Coopers Gap Wind Farm
AGL Energy Limited
6 June 2012
Document No. 60162856_Draft Updated Acoustic Report

DRAFT

Draft Updated Acoustic Report

D R A F T

Draft Updated Acoustic Report

Prepared for

AGL Energy Limited

Prepared by

AECOM Australia Pty Ltd
Level 8, 540 Wickham Street, PO Box 1307, Fortitude Valley QLD 4006, Australia
T +61 7 3553 2000 F +61 7 3553 2050 www.aecom.com
ABN 20 093 846 925

6 June 2012

60162856

AECOM in Australia and New Zealand is certified to the latest version of ISO9001 and ISO14001.

DRAFT

© AECOM Australia Pty Ltd (AECOM). All rights reserved.

AECOM has prepared this document for the sole use of the Client and for a specific purpose, each as expressly stated in the document. No other party should rely on this document without the prior written consent of AECOM. AECOM undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. This document has been prepared based on the Client's description of its requirements and AECOM's experience, having regard to assumptions that AECOM can reasonably be expected to make in accordance with sound professional principles. AECOM may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified. Subject to the above conditions, this document may be transmitted, reproduced or disseminated only in its entirety.

Quality Information

Document	Draft Updated Acoustic Report
Ref	60162856
Date	6 June 2012
Prepared by	Rhys Brown
Reviewed by	Emma Charlton

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	08-Aug-2011	Draft for Review	Amanda Kipniak Project Manager	
B	07-Dec-2011	Updated Draft for Review	Amanda Kipniak Project Manager	
C	12-Dec-2011	Updated Draft for Review	Amanda Kipniak Project Manager	
D	06-Jun-2012	Updated Draft for Community Consultation	Amanda Kipniak Project Manager	

DRAFT

D R A F T

Table of Contents

DRAFT

D R A F T

Appendix I

Facade Attenuation Review I

DRAFT

D R A F T

1.0 Noise and Vibration

1.1 Introduction

This report presents the Draft Updated Acoustic Report for the Coopers Gap Wind Farm project. The report has been compiled for the purposes of informing the future Revised Assessment Report. The report has been updated based on consultation on the Initial Assessment Report and ongoing dialogue with referral agencies.

In the absence of specific wind farm noise guidelines in Queensland, a review of wind farm noise guidelines across Australia was undertaken and criteria recommended on this basis.

Background noise measurements were undertaken at 12 locations near the proposed wind farm. This report presents the analysis of these measurements with respect to wind speeds measured around the site, to determine environmental noise criteria at the nearest residences to the proposed turbines.

Wind speed data measured at the meteorological masts on the site for the duration of the noise monitoring periods was provided by AGL.

An environmental noise model has been used to predict noise emission from the wind farm to the nearest noise sensitive receivers. The environmental noise predictions from the model have been compared to the recommended noise criteria for wind farms.

Acoustic terminology used in this report is summarised in Appendix A.

DRAFT

D R A F T

2.0 Approach and Methodology

2.1 Existing Acoustic Environment

The existing acoustic environment in the surrounding area was evaluated by undertaking a background noise monitoring program within the study area. The measurement locations were scattered across the study area and are shown in Map 14.1. Monitoring locations were selected to represent areas that are expected to have the greatest noise impact from the proposed wind farm. Section 3.0 details the background noise monitoring results.

All selected locations were situated away from existing significant noise sources where practicable in order to get an indication of the typical acoustic environment at noise sensitive receptors. Background noise monitoring was undertaken in accordance with the South Australian EPA *Wind farms environmental noise guidelines* (SA 2009). The background noise monitoring was also conducted in accordance with Australian Standard *AS4959-2010 Acoustics-Measurement, prediction and assessment of noise from wind turbine generators*.

Wind farms only generate noise when the wind is blowing at sufficient speed to generate electricity. In order to capture background noise levels under these conditions, the background noise monitoring collects a range of background noise measurements under a range of wind speeds. This approach differs from other industries in Queensland, where background noise monitoring data is only considered valid for wind speeds below 10kph (~2.8 m/s, measured at the microphone height), and data is excluded from consideration if the wind speeds during the measurement is above a defined limit set in the Department of Environment and Heritage Protection (DEHP, formerly Department of Environment and Resource Management) *Noise Measurement Manual 2000*. Accordingly the method of background noise monitoring undertaken at Coopers Gap is different to that used for other types of industrial noise assessments in Queensland.

2.2 Operational Noise Assessment

2.2.1 Overall Noise

South Australian EPA *Wind farms environmental noise guidelines* (SA 2009)

Wind Farms only generate noise when the wind is blowing at sufficient speed to generate electricity, and they typically generate higher noise levels during periods of high wind, when background noise levels are also typically higher. In this way, they differ from most other sources of environmental noise emission. On this basis they are typically assessed by governing authorities using dedicated guidelines and policies that take this wind speed variation into account.

Queensland does not yet have specific legislation or guidelines related to wind farm noise, so interstate guidelines must be used. The South Australian Guidelines 2003 (SA 2003) have typically been used to assess other wind farms in Queensland. The original noise assessment for the Coopers Gap Wind Farm (Marshall Day Acoustics, 2008) utilised the SA 2003. These have since been superseded by the 2009 version of these guidelines.

The SA 2009 guidelines are consistent with guidelines used for the assessment of wind farms in other states of Australia, They are also broadly consistent with QLD guidelines and legislation for other types of industrial noise, discussed further in the following sections.

The SA 2009 Guidelines state that:

> *The predicted equivalent noise level ($L_{Aeq,10}$), adjusted for tonality in accordance with these guidelines, should not exceed:*
>
> - 35 dB(A) at relevant receivers in localities which are primarily intended for rural living, or
> - 40 dB(A) at relevant receivers in localities in other zones, or
> - The background noise ($L_{A90,10}$) by more than 5 dB(A)
>
> whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the WTG *(wind turbine generator)* and each integer wind speed in between.

In regard to rural living, the SA2009 guideline states that:

> *A 'rural living' zone is a rural-residential 'lifestyle' area intended to have a relatively quiet amenity. The area should not be used for primary production other than to produce food, crops or keep animals for the occupiers' own use, consumption and/or enjoyment.*

DRAFT

The project area is predominantly surrounded by farms used for primary production including cropping and livestock. The area is zoned ‘Rural Zone’, with a key focus of ‘*retaining viability as an area of primary production’.* As such, it suggests the area is not considered to be primarily intended for rural living, and a base noise criterion of 40 dB(A) is applicable.

Section 2.3 of the SA 2009 Guidelines explains that the guidelines have been developed with the aim of minimising the impact on the amenity of premises that do not have an agreement with wind farm developers. In situations where landholders have a financial agreement with the wind farm proponent (i.e. have wind turbines on their property), the guidelines state that a base noise limit of 45 dB(A) outdoors is acceptable rather than the base noise limit of 40 dB(A).

We understand that there are 11 separate landowners who have entered into financial agreements with AGL for the Coopers Gap Wind Farm. This higher limit is applicable at those properties.

Penalty for Tonality

Tonality is defined as a clearly audible tone at a specific frequency that is more prominent than other broadband noise. The South Australian EPA has applied the following conditions for tonality to wind farms in South Australia.

> *When tested in accordance with IEC61400-11: Wind turbine generator systems, there must be no audible tones (Delta*$L_{a,k}$>0) where measured at a residence. Should tones be detected, a penalty of 5 dB(A) is to be added to the overall noise level.*

This condition has been adopted for this project.

2.2.2 Queensland Legislation and Guidelines

As noted above, there is currently no specific legislation or guidance for the assessment of noise emission from wind farms in Queensland. Some guidance however can be taken from current Queensland guidelines and legislation related to industrial noise emission.

Environmental Protection (Noise) Policy 2008 (EPP(Noise))

Part 3 of the Environmental Protection (Noise) Policy 2008 (EPP(Noise)) specifies that the following environmental values are to be enhanced or protected:

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following –
(i) sleep;
(ii) study or learn;
(iii) be involved in recreation, including relaxation and conversation; and
(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

DRAFT

Schedule 1 of the EPP (Noise) then details acoustic quality objectives to be met at various types of sensitive receptors in order for these environmental values to be protected. The schedule includes objectives for dwellings as summarised below.

Table 1 - EPP (Noise) 2008 Acoustic Quality Objectives at Dwellings

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at the receptor) dB(A)			Environmental Value
		$L_{Aeq, adj, 1hour}$	$L_{A10, adj, 1hour}$	$L_{A1, adj, 1hour}$	
Dwelling (Outdoors)	Daytime and Evening	50	55	65	Health and wellbeing
Dwelling (Indoors)	Daytime and Evening	35	40	45	Health and wellbeing
	Night	30	35	40	Health, wellbeing, sleep

These acoustic quality objectives in are intended to provide guidance as to the noise levels that protect the environmental value in question, i.e. that protect health, wellbeing and the ability to sleep. We understand that these limits are designed to be long term noise limits and are not applied to any individual project or enterprise, but can inform the decision making process around the limits and assist in identifying whether the environmental values are protected.

The *"Explanatory Notes for SL 2008 No. 442"* for the Environmental Protection (Noise) Policy 2008 states that:

> *The acoustic quality objectives are not point source noise levels but rather inform what the point source noise level as a condition of approval for a particular activity at a site may be.*
>
> *The acoustic quality objectives are to inform the decision making process including any conditions relating to noise levels in relation to the decision. The objectives assist in identifying whether the environmental values are protected.*

The base criterion of 40 dB(A) under the SA 2009 Guidelines is well within the outdoor daytime objective of $L_{Aeq, adj, 1hour}$ 50 dB(A), and consistent with the night time indoors acoustic quality objective of $L_{Aeq, adj, 1hour}$ 30 dB(A), when applying a typical reduction of 10 dB across a facade containing an open or partially open window[1] (refer Appendix I for more information about the typical attenuation through a residential façade). On this basis, the SA 2009 Guidelines levels are consistent with the Policy and the protection of relevant environmental values.

