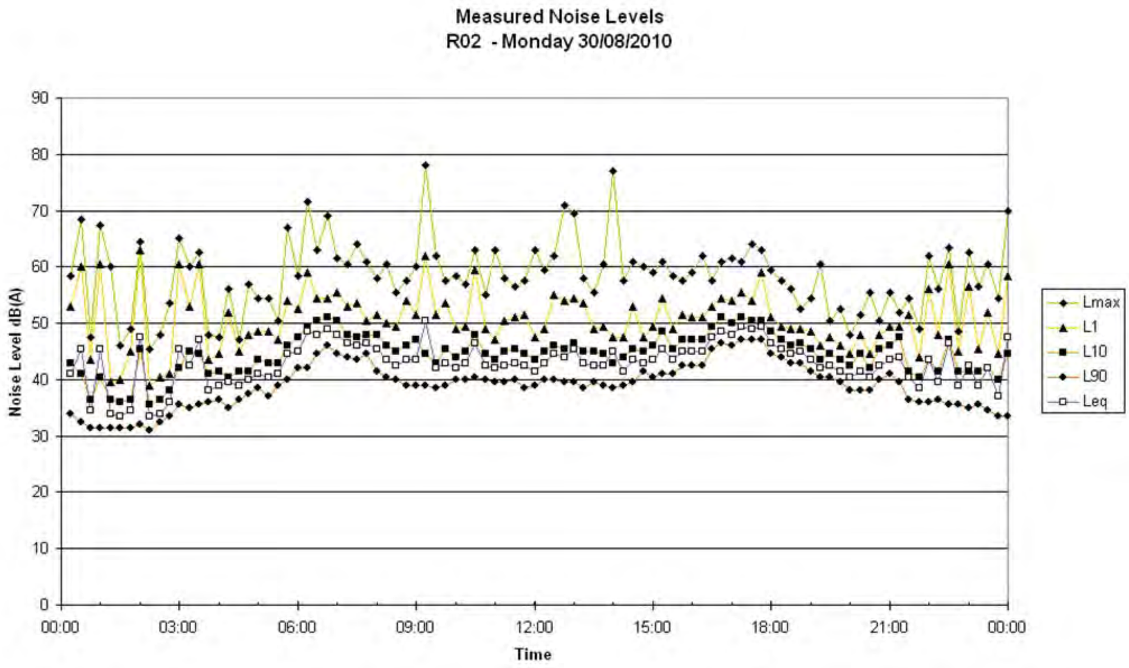

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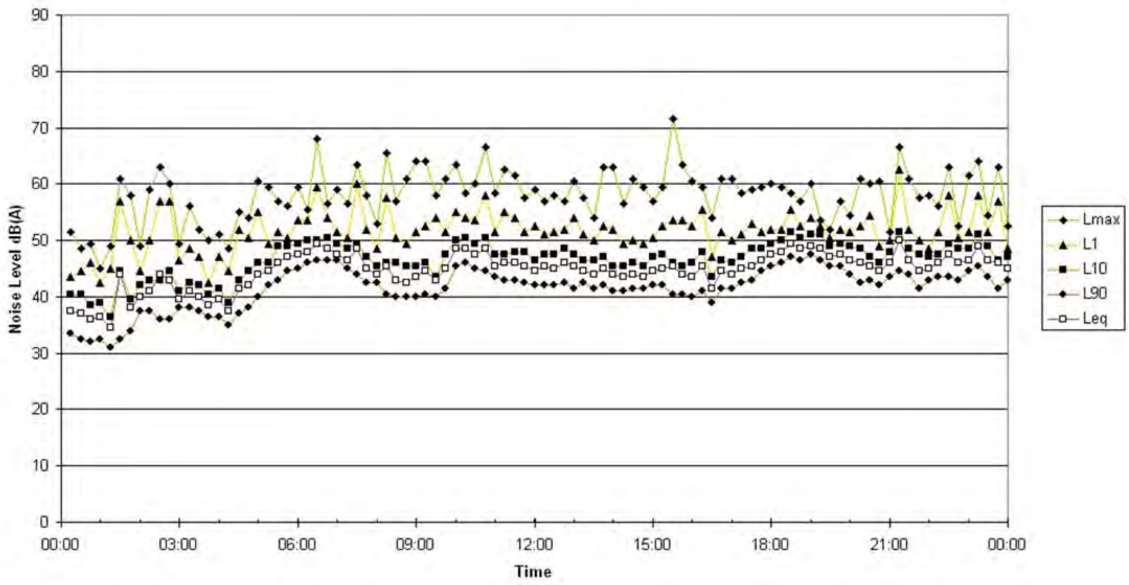

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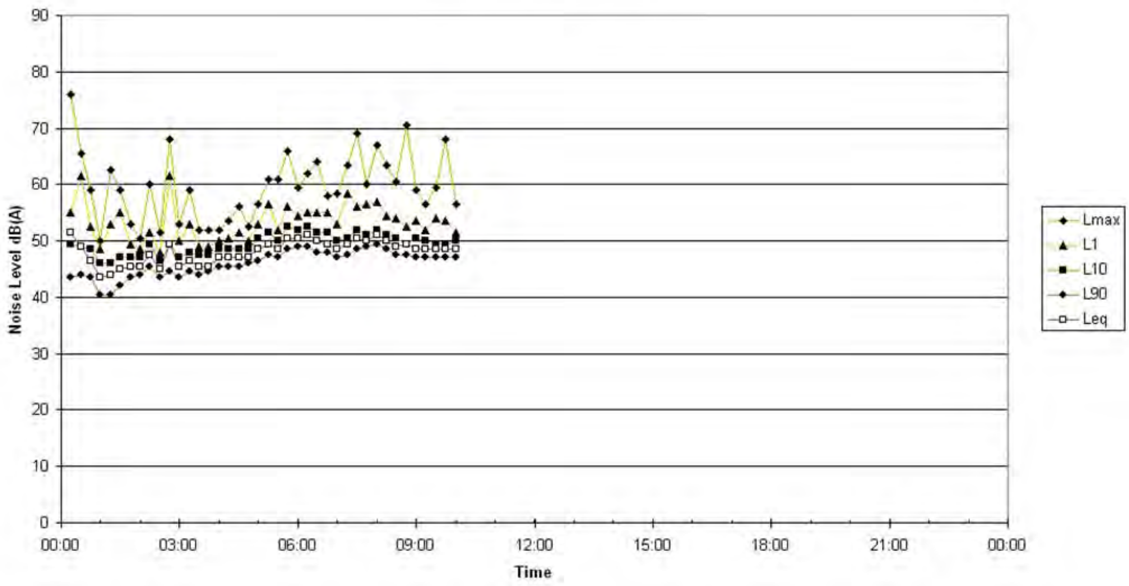

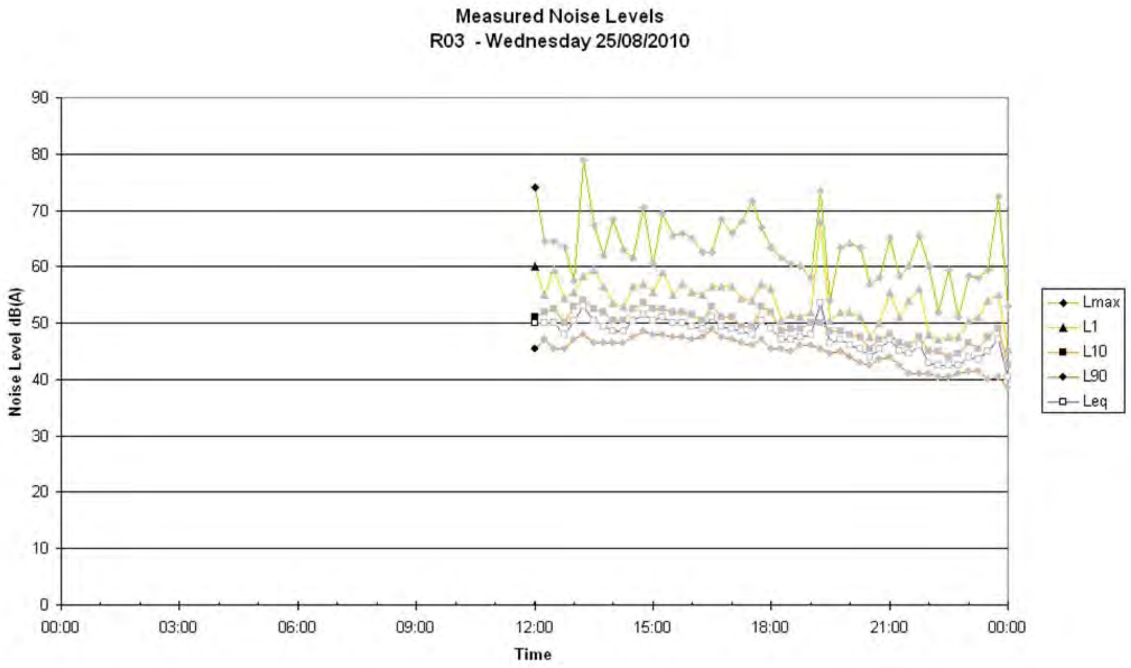
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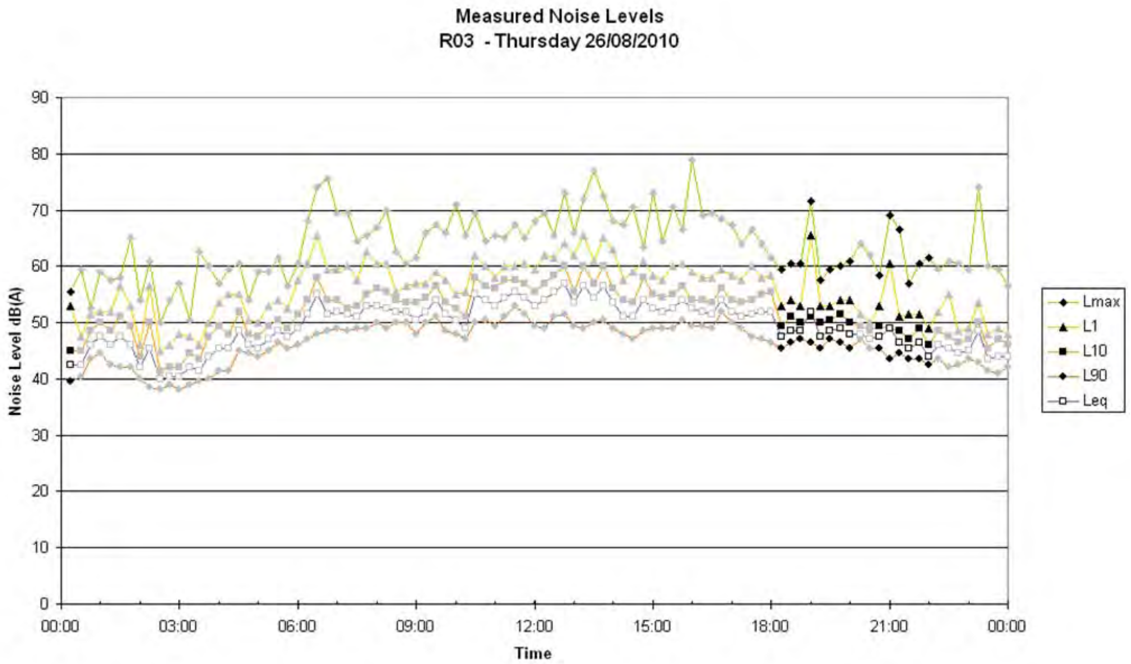
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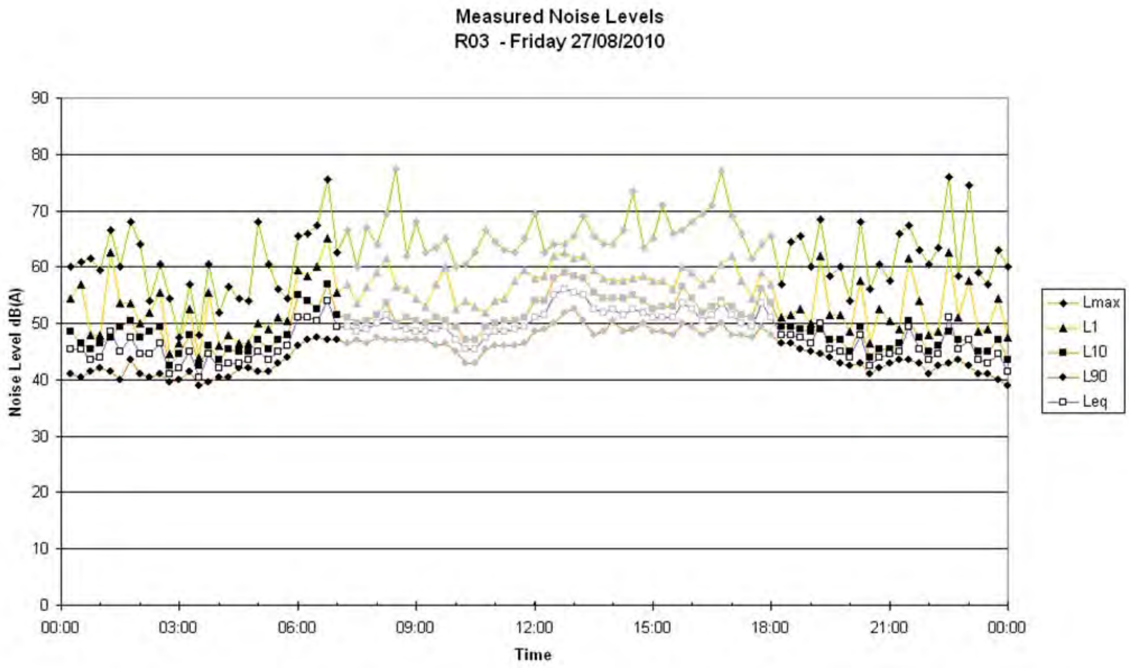
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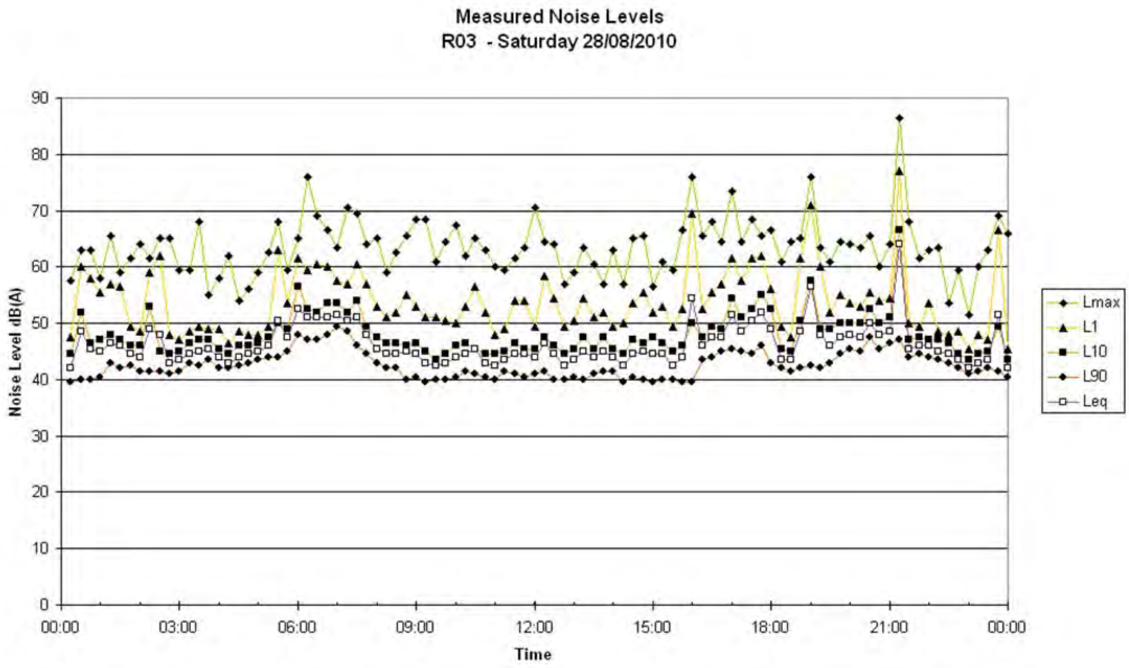
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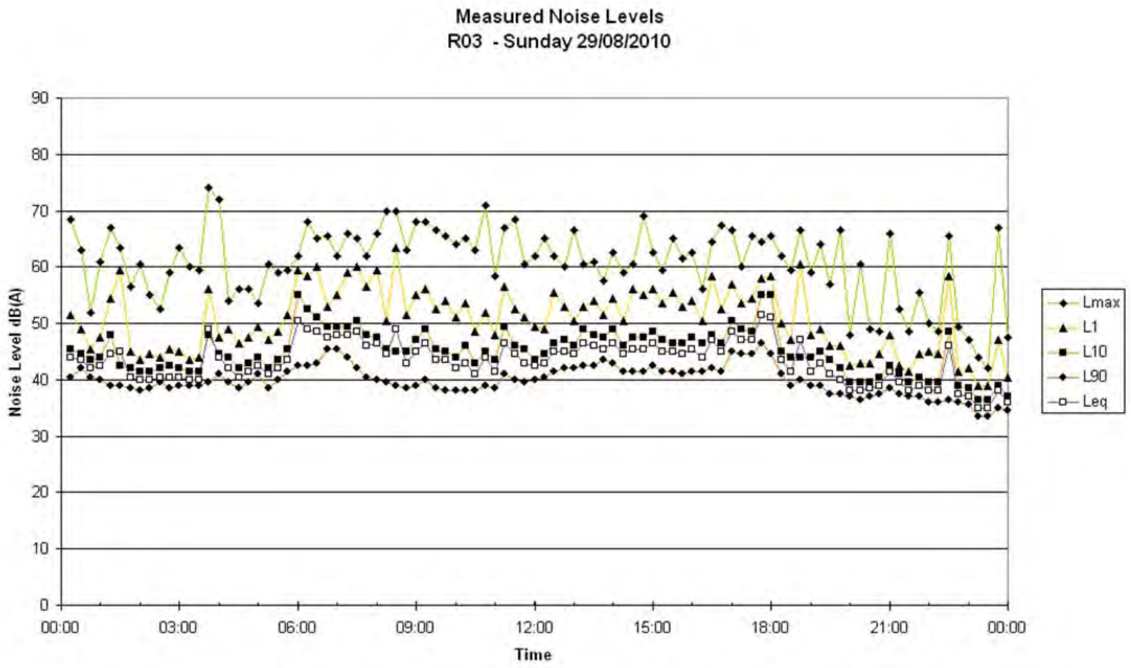

