LOGOS KEMPS CREEK LOGISTICS PROJECT

NOISE AND VIBRATION IMPACT ASSESSMENT

ACOUSTICS AND AIR

REPORT NO. 10164
VERSION B

WILKINSON MURRAY

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AUGUST 2010

PREPARED FOR

LOGOS PROPERTY PTY LTD
SUITE 3, LEVEL 15
25 BLIGH STREET
SYDNEY NSW 2000

Wilkinson Murray (Sydney) Pty Limited · ABN 39 139 833 060
Level 2, 123 Willoughby Road, Crows Nest NSW 2065, Australia • **Offices in SE Qld & Hong Kong**
t +61 2 9437 4611 • **f** +61 2 9437 4393 • **e** acoustics@wilkinsonmurray.com.au • **w** www.wilkinsonmurray.com.au

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1 INTRODUCTION

Wilkinson Murray (Sydney) Pty Limited has been engaged by LOGOS Property Pty Ltd to conduct a construction and operational noise and vibration assessment in relation to an industrial business park development at Kemps Creek. The site is will accommodate DHL and Metcash logistics operations.

This report sets out the assessment in relation to:

- construction noise;
- road traffic noise; and
- noise emissions from the operation of the development.

Based on the distance between the nearest receivers and the site vibration due to operational activities, does not have the potential to adversely impact on surrounding properties.

1.1 Project Description

LOGOS Property proposes to develop the site for industrial and employment purposes including warehouse, storage and distribution facilities. The current Project Application involves the development of the warehouse facility including subdivision, bulk earthworks, road access and utility connections.

The subject site is located on the south-eastern corner of the junction of Mamre Road and Bakers Lane, Kemps Creek - property description of Lot 1 within Deposited Plan 104958. The site is approximately rectangular in shape providing frontages of approximately 489 metres and 1,067 metres to Mamre Road and Bakers Lane respectively. The total site area is 51.72 hectares. The site and surrounding land is significantly undulating containing a number of dams within the low points.

The development is to consist of eight warehouses on the western half of the site servicing DHL, and a main warehouse and cold store serving Metcash. Figure 2-1 illustrates the proposed site layout.

Figure 1-1 LOGOS Site Layout

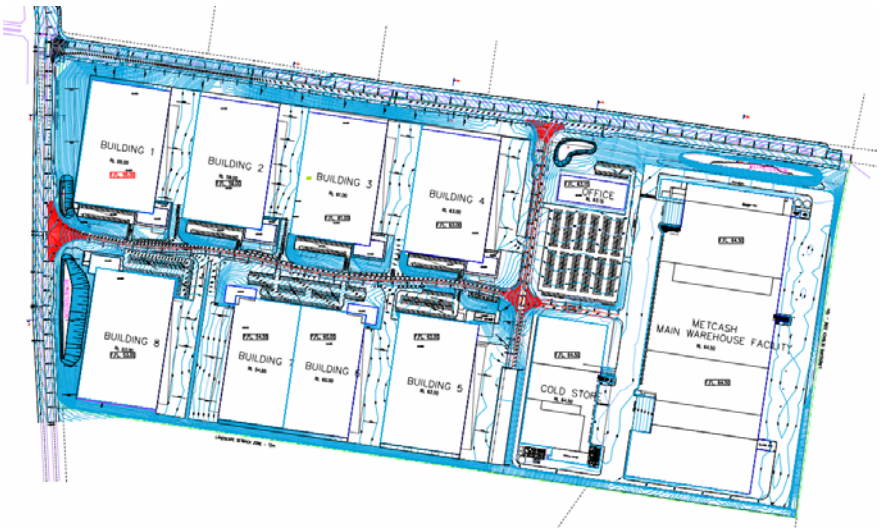
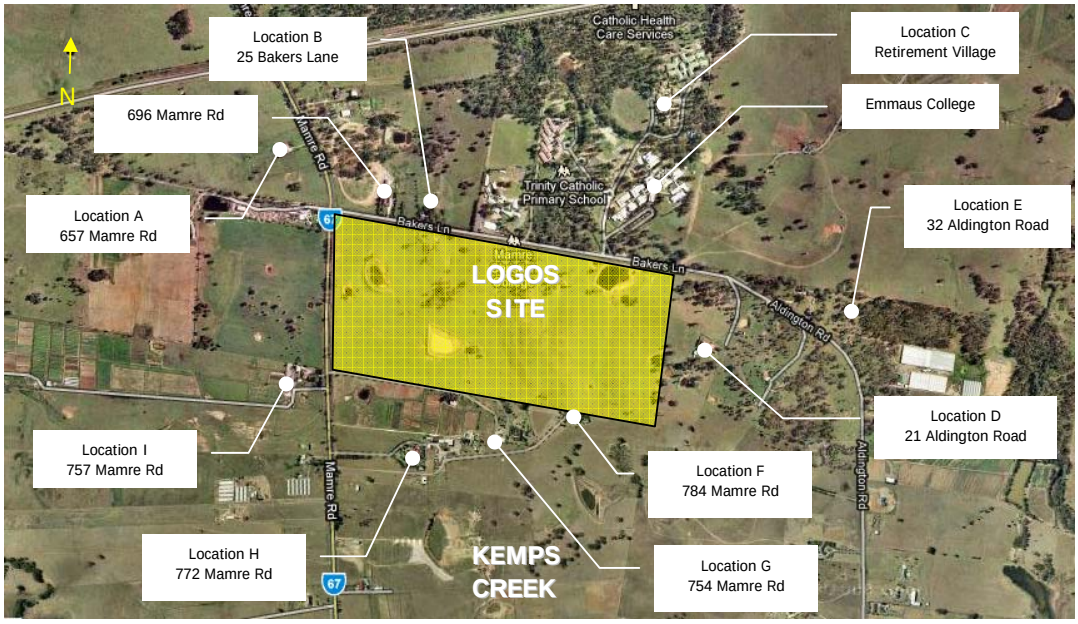


Figure 1-2 shows the site and surrounding residences. The site is in a mixed industrial / rural residential setting, with residences situated on rural land around the site. Surrounding residences have been identified as:

- 657 Mamre Road residence to the North West at a distance of approximately 250m (Residential Location A);
- 25 Bakers Lane and 696 Mamre Road – residences to the North, with the closest at a distance of approximately 30m (Residential Location B);
- Emmaus Retirement Village to the North at a distance 460m (Residential Location C);
- 21 and 32 Aldington Road Residences to the East at a distance of approximately 140m and 470m respectively (Residential Locations D & E);
- 784 Mamre Road Residence to the South at a distance of approximately 10m (Residential Location F);
- 754 Mamre Road Residence to the South at a distance of approximately 150m (Residential Location G);
- 772 Mamre Road Residence to the South at a distance of approximately 200m (Residential Location H); and
- 757 Mamre Road Residence to the South at a distance of approximately 80m (Residential Location I).

Figure 1-2 Proposed Site Showing Surrounding Residences & Noise Measurement Locations



Other surrounding noise-sensitive receivers are:

- Emmaus Secondary School to the north at approximately 110m;
- Trinity Catholic School on Bakers Lane, and
- Mamre Anglican School on Bakers Lane

1.2 Acoustic Terminology

The following report uses specialist acoustic terminology. An explanation of common terms is provided in Appendix A.

2 AMBIENT NOISE LEVELS AND SURROUNDING RECEIVERS

Long-term ambient noise levels were monitored at three locations surrounding the site, selected to cover the range of environments in the potentially-affected areas. The locations are presented in Table 2-1. The logger locations are shown in Figure 2-1 to 2-2.

Table 2-1 Long-Term Noise Monitoring Locations

Monitoring Site	Address	Relevant Noises Noted on Site Visits
A	657 Mamre Road, Kemps Creek	Noise from Mamre Road and agricultural activities
B	25 Bakers Lane, Kemps Creek	Noise from Mamre Road and schools
C	32 Aldington Road, Kemps Creek	Rural residential area – quiet

Noise monitoring at Locations A and B was conducted between Wednesday, 2 July and Monday, 14 July 2010. Noise monitoring at Location C was conducted between Monday, 19 July and Monday, 26 July 2010.

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

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

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

Table 2-2 summarises the noise results, for daytime, evening, night time periods as defined in by the DECCW. The summary noise descriptors are:

- $L_{Aeq,period}$ – the equivalent continuous L_{Aeq} noise level measured over the assessment period; and
- RBL – Rating Background Level is a measure of typical background noise levels which is used in determining noise criteria.

Table 2-2 Summary of Measured Noise Levels

Noise Logging Site	RBL (dBA)				$L_{Aeq,period}$ (dBA)			
	Daytime 7am-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-5pm	Daytime 7am-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-5pm
A	47	47	43	47	59	58	57	57
B	47	46	40	48	60	56	56	56
C	33	34	33	31	47	42	42	47

Figure 2-1 Locations A and B – 657 Mamre Road and 25 Bakers Lane

Figure 2-2 Location C – Aldington Road Residences

3 PERFORMANCE CRITERIA

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

- *Interim Construction Noise Guideline*;
- *NSW Industrial Noise Policy*; and
- *Environmental Criteria for Road Traffic Noise.*

3.1 Construction Noise Criteria

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

For residences, the basic daytime construction noise goal is that the noise level should not exceed the L_{A90} background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am to 6.00pm, and Saturday 8.00am to 1.00pm. Outside the standard hours, the criterion would be background + 5dBA. A more complete description of the guidelines is in Table 3-1.

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

- Active recreation areas (such as parks): external $L_{Aeq\ (15\ min)}$ 65dBA; and
- Schools: internal $L_{Aeq\ (15\ min)}$ 40dBA;

Based on the above, Table 3-2 presents the applicable noise management levels for construction activities.

Table 3-1 Construction Noise Goals at Residences using Quantitative Assessment

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

Table 3-2 Site Specific Construction Noise Management Levels

Location	Construction Noise Management Level, L_{Aeq} – dBA				Maximum Construction Noise Level, L_{Aeq} – dBA
	Day	Evening	Night	Saturday (8am-1pm)	
A – 657 Mamre Road	57	52	48	57	75
B – 25 Bakers Lane	57	51	45	58	75
C – Retirement Village	43	39	38	41	75
D – 21 Aldington Road	43	39	38	41	75
E – 32 Aldington Road	43	39	38	41	75
F – 784 Mamre Road	57	52	48	57	75
G – 754 Mamre Road	57	52	48	57	75
H – 772 Mamre Road	57	52	48	57	75
I – 757 Mamre Road	57	52	48	57	75
Schools on Mamre Road*	50	N/A	N/A	N/A	75

Note: * Based on a 10dBA reduction in noise from outside to inside through an open classroom window.

3.2 Construction Vibration Criteria

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-1992. Methods and criteria in that Standard are used to set "preferred" and "maximum" vibration levels in the document "*Assessing Vibration: A Technical Guideline*" (2006) produced by the NSW *DECCW*.

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

Table 3-3 Criteria for Exposure to Continuous Vibration

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

In the case of intermittent vibration, which is caused by plant such as rockbreakers, the criteria are expressed as a Vibration Dose Value (VDV) which is presented in Table 3-4.

Table 3-4 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

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

3.3 Building Damage

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 “Explosives - Storage and Use - Part 2: Use of Explosives” recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2” as they “are applicable to Australian conditions” BS7385.

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

The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 3-5.

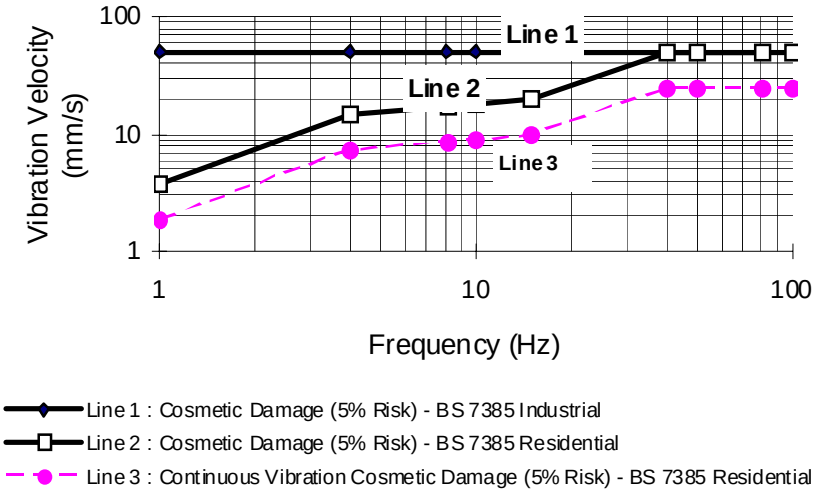
Table 3-5 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The Standard states that the guide values in Table 3-5 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Note that rockbreaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

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

Figure 3-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



3.4 Traffic Noise Criteria

Criteria for assessment of road traffic noise are set out in the NSW Government's *Environmental Criteria for Road Traffic Noise (ECRTN)*. Under the definitions in that document, the new Link Road associated with this project would be described as "

- Mamre Road Residences – "*Land use developments with potential to create additional traffic on existing freeways / arterials*".
- Bakers Lane Residences - "*Land use developments with potential to create additional traffic on collector road*".

"

Table 3-6 shows the relevant noise criteria for this case. The criteria in columns 2 and 3 of the table are referred to as “base” criteria. These should be met in all cases, where possible. Criteria in the fourth column of the table are referred to as “allowance” criteria. The “existing” noise levels referred to here represent traffic noise levels in the year of opening of the project. In this report, these levels are predicted based on traffic volumes for the year 2017. This is prior to the upgrading of the road as a link road by the RTA to services the Oakdale and Jacfin employment areas that are to the east of the site.

In summary, the noise level goals at the residential receivers, for this project, based on the *ECRTN* are:

- $L_{Aeq,1hr}$ = 60dBA (7am-10pm);
- $L_{Aeq,1hr}$ = 55dBA (10pm-7am); or
- where base criteria are already exceeded, *ECRTN* allowance criteria (existing +2dBA) applies.

Table 3-6 Traffic noise criteria extracted from the NSW *ECRTN*

Type of Development	Criteria		
	Day (7am-10pm) dB(A)	Night (10pm-7am) dB(A)	Where Criteria Are Already Exceeded
7. Land use developments with potential to create additional traffic on collector road	$L_{Aeq,15hr}$ 60	$L_{Aeq,9hr}$ 55	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.
8. Land use developments with potential to create additional traffic on collector road	$L_{Aeq,1hr}$ 60	$L_{Aeq,1hr}$ 55	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.

Accordingly all residences potentially affected by traffic noise associated with the development will be assessed with respect to the above criteria.

3.5 Industrial Noise Criteria

The *NSW Industrial Noise Policy (INP)* recommends two criteria, "Intrusiveness" and "Amenity", both of which are relevant for the assessment of noise. In most situations, one of these is more stringent than the other and dominates the noise assessment. The criteria are based on the L_{Aeq} descriptor, which is explained in Appendix A.

3.5.1 Intrusiveness Criterion

An intrusiveness criterion applies for residential receivers only.

The intrusiveness criterion requires that the L_{Aeq} noise level from the source being assessed, when measured over 15 minutes, should not exceed the Rating Background Noise Level (RBL) by more than 5dBA. The RBL represents the 'background' noise in the area, and is determined from measurement of L_{A90} noise levels, in the absence of noise from the source. The definition

of L_{A90} and RBL is given in Appendix A.

3.5.2 Amenity Criterion

The amenity criterion sets a limit on the total noise level from all industrial noise sources affecting a receiver. Different criteria apply for different types of receiver (e.g. residence, school classroom); different areas (e.g. rural, suburban); and different time periods, namely daytime (7.00am-6.00pm), evening (6.00pm-10.00pm) and night time (10.00pm-7.00am).

The noise level to be compared with this criterion is the L_{Aeq} noise level, measured over the time period in question, due to all industrial noise sources, but excluding non-industrial sources such as transportation.

Where a new noise source is proposed in an area with negligible existing industrial noise, the amenity criterion for that source may be taken as being equal to the overall amenity criterion. However, if there is significant existing industrial noise, the criterion for any new source must be set at a lower value. If existing industrial noise already exceeds the relevant amenity criterion, noise from any new source must be set well below the overall criterion to ensure that any increase in noise levels is negligible. Methods for determining a source-specific amenity criterion where there is existing industrial noise are set out in the *INP.*

3.5.3 Determination of Site Specific Industrial Noise Criteria

Table 3-7 shows the relevant noise industrial noise criteria for this project. Amenity criteria are based on a rural classification for Locations C, D and E and a suburban classification for the remainder of the assessment locations.

Table 3-7 Industrial Noise Intrusiveness & Amenity Criteria

Receiver Area	Time Period*	RBL (dBA)	Intrusiveness Criterion $L_{Aeq,15min}$ (dBA)	Amenity Criterion $L_{Aeq,period}$ (dBA)
Mamre Road Residences (A,F,G,H,I) – suburban	Daytime	47	52	55
	Evening	47	52	45
	Night time	43	48	40
Bakers Lane Residences B	Daytime	47	52	55
	Evening	46	51	45
	Night time	40	45	40
Retirement Village and Aldington Road Residences C,D,E	Daytime	33	38	50
	Evening	34	39	45
	Night time	33	38	40

*Daytime (7.00am–6.00pm)
Evening (6.00–10.00pm)
Night time (10.00pm–7.00am)

3.5.4 Sleep Disturbance Noise Criteria

Intermittent noises due to activities such as trucks starting and loading dock activities during the night-time period are not directly addressed by the *Industrial Noise Policy*.