Planning for Noise Control

DERM has produced a noise guideline entitled "*Planning for noise control*" *(PFNC)*. The methods and procedures described in the guideline are typically used for setting conditions relating to steady-state (constant) noise emitted from industrial premises, commercial premises and mining operations. The nominated PFNC criterion is typically taken as the lower of the Specific Noise Level and the Maximum Planning Noise Level. These noise levels are discussed below:

Specific Noise Level

The specific noise level criterion is calculated as a noise level 3 dB greater than the measured background level, described as a Rated Background Level (RBL). A procedure for determining the RBL is outlined in the PFNC. This method excludes noise measured when the wind speed is greater than 10kph (~2.8 m/s, measured at the microphone height) at the noise measurement site. As such, the particular method of determining background noise is not appropriate for determining a typical background noise condition applicable under varying wind speeds during wind farm noise emission Nevertheless, the 'background + x dB' approach is broadly consistent with the approach outlined in the SA Guideline 2009.

Maximum Planning Noise Levels

The *PFNC* guideline also defines a maximum planning noise level (PNL) for the setting of long term criteria in Table 3 on Page 3 of the document.

The category that best defines the area surrounding Coopers Gap is the Z2 noise area category in Table 3 of *PFNC* described as *'Negligible transportation. Less than 80 vehicles an hour.* This area category is considered appropriate for this area is it contains industry including primary production. The description for the Z1 noise category of '*purely residential'* is not considered to be an accurate representation of the project site due to the primary production activities.

The maximum planning noise levels for a Z2 area is presented below.

Table 2 - PFNC Z2 Noise area category

Noise area category	Description of neighbourhood	Maximum hourly sound pressure level, $L_{Aeq,1hour}$ (PNL)		
		Day	Evening	Night
Z2	Medium density transportation (less than 600 vehicles an hour) or some commerce or industry.	50	45	40

[1] Australian Standard AS3671-1989 *Acoustics – Road traffic noise intrusion – Building siting and construction*

The above planning noise levels are presented as external noise criteria and apply outside a dwelling. The criterion of 40 dB(A) recommended for the Coopers Gap project under the SA 2009 guidelines is consistent with these levels.

State Planning Policy 5/10 Air Noise and Hazardous Materials

The State Planning Policy (SPP) 5/10 *Air Noise and Hazardous Materials* is designed for assessing the appropriateness of the development of new sensitive land uses (e.g. residential dwellings) that encroach on industrial land uses and in particular the consideration of these matters in the preparation of new planning instruments (i.e. planning scheme).

Accordingly it is not specifically applicable to the Community Infrastructure Designation (CID) application for the Coopers Gap Project. Guidance can however be taken from this document as to the requirements likely to be imposed on any new residential development near the wind farm. Schedule 3 of the policy states that "Sensitive land uses must be developed to achieve indoor noise objectives consistent with those set out in the *Environmental Protection (Noise) Policy 2008".* Section 2.2.2 contains a discussion on the *Environmental Protection (Noise) Policy 2008* and demonstrates that the criteria recommended for the Coopers Gap Project are consistent with this policy and therefore unlikely to significantly restrict future development in the area.

2.3 Conservation Estates and National Parks

Schedule 1 of the EPP (Noise) details specific acoustic quality objectives to be met for various types of sensitive receptors. Schedule 1 outlines the following for conservation estates and other protected areas.

Table 3 - EPP (Noise) 2008 Acoustic Quality Objectives

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at the receptor) dB(A)		
		$L_{Aeq, adj, 1hour}$	$L_{A10, adj, 1hour}$	$L_{A1, adj, 1hour}$
Protected area, or an area identified under a conservation plan under the *Nature Conservation Act 1992* as a critical habitat or an area of major interest	anytime	the level of noise that preserves the amenity of the existing area or place		

EPP(Noise) does not provide specific guidance as to the level of noise that preserves the amenity of the existing area.

However, guidance is provided in PFNC. Table 1 of PFNC outlines the following criteria for passive recreation areas, this has been replicated in Table 4 below.

Table 4 - Table 1 of PFNC

Receiver Land Use	Receiver Area Dominant Land Use (description of neighbourhood)	Background noise level, min $L_{A90,1hour}$		
		Day	Evening	Night
Passive recreation area	Picnic grounds, public beaches, bush walks, public gardens, etc.	35	35	35

On this basis the Project has adopted a criterion of 35 dB(A) for all periods for the nearby Bunya Mountains Conservation Park, applicable at the boundary of the conservation estate.

2.4 Low Frequency Noise

The SA2009 Wind Farms Environmental Noise Guidelines do not require the specific assessment of low frequency noise. The document states that:

> *These guidelines have been developed with the fundamental characteristics of noise from a wind farm taken into account.*

DRAFT

D R A F T

Table 5 provides a summary of the approach taken by other states and territories in Australia to the assessment of low frequency noise from wind farms. No state except Tasmania requires an assessment of wind farm low frequency noise. Most guidelines specifically exclude any requirement to assess the impacts, on the basis that the guidelines already consider the nature of wind noise. The Tasmanian guideline outlines the same method of assessment that is used for other types of environmental noise in Tasmania.

Table 5 - Summary of Low Frequency Requirements of Various States of Australia for Wind Farms

State/Territory	Wind farms Noise Document	Comments
National	National Wind Farm Development Guidelines Draft (July 2010)	Does not require specific assessment of low frequency noise and infrasound. For the assessment of complaints it recommends a two stage method based upon the difference between dB(A) and dB(C) levels and DIN 45680:1997 *"Measurement and evaluation of low-frequency environmental noise"* for the assessment of the audibility of low frequency noise. The document discusses that low frequency noise and infrasound levels generated by modern wind farms are at levels that are well below the uppermost levels required to cause any health effects.
National	AS 4959:2010	No low frequency or infrasound criteria in the document. Specifically excludes any methodology for the measurement of infrasound or low frequency noise emissions. States that: *"Low frequency noise and infrasound levels generated by wind farms are normally at levels that are well below the uppermost levels required to cause any health effects. As a result, these Guidelines do not require specific assessment of low frequency noise and infrasound..."*
South Australia	SA EPA Windfarms Environmental Noise Guidelines 2009	No specific low frequency/infrasound criteria. States that the SA EPA has completed an extensive literature search and they are not aware of infrasound being present at any modern wind farm site.
Victoria (Wind farm DA's approved prior to 2010)	NZS 6808:1998	No low frequency/infrasound criteria. Discusses that the sound spectra for modern wind turbines facilitates compliance with the overall noise limits in the Standard which will ensure that infrasound emissions will be below the threshold of perception.
Victoria	NZS 6808:2010	No specific low frequency/infrasound criteria. States that there is not sufficient evidence of a causal link between wind farms and Vibro-acoustic disease at the time of publication. Also states that there is no justification of a low frequency/infrasound criterion that is more stringent or in addition to the overall noise criteria set by the standard.
New South Wales	Previously used SA EPA Windfarms Environmental Noise Guidelines 2003, currently developing their own guidelines.	See Western Australia for discussion on SA 2003 guidelines
ACT	No specific guidelines	-
Northern Territory	No specific guidelines	Windfarms assessed on a case-by-case basis.
Western Australia	Environmental Protection	Stated that the regulation used in WA by the National Wind

State/Territory	Wind farms Noise Document	Comments
	(Noise) regulations 1997. EPA Guidance for the Assessment of Environmental Factors No. 8 Environmental Noise s3.2.2 (Draft, May 2007)	Farm Development Guidelines. Requires assessment under the SA EPA Environmental Noise Guidelines: Wind Farms 2003. States that the SA EPA has completed an extensive literature search and they are not aware of infrasound being present at any modern wind farm site.
Tasmania	Department of Primary Industries, Parks, Water and Environment, (Tasmania), Noise measurement procedures manual, 2004.	References NZS 6808 as the primary source of procedures specified. Applies a low frequency penalty of 5 dB to the noise based on the following test: *The adjustment must be based on the difference between the measured A-weighted sound pressure level and the C-weighted sound pressure level. If this difference is greater than 15 dB(A), then the low frequency adjustment is 5 dB.* The measurement location is specified as external to the sensitive receiver.
Queensland	No specific guidelines	-

DERM Draft Low Frequency Guideline

DERM have previously released a draft guideline on the Assessment of Low Frequency Noise in 2004. This guideline has yet to be formally released and remains in draft form. The draft guideline separates low frequency noise into infrasound (1 -20 Hz) and low frequency noise (20Hz – 200Hz). For low frequency noise the guideline has a multi-step process which is summarized below:

1) Initial screening test – determine if the indoor linear noise level exceeds 50 dB(Linear) and is 15 dB greater than the indoor A-weighted noise level ($L_{LINeq} - L_{Aeq} > 15$ dB)

2) Audibility assessment – determine if noise between 20 Hz – 200 Hz is audible by comparing the forecast/measured noise between 20 – 200Hz with a medium threshold hearing curve

3) Determine if the low frequency content of the noise is annoying by comparing overall A-weighted low frequency noise levels against set criteria.

For Step 3 above, the draft guideline sets a criterion of $L_{pA,LF}$ 20 dB for dwellings during the evening and night-time period. $L_{pA,LF}$ is defined as the overall A-weighted noise level between 20 and 200Hz. This is not necessarily a definite measure of audibility however; a noise level that is 10 dB below the 'medium threshold hearing curve' in all of the one-third octave bands between 20 and 200Hz will still cause an exceedance of the $L_{pA,LF}$ 20 dB criterion by 2 dB. For the 'medium threshold hearing' curve, the draft guideline uses data contained in a paper by van den Berg and Passchier-Vermeer[2]. The curve used represents the levels that 90% of otologically (persons in a normal state of health who are free from all signs or symptoms of ear disease and from excessive wax in the ear canal) unselected 50 -60 year olds cannot hear noise below those levels, determined by experimentation.

Furthermore the draft guideline does not provide a mechanism for considering the ambient level of low frequency noise. This is a key limitation for the assessment of noise emission from wind farms. If the wind speed is greater than the wind turbine cut-in speed (the speed as to which the turbines begin generating electricity and emitting noise), the background level of low frequency noise would be raised. This is supported by studies showing that the background low frequency noise level is commonly a function of wind speed[3].