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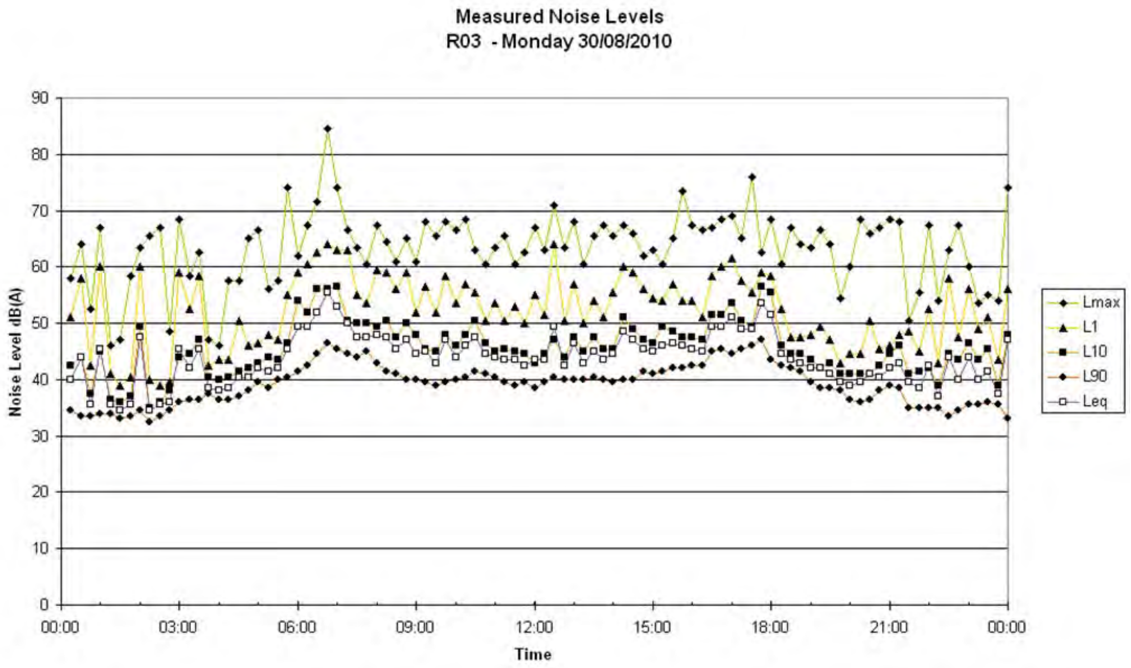