The most recent guidance in relation to sleep disturbance is that contained in the DECCW's "Application Notes – *NSW Industrial Noise Policy*" issued in July 2006. The pertinent section of the DECCW's Application Notes states the following:

DEC reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research, DEC recognised that current sleep disturbance criterion of an $L_{A1, (1\ minute)}$ not exceeding the $L_{A90, (15\ minute)}$ by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DEC will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or $L_{A1, (1\ minute),}$ that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:

- *how often high noise events will occur*
- *time of day (normally between 10pm and 7am)*
- *whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

The $L_{A1, (1\ minute)}$ descriptor is meant to represent a maximum noise level measured under 'fast' time response. DEC will accept analysis based on either $LA_{1,(1\ minute)}$ or $L_{A,(Max).}$

If an exceedance of the above is indicated then further review is recommended referencing the DECCW's *ECRTN* (*Environmental Criteria for Road Traffic Noise*). Appendix B which concludes:

Considering all of the foregoing information the following conclusions can be drawn:

- *Maximum internal noise levels below 50–55 dBA are unlikely to cause awakening reactions.*
- *One or two noise events per night, with maximum internal noise levels of 65–70 dBA, are not likely to affect health and wellbeing significantly*

An internal objective of 50 – 55dBA equates to an external objective of 60-65dBA assuming a 10 dB redirection in noise through an open window.

Table 3-5 details established sleep disturbance criteria.

Table 3-5 Sleep Disturbance Screening Criterion

Receiver Area	Sleep Disturbance Screening Criteria L_{Amax} (dBA)
Mamre Road Residences A, F, G, H, I	58
Bakers Lane Residences B	55
Retirement Village and Aldington Road Residences C, D, E	48

4 NOISE SOURCE LEVELS

Noise sources that are likely to be associated with the development are identified in the following sections.

4.1 Construction Noise Sources

Typical Sound Power Levels (SWL) of the plant likely to be used during earthworks and road building when the site is being established at various stages of the works are identified in Table 4-1. These SWLs have recently been measured at other similar construction sites.

Table 4-1 Typical Construction Plant Sound Power Levels (SWL)

Plant	SWL (dBA)
Excavator	107
Front End - Low Loader	112
Dump Trucks	112
Tower Crane or Mobile Crane	105
Generators	95
Smooth Drum Roller	107
Scrapers	119
Graders	109
Dozer	119
Concrete Trucks	109
Concrete Paver Roller	121
Water Truck	110
Vibratory Rollers	110
Skid Steer loader	112
Concrete Plant	103
Asphalt Plant	114

4.2 Operational Noise Sources

Whilst noise associated with facilities will be specific to each particular facility, there are a number of general sources that are likely to generate noise such as trucks, forklifts, mechanical plant (condensers and fans) and cars.

Table 4-2 presents a summary of the sound power levels utilised in the noise prediction model for the various items of plant and mobile equipment. The noise emission levels are based on typical 15 minute operational cycles.

Table 4-2 Summary of Sound Power Levels Used for Plant and Mobile Equipment

Item	Operating Condition	Overall L_{Aeq} Sound Power Level (dBA)
Semi-Trailer	Loading/Unloading	87
Petrol Forklift	Lifting, moving	96
Exhaust Fan	Operating	95
Semi-Trailer	Driving through yard	104
Exhaust Fan	Operating	95
Reverse Alarm*	Reversing	90

Note: *Based on operation for 10 seconds in a 15 minute period with a sound power level of 110dBA .

The following sections detail an assessment of potential noise impact and mitigation measures based on the noise levels presented in this section.

5 METEOROLOGY

At relatively large distances from a source, the received noise levels will be influenced by meteorological conditions, particularly wind and temperature gradients, and hence can vary from hour to hour and day to day. Where these factors are a feature of an area their effect on resultant noise levels is required to be taken into account.

The procedures described in the *INP* are directed toward finding a single set of meteorological conditions, representing generally adverse conditions for noise propagation, which should be used in noise assessment. It is Wilkinson Murray's view that for complex developments it is more appropriate to assess noise impacts under the entire range of meteorological conditions applying at the location.

However, the procedures of the *INP* have been adopted as this is considered adequate for this project, given the relatively short distances to relevant receivers.

5.1 Wind

Wind can increase noise at a receiver when it blows from the direction of the noise source. This effect should be considered when wind is a feature of the area under consideration. The *INP* defines this as where wind blows from source to receiver at speeds up to 3m/s for more than 30% of the time in any season. In this situation wind is considered to be a feature of the area and noise level predictions must be made under these conditions.

Twelve month weather data for the year 2006 was obtained for the DECCW air quality monitoring station located at St Marys. This data was analysed to determine the frequency of occurrence of seasonal winds up to speeds of 3m/s for the daytime, evening and night periods.

Seasonal wind records indicate that westerly winds of up to 2.6 m/s are a feature of the area during the evening and night periods in the area. Appendix C presents wind roses for the site.

5.2 Temperature Inversion

Temperature inversions can increase noise levels at surrounding receivers by the refraction of sound waves by warmer upper layers of air. Temperature inversions occur predominantly at night. For a temperature inversion to be a "feature" of the area it needs to occur for approximately 30% of the total night-time during a season, typically winter.

Inversion data was assessed using the recorded Pasquill Stability Class for the winter night period. A frequency of 11% was determined for F & G class stability (representing a potential temperature inversion). Therefore, temperature inversion has not been included in the assessment of noise impacts.

6 CONSTRUCTION NOISE ASSESSMENT

6.1 Construction Noise

Assessment of likely airborne noise at surrounding residential receivers has been performed for construction sites during excavation and construction.

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

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground Absorption; and;
- atmospheric absorption.

During the initial site consolidation stage, the following works are proposed:

- construction of the required traffic facilities;
- upgrade of existing roads and construction of new roads and bridges in the vicinity of the site;
- construction (and use) of utility connections to the site;
- demolition, relocation or removal of existing dwellings and structures on the site;
- sub-division of the site and associated sub-division works including construction of roads; stormwater drainage systems, sewerage and water works, utilities and services; landscaping and earthworks;
- works for the site water management strategy; and
- construction and use of buildings and associated works.

The loudest construction period is expected to be the earthmoving phase, with perhaps six machines including excavators, trucks, a dozer and a grader working around the site simultaneously. A total site sound power of 116dBA can be expected during this phase. Earthmoving activity is likely to occur in various sections of the development, and given the size of the site it would only be equipment that is in the vicinity of residences that would be acoustically significant.

Table 6-1 presents the results of initial noise calculations at surrounding residential receivers based on distance attenuation alone, allowing for the noise source to be generally around the centre of each warehouse site.

Table 6-1 Predicted L_{Aeq} Construction Noise Levels at Residential Receivers – dBA

Receiver Area	Predicted Construction Noise – dBA	Construction Noise Objective – dBA*	Compliance
A – 657 Mamre Road	44	57 / 57	Yes
B – 25 Bakers Lane	53	57 / 58	Yes
C – Retirement Village	40	43 / 41	Yes
D – 21 Aldington Road	56	43/ 41	No
E – 32 Aldington Road	43	43 / 41	No – Marginal Exceedance Saturday
F – 784 Mamre Road	54	57 / 57	Yes
G – 754 Mamre Road	52	57 / 57	Yes
H – 772 Mamre Road	46	57 / 57	Yes
I – 757 Mamre Road	47	57 / 57	Yes
Schools on Bakers Lane	50	55 / -	Yes

Note: *Normal construction hours and Saturday criteria are shown.

These initial calculations indicate that the only location at which construction noise criteria may be exceeded is at rural residences on Aldington Road immediately to the east of the site, when Metcash is developed. Other residences are unlikely to be adversely affected by construction noise from the site. Exceedances of construction noise criteria are quite common for construction projects and given the relatively short duration of construction work compared to the life of the development, some tolerance is usually expected.

While it is impractical to require strict compliance with the construction noise criteria at all times, the following noise mitigation measures are considered reasonable and feasible.

- Construction activities that are likely to be audible at any residence must not occur outside the usual hours of 7.00am-6.00pm Monday to Friday and 8.00am-1.00pm on Saturday. Construction vehicles should not approach the site before 7.00am.
- Noisy activities such as earthworks in close proximity to residences should ideally be programmed to avoid early mornings and Saturdays. While this may not be always practical, consideration should be given to surrounding residential receivers when planning the construction program.
- Spoil quantities should be carefully considered to avoid truck movements to and from the site to provide additional fill or remove excess spoil.
- Diesel powered machines such as trucks, bobcats and excavators should be switched off if not required for more than a few minutes rather than left idling unnecessarily.
- Machines used on site should be maintained in good condition, particularly considering the exhaust system on diesel powered machines, to minimise noise emissions. Excessively loud machines should be repaired, modified or removed from the site. Sound pressure level measurements should be conducted on all plant prior to works beginning on-site.

- A representative from the construction contractor should be available to respond to questions and complaints from the community in a professional, considerate and timely manner.
- Reversing alarms should be controlled to the minimum sound level consistent with safety by replacing, shielding or relocating the alarm unit on noisy machines.

The above noise control recommendations may not necessarily result in the construction noise criteria being met at all times, although they will result in the lowest possible noise impacts consistent with efficient and safe construction work on the site.

6.2 Construction Vibration

All residences, with the exception of 784 Mamre Road, are at a sufficient distance from the site that vibration associated with construction and excavation will not be significant.

Table 6-2 sets out the typical ground vibration levels at various distances from rock breakers operating in hard sandstone.

Table 6-2 Rockbreaker PPV Vibration Levels (mm/s) versus Distance

Operation	PPV Vibration Level (mm/s) at given Distance					
	5 m	10 m	20 m	30 m	40 m	50 m
Heavy Rock Hammer (e.g. 1500kg)	4.5	1.3	0.4	0.2	0.15	0.02
Medium Rock Hammer (e.g. 600kg)	0.2	0.06	0.02	0.01	-	-

The property at 784 Mamre Road is in order of 5-10 metres from the site boundary. Table 6-2 indicates that PPV vibration levels from heavy (1500kg) will be in the order 1.3-4.5 mm/s at this residence compared with the “maximum” daytime criterion of 0.56 mm/s for human comfort. Therefore, should rockbreaking occur in the vicinity of this residence detailed assessment of potential mitigation measures would be required. The predicted vibration levels remain below criteria for building damage.

At all other residences, predicted vibration levels from rock hammering are within relevant criteria for both human comfort and building damage.

7 OPERATIONAL NOISE ASSESSMENT

The site is proposed to be located in an industrial / rural area and consequently, ambient noise levels are relatively low. As a result, noise emissions associated with proposed facilities will need to be managed to protect the acoustic amenity of the surrounding residences. This is particularly important on the southern and eastern boundaries where the site is close to a few residences.

7.1 Facility Noise

Warehouse / distribution type facilities are not typically associated with major manufacturing plant and, as such, do not require significant noise controls on process plant. Associated stationary noise sources such as fans, air-conditioning and refrigeration plant, compressors and operations within buildings can be controlled by planning, engineering noise control (silencers, acoustic louvers, enclosures etc.) or selection of building components (masonry walls etc).

These strategies must be implemented during the plant selection and installation process to optimise the control of noise emission from mechanical plant and equipment. This analysis should include detailed spectral noise data to assess the need for possible tonality corrections, in accordance with the *INP*.

7.2 Indicative Operational Noise Levels

Noise levels at adjacent residential receivers have been predicted based on indicative types and locations of plant throughout the development. Operational site noise will be mainly associated with roof fans, truck movements and associated dock activities. The number, type and noise emission level of the plant is based on previous measurements conducted at similar facilities including warehouses and storage facilities.

Predictions assume 24 hour operation of the equipment.

Site-related cumulative noise emissions were modeled using the “CadnaA” noise prediction program, using the ISO 9613 noise prediction algorithms with CONCAWE meteorological corrections, as for the construction noise assessment.

7.2.1 Noise Model Scenario

Noise emanating from fans, and loading and unloading yard activities associated with the facilities, was modelled based on the proposed building layout as presented in Figure 1-1. Table 7-1 and Table 7-2 present typical “worst case” operational scenarios of the warehouse in the day and night periods used in the noise model. Typically such facilities will ebb and flow with respect to yard activities, and the scenarios presented below represent the busy periods for a facility.

The fixed sources in Table 7-1 and Table 7-2 were distributed across the buildings on the sites, and mobile sources were located in areas between the buildings.

Evening and night operating scenarios have been modelled on the same scenario whereby compliance with night criteria will be the most stringent. Therefore only night noise levels have been presented in the following sections.

Table 7-1 Daytime Operating Scenario (15 minute period)

Plant/Equipment Type	Number of Items	Description of Modelled Industrial Operations
Loading Docks	25	Loading/Unloading operating for a period of 15 minutes
Forklift	9	Operating for the entire 15 minute period
Semi Trailer	18	Truck turning (1 minutes duration)
Roof Fans	32	Operating for the entire 15 minute period
Reversing Alarms	12	Each Operating for 10 seconds

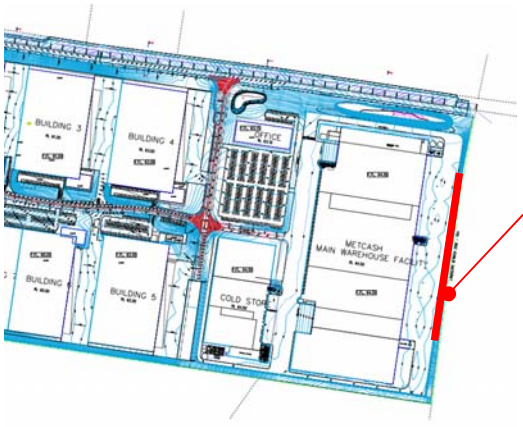
Table 7-2 Night Operating Scenario (15 minute period)

Plant/Equipment Type	Number of Items	Description of Modelled Industrial Operations
Loading Docks	16	Loading/Unloading operating for a period of 15 minutes
Forklift	9	Operating for the entire 15 minute period
Semi Trailer	9	Truck turning (1 minutes duration)
Roof Fans	32	Operating for the entire 15 minute period
Reversing Alarms	12	Each Operating for 10 seconds

Initial modelling indicated that the residence at 21 Aldington Road was likely to be subjected to the greatest noise impact from the site. Therefore, a 4 metre barrier approximately 250 metres long has been included in the noise model. This barrier has been located on top of the eastern site embankment.

Figure 7-1 illustrates the location of the barrier.

Figure 7-1 Recommended Eastern Noise Barrier



7.2.2 Results

Table 7-3 presents predicted daytime noise levels at surrounding residences, with the above barrier in place.

Table 7-3 Predicted $L_{Aeq(15\ minute)}$ Operational Daytime Noise at Surrounding Residences

Receiver Location	Predicted Resultant Noise Levels at Residences (dBA)		Intrusiveness Noise Goal $L_{Aeq,15min}$ (dBA)	Compliance
	Calm Conditions	Wind Condition		
A – 657 Mamre Road	31	28	52	Yes
B – 25 Bakers Lane	40	40	52	Yes
C – Retirement Village	34	38	38	Yes
D – 21 Aldington Road	42	44	38	No
E – 32 Aldington Road	39	39	38	No – Marginal
F – 784 Mamre Road	45	46	52	Yes
G – 754 Mamre Road	43	43	52	Yes
H – 772 Mamre Road	40	40	52	Yes
I – 757 Mamre Road	34	32	52	Yes
Schools on Mamre Road	43	43	50	Yes

The predictions indicate a possible exceedance of criteria by between 4-6dBA at the adjacent eastern residence at 21 Aldington Road. Compliance is predicted at all other receivers under normal weather conditions, whilst a marginal exceedance of 1dBA is predicted at 32 Aldington Road when westerly winds occur.

Figure 7-2 illustrates the predicted noise levels at surrounding residences during calm isothermal weather conditions.

Table 7-4 presents predicted night time noise levels at surrounding residences, and Figure 7-3 illustrates the noise modelling and predicted noise levels at surrounding residences during calm isothermal weather conditions.