Other Environmental Approvals

[2] van den Berg, G.P., and Passchier-Vermeer, W. (1999): Assessment of low frequency noise complaints. Proc Internoise'99, Fort Lauderdale.
[3] DELTA, *EFP-06 project Low Frequency Noise from Large Wind Turbines Final Report* 21 November 2010

DEHP have also previously recommended alternative criteria to low frequency noise in other Environmental Authorities. The Authorities reviewed in the preparation of this report were issued by DERM in July 2011. The extract below shows a low frequency noise condition that formed part of the Environmental Authority conditions for previous industrial developments in Queensland.

Low Frequency Noise

(E11) Notwithstanding Condition (E8), emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority:

(a) 60 dB(C) measured outside the sensitive receptor; and

(b) the difference between the internal A-weighted and C-weighted noise levels is no greater than 20dB; or

(c) 50 dB(z) measured inside the sensitive receptor; and

(d) the difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.

Figure 1 – Extract from Previous Queensland Low Frequency Noise Conditions in Environmental Authorities

The criteria presented in Figure 1 above provide guidance as to the low frequency noise levels that have previously found acceptance for other developments. It should also be noted that the guidelines provides both an external and an internal noise limit, which facilitates easier and less intrusive measurements to determine compliance with operating conditions.

DRAFT

Draft National Wind Farm Guidelines

The Draft National Wind Farm (Draft NWFD) Guidelines state:

> *There have also been concerns raised about possible health impacts associated with low frequency noise (rumbling, thumping) and infrasound (noise below the normal frequency range of human hearing) from wind farms. Low frequency noise and infrasound levels generated by wind farms are normally at levels that are well below the uppermost levels required to cause any health effects. As a result, these Guidelines do not require specific assessment of low frequency noise and infrasound, but do present guidance on their assessment in response to complaints.*

In their recommendations for the assessment of low frequency noise in response to complaints, the Draft National Wind Farm Guidelines recommend a difference between indoor A-weighted and C-weighted levels of not more than 20 dB. This requirement is consistent with previous low frequency noise criteria applied by DERM which have been discussed above.

Proposed Approach to Low Frequency Noise

Based on the a review of all national and state based low frequency noise criteria and recent DERM Environmental Authority conditions we recommend the adoption of the following low frequency criteria for non-financial locations:

> *Emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority:*
>
> *- 60 dB(C) measured outside the sensitive receptor; and*
>
> *- The difference between the internal A-weighted and C-weighted noise levels is no greater than 20 dB; or*
>
> *- 50 dB(Z) measured inside the sensitive receptor; and*
>
> *- The difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.*

These conditions are generally in accordance with other guidelines for the assessment of low frequency noise from wind farms and provide an avenue for simplified compliance measurements if required.

Infrasound

The SA2009 Wind Farms Environmental Noise Guidelines state:

> *Infrasound was a characteristic of some wind turbine models that has been attributed to early designs in which turbine blades were downwind of the main tower. The effect was generated as the blades cut through the turbulence generated around the downwind side of the tower.*
>
> *Modern designs generally have the blades upwind of the tower. Wind conditions around the blades and improved blade design minimise the generation of the effect. The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site.*

A review of literature was undertaken to determine a suitable criterion for infrasound at sensitive receivers. The G-weighting is defined in ISO 7196:1995 *"Acoustics – Frequency weighting characteristics for infrasound measurements"* and is used to determine human perception and annoyance due to noise that is contained within the infrasound frequency range (below 20 Hz). A range of studies has recommended the use of a criterion of 85 dB(G) to represent the audibility threshold for infrasound, including a study by Jacobsen[4]. This criterion for infrasound is consistent with other standards and studies, including those applied in the UK and Germany. The DERM Draft Guideline "Assessment of Low Frequency Noise" also recommends an infrasound criterion of 85 dB(G). Accordingly the project has adopted the following criteria for infrasound outlined in Table 6.

Table 6 - Infrasound Criteria

Receiver	Infrasound Criteria dB(G)		
	Day	Evening	Night
Dwellings and commercial places	85	85	85

Ground-borne Vibration

Ground-borne vibration is not perceptible at the base of a wind turbine, so therefore is extremely unlikely be perceptible at surrounding residences. The Draft NWFD Guidelines state:

> *Ground-borne vibration from wind turbines is not likely to be perceptible to humans outside the wind farm site boundary and so has not been specifically addressed in these Guidelines.*

A study on a wind farm in the UK found that the absolute level of the vibration measured at all frequencies at 100 metres from the nearest turbine was significantly below both the criteria for 'residential premises' and 'critical working areas' as outlined in BS6472:1992 *"Evaluation of human exposure to vibration in buildings (1Hz to 80Hz)*[5]*.* A detailed assessment of ground borne vibration has therefore not been undertaken for this assessment.

Summary of Environmental Noise Criteria

Table 7 presents the base environmental noise criteria for noise emission from the proposed Coopers Gap wind farm.

Table 7: Environmental noise criteria

Description	Descriptor	Criterion
Residential Owner (or leasee)	$L_{Aeq,10}$, dB(A)	40 or background noise ($L_{A90,10}$) + 5, whichever is greater
Residential Owner and Stakeholder	$L_{Aeq,10}$, dB(A)	45 or background noise ($L_{A90,10}$) + 5, whichever is greater
Residential Owner (or leasee)	-	Emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority: 60 dB(C) measured outside the sensitive receptor; and The difference between the internal A-weighted and C-weighted noise levels is no greater than 20 dB; or 50 dB(Z) measured inside the sensitive receptor; and

[4] Jacobsen, J. Danish guidelines on environmental low frequency noise, infrasound and vibration. Journal Low Frequency Noise, Vibration and Active Control Volume 20 Issue 3.
[5] D J Snow *'Low Frequency Noise and Vibrations Measurement at a Modern Wind Farm'* ETSU (1997)

DRAFT

DRAFT

Description	Descriptor	Criterion
		The difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.
Residential Owner (or leasee)	L_{pG} dB(G)	85
Conservation Estates	$L_{Aeq,10}$, dB(A)	35

All criteria above are external noise limits i.e. taken outside the dwelling, unless otherwise specified.

2.5 Infrastructure associated with the wind farm

The wind farm will include an operation and maintenance building and some other minor support infrastructure. Assessment of noise emission from this infrastructure has not been conducted at this stage. It is considered unlikely that noise emission from this equipment will cause any issues at the closest receivers due to the minor nature of the equipment and significant distances to the closest residences. Nevertheless, a requirement for suppliers to provide equipment that achieves the relevant steady-state noise emission criteria will be included in the specification and compliance with the relevant criteria will be confirmed with post construction noise monitoring.

2.6 Construction Noise and Vibration Assessment

An assessment has been carried out of noise and vibration impacts related to the construction of the Coopers Gap Wind Farm. This is discussed in Section 5.0 of this report. Criteria and goals relating to construction noise and vibration impacts are also discussed in that section.

DRAFT

3.0 Background Noise Assessment

3.1 Monitoring Locations

The residences at which background noise levels were monitored, and the wind mast locations used for each site, are listed in Table 8. Appendix B includes photographs of each of the monitoring sites.

Table 8: Background noise monitoring locations

Location and ID	GPS coordinates (GDA 1994 Projection MGA Zone 56 co-ordinate system)	
	Easting	Northing
CG1	347122	7042866
1. G	346205	7042906
2. I	343380	7043809
CG2	345634	7039537
3. O	339757	7041616
4. Y	345865	7038516
CG4	348402	7039566
5. AD	350475	7038587
CG5	336703	7048697
6. C	336802	7049669
7. F	341674	7047086
8. J	341089	7045504
9. A	340109	7046343
10. BD	340438	7049413
11. AA	346822	7038250
12. CF	349763	7038201

Eastings and Northings are defined based on the GDA 1994 Projection MGA Zone 56 co-ordinate system.

DRAFT

The monitoring was carried out across three periods for approximately one month during each period. Both wind speed and noise data was collected as an average for each 10 minute measurement period throughout the monitoring. In all cases, the microphone was located a minimum of 1.2 metres above the ground and at least 5 metres from any reflecting surface, including buildings or significant vegetation such as trees. Background noise monitoring was undertaken in accordance with the South Australian EPA *Wind farms environmental noise guidelines* (SA 2009). The background noise monitoring was also in accordance with Australian Standard *AS4959-2010 Acoustics-Measurement, prediction and assessment of noise from wind turbine generators*.

The background noise data collected at the site was correlated with wind speed data collected at 84 metres above the ground, which has been extrapolated from wind speed data measured at various heights on each meteorological mast.

The following masts were used to assess each location:

- CG1 – Location G and I
- CG2 – Location O and Y
- CG4 – Location AD
- CG5 – Locations C, F, J, A, BD, AA and CF

The approximate worst-case direction (receiver to wind turbine) for each of the monitoring locations, as well as the overall number of valid data points and valid data points within 45° of the worst-case direction, are summarised in Table 9.

Table 9: Valid collected data at each of the background noise monitoring locations

ID	Total number of valid data points	Worst case direction (° clockwise from N)	Valid data points in worst case direction
G	4804	5	843
I	3785	240	**81**
O	3885	105	777
Y	3507	325	**47**
AD	11222	300	**356**
C	2719	75	2009
F	3334	225	**378**
J	4256	120	784
A	4569	25	2542
BD	4529	270	**200**
AA	4629	340	1509
CF	4165	330	**213**

DRAFT

Six locations did not achieve the minimum number of data points (locations I, Y, AD, F, BD and CF), shown in bold and red), due to the low prevalence of worst-case wind conditions in that direction (225 – 330 ° clockwise from N). Three periods of background monitoring across differing seasons have been undertaken to attempt to capture the minimum number of data points at the noise monitoring locations.

Background noise criteria for the site can still be determined in accordance with the SA2009 Guidelines without the minimum data requirements for worst case wind directions, as the data from the worst-case direction is only used for background noise correction during compliance measurements. Any additional background noise data gathered will be added to the existing data for completeness and to ensure the additional data has not changed the criteria presented in this report. It is noted that it may not be possible to collect the minimum number of data points in the worst-case wind direction at all locations due to the wind conditions at the site (i.e. the lack of worst-case wind as highlighted above). This would preclude corrections for background noise at some locations during compliance noise measurements.