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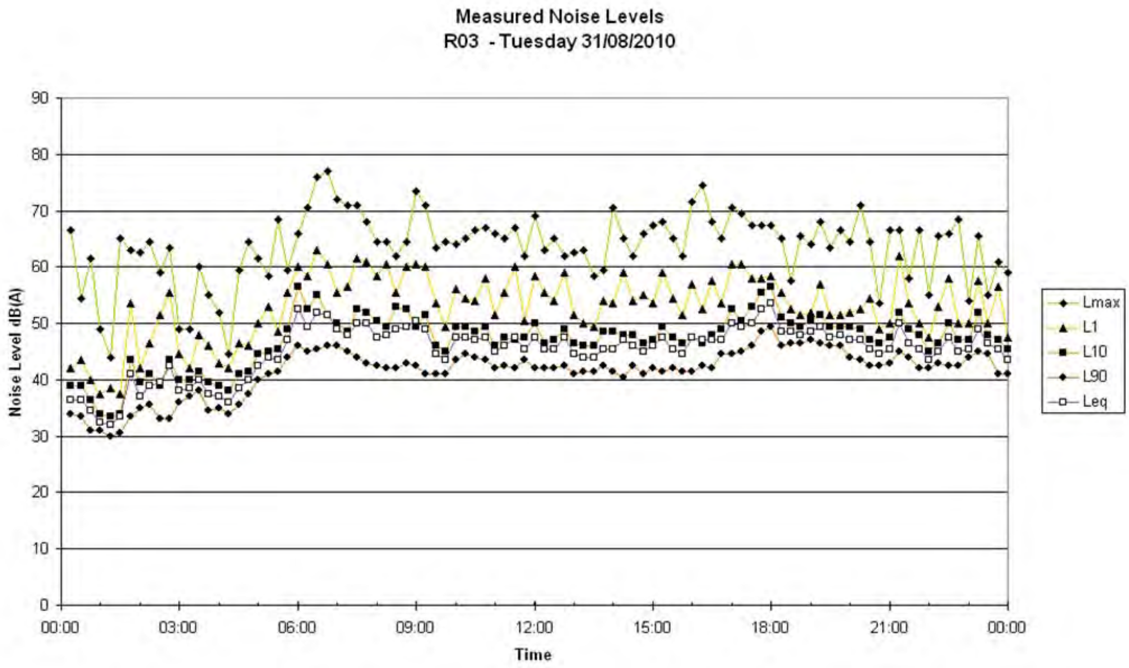
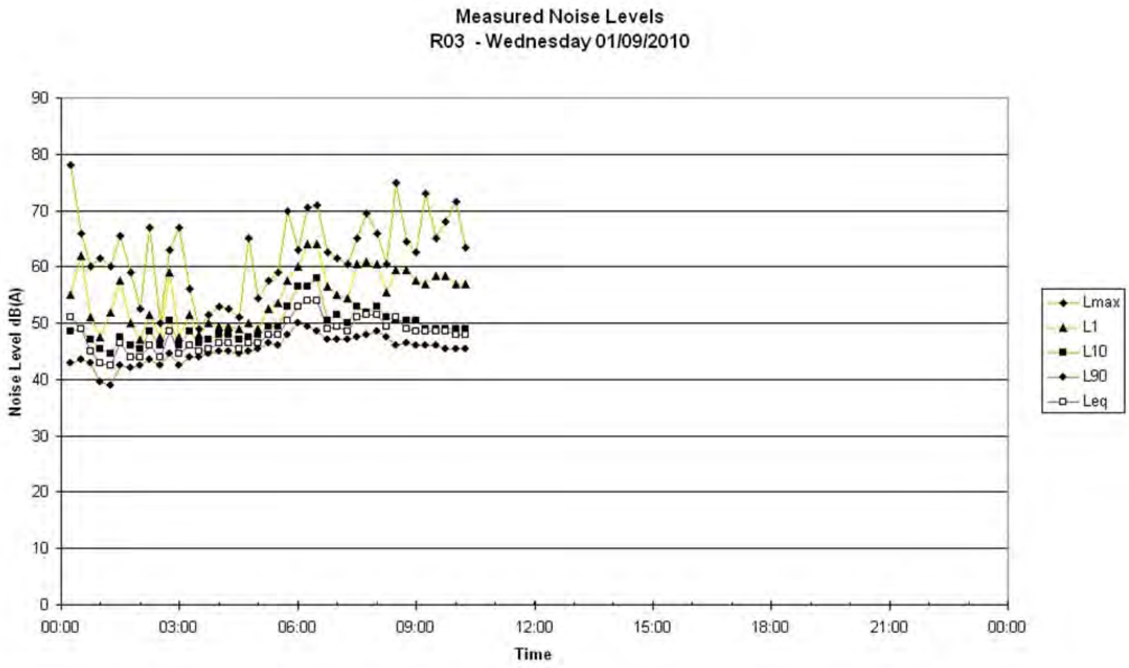
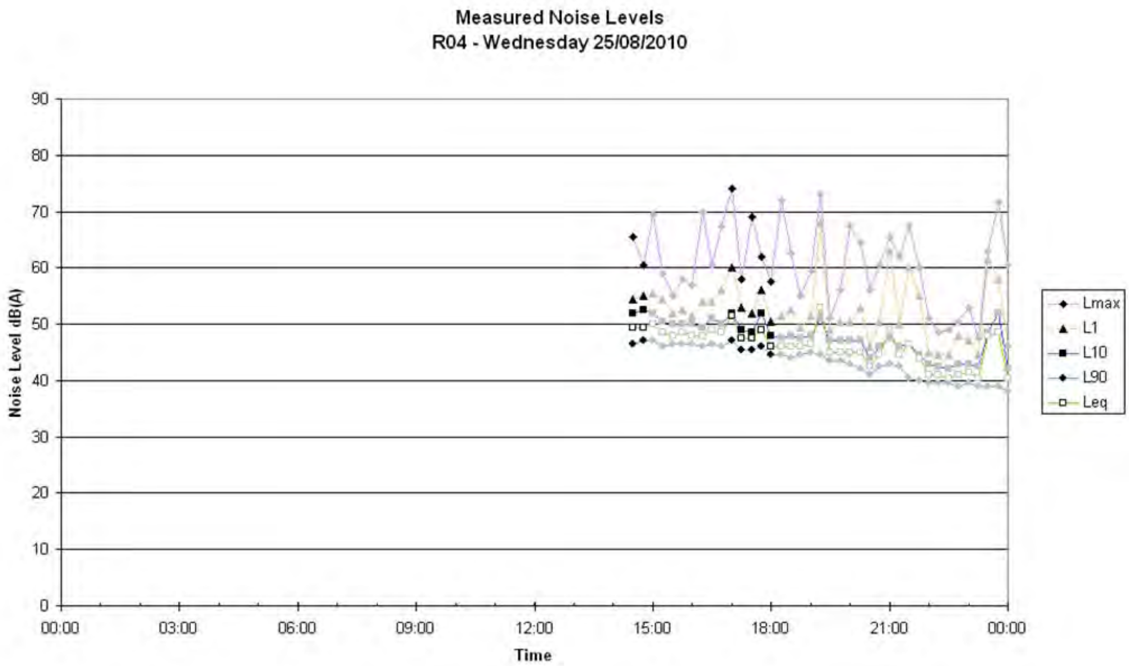
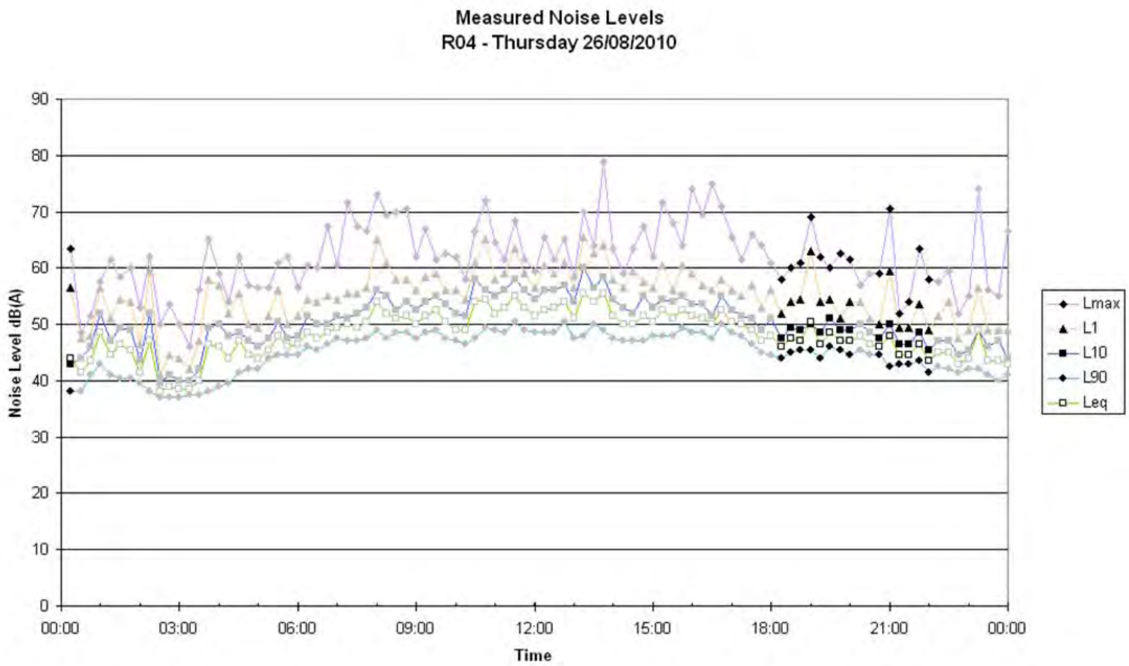
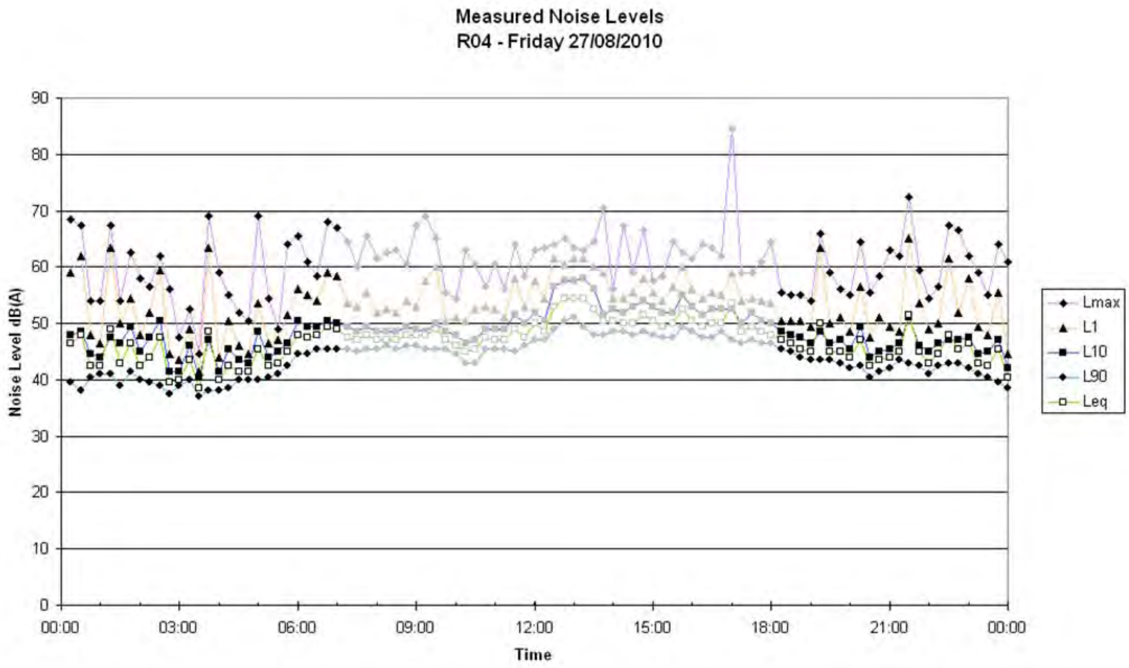
L90
Leq

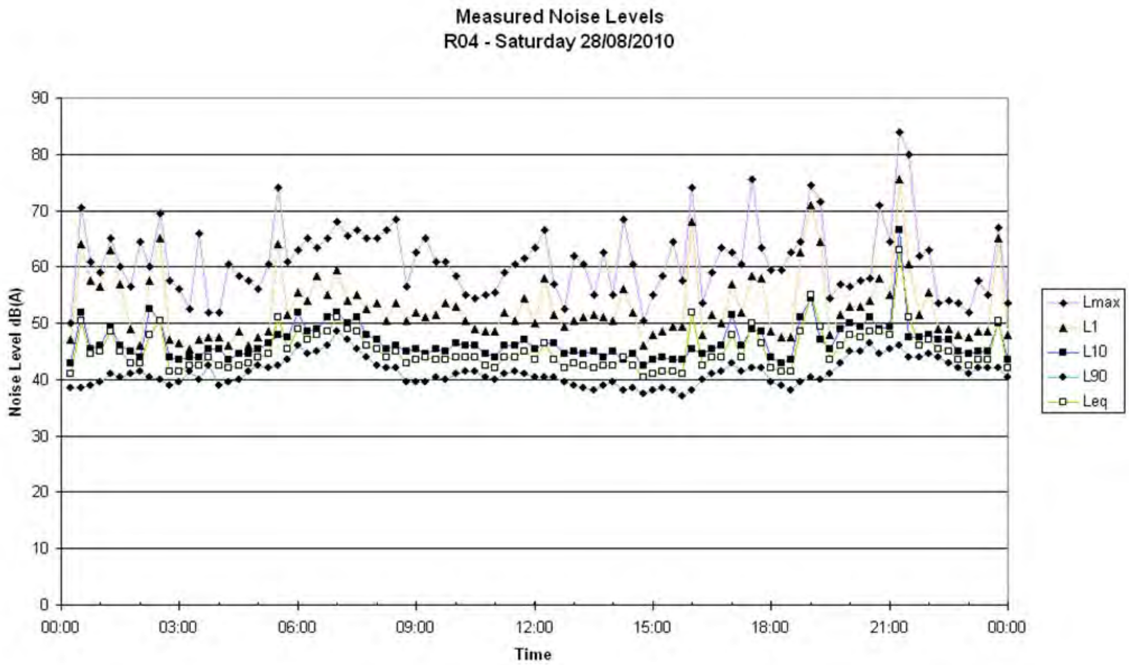

Measured Noise Levels
R03 - Tuesday 31/08/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

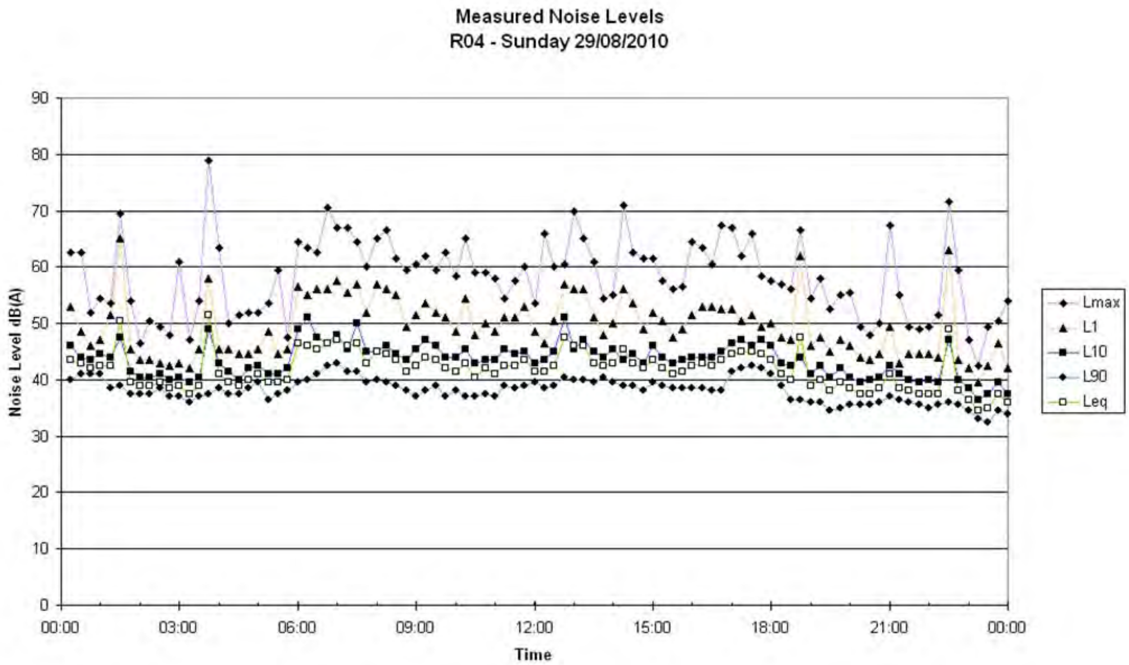

Measured Noise Levels
R03 - Wednesday 01/09/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