Figure 7-2 Predicted LOGOS Operational Daytime Noise Levels – $L_{Aeq(15\ minutes)}$

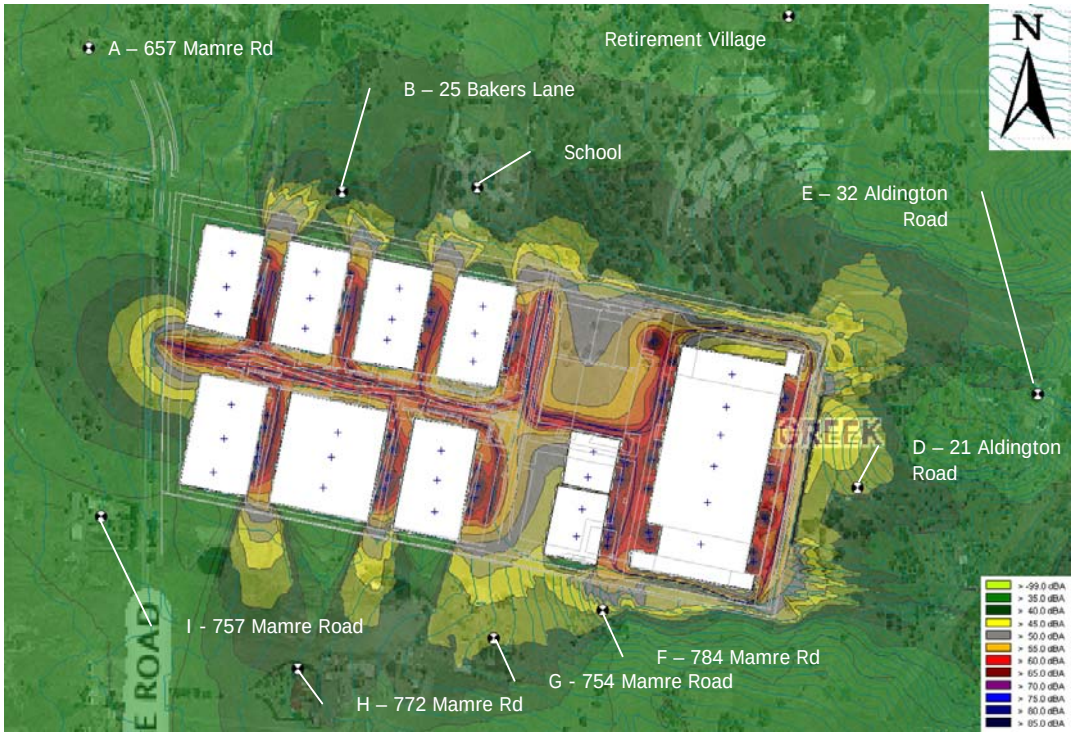
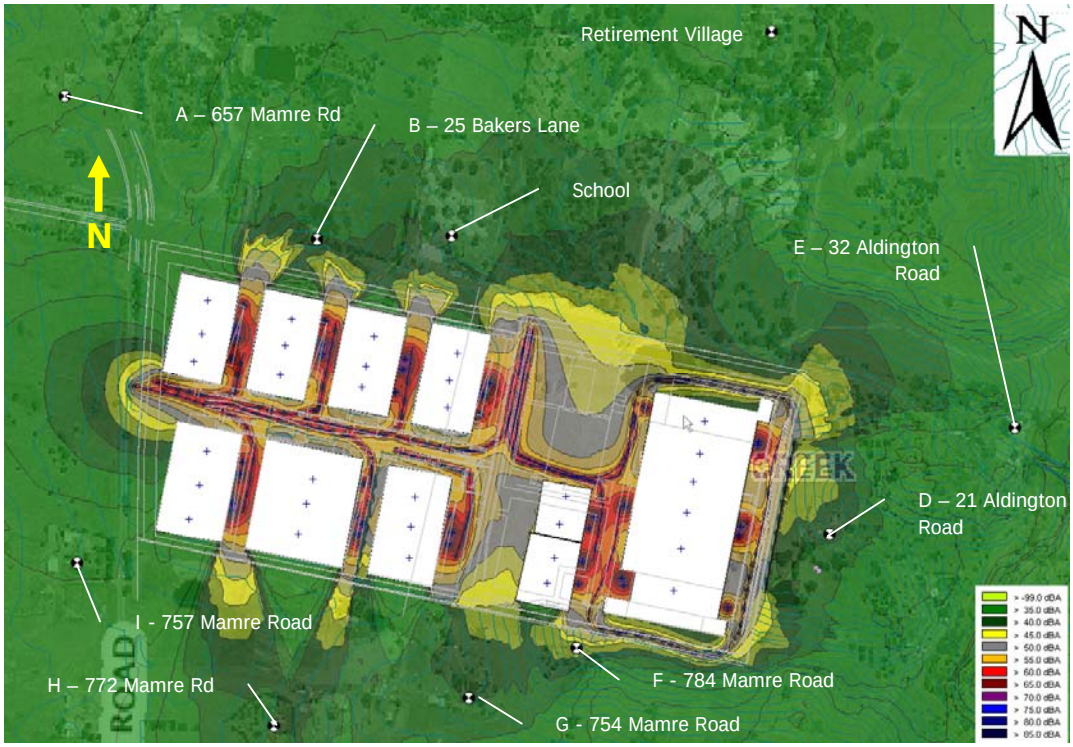


Table 7-4 Predicted $L_{Aeq(15\ minute)}$ Operational Night Time Noise at Residences

Receiver Location	Predicted Resultant Noise Levels at Residences (dBA)		Intrusiveness Noise Goal $L_{Aeq,15min}$ (dBA)	Compliance
	Calm Conditions	Wind Condition		
A – 657 Mamre Road	30	28	48	Yes
B – 25 Bakers Lane	39	39	45	Yes
C – Retirement Village	34	37	38	Yes
D – 21 Aldington Road	41	44	38	No
E – 32 Aldington Road	34	38	38	Yes
F – 784 Mamre Road	43	44	48	Yes
G – 754 Mamre Road	40	41	48	Yes
H – 772 Mamre Road	40	39	48	Yes
I – 757 Mamre Road	33	30	48	Yes

Figure 7-3 Predicted LOGOS Operational Night Noise Levels – $L_{Aeq\ (15\ minutes)}$



The only significant exceedances indicated above are at the closest residence to the east of the site, represented by Location D.

The greatest exceedance is predicted during westerly winds when a noise level of up to 44dBA is predicted during both day and night periods – an exceedance of 6dBA in both cases. This is due to the low intrusive noise criteria, as this area is shielded from Mamre Road noise by the intervening topography.

It should be noted that the acoustic environment of this area will change once the surrounding employment areas are developed, leading to generally higher background noise levels. The above assessment has not taken this potential change into account.

7.2.3 Additional Noise Mitigation

A 4 meter barrier has been included on the boundary to mitigate noise, however higher barriers have been investigated and determined to not be feasible or reasonable. This is because above 4 metres very little noise reduction is achieved by extra barrier height. Given that the 6dBA exceedance is predicted at only one residence, the adoption of architectural treatment to this residence may be considered.

Architectural treatments (typically involving acoustic treatment of facades) are generally recommended where future noise levels are more than 5dBA in excess of relevant noise criteria. The mitigation measures are designed to achieve internal noise levels that would have normally prevailed if the external noise criteria were achieved. The typical outdoor to indoor noise reduction provided by most standard dwellings (i.e. without special acoustical treatment) is generally accepted as being 10dBA with windows open (allowing for natural ventilation) and 20dBA with windows and doors closed.

In this case, as the design noise levels cannot be achieved within the relevant residence with windows and/or doors open, a system of "mechanical ventilation" would be required to enable openings in the external facade to remain tightly closed during noisy periods.

7.3 Amenity Criteria

The predicted noise levels shown above refer to an assumed worst-case 15-minute period, as is required for comparison with the intrusiveness criterion. Comparison with the amenity criterion requires assessment of $L_{Aeq,Period}$ – that is, the L_{Aeq} level averaged over the day, evening or night period. The resultant noise levels at residence will be lower than $L_{Aeq,15min}$, because the number of truck movements will not be constant in every 15-minute period, and meteorological conditions will also vary between nights. $L_{Aeq,period}$ can be conservatively estimated at 2dBA below the "calm conditions" value of $L_{Aeq,15min}$.

For the daytime period, $L_{Aeq,Period}$ levels are below the relevant amenity criteria in all cases. In the case of the night-time period, a 1dBA exceedance of the 40dBA amenity criterion is predicted at Location F. This marginal exceedance is not considered significant given the indicative nature of these calculations.

7.4 Sleep Disturbance

In the case of noise from events such as reversing alarms, there is the potential for sleep disturbance from areas that potentially operate in the night period. The L_{Amax} noise levels due to reversing alarms have been predicted at surrounding residences. Each predicted noise level is based on an alarm operating on the site closest to each assessed residence, thereby representing a "worst case" scenario. Results are shown in Table 7-5.

It is noted that an exceedance of sleep disturbance screening criterion at Locations D and E – residences on Aldington Road – under westerly wind conditions.

However, the predicted L_{Amax} noise levels are below the values of 60-65dBA which are regarded as being "unlikely to result in awakening reactions", and hence are considered acceptable.

Table 7-5 Predicted Truck Reversing Alarm Noise Levels at Residences – dBA

Receiver Location	Predicted Resultant Noise Levels at Residences (dBA)		L_{Amax} Sleep Disturbance Screening Criteria – dBA	Compliance
	Calm Conditions	Wind Condition		
A – 657 Mamre Road	35	36	58	Yes
B – 25 Bakers Lane	46	48	55	Yes
C – Retirement Village	45	48	48	Yes
D – 21 Aldington Road	53	56	48	No
E – 32 Aldington Road	48	51	48	No
F – 754 Mamre Road	54	54	58	Yes
G – 784 Mamre Road	51	50	58	Yes
H – 772 Mamre Road	53	52	58	Yes
I – 757 Mamre Road	37	35	58	Yes

8 TRAFFIC NOISE ASSESSMENT

In order to obtain an estimate of the future traffic demands immediately surrounding the subject site, Thompson Stanbury Associates, the project traffic consultants, requested preliminary strategic modelling outputs from the Roads & Traffic Authority. Table 8-1 provides a summary of the projected 2016 and 2031 traffic volumes surrounding the subject site incorporating the planned development of the Western Sydney Employment Area.

Table 8-1 Projected Future Peak Hour Traffic Volumes

Road	2016		2031	
	AM	PM	AM	PM
Bakers Lane				
Eastbound	943	283	2117	164
Westbound	283	1032	237	2257
Mamre Road (south of Bakers Lane)				
Northbound	1074	704	1822	966
Southbound	729	1150	980	1850
Mamre Road (north of Bakers Lane)				
Northbound	723	1061	1102	2259
Southbound	1087	758	2140	1050

The 2031 traffic volume projections incorporate the planned future road network associated with the redevelopment of the Western Sydney Employment Area, whilst the 2016 projections assume the existing road network still prevails.

To assess likely conformance to the *ECRTN* noise criteria, the traffic noise level emissions associated with the site when fully developed in 2016 has been calculated. Bakers Lane is proposed to be upgraded as a link road by 2031 servicing the western employment area and the fundamental nature of this road will change. This is beyond the scope of this project therefore assessment of 2031 traffic noise is the responsibility the RTA and it envisaged that traffic noise at for this stage will be addressed in the road upgraded environmental assessment.

Noise predictions have been based on projected traffic volumes in 2016 (as supplied by the traffic consultant) using the *Calculation of Road Traffic Noise (CORTN)* traffic noise prediction technique.

Discussions with the traffic consultants indicates that site will potentially generate 1000 truck movements per day with 70% of these using the Bakers Lane entrance to the site. This equates to an average hourly traffic flow of 29 truck movements per hour on Bakers Lane.

In the case of traffic on Mamre Road in 2016 the following is concluded

- 65% of traffic will access the site from the north via Mamre Road and thence Bakers Lane; and

- The remaining 35% of traffic will access the site from the south via Mamre Road and thence Bakers Lane.

The same directional split is assumed for vehicles exiting the site.

Based on the above an assessment of 2106 traffic noise has been conducted as follows:

8.1 Bakers Lane Traffic Noise

Two residences face Bakers Lane between the Mamre Road intersection and the site entrance, being 696 Mamre Road and 25 Bakers Lane. These residences are at distances of 14 m and 35 m from Bakers Lane to the front of the residences, respectively.

At these locations traffic noise levels have been predicted for peak hours and in the night period. In peak hours the 2016 traffic data supplied in the traffic report has been used. In the night period noise levels due to the trucks alone have been used as the existing traffic flows in Bakers Lane at night are very low.

The following table details the predicted noise level calculated using the CORTN traffic noise prediction algorithm.

Table 8.1 Peak Hour Traffic Noise Levels at Residences on Bakers Lane – $L_{Aeq(1\ hr)}$ dBA

Receiver	Traffic Noise without development -	Traffic Noise with development
25 Bakers Lane	63.7	66.7
696 Mamre Road	58.9	62.1

Traffic noise levels at both residences are predicted to exceed ECRTN noise gaols with and without the development. It is also noted that with the development the increase in noise levels will exceed the 2 dB increase recommended by the policy.

In addition night time noise levels associated with truck movements have been predicted to be 58.9 dBA and 62.1 dBA for residences at 696 Mamre Road and 25 Bakers Lane respectively. These levels also exceed ECRTN noise criteria.

Given the number of affected residences a noise barrier in front of these residences is not likely to be practicable. Therefore facade treatment and ventilation measures, similar to those recommended in section 7.2.3 are likely to be the most effective and practical.

8.2 Mamre Road Residences

Based on RTA data, Mamre Road is subjected to AADT traffic flows in excess of 14,000 vehicles per day (2005 data). No split of night and day traffic data is available however measured noise levels at 657 Mamre Road have been processed to determine existing traffic noise levels in site, which are:

- Day 58.7 dBA
- Night 57.1 dBA

Based on this information the night criterion of $L_{Aeq(9\ hr)}$ 55 dBA is already exceeded. Therefore

the 2 dB increase requirement is applicable.

A worst case assessment will be when 27 additional trucks per hour (65 % of 42 trucks) passby this residence at night. The noise contribution from these additional trucks is calculated to be 53.5 dBA at the residential facade. Therefore adding this noise level to the existing measured traffic noise level of 58.7 dBA will result in an overall noise level of 59.8 dBA. This increase is below the permissible 2 dB increase in traffic noise levels. Therefore the impact at Mamre Rd residences in considered complying with applicable noise criteria.

9 SUMMARY OF RECOMMENDATIONS

Based on our investigations of the site at the Project Application Plan Stage of the development the following recommendations have been established.

9.1 Noise Criteria

Noise criteria for construction and operation have been established based on noise measurements processed in accordance with DECCW procedures. These criteria should be adopted on the facilities.

9.2 Construction Noise and Vibration

Noise from construction activities will potentially exceed established noise goals at residences to the east of the site. Therefore the planning and management of construction activities should take into account the sensitivities of surrounding residences to minimise the impact of construction noise at these receivers.

The control of construction noise should form a part of the site Environmental Management Plan where best practice procedures and community consultation is employed.

Should rockbreaking occur in the vicinity of the nearest southern residence at 784 Mamre Road then potential for adverse impact is indicated. Currently, equipment to be used in this area is not known; therefore, should this activity occur, assessment with respect to Human Comfort and structural damage criteria should be conducted.

9.3 Operational Noise

It is predicted that operational noise will comply with established site specific noise criteria at all residences with the exception of eastern residences on Aldington Road.

In order to achieve compliance with noise criteria at the Aldington Road, the following measures can be adopted:

- Install a 4 metre boundary on the eastern embankment.
- Provide localised facade treatment at the residence at 21 Aldington Road.

Noise from future fixed plant and buildings can be controlled by the implementation of engineering noise controls such as enclosures, silencers and acoustic louvers. These can be adequately addressed at the detail design stage of the project.

9.4 Traffic Noise

There are two residences on Mamre Road that are likely to be affected by traffic noise generated by the development. These are Mamre Road and 25 Bakers Lane. During peak hours and in the night period, noise levels are expected to exceed traffic noise objectives at these two residences.

It is recommended that façade treatment be adopted at these residences to protect the internal acoustic amenity of occupants.

10 CONCLUSION

This assessment establishes that noise criteria should be able to be met during operation of the proposed LOGOS site at most receivers surrounding the site. The exception to this finding is at receivers to the east of the site which are currently in an area with low ambient noise levels typical of a rural area. As a result, the intrusive noise criteria are stringent.

Noise controls in the form of a 4 metre barrier and possible façade treatment are recommended to address predicted noise exceedances at the adjacent residence at 21 Aldington Road.

In the case of other residences to the east and the retirement villages, the predicted exceedances are only predicted during westerly winds and are marginal in magnitude. Given these facts and the absolute magnitude of the predicted noise levels at these receivers, it is considered unlikely that adverse noise impact will occur.

Construction activities are likely to marginally exceed established goals at surrounding eastern rural properties; accordingly management of this issue will require particular attention in minimising the acoustic impact at residences.

In the case of the operational activities, resultant noise levels have been predicted. It has been determined that the operation of this facility will comply with established noise criteria with the exception of eastern residences on Aldington Road.

Traffic noise on Bakers Road will affect the two residences between Mamre Road and the site entrance. Therefore façade treatment is recommended to protect the acoustic amenity of these residences.

Version	Status	Date	Prepared by	Checked by
A	Draft	18 August 2010	Brian Clarke	Rob Bullen
B	Final	19 August 2010	Brian Clarke	Rob Bullen

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY

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

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

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

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

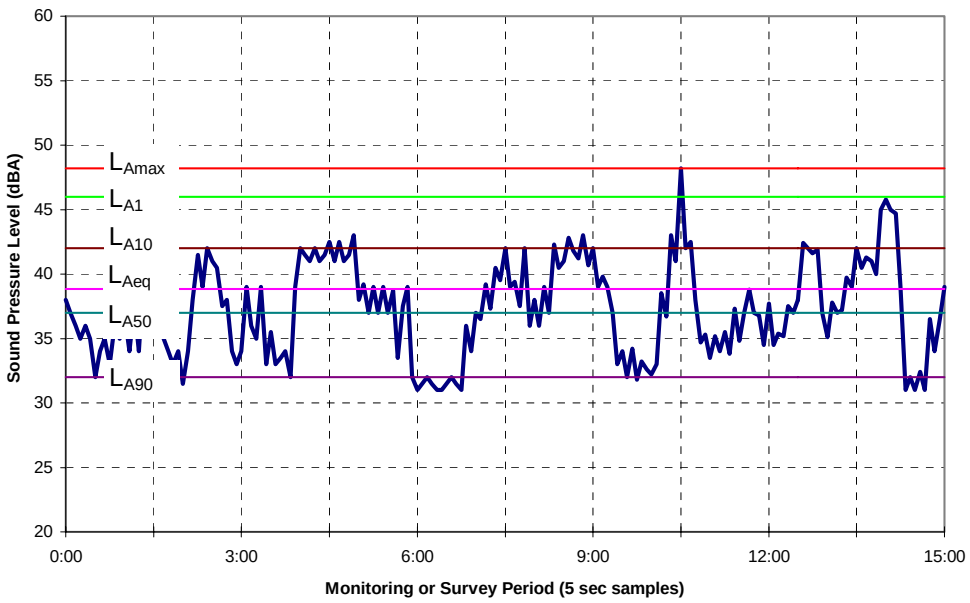
L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise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

L_{A50} – The L_{A50} level is the noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the L_{A50} level for 50% of the time.

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

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

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



Sound pressure level (SPL) or sound level L_p is a logarithmic measure of the effective sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level.

$$L_p = 10 \log_{10} \left(\frac{{p_{\mathrm{rms}}}^2}{{p_{\mathrm{ref}}}^2} \right)$$

where p_{ref} (20 µPa)is the reference sound pressure and p_{rms} is the rms sound pressure being measured.