A wind speed range of 4 to 25 m/s at the turbine hub height (84 metres) was considered for the assessment as it represents the operational wind speed range of a potential turbine.

3.2 Noise Criteria

From the monitored noise and wind speed data, regression curves were plotted and used to determine $L_{Aeq,10}$ noise criteria for the wind farm at the residential receivers. The correlation between wind speed and background noise level was calculated by a least-squares regression formula. Data periods where the wind speed was below the turbine cut-in speed (4 m/s), where rain was recorded or where the measurements appear to have been affected by extraneous noise sources (noise sources not associated with the general environment such as a period of lawn mowing) have been excluded from the assessment. The regression curves and their equations are included in Appendix C.

For all sites, linear equations, second-order and third-order polynomial equations for regression lines were calculated. The coefficients of determination (R^2) for each order of polynomial for each of the residential monitoring locations are included in Table 10.

DRAFT

Table 10: Coefficients of determination for polynomial regression lines

Location	Coefficient of determination (R^2)		
	Linear	Polynomial order 2	Polynomial order 3
G	0.6408	**0.6540**	0.6660
I	0.2440	**0.2560**	0.2564
O	0.5330	**0.5470**	0.5471
Y	0.3703	**0.3788**	0.3791
AD	0.4644	**0.4645**	0.4677
C	0.2889	**0.3203**	0.3204
F	0.2240	**0.2259**	0.2259
J	0.0738	0.0767	**0.0779**
A	0.4378	**0.4535**	0.4554
BD	0.8790	**0.9340**	0.0938
AA	0.3683	**0.3780**	0.3845
CF	0.6642	0.673	**0.7085**

The coefficients in bold indicate those that provided the "best fit" curve for the polynomial regression lines. These curves were selected as providing the best fit of the data, defined as the highest coefficient of determination. The exception was where two curves provided a very similar coefficient. The lowest order curve was selected in this instance as being the most sensible fit of the data. The regression curves and their equations are included in Appendix C.

The noise criteria determined using the curve of best fit are summarised in Table 11. Data has only been presented for wind speeds where sufficient valid data points have been collected. For a majority of noise monitoring locations, no valid data points were collected at high wind speeds (~18 m/s and above).

DRAFT

D R A F T

Table 11: $L_{Aeq,10}$ noise criteria based on wind speed at turbine hub height (84 metres) in dB(A)

Location ID		Wind speed (m/s) at Hub height[1], 84 m																
		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
G	Noise level, $L_{A90,10}$	28	29	30	31	32	34	35	37	38	40	42	44	46	48	50	52	55
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	47	49	51	53	55	57	60
I	Noise level, $L_{A90,10}$	33	33	33	34	35	36	37	39	40	42	45	47	-	-	-	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	41	42	44	45	47	50	52	-	-	-	-	-
O	Noise level, $L_{A90,10}$	29	29	30	31	32	34	35	36	38	39	41	43	45	-	-	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	40	40	41	43	44	46	48	50	-	-	-	-
Y	Noise level, $L_{A90,10}$	32	32	33	34	35	35	36	37	38	39	40	41	-	-	-	-	-
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	45	46	-	-	-	-	-
ADy	Noise level, $L_{A90,10}$	22	23	25	26	28	29	31	33	35	37	39	41	43	45	48	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	40	40	40	40	42	44	46	48	50	53	-	-
CC	Noise level, $L_{A90,10}$	33	34	34	35	35	36	37	38	39	40	42	43	45	46	-	-	-
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	47	48	50	51	-	-	-
FStewart	Noise level, $L_{A90,10}$	28	29	30	31	32	32	33	34	34	35	35	36	36	37	-	-	-
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	45	45	45	45	-	-	-
JHoare	Noise level, $L_{A90,10}$	34	34	35	35	35	36	36	37	37	38	39	40	42	43	-	-	-
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	45	45	47	48	-	-	-
ASparkes	Noise level, $L_{A90,10}$	31	32	33	35	36	37	38	39	39	40	41	41	41	41	-	-	-
	Criterion, $L_{Aeq,10}$	45	45	45	45	45	45	45	45	45	45	46	46	46	46	-	-	-
BD	Noise level, $L_{A90,10}$	33	33	33	34	34	34	35	35	35	35	36	36	36	37	-	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	40	40	40	40	40	41	41	41	42	-	-	-
AAGleeson	Noise level, $L_{A90,10}$	23	24	25	26	27	28	29	30	32	33	35	37	39	41	-	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	40	40	40	40	40	40	42	44	46	-	-	-
CFCF	Noise level, $L_{A90,10}$	19	20	22	24	26	29	31	32	34	34	34	34	-	-	-	-	-
	Criterion, $L_{Aeq,10}$	40	40	40	40	40	40	40	40	40	40	40	40	-	-	-	-	-

DRAFT

3.3 Instrumentation Details

The details of the noise loggers and equipment used to record noise levels at the ten residential locations are summarised in Table 12.

Table 12: Measurement equipment

Location ID	Equipment make & model	Logger Serial number and calibration dates						Windscreen
		Site Visit 1	Cal. Date	Site Visit 2	Cal. Date	Site Visit 3	Cal. Date	
G	Rion NL-21	276273	17/03/2009	-	-	-	-	Rion 90 mm
I	Rion NL-21	365350	26/02/2010	-	-	-	-	Rion 90 mm
O	Rion NL-21	598492	26/05/2009	-	-	-	-	Rion 90 mm
Y	Rion NL-21	1277353	22/03/2010	00187448	11/05/2010	276273	23/03/2011	Rion 90 mm
AD	Rion NL-21	676782	21/10/2010	00187447	30/03/2010	1043718	18/04/2011	Rion 90 mm
C	Rion NL-21	187446	16/04/2010	-		-	-	Rion 90 mm
F	Rion NL-21	276274	17/03/2009	00465445	19/04/2010	365350	26/02/2010	Rion 90 mm
J	Rion NL-21	487669	07/07/2010	-		-	-	Rion 90 mm
A	Rion NL-21	487697	07/07/2010	00765699	31/07/2010	-	-	Rion 90 mm
BD	Rion NL-21	776886	10/08/2009	00265112	20/01/2010	-	-	Rion 90 mm
AA	Rion NL-21	-	-	-	-	276274	23/03/2011	Rion 90 mm
CF	Rion NL-21	-	-	-	-	487697	7/07/2010	Rion 90 mm
Calibrator	Rion NC-74	34483785	15/04/2010	34483785	15/04/2010	34483785	19/04/2011	-

DRAFT

The Rion NL-21s are Type 2 instruments suitable for background noise measurements in accordance with the SA 2009 Guidelines. All noise loggers were field calibrated at the start and finish of the measurement periods using a Rion NC-74 calibrator and no significant drift in calibration was observed.

All items of equipment used carry a current calibration certificate from a National Association of Testing Authorities (NATA) accredited laboratory, with the exception of logger 598492, which still held a manufacturers calibration certificate at the time of the measurements as it was less than 2 years old. Copies of the calibration certificates are attached in Appendix D.

Wind speed at microphone

In order to determine any wind effects on the measurements, wind speeds were also measured at microphone height. at location 3 (McQuaker) and location 7 (Stewart). A WindSonic ultrasonic anemometer was used. The anemometer has a reported accuracy of 0.1 m/s for wind speeds from 5 m/s to 25 m/s. These locations were considered to be two of the most exposed monitoring locations and therefore most likely to have results influenced by high wind speeds at the microphone. During the measurement period, the maximum wind speed that was exceeded at the microphone location for 90% of any 10-minute period was 5.5 m/s.

The level of wind induced background noise on a microphone fitted with a 90 mm wind shield can be predicted from wind speed measured at the microphone using the following equation[1]:

$$L_{A90wind} = 10 \times \log(v^{6.14}) - 7.6$$

Where *v* is the wind speed exceeded for 90 % of the time in metres per second.

The predicted wind-induced noise level at the microphone was compared to the measured noise level for each 10-minute period for location 3 and location 7. The measured L_{90} level exceeded the predicted wind-induced L_{90}

[1] J. Cooper, D. Leclercq, and M. Stead. *'Wind induced aerodynamic noise on microphones from atmospheric measurements'*. International Congress on Acoustics 2010, Sydney, August 23-27 2010.

D R A F T

level by 10 dB(A) or more for all but two of the measurement periods, with the smallest difference between measured and predicted level calculated to be 9.1 dB(A). The two data points where wind-induced noise was within 10 dB(A) of the measured level were corrected for induced noise in accordance with the requirements of the SA 2009 Guidelines. Correcting the two data points for wind induced noise made no difference to the calculated noise criteria, due to the low number of affected data points and small correction applied to those points. On this basis, it is considered that wind-induced noise has not significantly influenced the background noise measurements.

DRAFT

DRAFT

4.0 Potential Impacts and Mitigation – Operational Noise

4.1 Noise model Overview

A three-dimensional noise model of the proposed wind farm site was created in SoundPLAN Version 7.0 environmental noise modelling software. Environmental noise predictions were carried out using CONCAWE[6] algorithms, as implemented in the SoundPLAN software. SoundPLAN is a modelling package that has been used in Queensland for numerous other infrastructure developments and is accepted and endorsed by the Queensland DEHP and South Australia EPA.

4.1.1 Model inputs

The noise model includes the following inputs:

The noise model included the following inputs:

- Topographical ground contours for the wind farm site and surrounding area, received from AGL on 7 December 2010
- Proposed wind turbine locations for the site, received from AGL on 7 December 2010
- Noise data for a Vestas V112 wind turbine with hub height of 84 metres above ground level
- An assumed receiver height of 1.8m above ground level
- Receiver locations, determined from aerial photograph and cadastral data overlaid on the ground contours

The following assumptions were made

- soft, absorptive ground (ground attenuation factor of 1.0) for the terrain around the wind farm site. It is noted that the Wind Farms Environmental Noise Guidelines recommends ISO9613 with fully hard ground as a modelling methodology, however it has been found that utilizing the CONCAWE methodology with fully soft ground generally provides more conservative results (i.e. forecasts higher noise levels) than the ISO9613 and hard ground methodology
- worst-case meteorological conditions were assumed (CONCAWE Weather Category 6)
- temperature of 10°C and humidity of 80% as recommended in the Wind Farms Environmental Noise Guidelines

The modelling methodology has previously been used at other wind farm sites in Australia and has been validated through noise measurements[7].