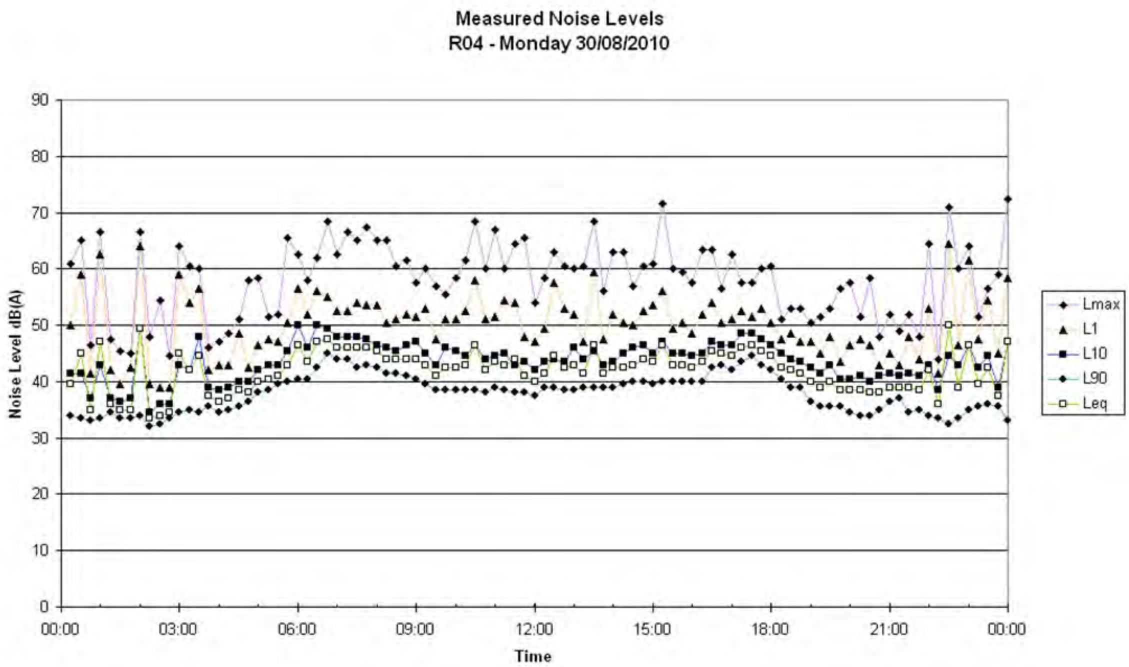

Measured Noise Levels
R04 - Wednesday 25/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

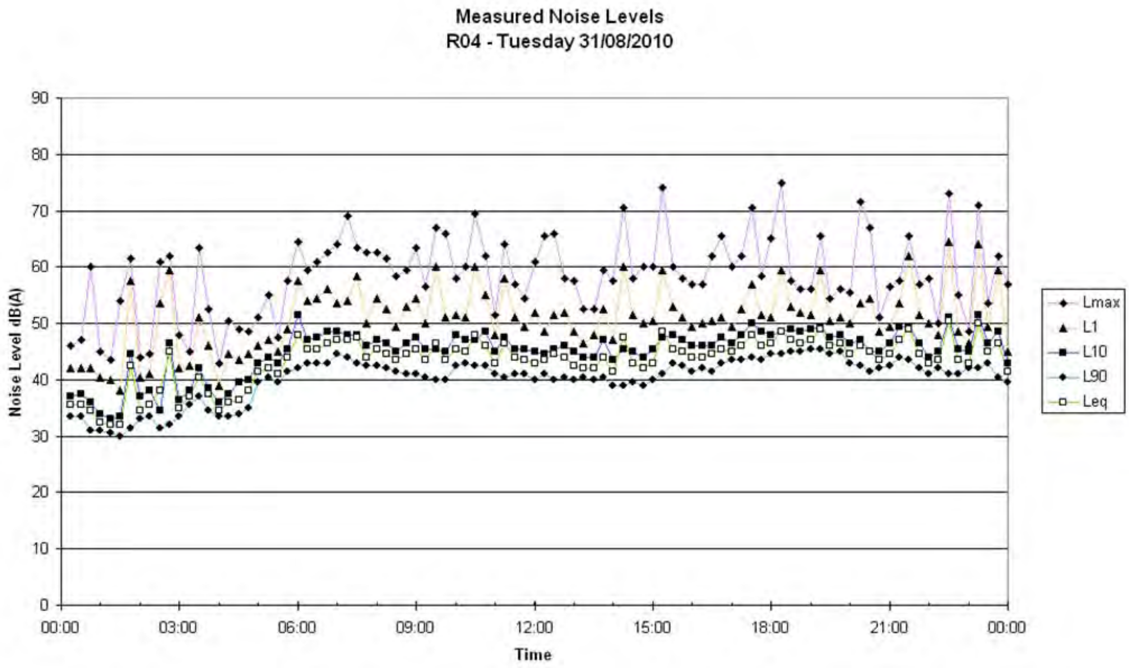

Measured Noise Levels
R04 - Thursday 26/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

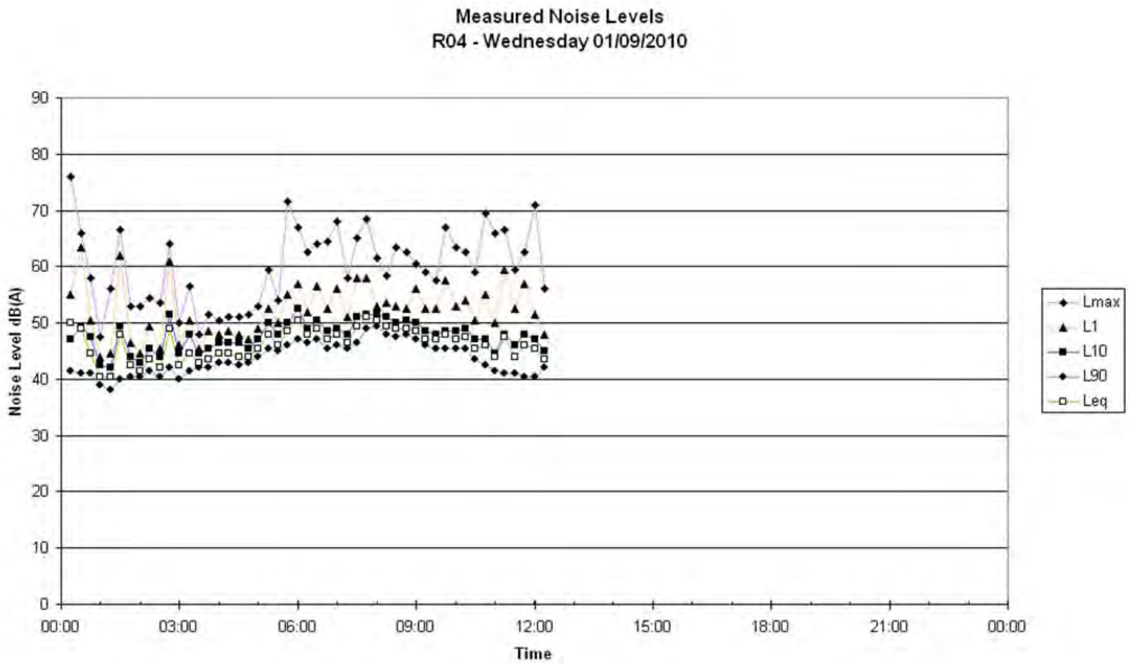

Measured Noise Levels
R04 - Friday 27/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

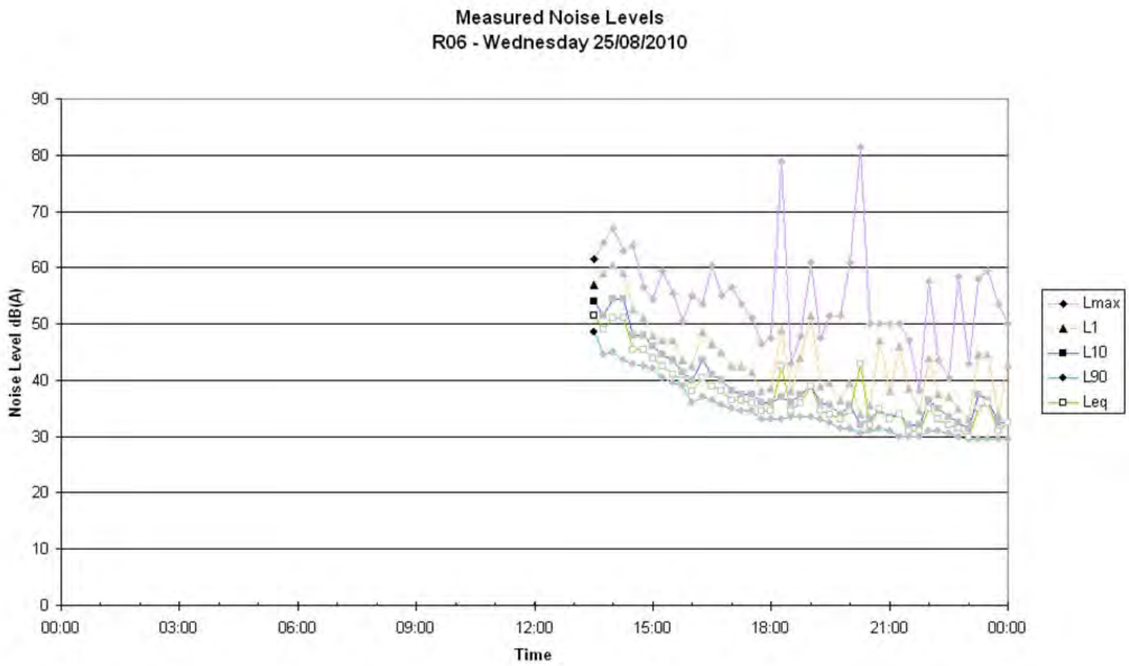

Measured Noise Levels
R04 - Saturday 28/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

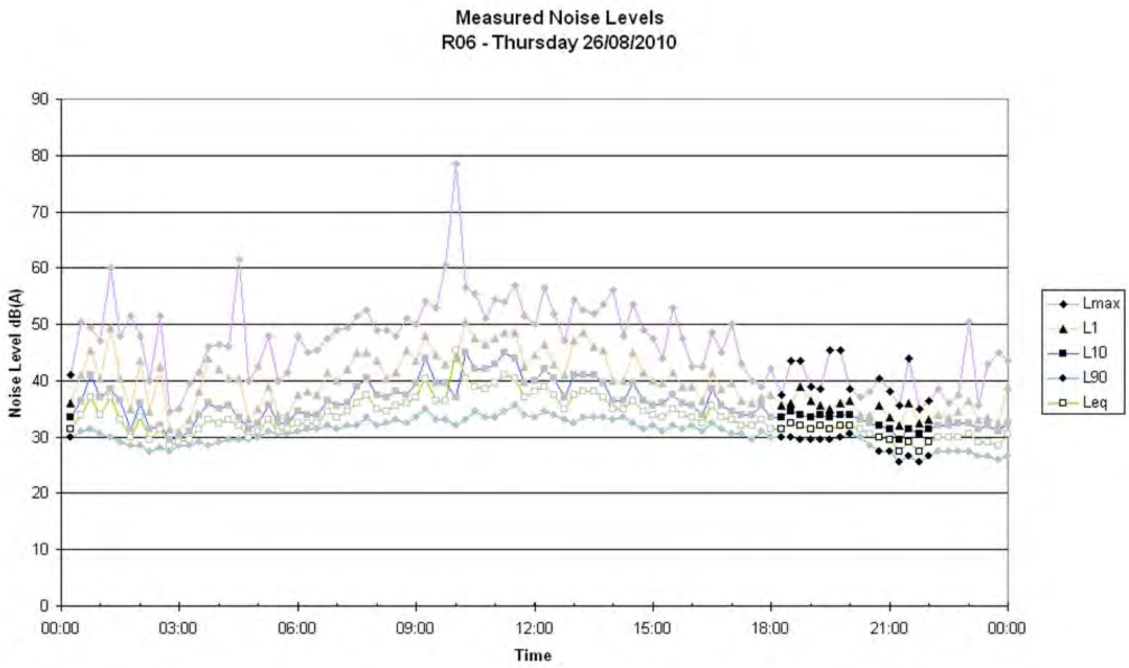

Measured Noise Levels
R04 - Sunday 29/08/2010
90
80
70
60
50
40
30
20
10
0
Noise Level dB(A)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