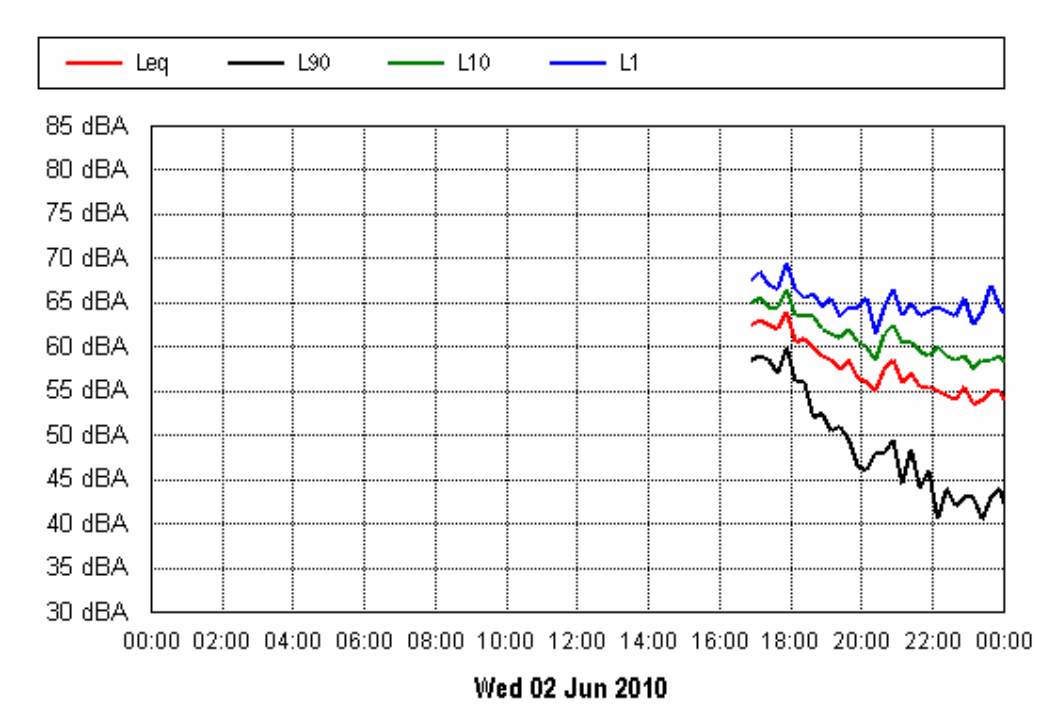
Sound power level is a logarithmic measure of the sound power in comparison to a specified reference level. While sound pressure level is given in decibels SPL, or dB SPL, sound power is given in dB SWL. The dimensionless term "SWL" can be thought of as "sound watts level," the acoustic output power measured relative to a very low base level of watts given as 10^{-12} watts.

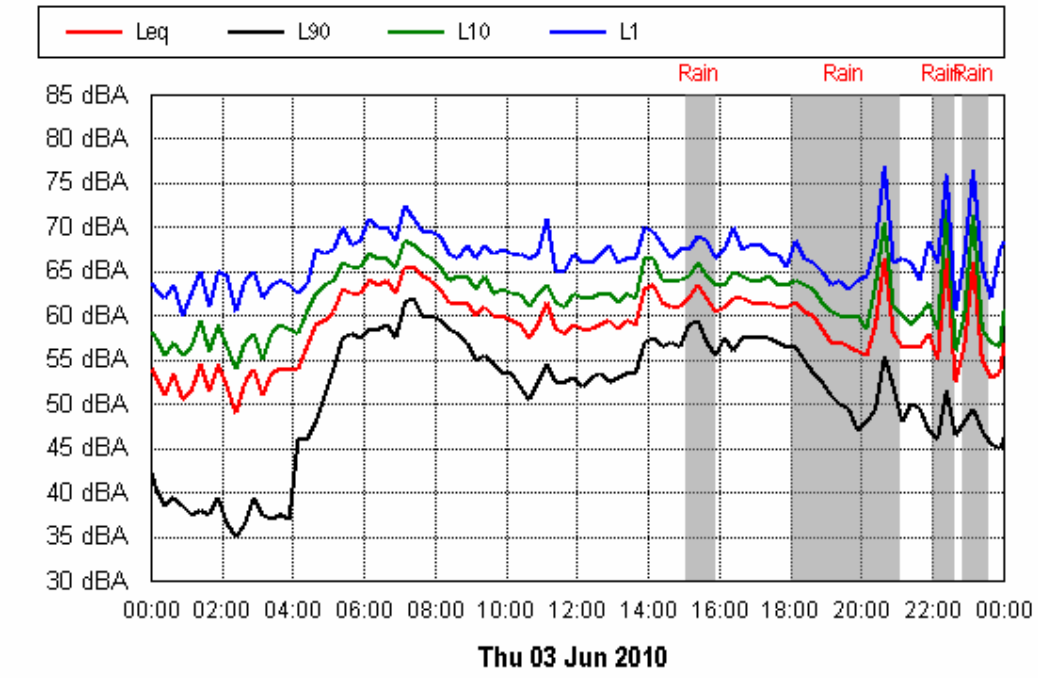
$$L_{\mathrm{W}} = 10 \log_{10} \left(\frac{W}{W_0} \right) \ \mathrm{dB}$$

APPENDIX B

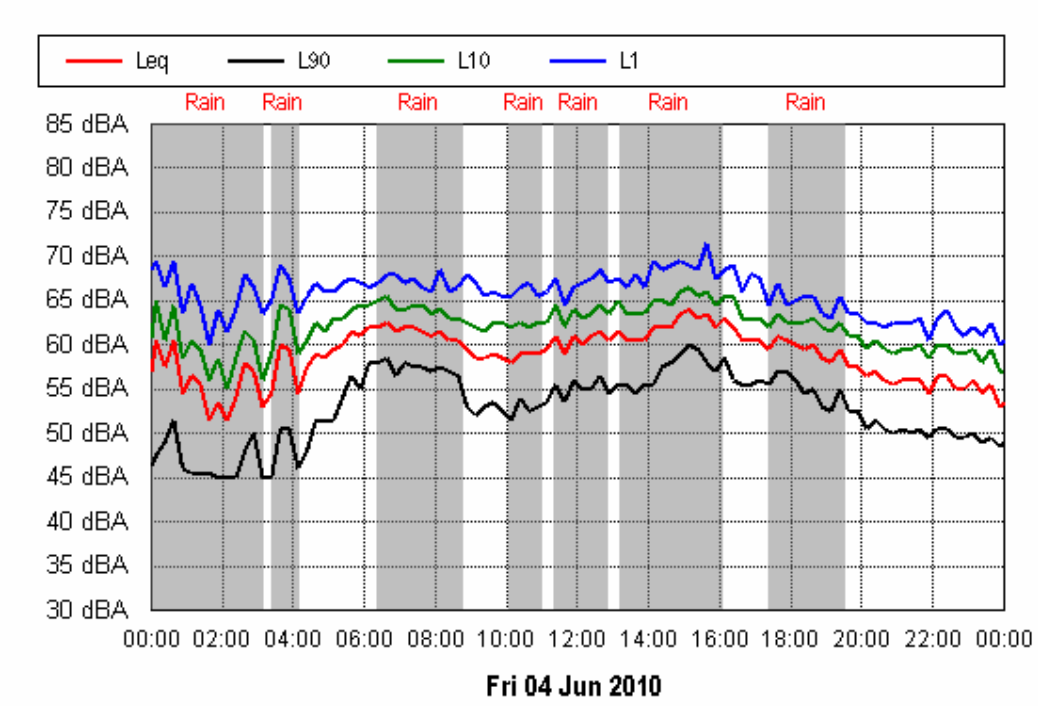
NOISE MEASUREMENT RESULTS

Location A: 657 Mamre Road

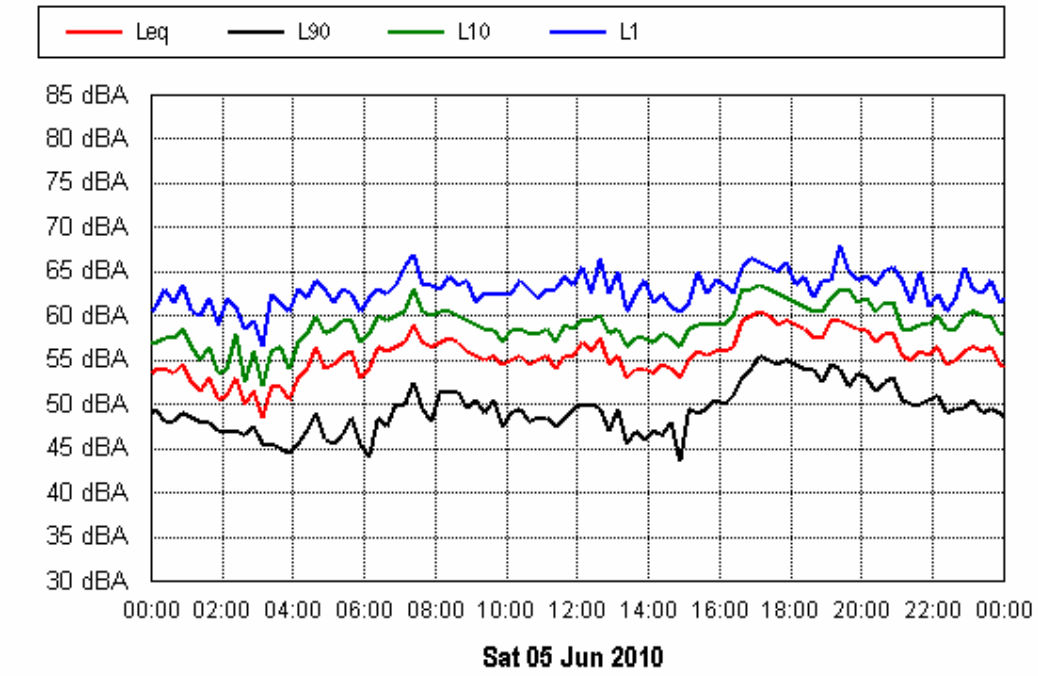




Location A: 657 Mamre Road



Fri 04 Jun 2010



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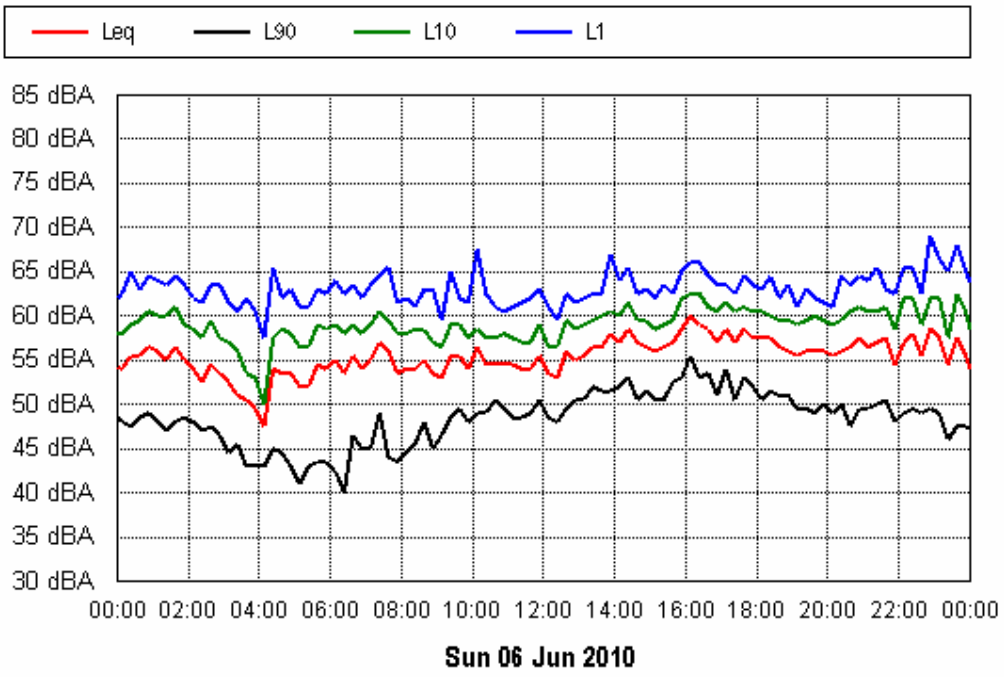
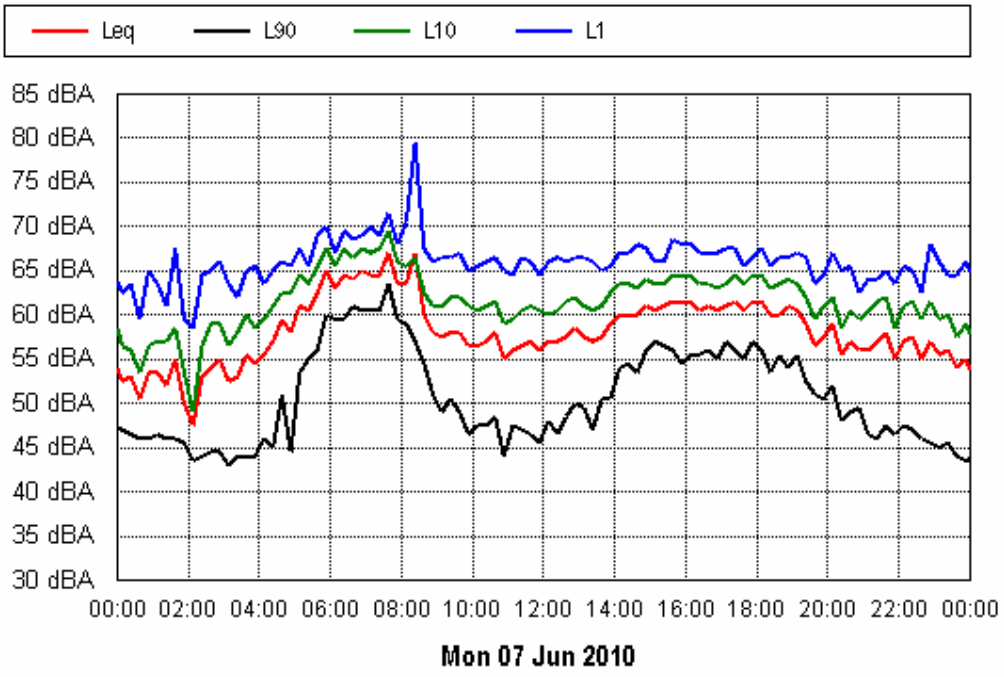
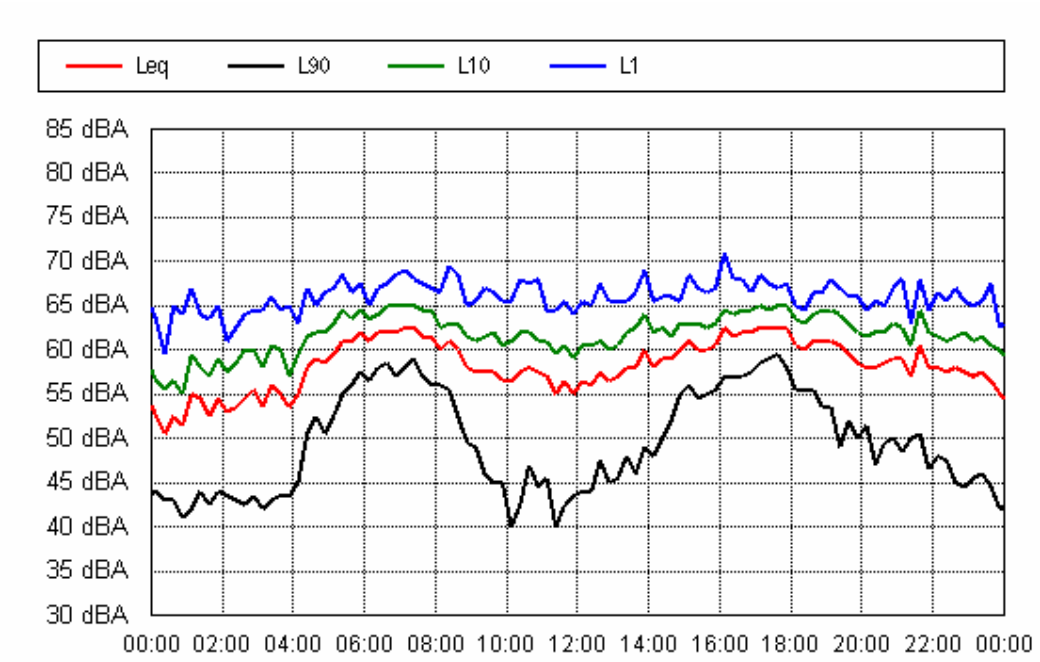
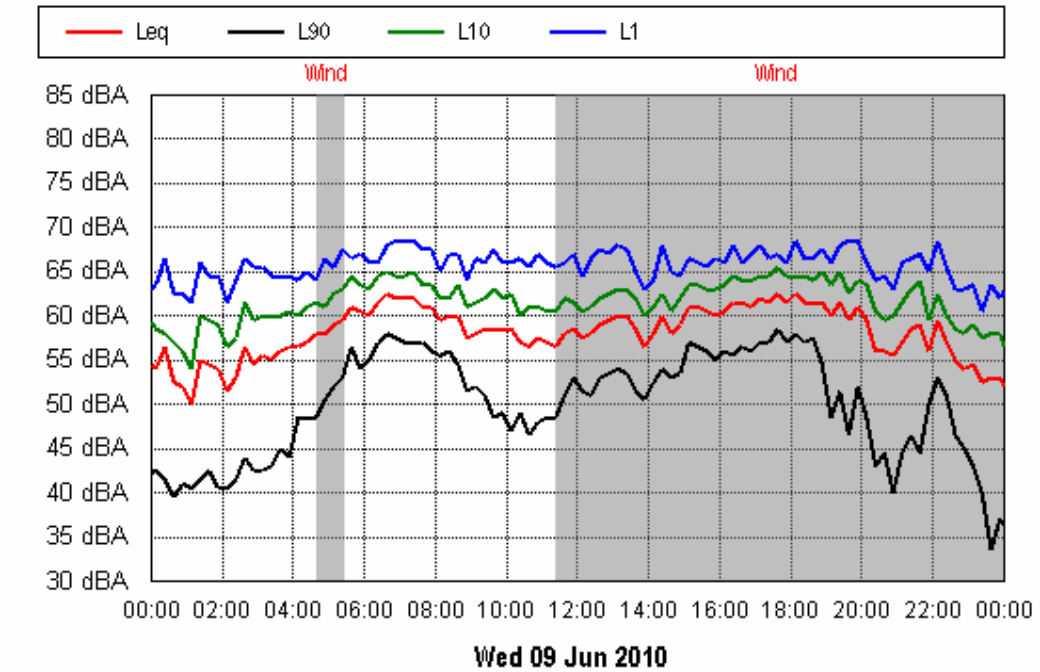