The wind turbine and receiver locations are included in Appendix E.

Table 13 outlines the sound power levels at various wind speeds as provided by the manufacturer. Table 14 presents the octave band sound power level used for the environmental noise modelling. It is noted that these sound power levels will become guaranteed sound power levels as part of an agreement between the developer and supplier once a turbine manufacturer and type has been selected.

Table 13 - Sound power level of Vestas 112 3.0 MW turbines at various wind speeds (at hub height)

Wind Speed (Hub Height)	Sound Power Level - dB(A)
4.3	95.0
5.7	97.7
7.2	102.5

[6] CONCAWE Report 4/81. "The propagation of noise from petroleum and petrochemical complexes to neighbouring communities". This is a noise propagation model for the prediction of industrial noise recommended by the South Australian Wind Farms Environmental Noise Guidelines.

[7] Evans, T and Cooper, J "Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms" Paper Number 30, Proceedings of Acoustics 2011.

Wind Speed (Hub Height)	Sound Power Level - dB(A)
8.6	105.7
10 and above	106.5

Table 14: Octave band sound power level used for noise modelling.

Wind speed, m/s	Sound power level in dB(A) at octave band centre frequency in Hz								Overall, dB(A)
84 m AGL	31.5	63	125	250	500	1k	2k	4k	8k	
10	74.2	85.8	94.8	101.5	102.1	98.5	94.5	89.7	84.9	106.5

The noise from a modern wind turbine is primarily controlled by the speed that the blades are moving, with the angle of attack of the blades also altering the noise level. Control systems in the wind turbine control both the speed of the blades as well as the angle of attack (often referred to as 'feathering'). Faster moving blades create more noise, and high angles of attack create more turbulence and more noise. As the wind speed increases beyond the cut-in speed, the speed of blades also increases, up to the point that the turbine reaches maximum speed and rated power. Wind turbines blades do not turn faster above rated power so there is no further increase in noise. Furthermore, modern wind turbines alter the angle of attack of their blades to prevent blade stall which minimises noise from turbulence. Accordingly the noise modelling has used the sound power data provided for wind speed of 10 m/s at hub height.

Turbine manufactures enter into agreements to supply turbines for a wind farm development. These agreements typically contain guaranteed sound power levels over a range of wind speeds, including above 10m/s.

4.2 Predicted noise levels

A noise-compliant wind turbine layout was generated using the modelling software and the proposed turbine locations provided by AGL. This resulted in the wind turbine layout 'Rev AA', which informed the CID corridor, and is the basis of this CID application. Any alterations to this 'Rev AA' layout within the CID corridor must be tested for noise compliance (and compliance with other criteria such as Shadow Flicker) prior to detailed design and construction.

Appendix F presents the predicted noise levels at the residential receivers adjacent to the Coopers Gap Wind Farm for various hub height wind speeds for the 'Rev AA' wind turbine layout. The results indicate that the noise levels due to the proposed wind farm will comply with the relevant criteria at each sensitive location for all operational wind speeds. These predicted noise levels are also illustrated in Map 14.2. The noise modelling is undertaken for 'worst case' conditions, which occur when the wind blows from the turbines towards each residence. Noise levels will be lower at the residences when the wind blows upwind, or at cross winds, from the residence.

The forecast noise level for a variety of wind speeds has been compared with both the measured background noise level and associated criteria for some monitoring locations. These plots are contained in Appendix G..

It should be noted that for the CID process, a corridor for the construction and operation of the wind farm has been nominated. The final make and model of the wind turbine used at the site will be determined through a procurement process. Whilst wind turbine sound power levels and locations are not forecast to significantly change within this corridor, the final turbine layout will be modelled prior to construction commencing to ensure that compliance with the environmental noise criteria will be achieved. Additionally, compliance noise measurements will be undertaken at a number of the sensitive receivers adjacent the site at completion of the project, to demonstrate that compliance with the relevant criteria is achieved.

4.3 Predicted noise levels – Conservation Park

The Bunya Mountains Conservation Park boundary is approximately 3.5kms from the nearest turbine, to the South East of the project site. The forecast noise level at the boundary of the Bunya Mountains Conservation

DRAFT

D R A F T

Park is 25 dB(A). This forecast noise level complies with the project criterion for Conservation Estates of 35 dB(A) at all periods.

4.4 Wind Frequency Analysis

The predictions discussed in Section 4.2 are typical worst case results, which represents the forecast noise level when the wind is blowing from the nearest wind turbine towards each receiver. Such a situation will only occur for a certain percentage of time. The noise from the wind turbines will be reduced under different wind conditions, e.g. with wind blowing perpendicular to the line in between the nearest turbine and receiver, or the wind blowing from the receiver towards the nearest turbine. Analysis was undertaken to determine the frequency of occurrence for various noise levels from the wind farm at each sensitive receiver. Long-term meteorological data was obtained from the meteorological masts on site to provide an indication of the typical distribution of wind speed and direction at the project site. A combination of financial and non-financial locations was reviewed.

From the analysis it was found that the worst-case forecast noise level does not occur consistently due to varying wind speed and direction in the area. For the sites analysed, it was found that the worst case forecast noise level will occur anywhere between 15% and 50% of the night-time period (10pm – 7am), with an occurrence of less than 35% for 8 of the 11 sites analysed. Appendix H contains this information for a selection of receivers.

4.5 Predicted low frequency noise levels

Low frequency noise emission was forecast based on previous wind farm noise measurements for the purposes of determining compliance. Previous turbine sound power measurements and wind farm compliance measurements were used to determine both the forecast dB(C) level of the wind farm noise external to the residence.

This assessment indicated that for similar turbine types and sizes, the low frequency noise content is such that where noise emission complies with the base criterion of 40 dB(A) at nearby residential receivers, it will also comply with the low frequency project criterion of 60 dB(C). Therefore the proposed layout is forecast to comply with the low frequency project criterion of 60 dB(C) outside nearby residential receivers.

4.6 Comparison with other low frequency noise sources

The forecast worst case low frequency noise level from the wind farm operation has also been compared to the measured low frequency noise levels of other industrial sites within Queensland to provide some context to the predicted levels. Figure 2 outlines a comparison between the forecast wind farm low frequency spectrum and the measured low frequency noise levels of other industrial sites within Queensland. Measurements of the Coal Seam Gas (CSG) operations were not available at large distances from the source so closer range measurements were reduced to 35 dB(A) based on geometrical spreading.

DRAFT

D R A F T

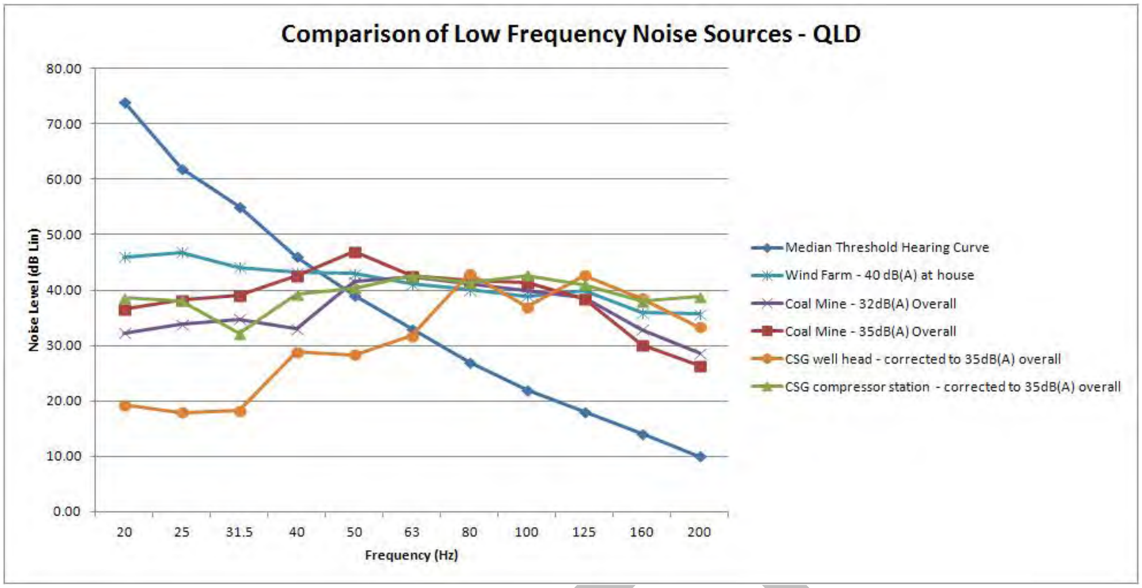


Figure 2 - Comparison of forecast wind farm low frequency noise with other industrial sources in Queensland

It was found that the for an overall noise level of 40 dB(A), the likely spectrum of noise arising from the proposed wind farm will be similar to that of other industrial sites within Queensland at low frequencies. Based on this comparison, wind farms are not likely to have a greater low frequency impact than other industrial sources in Queensland.

4.7 Predicted infrasound noise levels

The turbines proposed for Coopers Gap are upwind turbines, in that the turbine blades face into the wind. A range of studies of upwind turbines have been conducted and it has been found that they do not generate significant levels of infrasound. One such study was conducted by consultancy Sonus[8]. They measured infrasound levels of less than 63 dB(G) at 200 metres from an upwind turbine. This is well below the criterion of 85 dB(G), indicating that infrasound noise is likely to comply with the recommended criteria at any distance beyond 200 metres from the turbines. The study also undertook infrasound noise measurements of other natural and manmade sources, which has been replicated in Figure 3. It found that natural sources such as ocean waves and man-made sources such as a power station emit similar levels of infrasound to a wind farm.