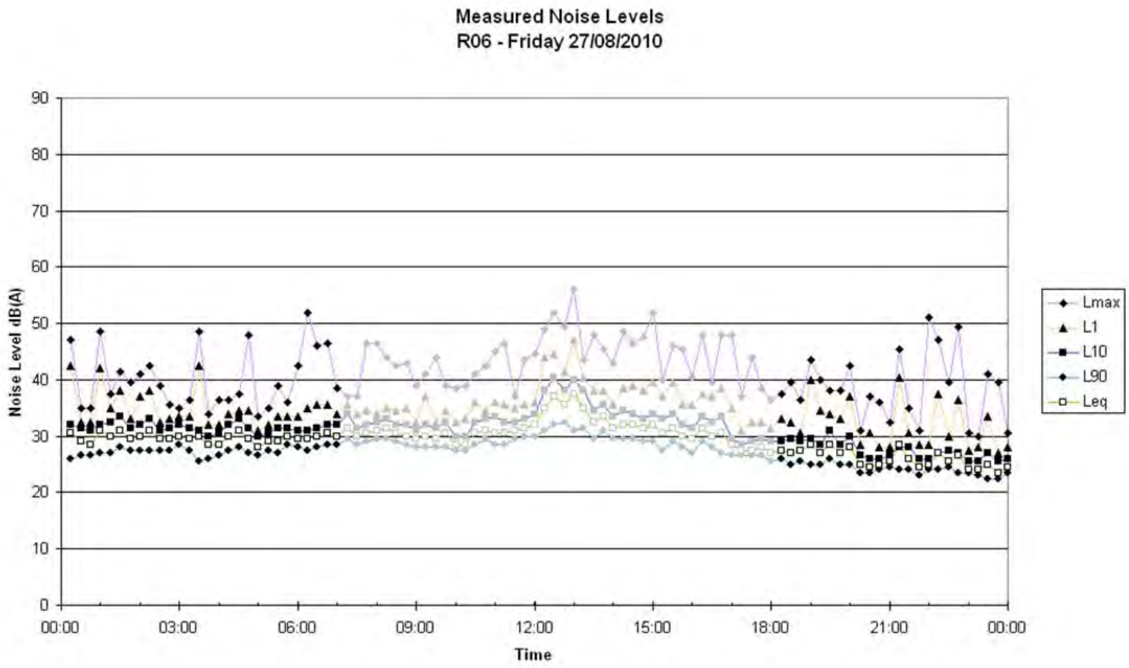

Measured Noise Levels
R04 - Monday 30/08/2010
90
80
70
60
50
40
30
20
10
0
Noise Level dB(A)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

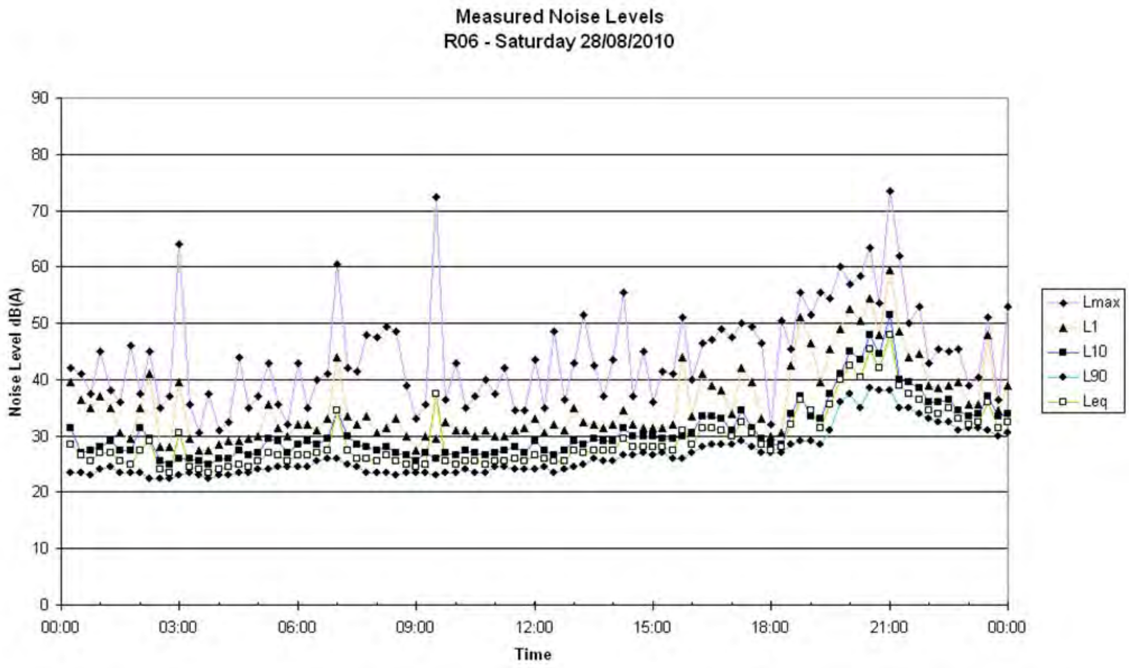

Measured Noise Levels
R04 - Tuesday 31/08/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq


Measured Noise Levels
R04 - Wednesday 01/09/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

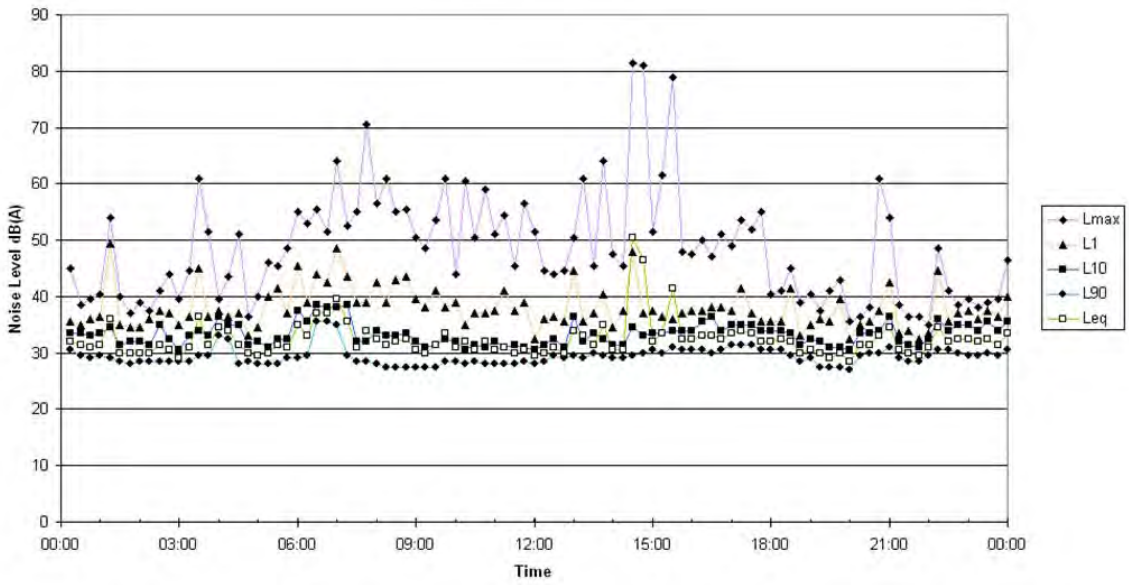

Measured Noise Levels
R06 - Wednesday 25/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq


Measured Noise Levels
R06 - Thursday 26/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

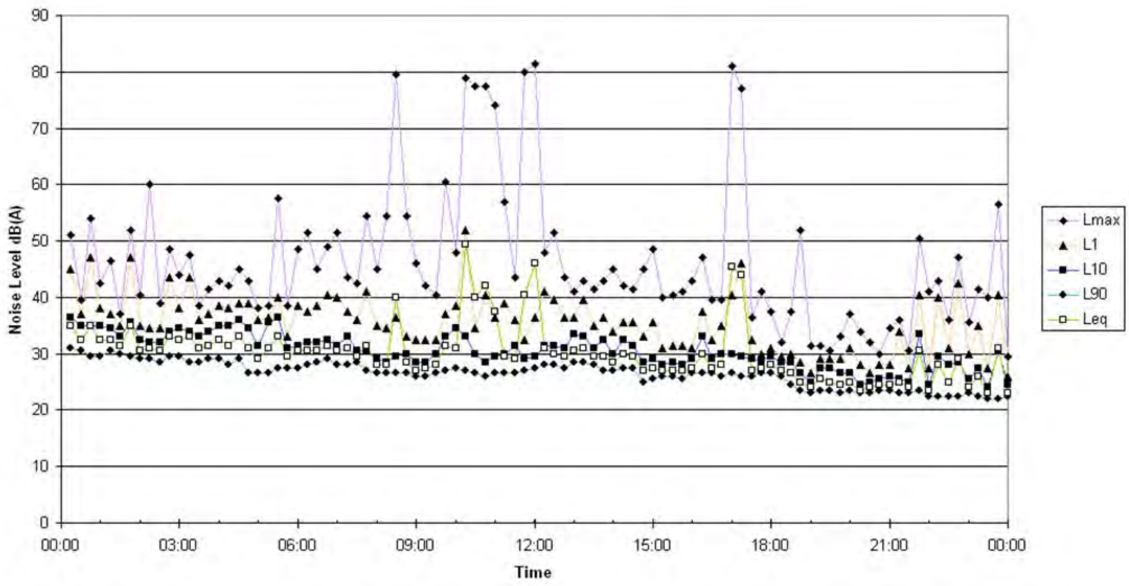

Measured Noise Levels
R06 - Friday 27/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

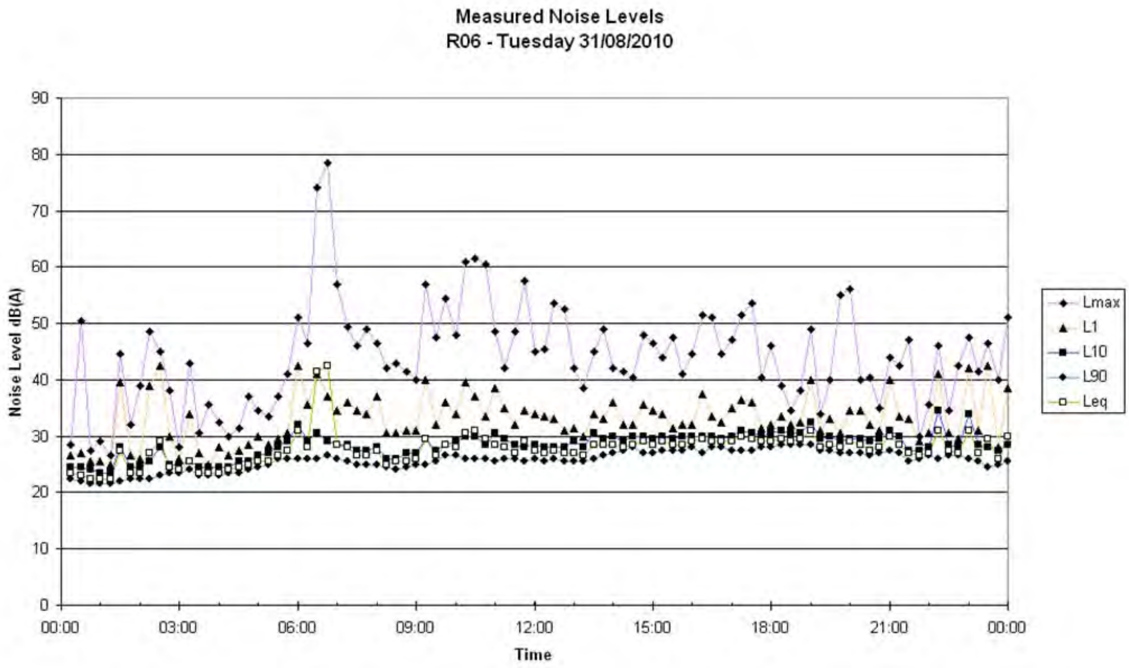

Measured Noise Levels
R06 - Saturday 28/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

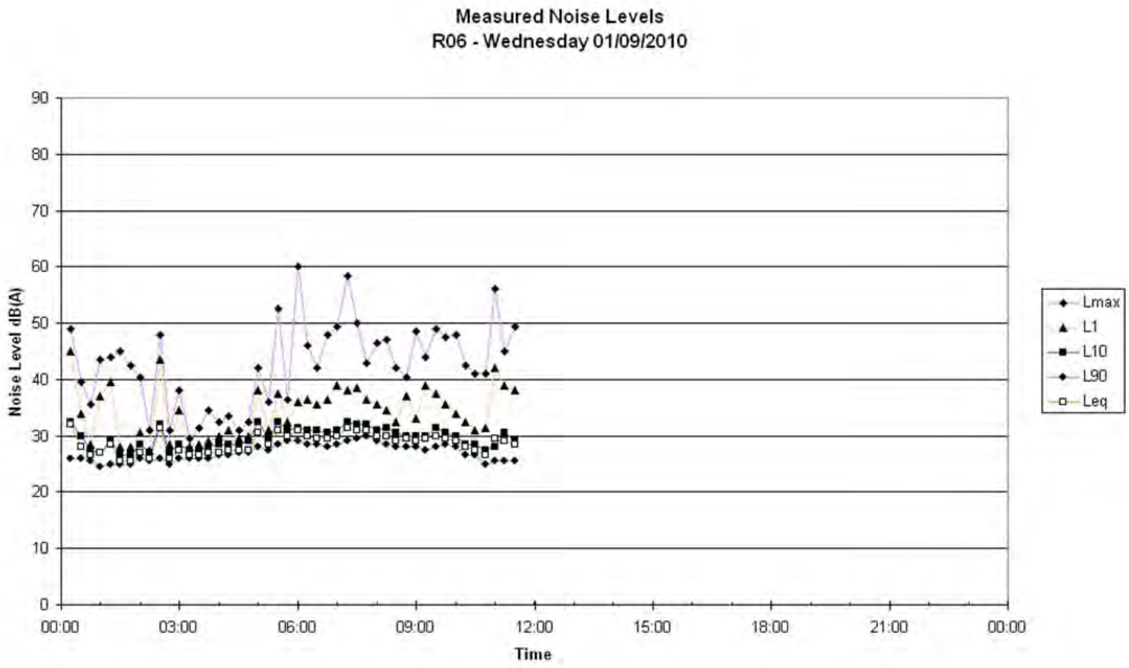
Measured Noise Levels
R06 - Sunday 29/08/2010