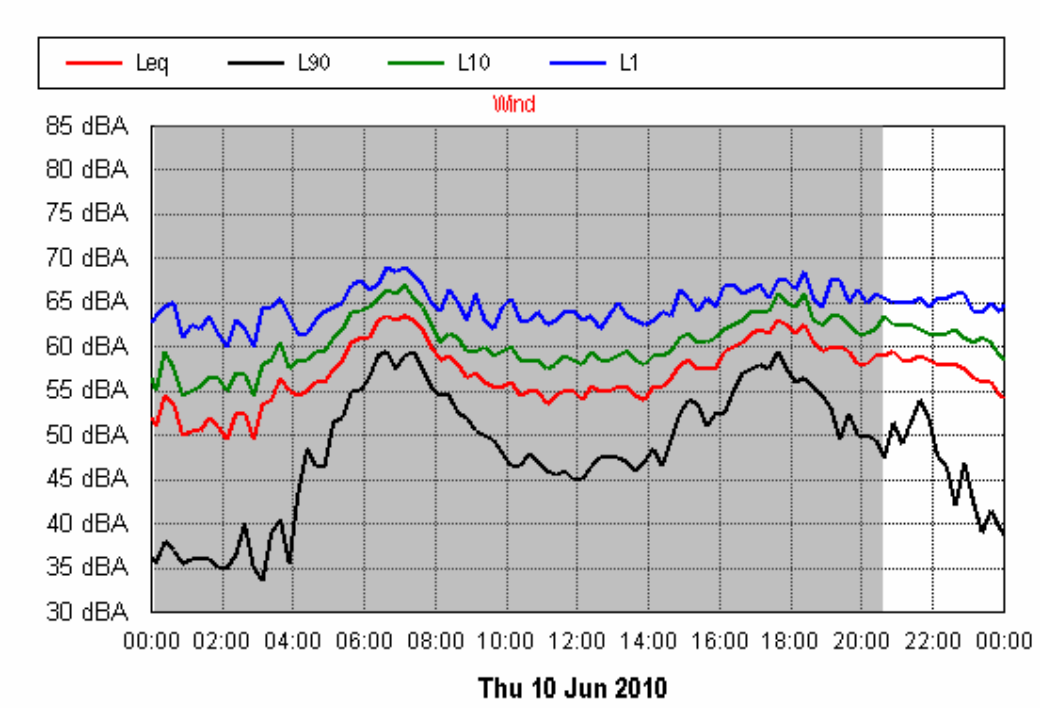


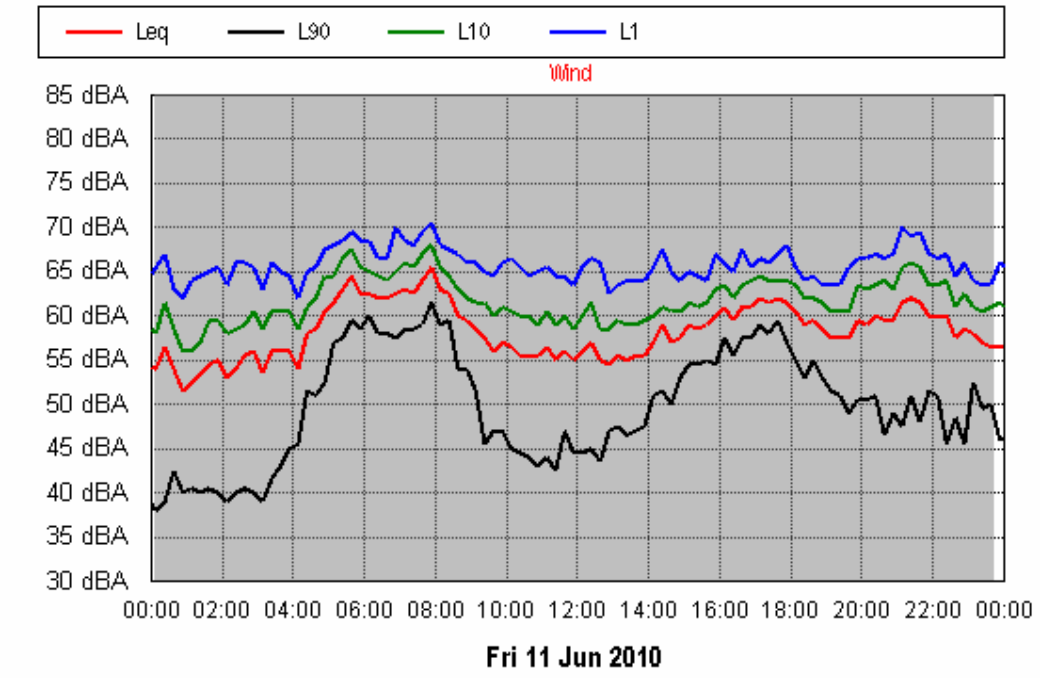
Location A: 657 Mamre Road



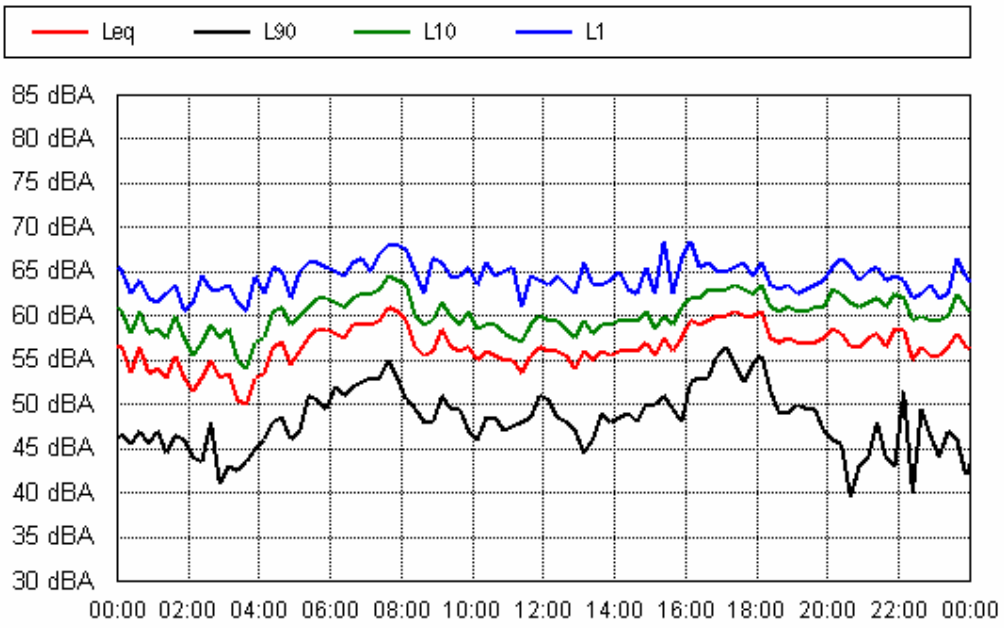


Location A: 657 Mamre Road

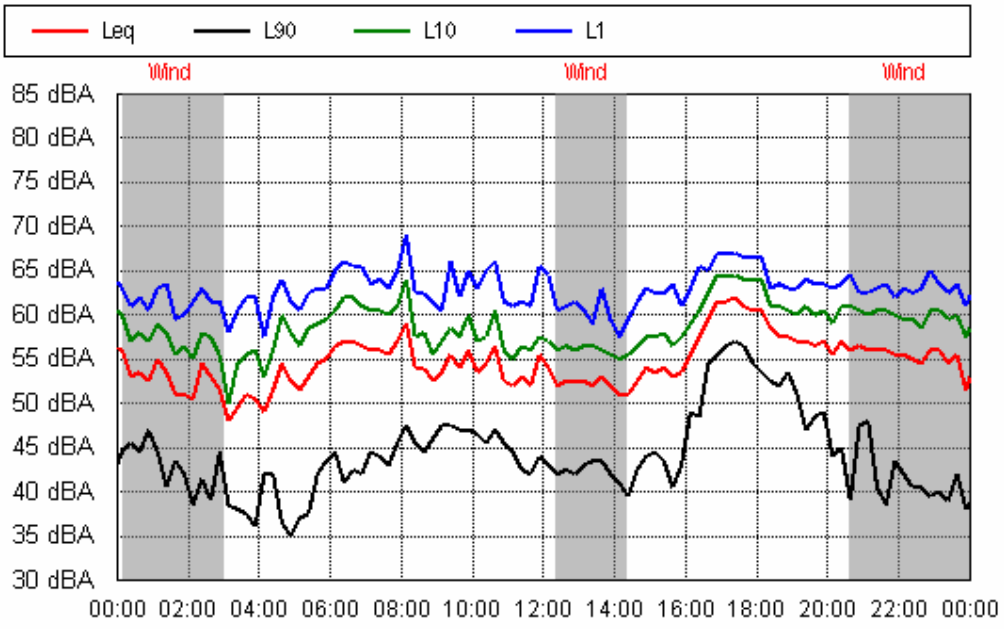




Location A: 657 Mamre Road

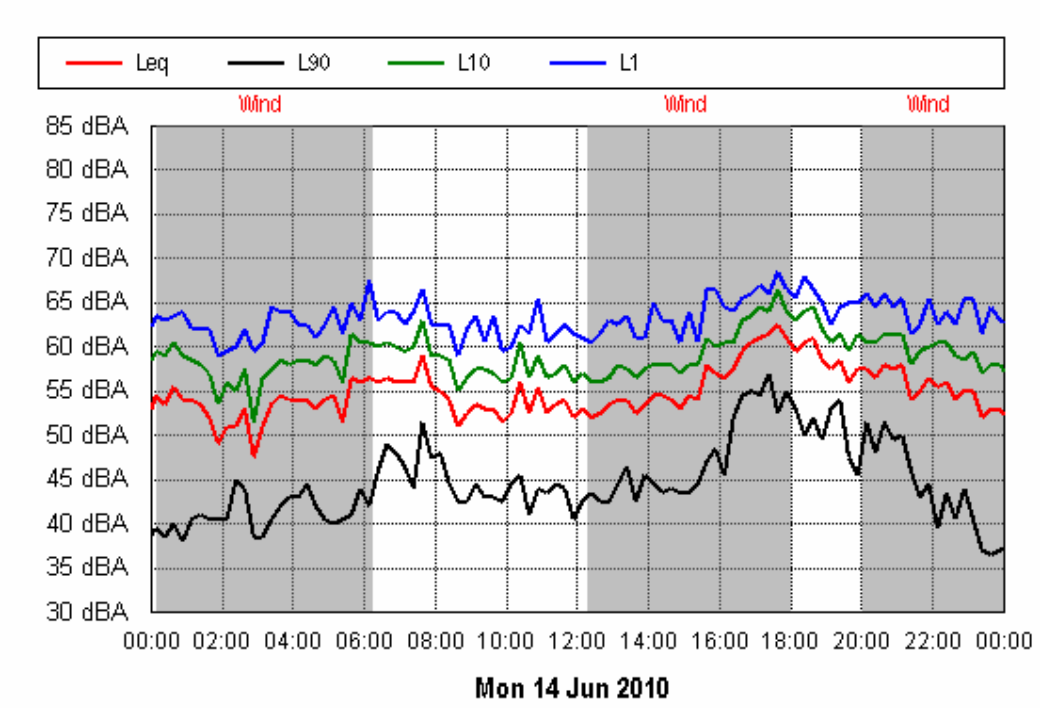


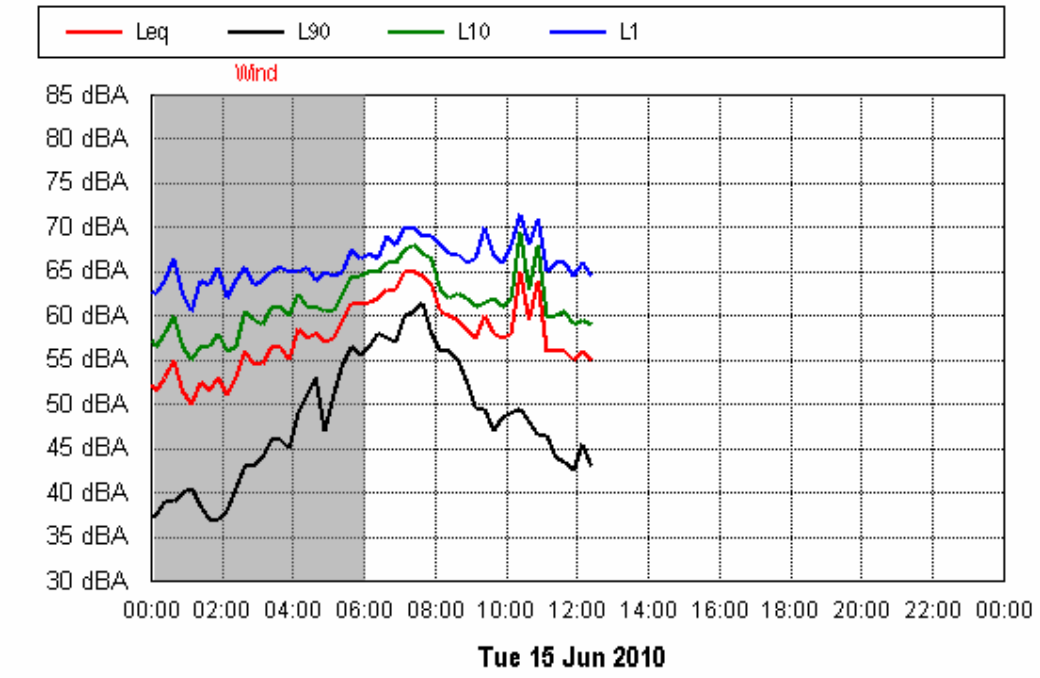
Sat 12 Jun 2010



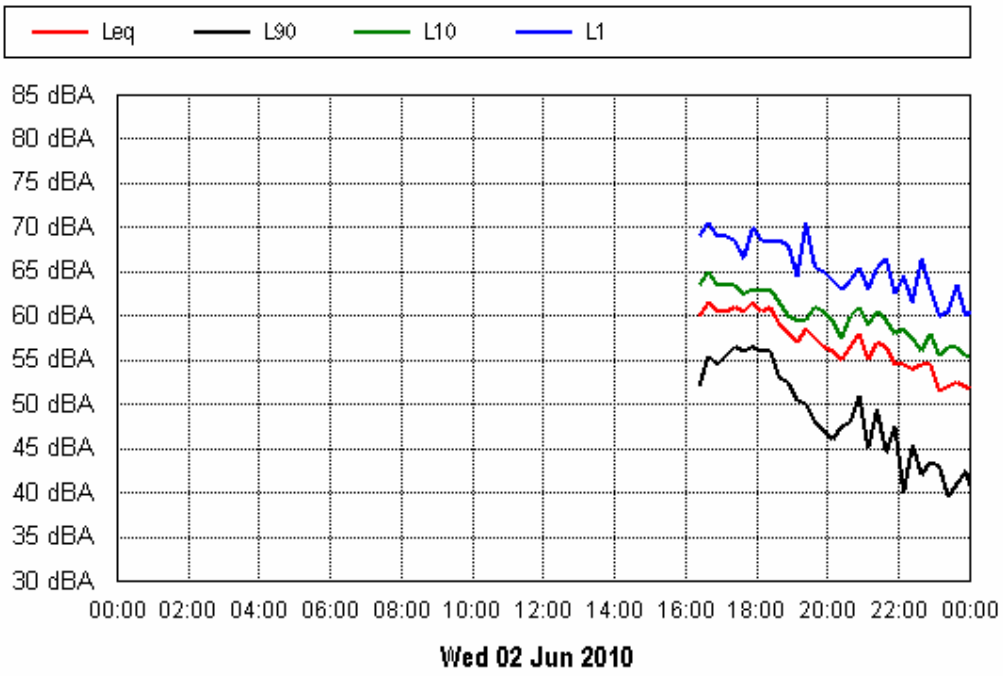
Sun 13 Jun 2010

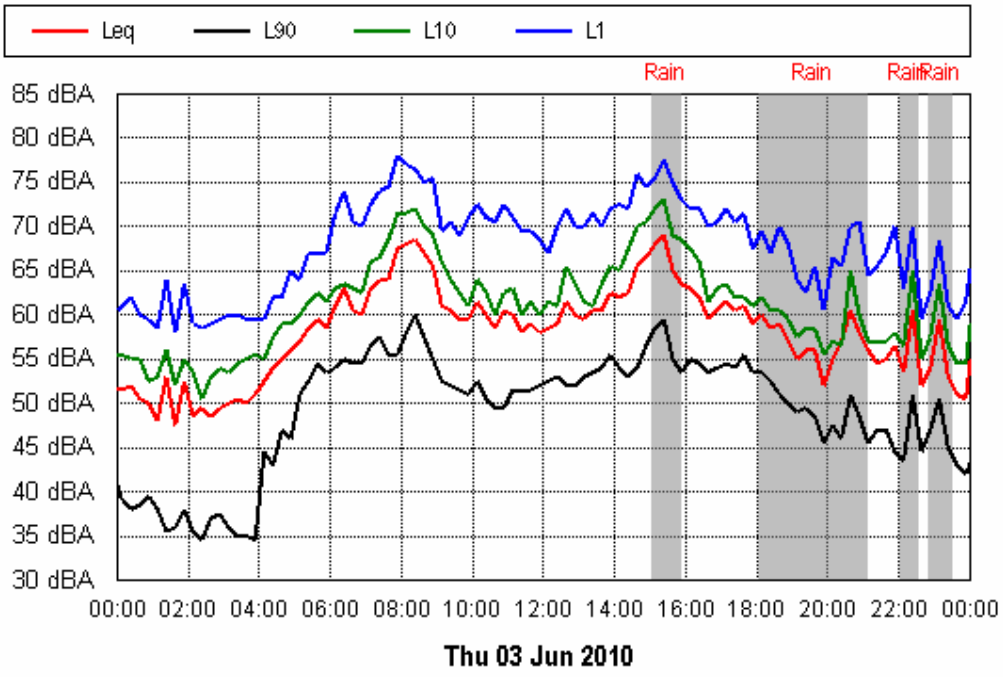
Location A: 657 Mamre Road



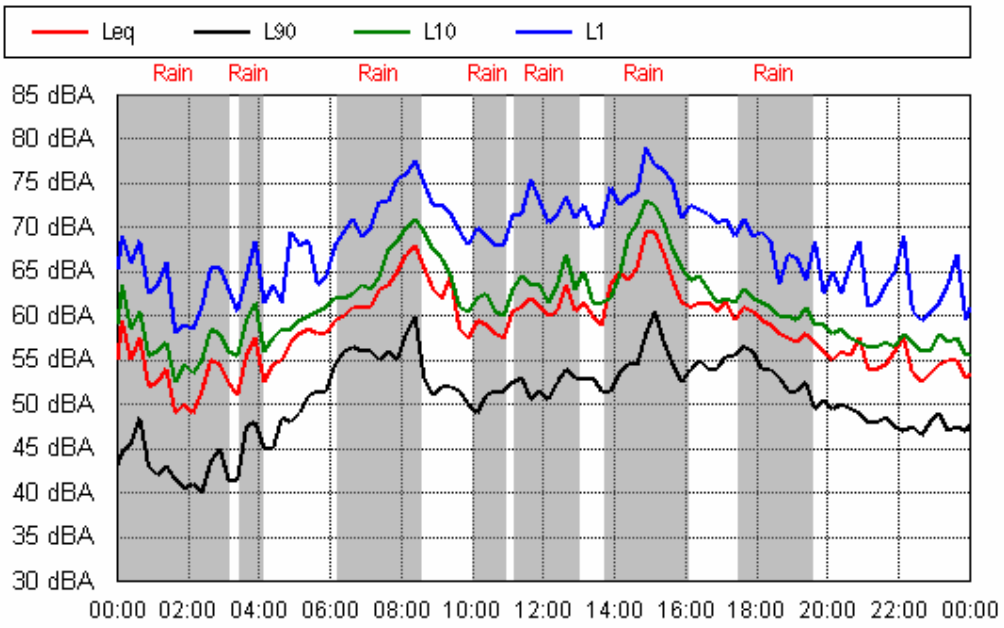