DRAFT

[8] Sonus Pty Ltd *Infrasound Measurements from Wind Farms and Other Sources* November 2010

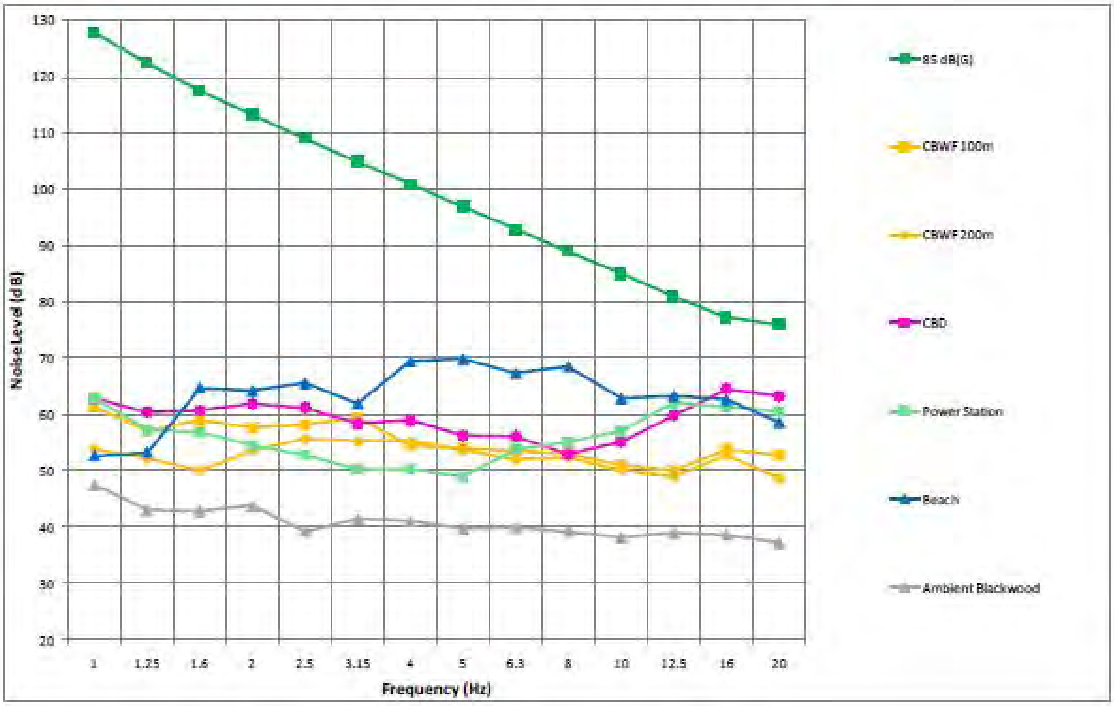


Figure 3 - Comparison between wind farm and natural and manmade sources of infrasound (Source: Sonus)

DRAFT

The proposed turbines at Coopers Gap will be upwind turbines, accordingly it is forecast that the relevant infrasound criteria will not be exceeded at any dwelling surrounding the Coopers Gap wind farm.

4.8 Amplitude Modulation

Amplitude modulation refers to a regular or cyclic variation in noise level or pitch. Significant levels of amplitude modulation are not expected under normal operation of the wind farm. The Draft National Wind Farm Development Guidelines state that:

...modulation may only be evident when the operation of multiple turbines causes a periodic variation in level due (to) synchronous operation of some of the turbines and remedial actions (such as varying operational speeds to avoid synchronous operation of turbines) would be directed to eliminate such effects.

Should amplitude modulation be detected upon commissioning, the wind farm operator would be required to alter the operating speeds of some turbines to remove this effect.

4.9 Determining Compliance

The SA 2009 Guidelines require that the $L_{A90,10min}$ noise level is measured over the range of wind speeds from cut-in speed to the speed of the rated power of the turbines. The data is to cover at least 2000 intervals, with at least 500 pairs of data corresponding to the worst case wind direction. Where available, previous background noise measurements (noise measurements without the presence of the wind farm) are used to determine the contribution that the general background noise may have made to the measured levels. The resultant $L_{A90,}$ noise level is then compared to the noise criteria for all wind speeds measured.

The worst case wind direction is defined as wind directions within 45° downwind of the nearest wind turbine to the measurement site. The compliance assessment is based on only the data measured under the worst case wind direction – all data from other directions is excluded from the compliance assessment as noise from these directions is expected to be less than that from the worst case direction. Where a sensitive receiver is located with wind turbines from multiple directions e.g. two or more turbines are located at similar distances from the receiver but in different directions, then a separate analysis is to be undertaken to determine compliance in both

D R A F T

‘worst case’ directions. A polynomial regression analysis is undertaken to determine the measured wind turbine noise level, with correction for the previously measured background noise data applied if required.

Compliance measurements should be undertaken at a selected number of the potentially most affected sensitive receivers following the commissioning of the wind farm. Monitoring should be performed in accordance with the SA2009 Guidelines. Testing should be undertaken once all noise sources associated with the wind farm are in operating mode, i.e. all turbines have been commissioned and are operating correctly.

DRAFT

D R A F T

5.0 Potential Impacts and Mitigation: Construction Noise and Vibration

5.1 Construction Impact Assessment

AECOM has conducted a general assessment of construction noise and vibration related to the construction of the Coopers Gap wind farm. A more detailed construction noise and vibration assessment may be required by the contractor when construction methods are finalised.

5.2 Construction Activities

This report addresses construction noise and vibration in general terms. Specific details of the construction methodology and equipment are not known at this early stage of the project.

It is anticipated that the construction work may include excavation, rock hammering, drilling and bulldozing. Noise will be generated by mobile plant such as excavators, bulldozers, mobile cranes and semi-trailers delivering or removing material from construction sites. It is expected that the following typical equipment will be used:

- Excavators
- Tracked bulldozers
- Semi-trailers
- Tractors
- Mobile cranes; and
- Concrete trucks.

It is recommended that construction plant be selected on the basis of low noise emission. Noise emissions from construction plant can be reduced by fitting exhaust mufflers, using reversing alarms that emit a broadband noise (e.g. white noise) rather than a beep, maintaining plant in good working order and following best practice construction methodologies. A Construction Environment Management Plan (CEMP) should be developed to manage possible noise and vibration impacts from construction.

5.3 Construction Phase Noise Criteria

There is no legislation in Queensland that specifically sets construction noise limits. For construction activity in Queensland, the Environmental Protection Act 1994 states that:

"A person must not carry out building work in a way that makes an audible noise –

(a) On a business day or Saturday, before 6:30am or after 6:30pm; or

(b) On any other day, at any time."

Thus noise from construction activity is generally controlled through limiting the hours of operation, and through application of best practice management techniques.

A number of 'good practice' mitigation measures have been outlined in Section 5.5 to reduce noise and vibration impacts associated with construction of the wind farm and to minimise the likelihood of adverse comment from nearby residents. Construction outside of the hours listed above typically requires permission from a governing authority (e.g. DERM) and advance warning to nearby locations.

The CEMP should outline the recommended hours of work and mitigation measures to be implemented.

DRAFT

5.4 Construction Vibration Guidelines

Human Response to Vibration

To assess perceptible vibration to humans, AECOM recommends the use of vibration criteria from the Australian Standard AS 2670.2 - 1990 *Evaluation of human exposure to whole-body vibration - Part 2: Continuous and shock induced vibration in buildings (1 to 80Hz).*

These criteria are summarised in Table 15. Both continuous and intermittent vibrations are assessed. Earthmoving construction equipment will typically operate between 6:30am and 6:30pm, Monday to Saturday. Accordingly only daytime criteria have been shown. Where out of hours construction is proposed, consultation with surrounding residences will need to be undertaken.

Table 15: AS2670 Extract - Human Comfort Vibration Limits (8Hz to 80Hz)

Space Occupancy	Time of Day	Peak Vibration Levels in mm/s over the frequency range 8 Hz to 80Hz likely to cause "adverse comment"			
		Continuous Vibration		Intermittent Vibration and Impulsive Vibration excitation with several occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Residential	Day	0.6 mm/s	1.6 mm/s	12.6 mm/s	36 mm/s
Workshops	Day	1.2 mm/s	3.2 mm/s	18 mm/s	51 mm/s

Structural Response to Vibration

International standards exist for vibration-induced damage to structures and can provide guidance on acceptable limits. These documents are commonly used to assess structural response to vibration throughout Australia.

The German standard DIN 4150 Part 3, and British Standards BS 5228 Part 4 and BS 7385 Part 2 recommend vibration criteria relating to structural damage of buildings. These standards are considered to be best practice in Australia. The criteria from the standards are summarised in Table 16 and Table 17.

Table 16: DIN 4150 Vibration Criteria, in PPV (mm/s)

Line	Structure Type	Guideline vibration values			
		Vibration at foundation			
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	Vibration at horizontal plane of highest floor at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design or occupancy	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 or 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

Table 17: BS 5228-4 Criteria, in PPV (mm/s)

Structure	Intermittent			Continuous		
	<10 Hz	10-50 Hz	> 50 Hz	<10 Hz	10-50 Hz	> 50 Hz

DRAFT

Structure	Intermittent			Continuous		
	<10 Hz	10-50 Hz	> 50 Hz	<10 Hz	10-50 Hz	> 50 Hz
Soundly constructed residential properties	5	10	20	2.5	5	10
Industrial and commercial – light	10	20	40	5	10	20
Industrial and commercial – heavy	15	30	60	7.5	15	30

The criteria in BS 5228-4 are generally more stringent than those in DIN 4150. It is recommended that the project adopts an objective of complying with the intermittent vibration levels specified in BS 5228-4 (i.e. Table 17), with the levels specified in DIN 4150 (i.e. Table 16) as an upper limit.

Recommended vibration criteria are discussed in Section 5.4. The BS 5228-4 criteria for intermittent vibration in "Soundly constructed residential properties" apply to the construction area and will be used as the construction vibration guideline for this project.

Table 18: BS 5228-4 Criteria, in PPV (mm/s)

Structure	Intermittent		
	<10 Hz	10-50 Hz	> 50 Hz
Soundly constructed residential properties	5	10	20

DRAFT

A summary of the vibration criterion in relation to human comfort is given below in Table 19.