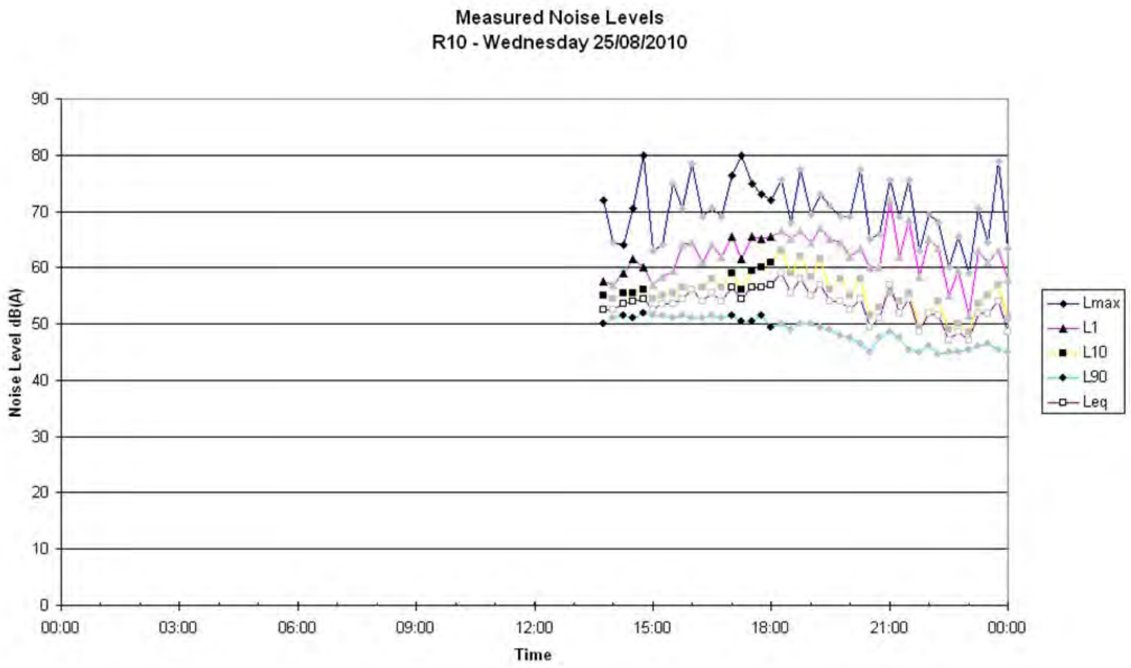


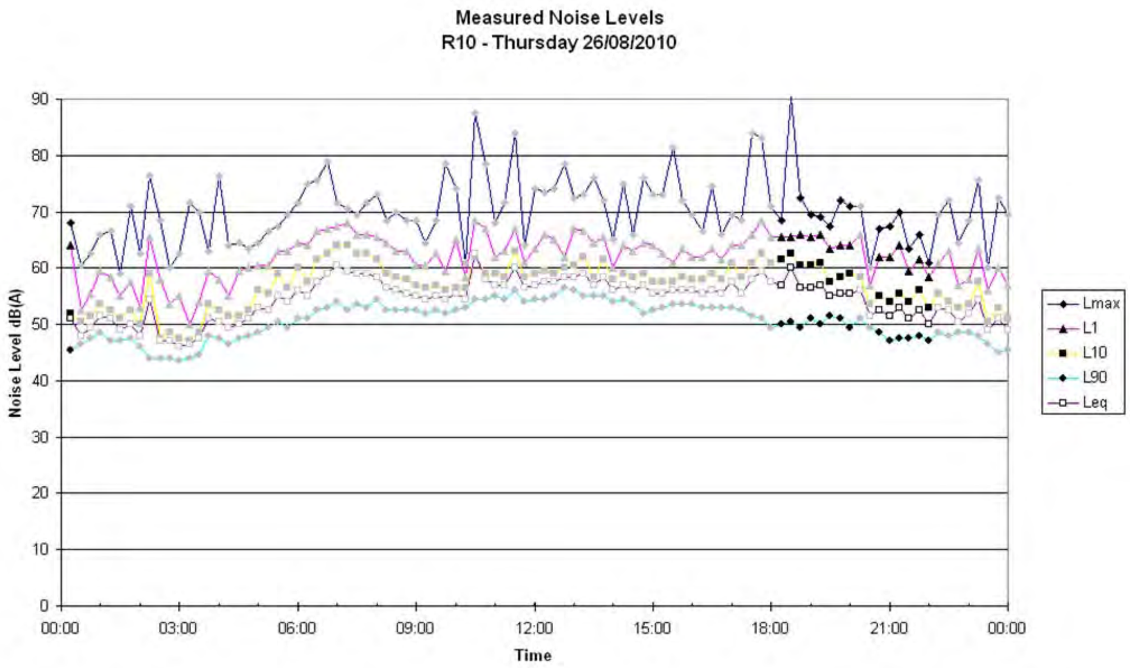
Measured Noise Levels
R06 - Monday 30/08/2010

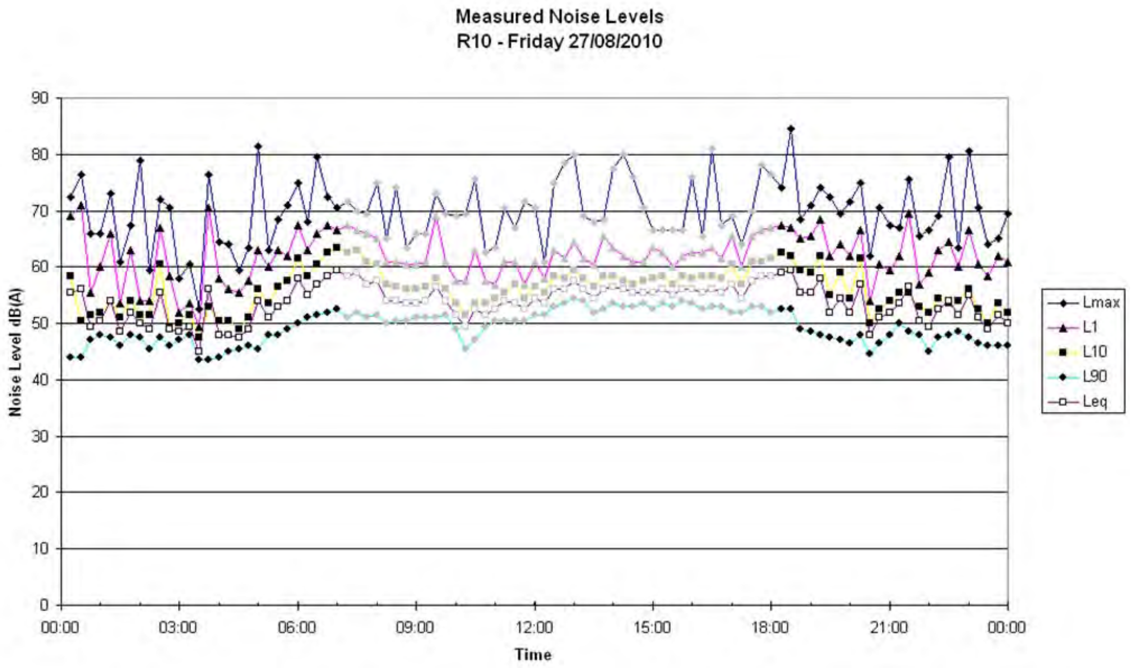



Measured Noise Levels
R06 - Tuesday 31/08/2010
Noise Level dB(A)
0
10
20
30
40
50
60
70
80
90
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

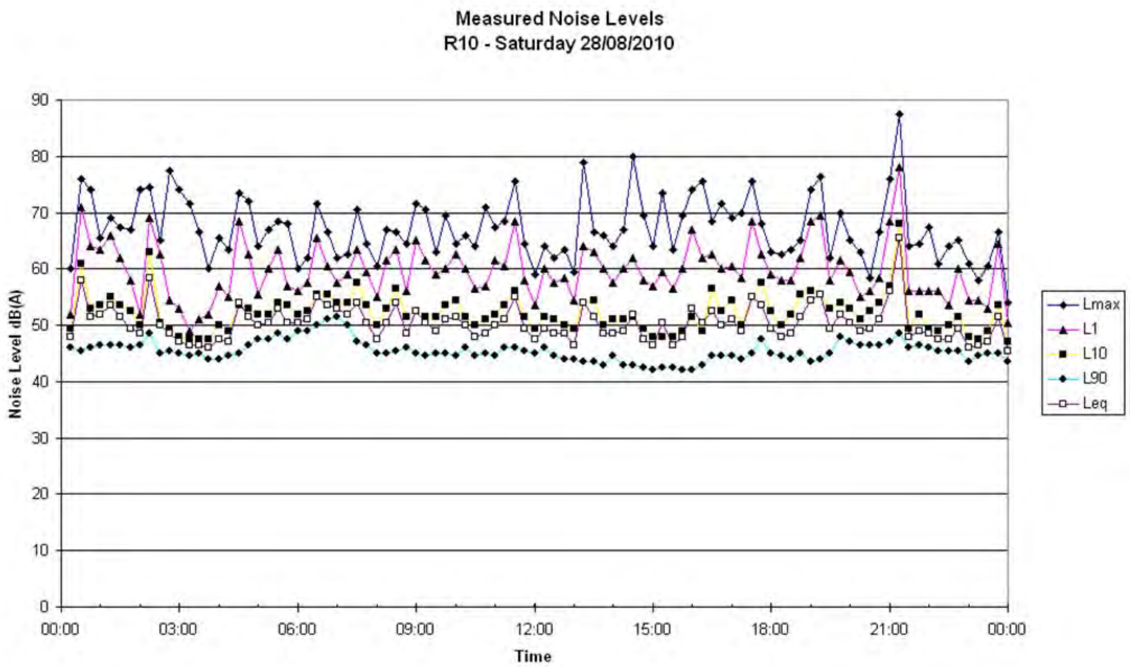

Measured Noise Levels
R06 - Wednesday 01/09/2010
Noise Level dB(A)
0
10
20
30
40
50
60
70
80
90
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq


Measured Noise Levels
R10 - Wednesday 25/08/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

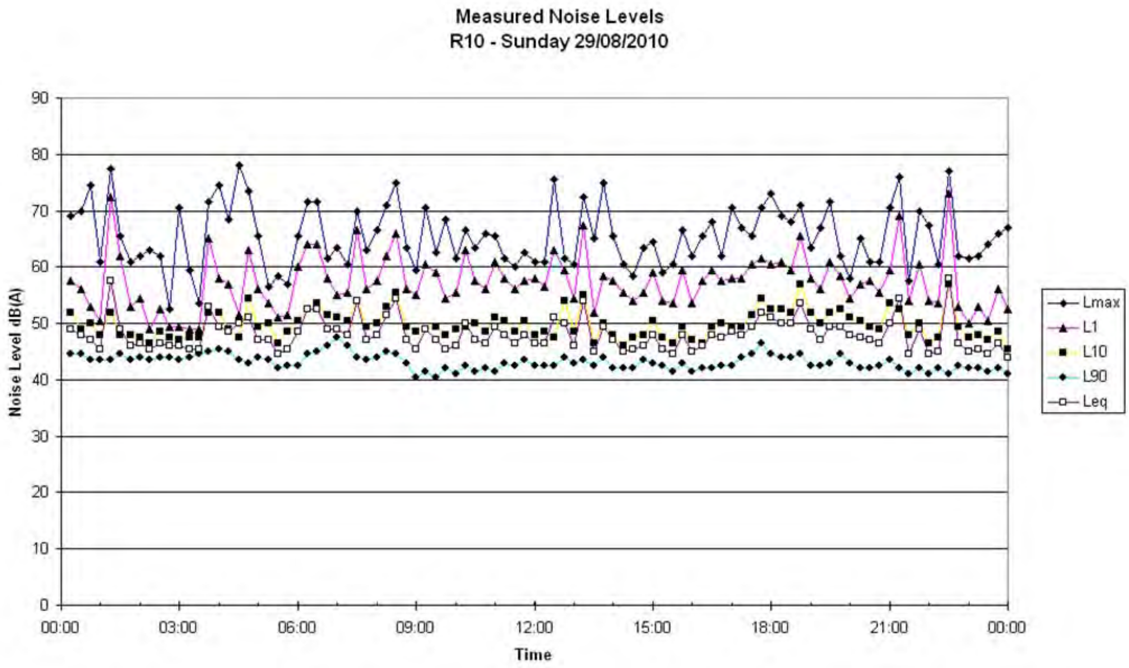

Measured Noise Levels
R10 - Thursday 26/08/2010
Noise Level dB(A)
90
80
70
60
50
40
30
20
10
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq



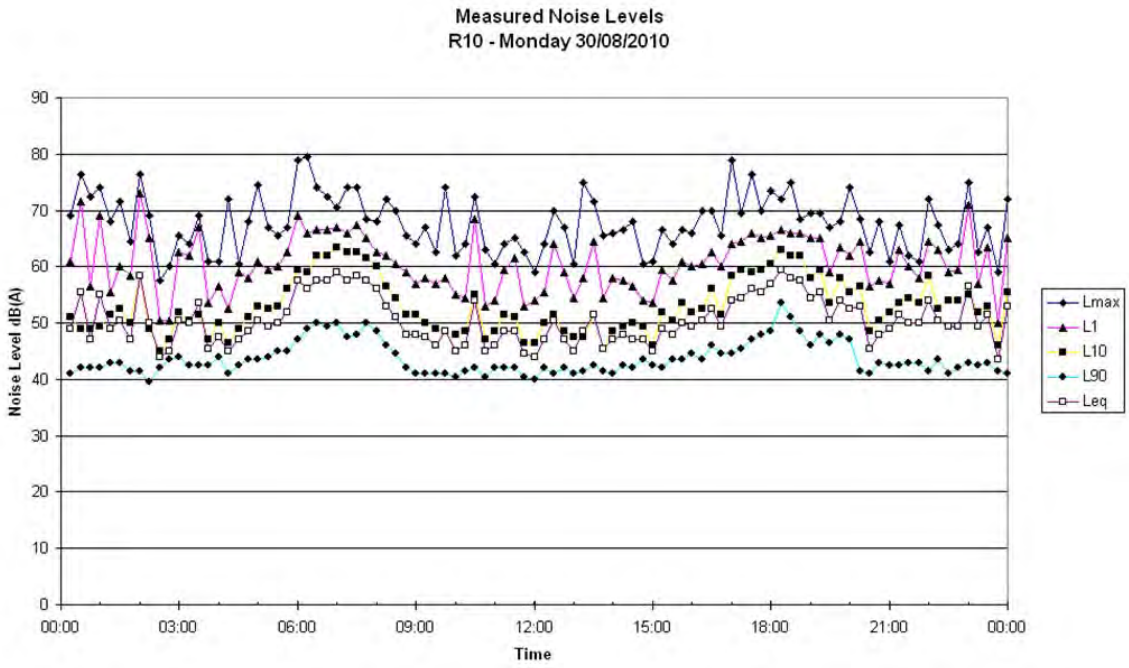
Measured Noise Levels
R10 - Friday 27/08/2010
Noise Level dB(A)
0
10
20
30
40
50
60
70
80
90
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq



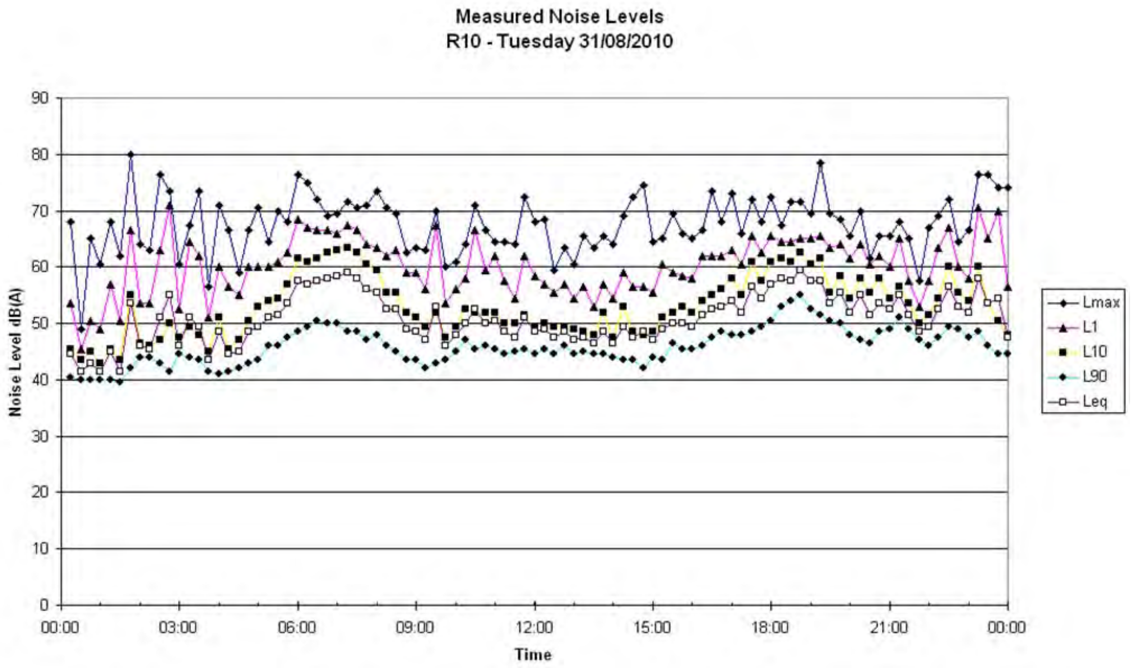
Measured Noise Levels
R10 - Saturday 28/08/2010
Noise Level dB(A)
0
10
20
30
40
50
60
70
80
90
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time
Lmax
L1
L10
L90
Leq

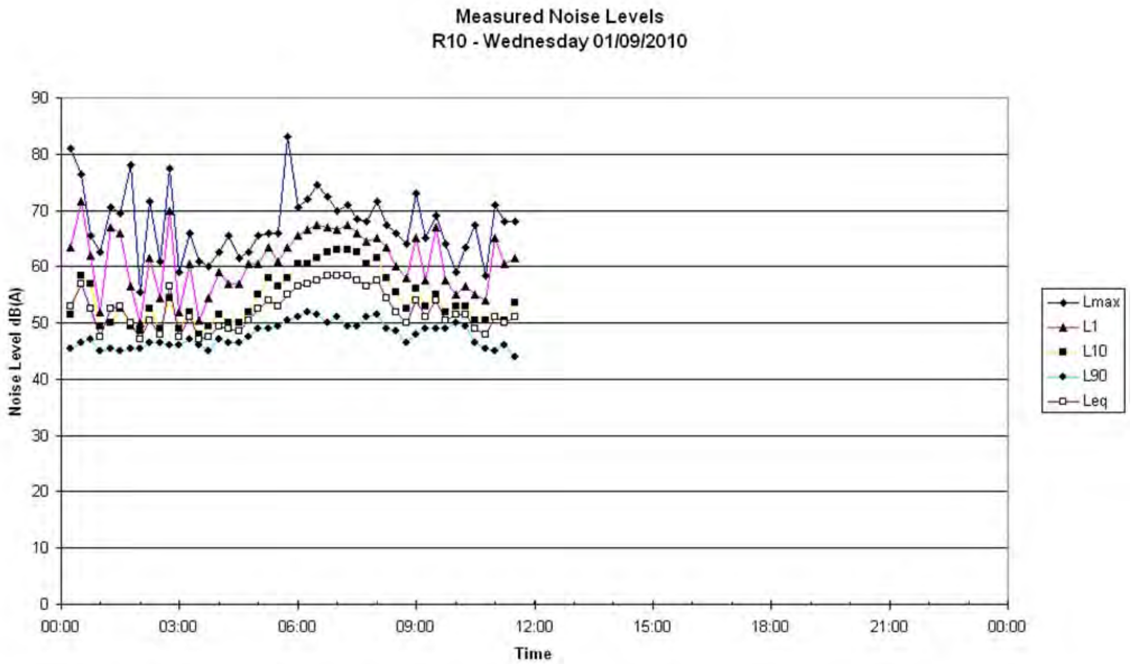


Measured Noise Levels
R10 - Sunday 29/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq



Measured Noise Levels
R10 - Monday 30/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq


Measured Noise Levels
R10 - Tuesday 31/08/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq


Measured Noise Levels
R10 - Wednesday 01/09/2010
Noise Level dB(A)
Time
Lmax
L1
L10
L90
Leq

Appendix 3: QA/QC Procedures

Sound Level Meters

Calibration of Sound Level Meters

A sound level meter requires regular calibration to ensure its measurement performance remains within specification. Benbow Environmental sound level meters are calibrated by a National Association of Testing Authority (NATA) registered laboratory or a laboratory approved by the NSW DECC every two years and after each major repair, in accordance with AS 1259-1990.

The calibration of the sound level meter was checked immediately before and after each series of measurements using an acoustic calibrator. The acoustic calibrator provides a known sound pressure level, which the meter indicates when the calibrator is activated while positioned on the meter microphone.

The sound level meters also incorporate an internal calibrator for use in setting up. This provides a check of the electrical calibration of the meter, but does not check the performance of the microphone. Acoustical calibration checks the entire instrument including the microphone. Calibration certificates for the instrument sets used are available on demand.

Care and Maintenance of Sound Level Meters

Noise measuring equipment contains delicate components and therefore must be handled accordingly. The equipment is manufactured to comply with international and national standards and is checked periodically for compliance. The technical specifications for sound level meters used in Australia are defined in Australian Standard AS 1259 – 1990 "*Sound Level Meters*".

The sound level meters and associated accessories are protected during storage, measurement and transportation against dirt, corrosion, rapid changes of temperature, humidity, rain, wind, vibration, electric and magnetic fields. Microphone cables and adaptors are always connected and disconnected with the power turned off. Batteries are removed (with the instrument turned off) if the instrument is not to be used for some time.

Investigation Procedures

All investigative procedures were conducted in accordance with AS 1055.1-1997 *Acoustics – "Description and Measurement of Environmental Noise (Part 1: General Procedures)"*.

The following information was recorded and kept for reference purposes:

- Type of instrumentation used and measurement procedure conducted;
- Description of the time aspect of the measurements, ie. measurement time intervals; and
- Positions of measurements and the time and date were noted.

As per AS 1055.1-1997, all measurements were carried out at least 3.5 m from any reflecting structure other than the ground. The preferred measurement height of 1.5 m above the ground was utilised.

Unattended Noise Monitoring

NOISE MONITORING EQUIPMENT

The measured data is processed statistically and stored in memory every 15 minutes. The equipment was calibrated prior and subsequent to the measurement period using a Rion NC-73 sound level calibrator. There were no significant variances observed in the reference signal between the pre-measurement and post-measurement calibrations. Instrument calibration certificates have also been included in Attachment 3.

Attended Noise Monitoring

NOISE MONITORING EQUIPMENT

The sound level meters utilised during the attended noise monitoring programme were calibrated by a NATA-accredited laboratory within two years of the measurement period. The instrument sets comply with AS 1259 and was set on A-weighted, fast response, A-weighted, impulse response and C-weighted, fast response in order to accurately analyse the existing ambient noise environment.

The microphone was positioned at approximately 1.5 metres above ground level and was fitted with windsocks to prevent weather bias. The instrument was calibrated using a Bruel & Kjaer type 4230 acoustic calibrator prior and subsequent to the measurement period to ensure the reliability and accuracy of the instrument sets. There were no significant variances observed in the reference signal between the pre-measurement and post-measurement calibrations. Instrument calibration certificates have also been included in Attachment 3.

Meteorological Consideration during Monitoring

For the long-term attended monitoring, meteorological data for the relevant period were provided by the Bureau of Meteorology, and this data is considered representative of the monitoring period for the site.

Measurements affected by wind or rain over certain limits were precluded from the final analyses of the recorded data in accordance with the DECCW's Industrial Noise Policy (INP).