Location B: 25 Bakers Lane

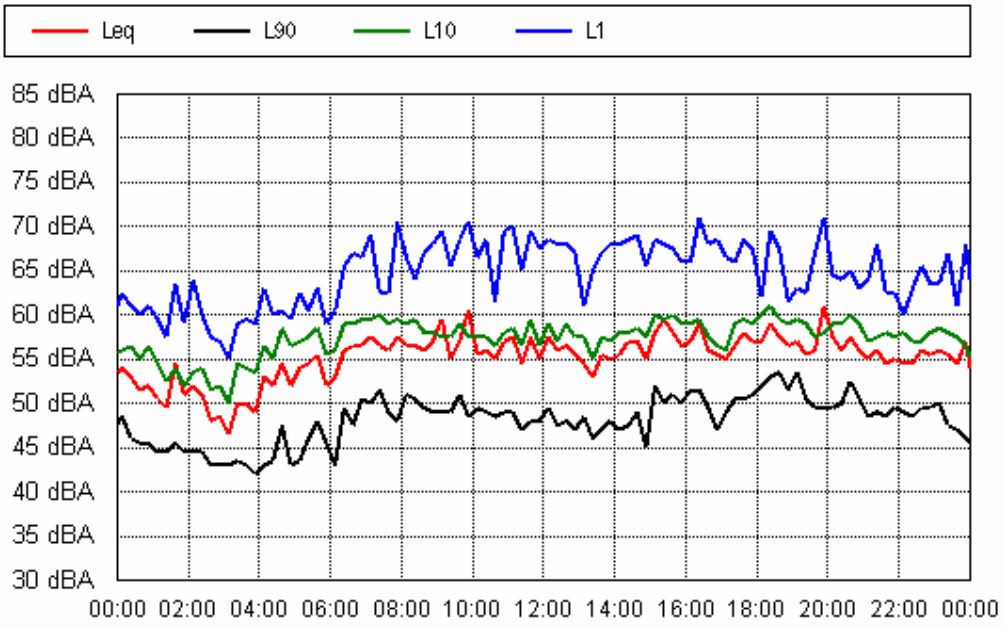




Location B: 25 Bakers Lane

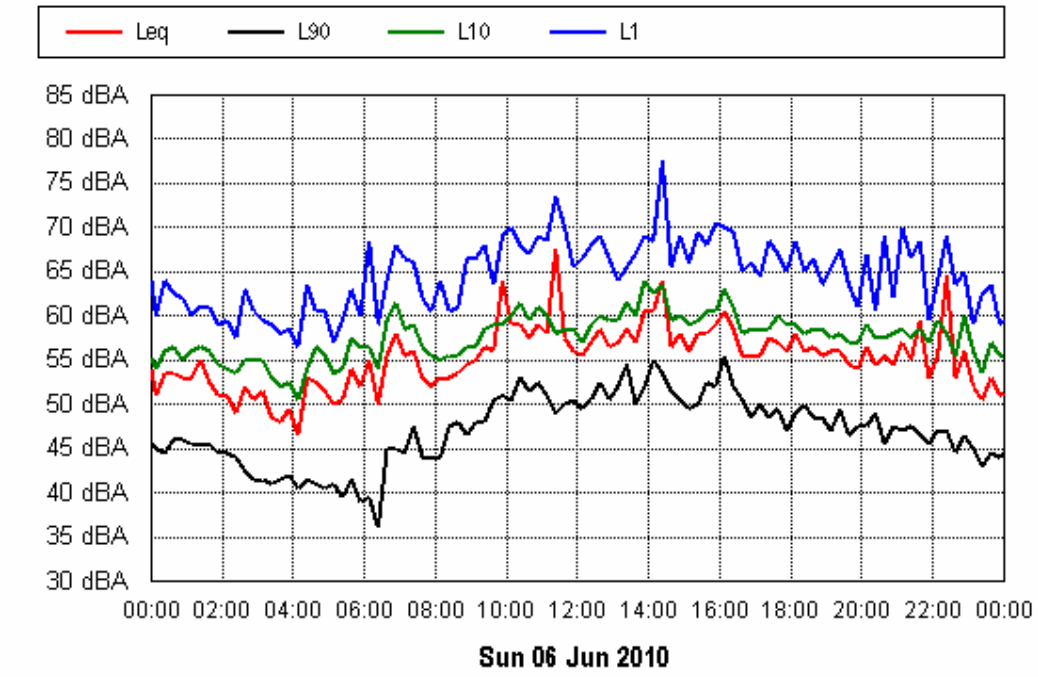


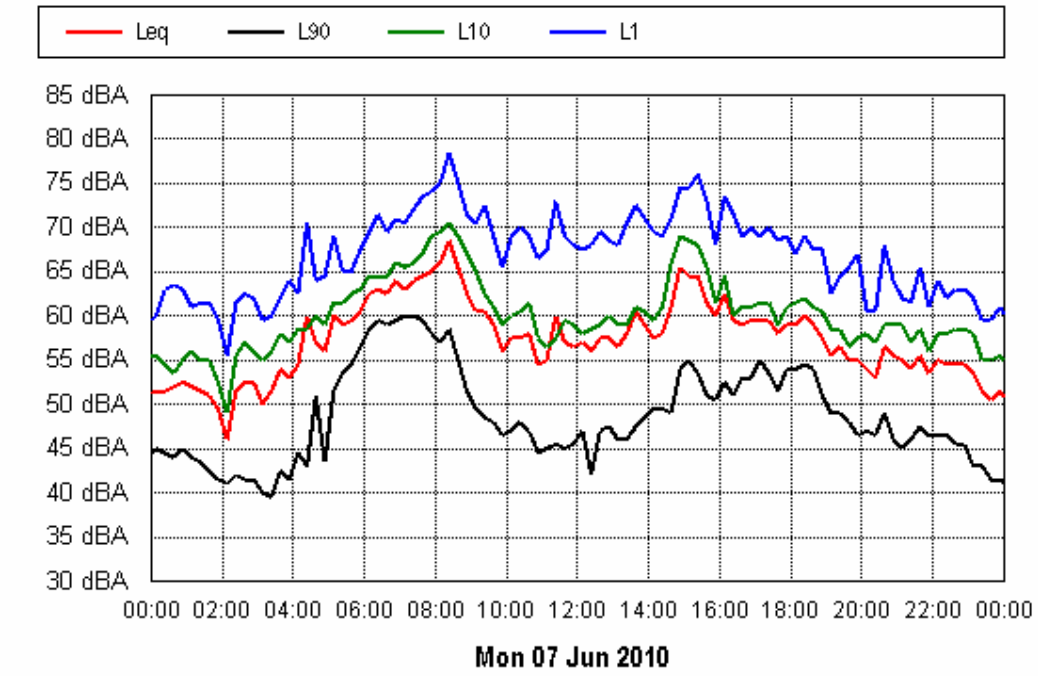
Fri 04 Jun 2010



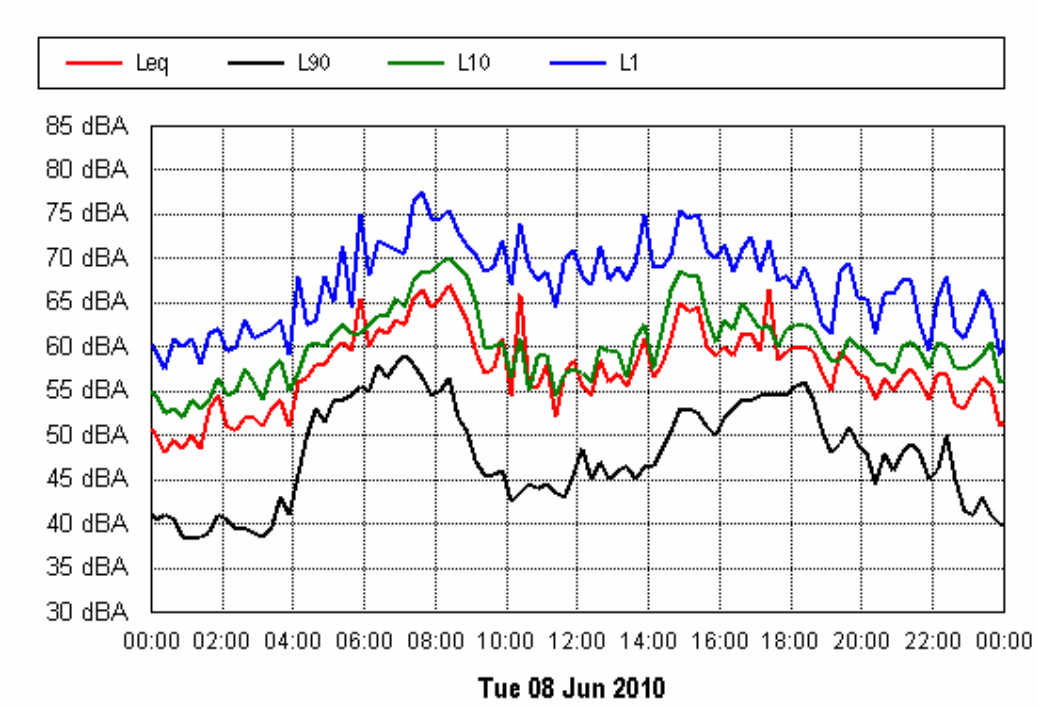
Sat 05 Jun 2010

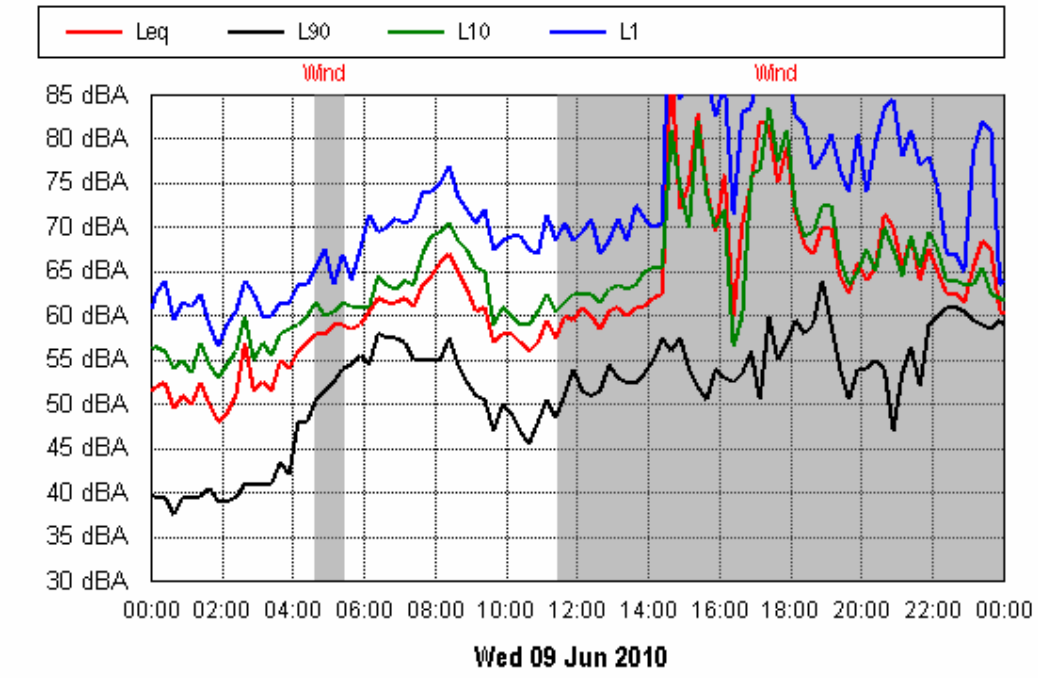
Location B: 25 Bakers Lane



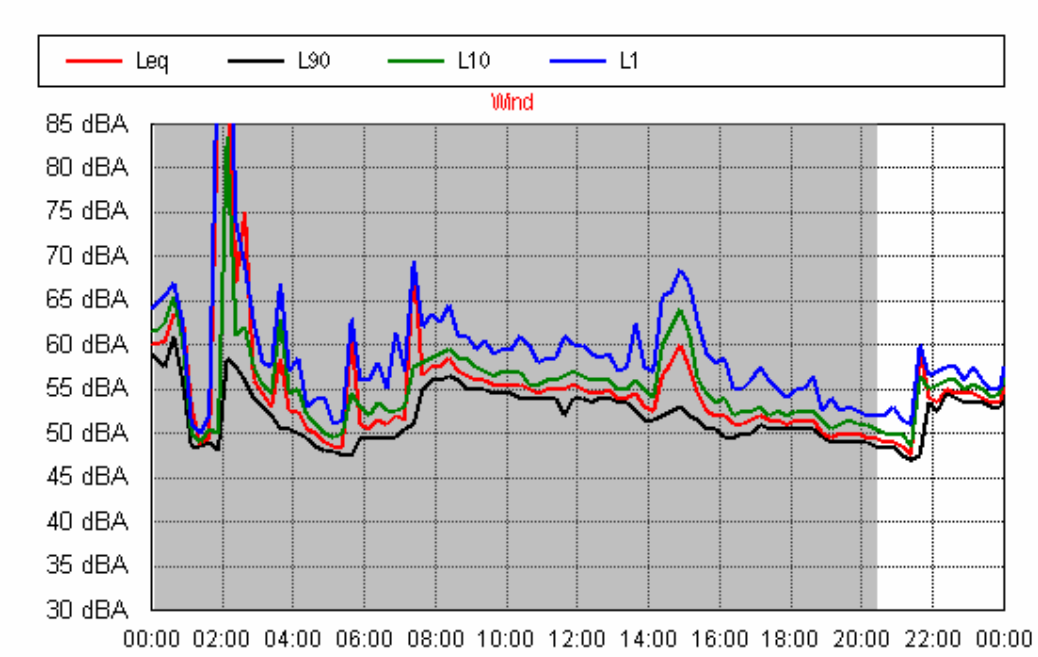


Location B: 25 Bakers Lane

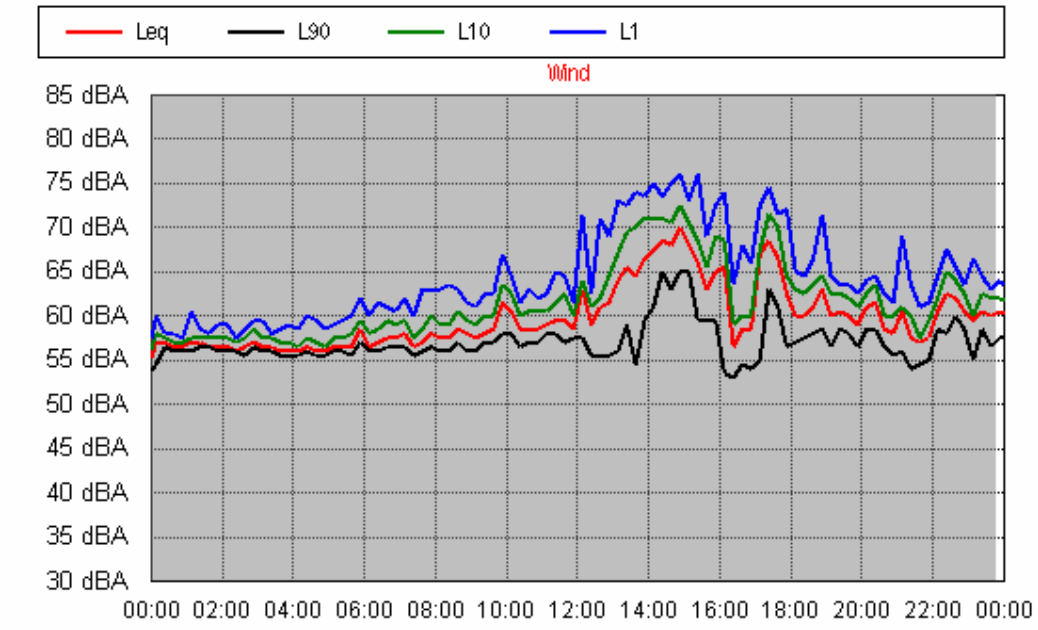




Location B: 25 Bakers Lane

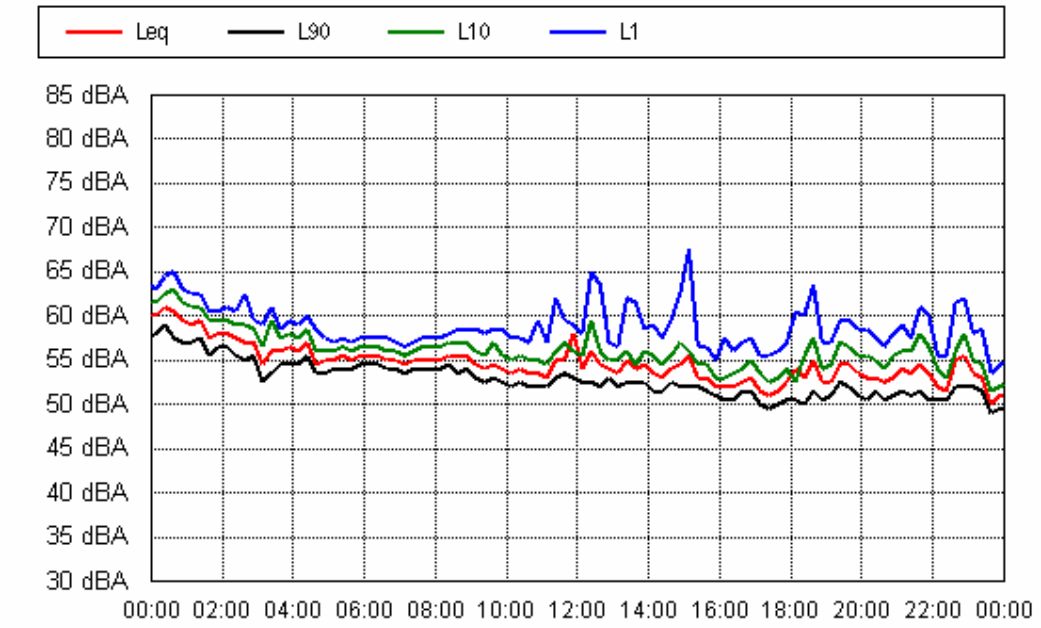


Thu 10 Jun 2010