Table 19: Vibration criteria for human comfort

Space Occupancy	Time of Day	Peak Vibration Levels in mm/s over the frequency range 8 Hz to 80Hz likely to cause "adverse comment"			
		Continuous Vibration		Intermittent Vibration and Impulsive Vibration excitation with several occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Residential	Day	0.6 mm/s	1.6 mm/s	12.6 mm/s	36 mm/s
Workshops	Day	1.2 mm/s	3.2 mm/s	18 mm/s	51 mm/s

5.5 Proposed Mitigation Options: Construction Noise and Vibration

It is noted that there exists the potential for noise impacts to surrounding residents during the construction of the Coopers Gap Wind Farm. Appropriate techniques need to be implemented to minimise these impacts. The CEMP will outline these measures.

Noise Mitigation Measures

To minimize the impacts of construction noise the EPC Contractor shall prepare a Construction Noise and Vibration Management Plan which outlines the proposed methodology and monitoring procedures to be put in place for the duration of the works, incorporating the following issues as a minimum:

- Community Noise Consultation
  - Regular consultation with noise sensitive receivers to provide details of the construction plan and duration of predicted construction noise. For example advising noise sensitive receivers of the duration and activities they can expect (e.g. which turbine locations in their vicinity are having the concrete pads laid, expected time until the construction crews will return to commence installing towers, etc.)
  - Advanced notice of road works
  - Advise local councils of planned construction works to assist in complaint management

- Preparation of a noise complaints procedure and register; and
- Letterbox drops.

- Site Management – the following recommendations are provided to minimise construction noise levels and manage the impact of construction noise from the project:
  - Limit construction hours to Monday to Saturday, 6.30am to 6.30pm, where it is practicable to do so. Construction activities undertaken outside of these hours are to be minimised, particularly those that are likely to have some noise impact such as earthworks activities
  - The contractor should keep residents informed of when any noisy construction works will occur
  - Where practicable, upgrade local roads both before and after the construction of the wind farm to minimise the effect of heavy vehicle movements
  - Selection and location of site access roads as far away from noise-sensitive receptors as possible. The contractor shall work closely with landowners who are affected by site roads and ensure minimal disruption to their operations
  - Careful selection of the main site office and turbine component stockpile to minimize disruption to sensitive receivers
  - Vehicles and plant should not be left idling unnecessarily
  - All engine exhausts should be fitted with suitable and well maintained mufflers / silencers
  - Any noisy fixed plant should be located in a suitable acoustic enclosure away from residential locations
  - Care should be taken not to drop materials to cause peak noise events, including materials from a height into a truck
  - Machines that are used intermittently should be shut down in the intervening periods between works, or throttled down to a minimum
  - It is noted that the construction of the wind farm will involve progressively moving through the area as various construction activities are undertaken. Regularly moving particularly noisy pieces of equipment through the area during construction where practical can reduce the noise impact duration on surrounding residences
  - The reversing of vehicles should be minimised to reduce the noise from reversing signals
  - Truck operators should ensure that tailgates are cleared and locked at the point of unloading
  - Vehicle warning devices such as horns should not be used as signalling devices
  - Worksite induction training should be implemented, educating staff on noise sensitive issues and the need to make as little noise as possible
  - Workers should avoid shouting and whistling; and
  - When work is complete, the noise of packing up plant and equipment and departing from the site should be minimised.

- Equipment management – equipment management should include the following:
  - Selection of low noise plant and equipment
  - Equipment should be well maintained and fitted with adequately maintained silencers which meet the design specifications
  - Silencers and enclosures should be kept intact, rotating plants should be balanced, loose bolts tightened, frictional noise reduced through lubrication and cutting noise reduced by keeping equipment sharp
  - Only necessary power should be used to complete the task
  - Only necessary equipment should be on site
  - Loaders and bobcats fitted with articulated buckets should be rubber lined at the contact points to ensure that noise levels are minimised during the release of materials, where practicable

DRAFT

D R A F T

- Resonance should be avoided where possible e.g. changing the speed of machines; and
- Traffic practice controllers should be used to prevent vehicles and equipment queuing, idling or reversing near noise sensitive receivers.

- Noise Monitoring – monitoring of construction noise levels should be undertaken in response to complaints where this is considered an appropriate response. Noise measurements are to be conducted in accordance with the requirements of the DERM *Noise Measurement Manual* or other equivalent guideline.
- Vibration Mitigation Measures – based on typical levels of vibration from construction activities, it is expected that dwelling occupants at distances of 200 metres and greater from the works area would not be able to perceive construction vibration; much less the buildings themselves experience vibration levels resulting in damage. Where adverse comment specifically arising from vibration is received after the commencement of construction it is recommended that the following measures be considered:
  - Vibration levels be measured
  - If high levels are recorded:
    - Increasing the distance between offending plant equipment
    - Replacing offending plant equipment with equipment that does not produce large levels of vibration
    - Building structure surveys

DRAFT

DRAFT

6.0 Conclusion

In the absence of specific legislation in Queensland, the South Australia Wind Farm guidelines have been used and are considered to be consistent with QLD guidelines and legislation for other industrial noise as well as guidelines used for the assessment of wind farms in other states of Australia. A review of low frequency and infrasound criteria applied to other industry was also undertaken and appropriate criteria have been recommended.

The operational noise criteria assessed for this study are listed below in Table 20.

Table 20: Summary of Noise Criteria

Description	Descriptor	Criterion
Residential Owner (or leasee)	$L_{Aeq,10}$, dB(A)	40 or background noise ($L_{A90,10}$) + 5, whichever is greater
Residential Owner and Stakeholder	$L_{Aeq,10}$, dB(A)	45 or background noise ($L_{A90,10}$) + 5, whichever is greater
All residential owners	-	Emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority: 60 dB(C) measured outside the sensitive receptor; and The difference between the internal A-weighted and C-weighted noise levels is no greater than 20 dB; or 50 dB(Z) measured inside the sensitive receptor; and The difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.
All residential owners	L_{pG} dB(G)	85
Conservation Estates	$L_{Aeq,10}$, dB(A)	35

DRAFT

The criteria above are considered to be objectives that would protect the environmental values from significant noise and vibration impacts. Accordingly it is proposed that the criteria above be used to condition the proposed development.

An environmental noise model of the site was created to predict noise levels at the nearest sensitive receiver locations. A noise-compliant wind turbine layout was generated for this CID application, and has formed the basis of the CID corridor. The predicted noise levels from the Coopers Gap Wind Farm were found to comply with the recommended noise criterion at each sensitive receiver, for all wind speeds. On this basis, the recommended 'noise-compliant' wind turbine layout can be considered to protect the existing environmental values in the area from impacts by noise and vibration from the Project.

Best practice construction techniques have also been recommended to reduce possible impacts during the construction of the wind farm. These are to be outlined in the CEMP. These techniques are considered to minimise environmental nuisance and harm from noise and vibration during construction.

This report has also described how the achievement of the objectives will be monitored, audited through outlining the requirements for post-commissioning measurement and reporting.

D R A F T

Appendix A

Acoustic Terminology

Appendix A Acoustic Terminology

'A' Weighted	Frequency filter applied to measured noise levels to represent how humans hear sounds.
Ambient Noise	Total noise at a site comprising all sources such as industry, traffic, domestic, and natural noises.
Attended Measurement	Measurements that are attended by a person and measured with a sound level meter.
dB(A)	'A' Weighted overall sound pressure level.
dB(G)	The G-weighting for the determination of weighted sound pressure levels of sound or noise, whose spectrum lies partly or wholly within the frequency range from 1 Hz to 20 Hz, has been standardised in ISO 7196, (1995). G-weighted sound pressure levels are denoted L_{pG} and are measured or estimated in dB(G)
Frequency	The number of cycles per second, where 1 cycle per second is equal to 1Hz. The human ear responds to sounds of frequency 20 Hz to 20,000 Hz.
Impulsiveness	Noise that comprises distinct impulses in the noise (bangs, clicks, clatters, or thumps) etc.
Intermittent	Stopping and starting at irregular intervals.
L_{Aeq}	The 'A' Weighted energy-averaged noise level over the measurement period.
$L_{Aeq,\ 1hour}$	The energy-averaged level of the total noise measured without adjustment for the character of the noise (e.g. tonal or impulsive), over a period of 1 hour.
$L_{Ar,\ 1hour}$	The noise level of the component of the total noise that can be specifically identified by acoustical means which is associated with the noise from mining operations and shall be measured with an adjustment for the character of the noise (tonal or impulsive) over a period of 1 hour.
L_{max}	Maximum noise level of the measurement period.
L_{10}	Noise level exceeded for 10% of the measurement period. The L_{10} represents the intrusive noise level and is often used to represent traffic/ music noise.
L_{90}	Noise level exceeded for 90% of the measurement period. This represents the background noise level excluding nearby sources.
$L_{w(A)}$	'A' Weighted sound power level, measured in dB(A). The sound power level is a measure of the total acoustic energy produced by a source and is independent of distance and source location. The sound power level is expressed as a ratio against a reference level of 10^{-12} watts.
Least-squares regression	The method for finding a line that summarizes the relationship between the two parameters, e.g. wind speed and measured noise level.
Tonality	A characteristic of noise, describing a sound that contains a perceptible pitch or tone. As a general rule, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5 dB or more.
Unattended Measurement	Measurements that are taken by a noise logger at a given location unattended.