Methodology

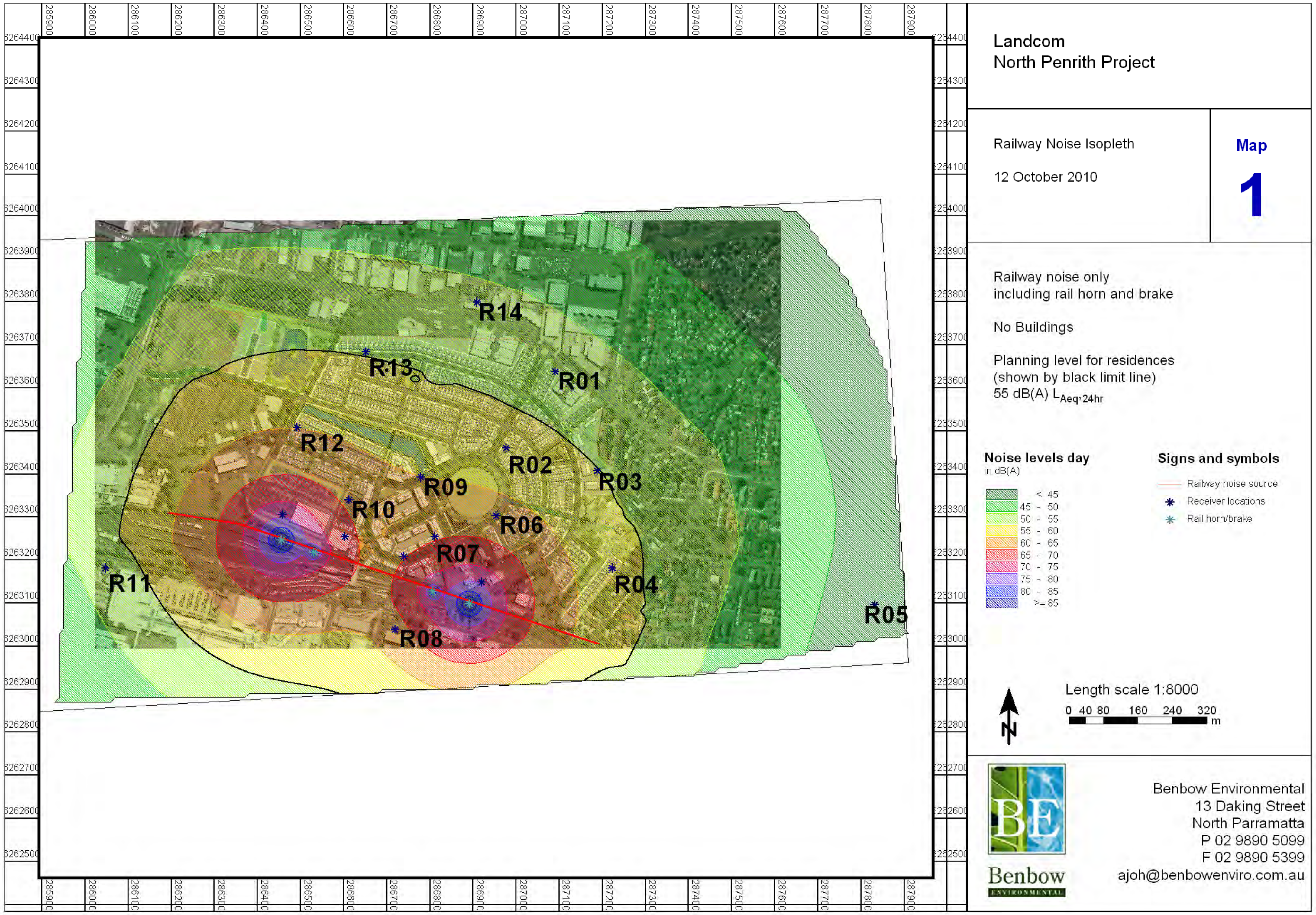
The attended noise measurements were carried out generally in accordance with Australian Standard AS1055-1997 - "Acoustics – Description and Measurement of Environmental Noise".

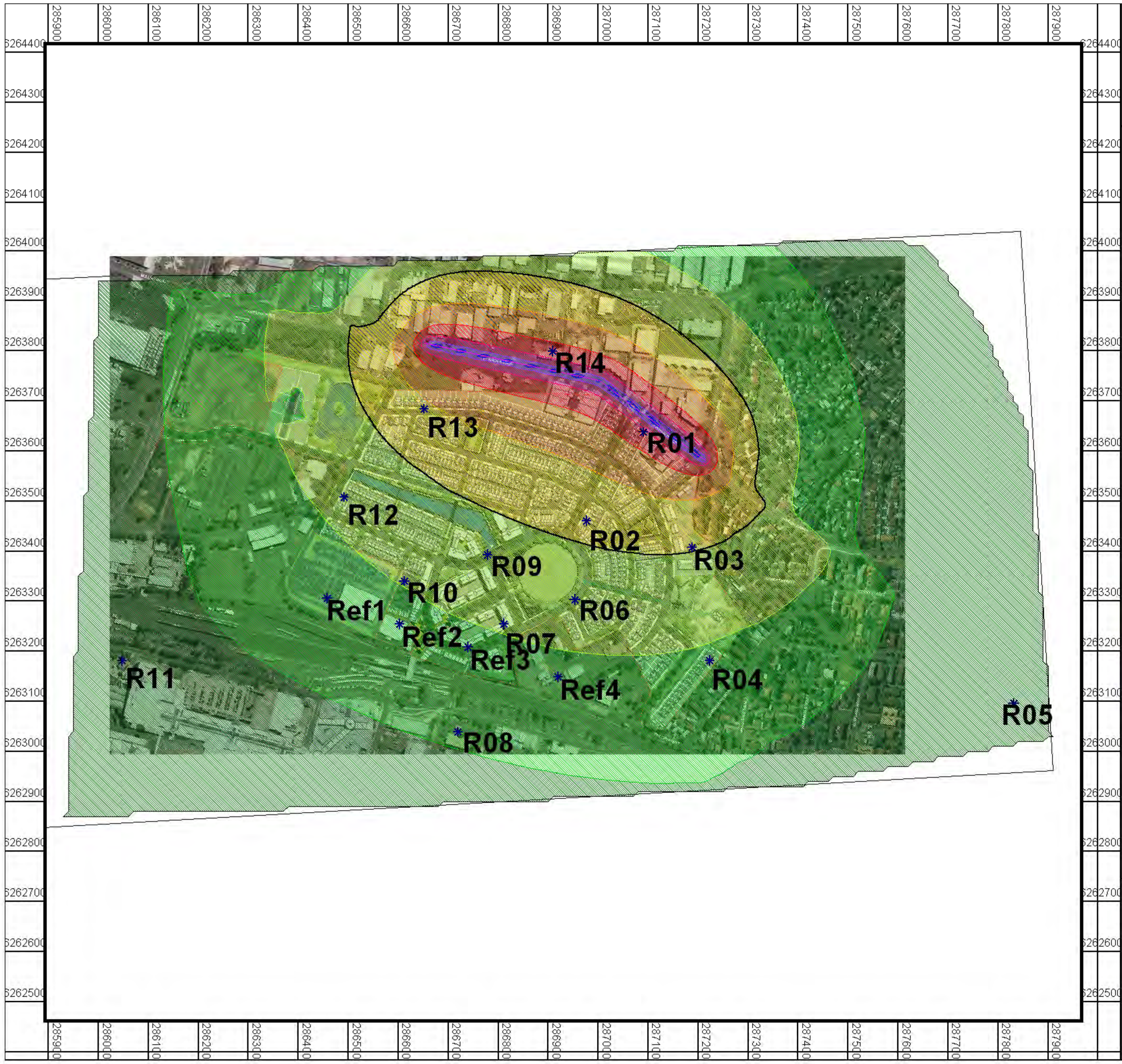
Descriptors & Filters used for Monitoring

Noise levels are commonly measured using A-weighted filters and are usually described as dB(A). The "A-weighting" refers to standardised amplitude versus frequency curve used to "weight" sound measurements to represent the response of the human ear. The human ear is less sensitive to low frequency sound than it is to high frequency sound. Overall A-weighted measurements quantify sound with a single number to represent how people subjectively hear different frequencies at different levels.

Noise environments can be described using various descriptors depending on characteristics of noise or purpose of assessments. For this survey the L_{A90}, L_{Aeq} and L_{Amax} levels were used to analyse the monitoring results. The statistical descriptors L_{A90} measures the noise level exceeded for 90% of the sample measurement time, and is used to describe the "Background noise". Background noise is the underlying level of noise present in the ambient noise, excluding extraneous noise or the noise source under investigation. The L_{Aeq} level is the equivalent continuous noise level or the level averaged on an equal energy basis which is used to describe the "Ambient Noise". The L_{Amax} noise levels are maximum sound pressure levels measured over the sampling period and this parameter is commonly used when assessing noise impact.

Appendix 4: Noise Isopleths





Landcom
North Penrith Project

Road Traffic Noise Isopleth
(Coreen Avenue 2016)

12 October 2010

Map 2

Road traffic noise only

No Buildings

Planning level for residences
7am to 10pm: 60 dB(A) $L_{Aeq,1hr}$
10pm to 7am: 55 dB(A) $L_{Aeq,1hr}$
(shown by black limit line)

Noise levels day
in dB(A)

< 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
>= 85

Signs and symbols

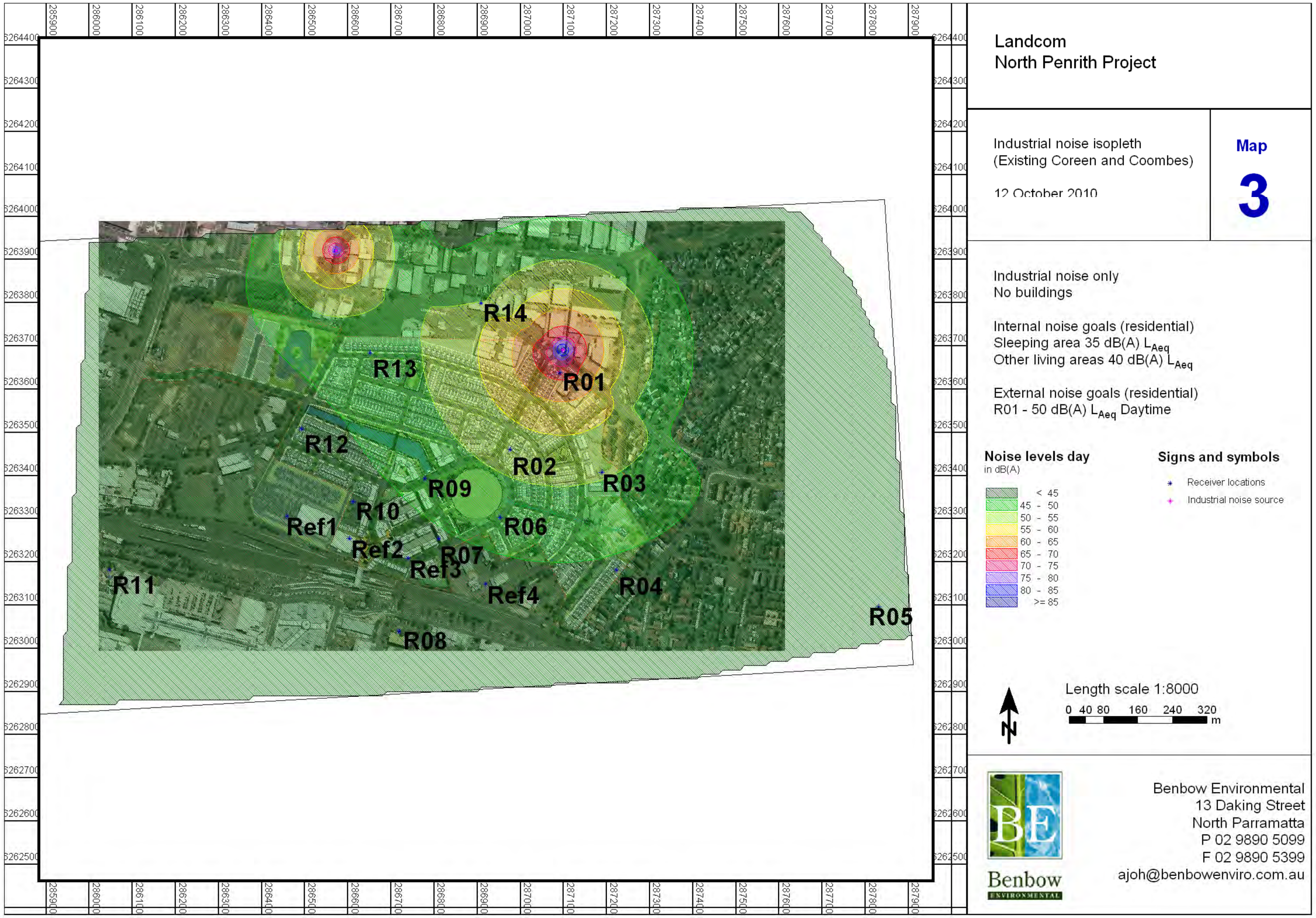
* Receiver locations
Road traffic noise source

N

Length scale 1:8000
0 40 80 160 240 320 m

Benbow Environmental

Benbow Environmental
13 Daking Street
North Parramatta
P 02 9890 5099
F 02 9890 5399
ajoh@benbowenviro.com.au


Landcom
North Penrith Project
Industrial noise isopleth
(Existing Coreen and Coombes)
12 October 2010
Map
3
Industrial noise only
No buildings
Internal noise goals (residential)
Sleeping area 35 dB(A) L_{Aeq}
Other living areas 40 dB(A) L_{Aeq}
External noise goals (residential)
R01 - 50 dB(A) L_{Aeq} Daytime
Noise levels day
in dB(A)
< 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
>= 85
Signs and symbols
Receiver locations
Industrial noise source
Length scale 1:8000
0 40 80 160 240 320
m
N
Benbow Environmental
13 Daking Street
North Parramatta
P 02 9890 5099
F 02 9890 5399
ajoh@benbowenviro.com.au
Benbow
ENVIRONMENTAL
R01
R02
R03
R04
R05
R06
R07
R08
R09
R10
R11
R12
R13
R14
Ref1
Ref2
Ref3
Ref4