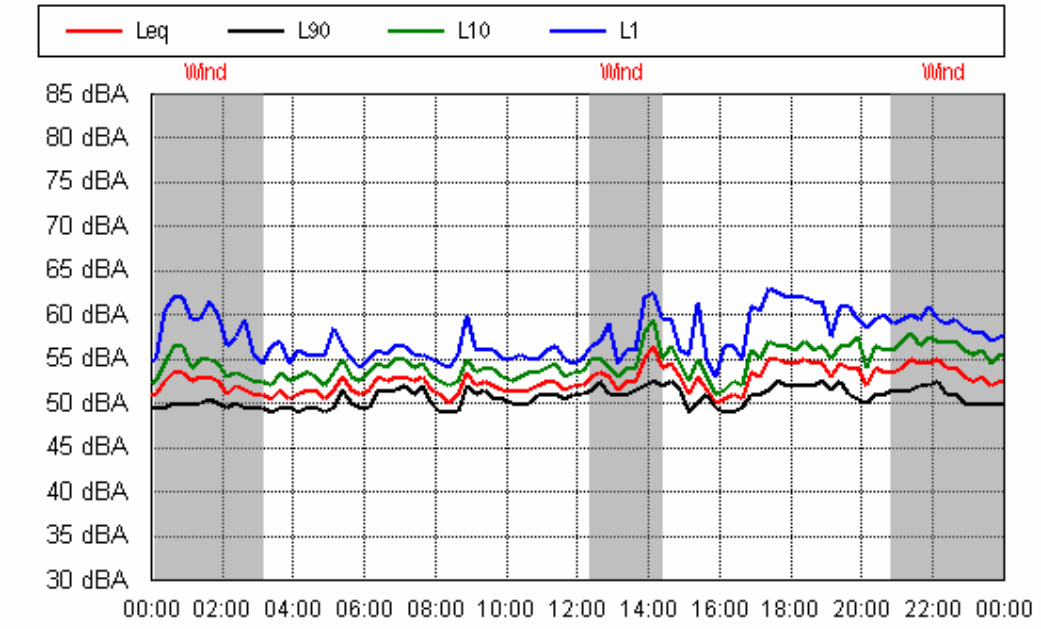


Fri 11 Jun 2010

Location B: 25 Bakers Lane

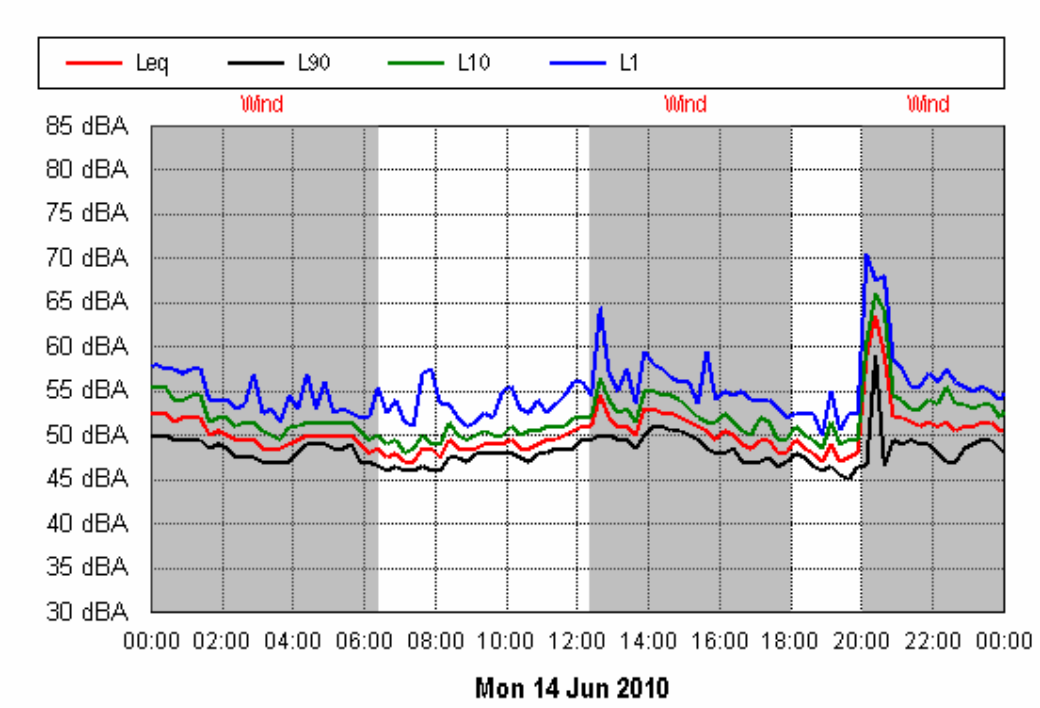


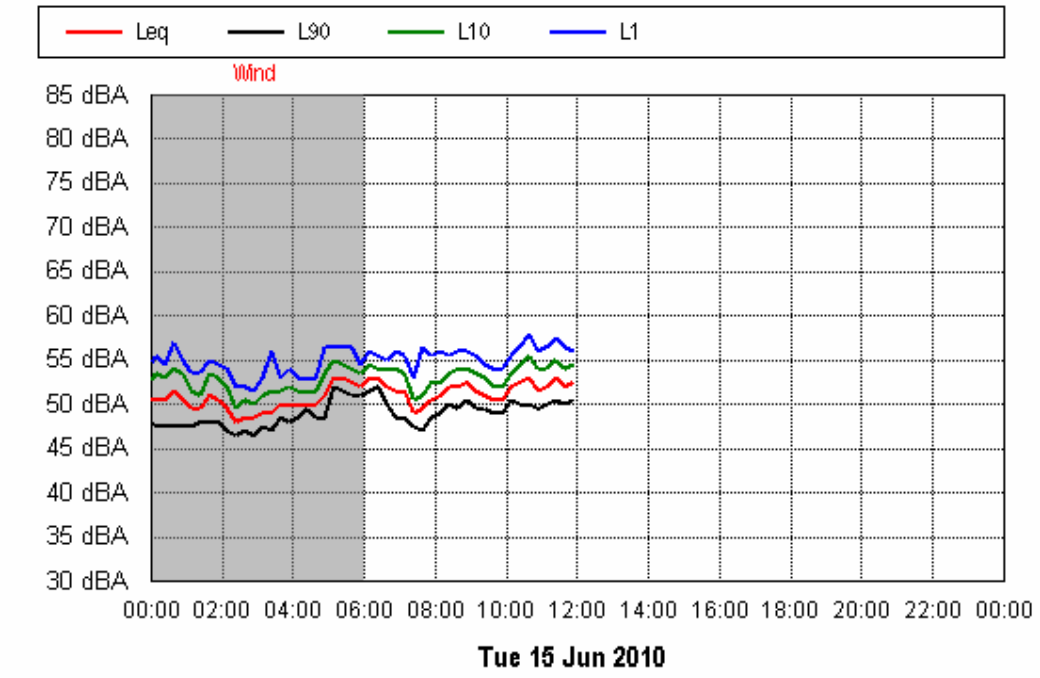
Sat 12 Jun 2010



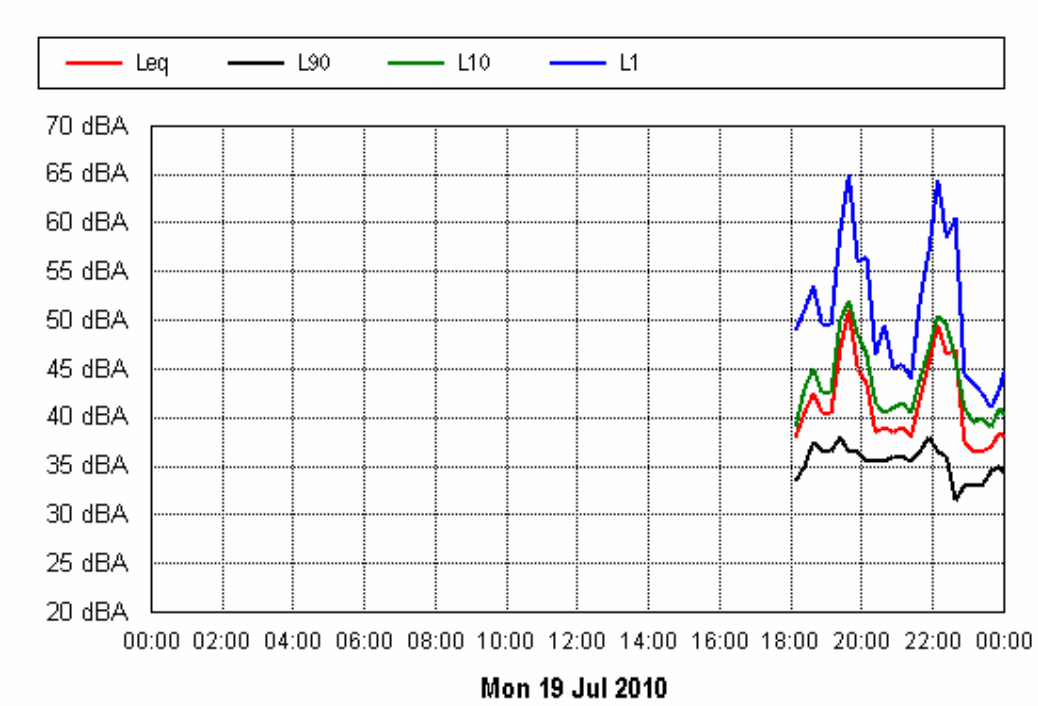
Sun 13 Jun 2010

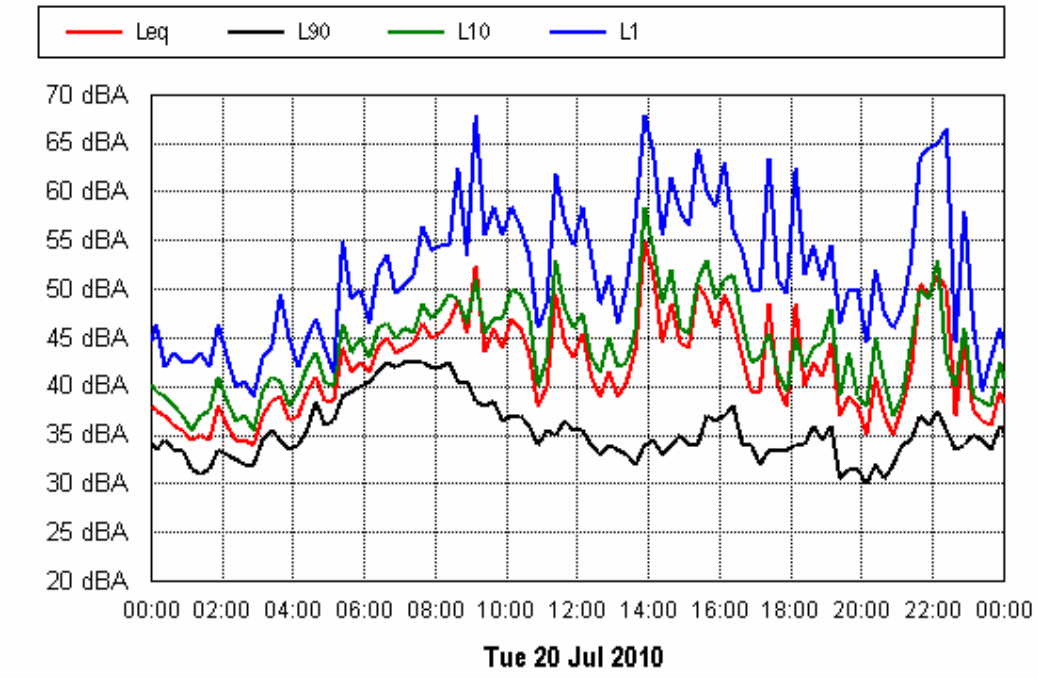
Location B: 25 Bakers Lane



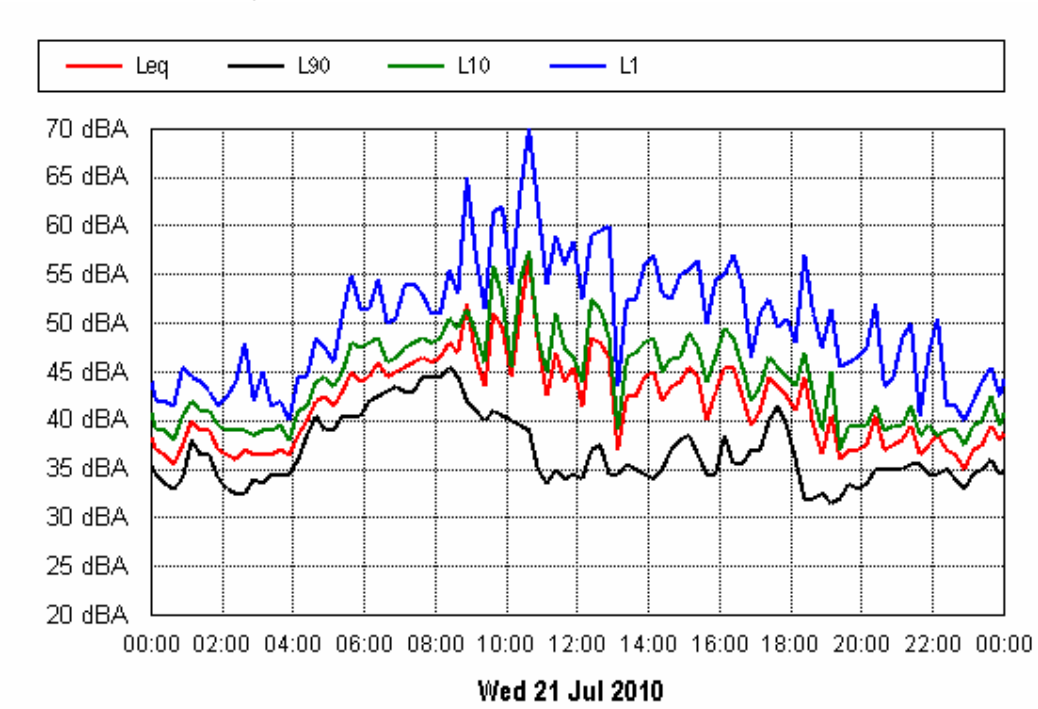


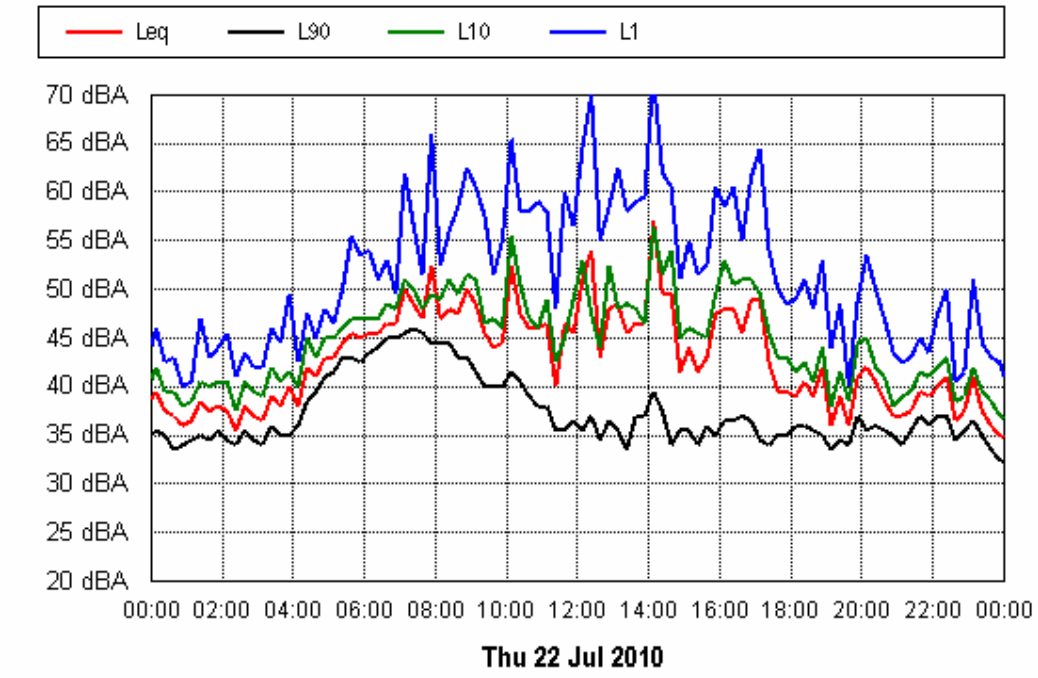
Location C: 32 Arlington Road



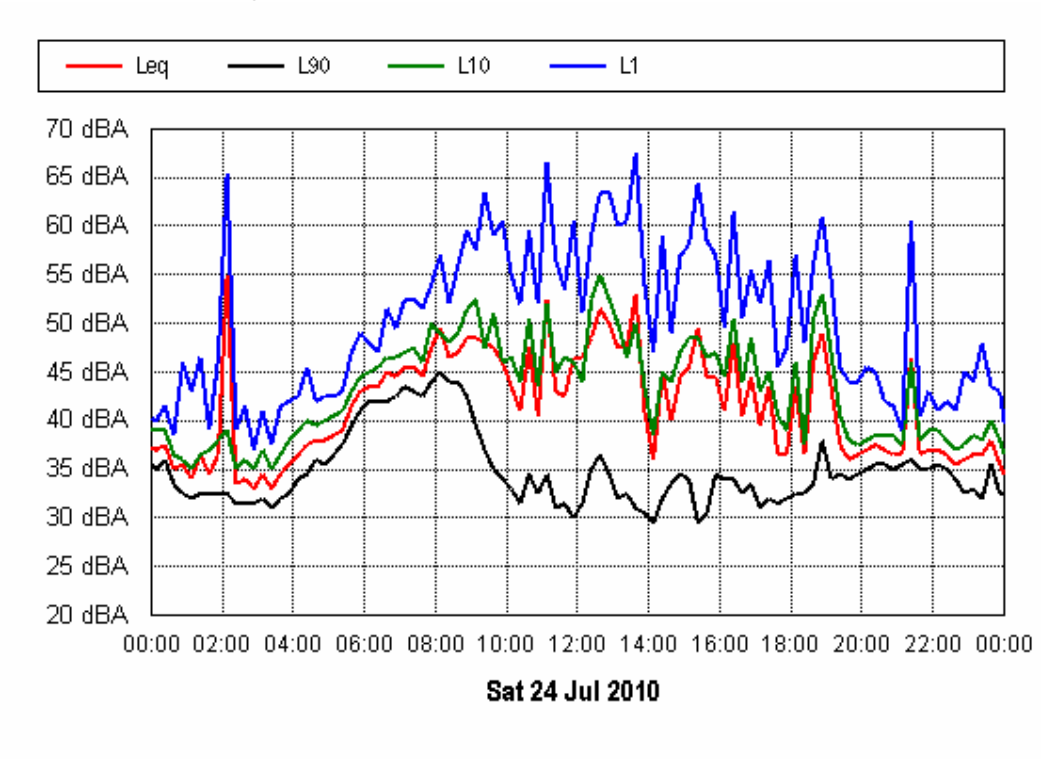


Location C: 32 Arlington Road

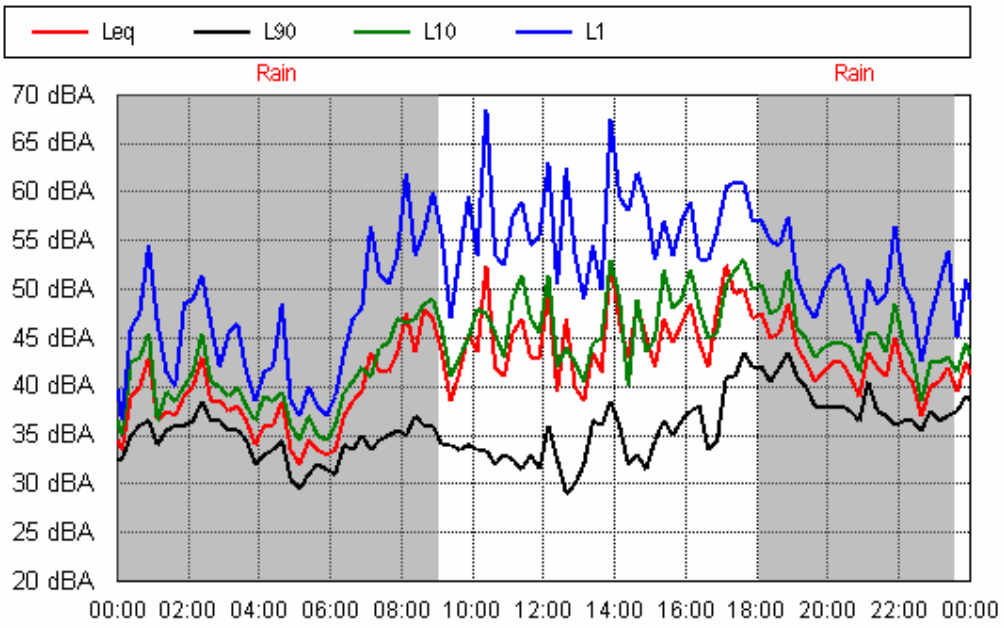


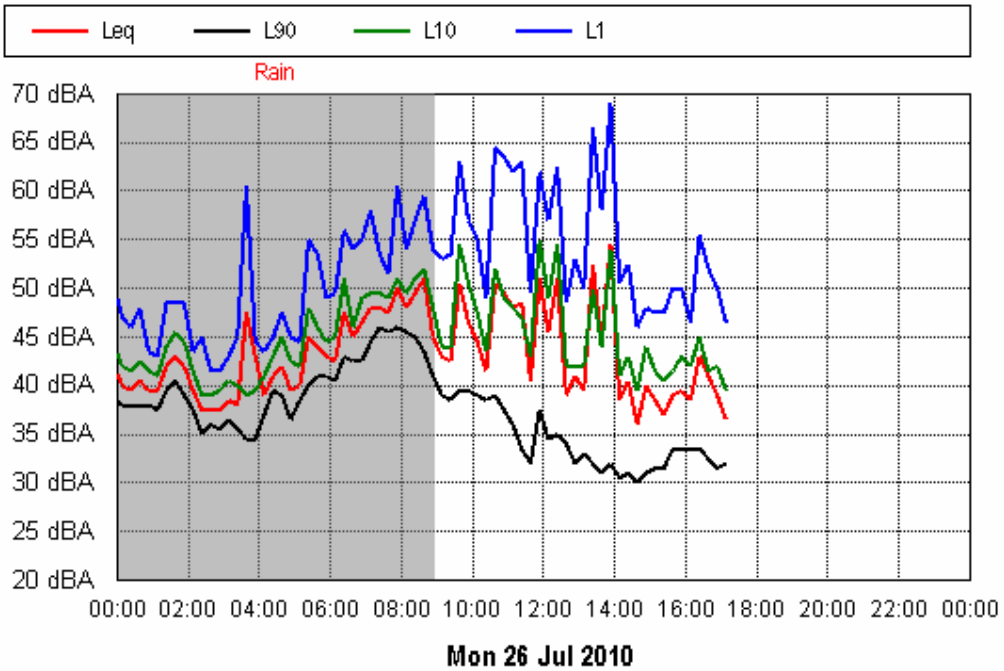


Location C: 32 Arlington Road



Location C: 32 Arlington Road

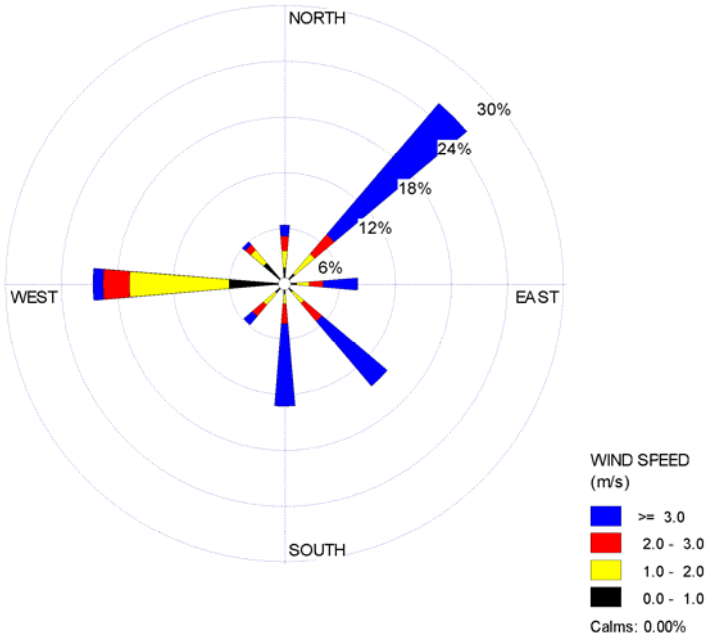




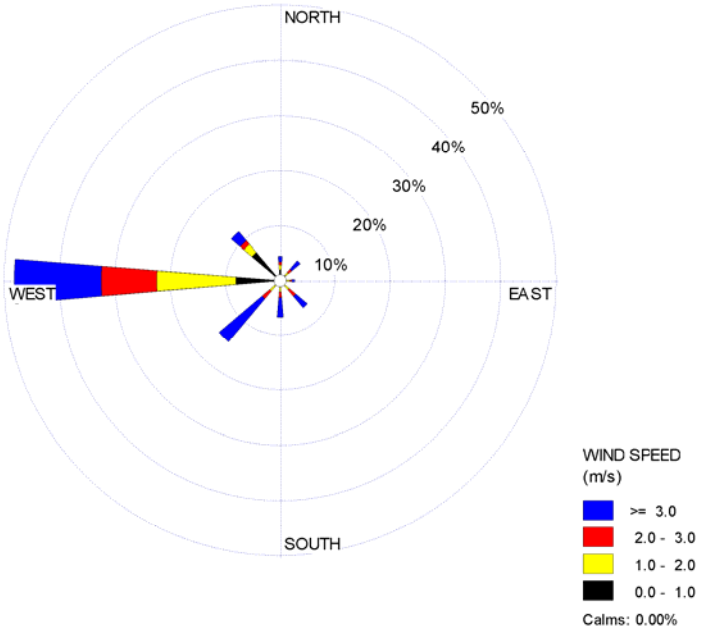
APPENDIX C

WIND ROSES

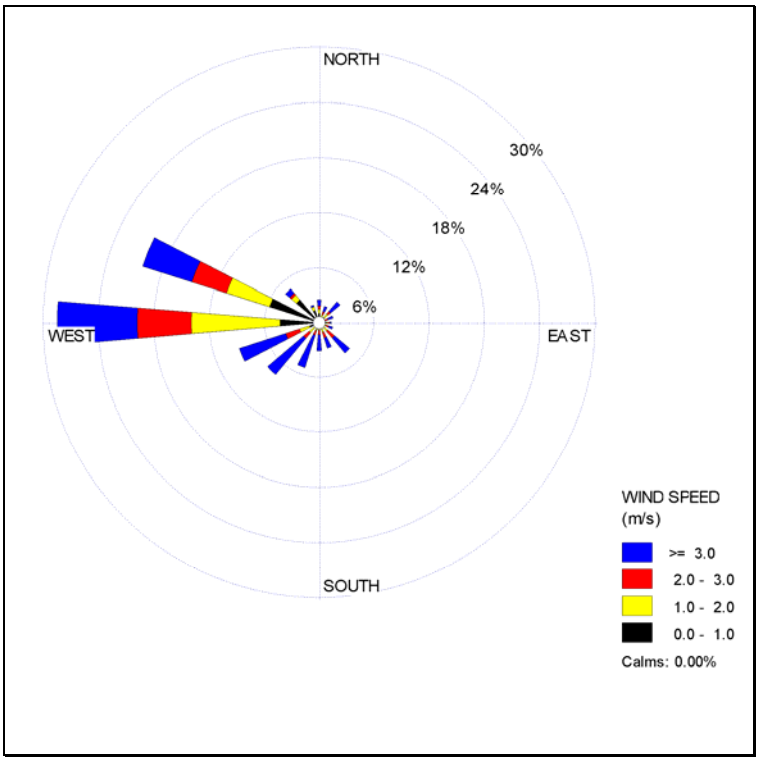
Summer



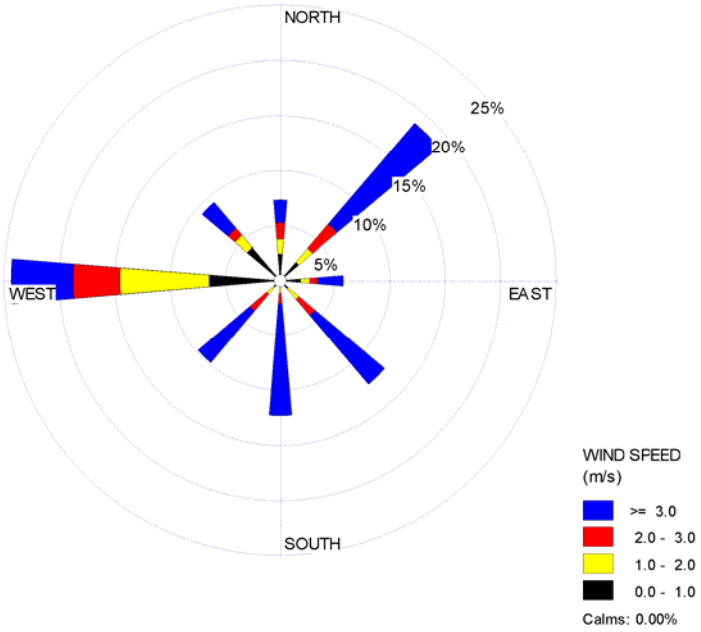
Autumn Winds



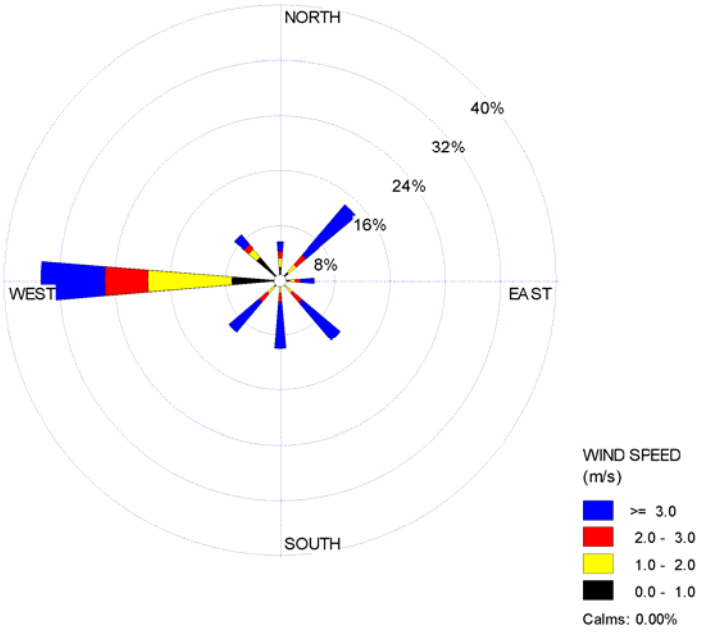
Winter Winds



Spring Winds



Yearly Winds


NORTH
40%
32%
24%
16%
8%
WEST
EAST
SOUTH
WIND SPEED
(m/s)
>= 3.0
2.0 - 3.0
1.0 - 2.0
0.0 - 1.0
Calms: 0.00%