DRAFT

D R A F T

Appendix B

Noise Monitoring Locations

Appendix B Noise Monitoring Locations

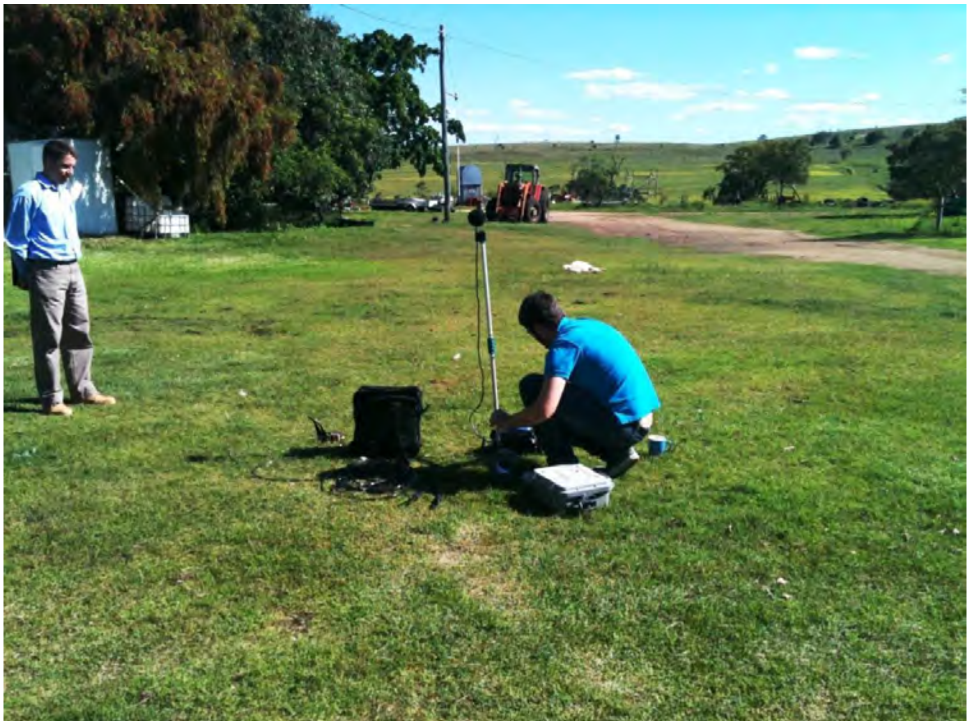


Figure 4: Location G

Figure 5: Location G

DRAFT

Figure 6: Location I

Figure 7: Location I

DRAFT

Figure 8: Location O

Figure 9: Location O

D R A F T

Figure 10: Location Y

Figure 11: Location Y

D R A F T

Figure 12: Location AD

Figure 13: Location AD

DRAFT

Figure 14: Location C

Figure 15: Location C

D R A F T

Figure 16: Location F

Figure 17: Location F

DRAFT

Figure 18: Location J

Figure 19: Location J

D R A F T

Figure 20: Location A

Figure 21: Location A

D R A F T

Figure 22: Location BD

Figure 23: Location BD

D R A F T

Figure 24 – Location AA

D R A F T

Figure 25 – Location AA

D R A F T

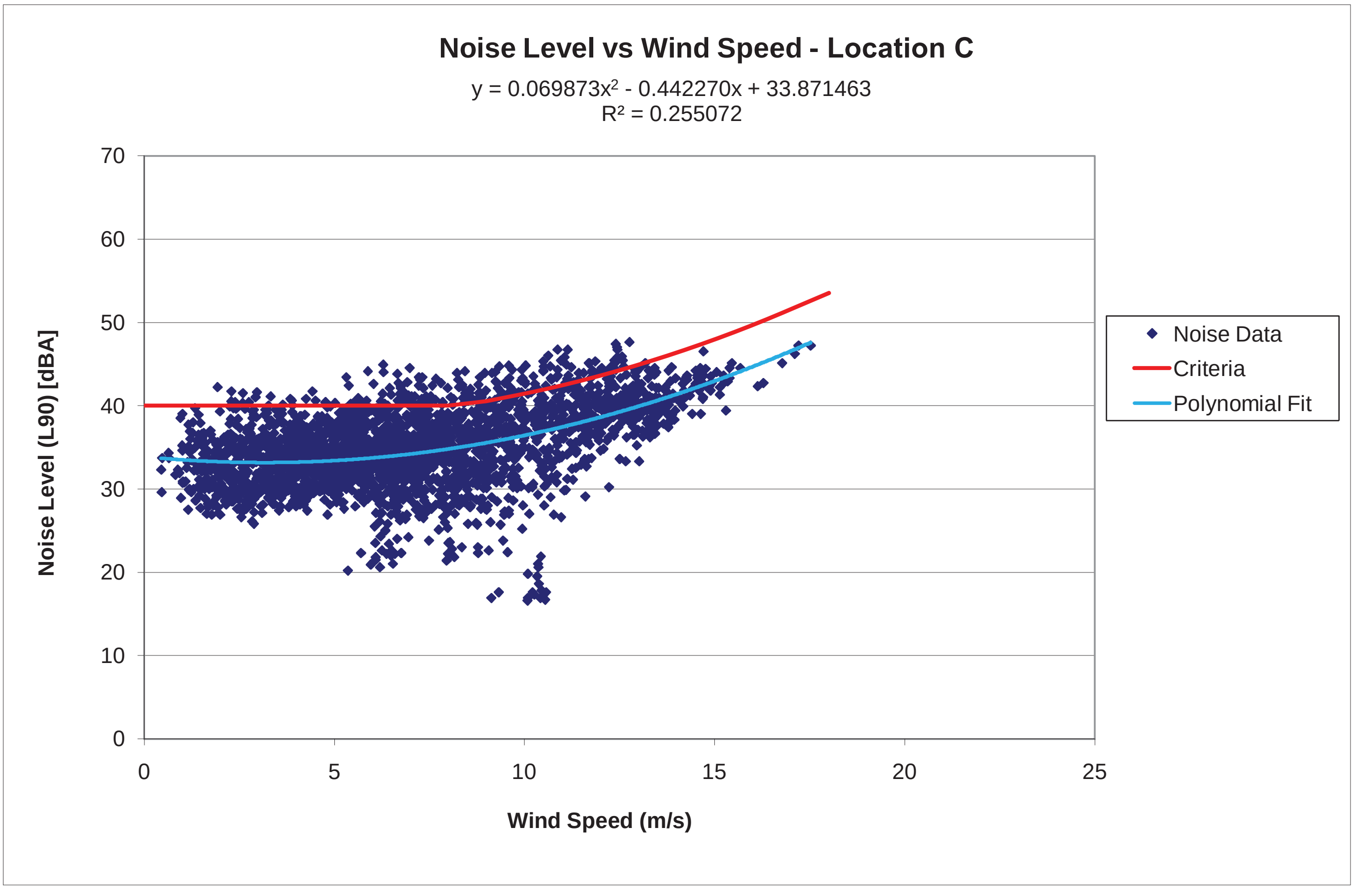
Figure 26 – Location CF

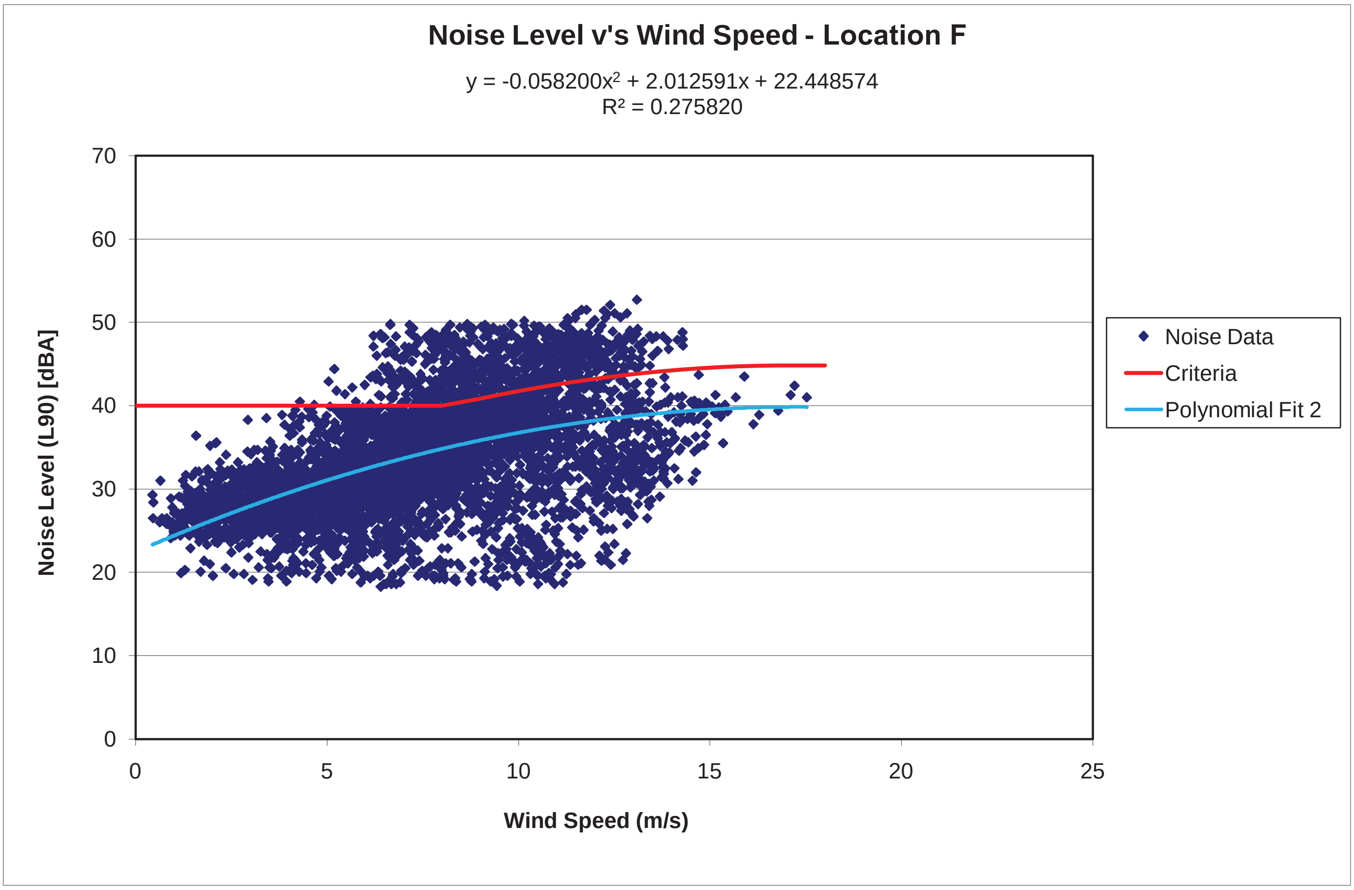
D R A F T

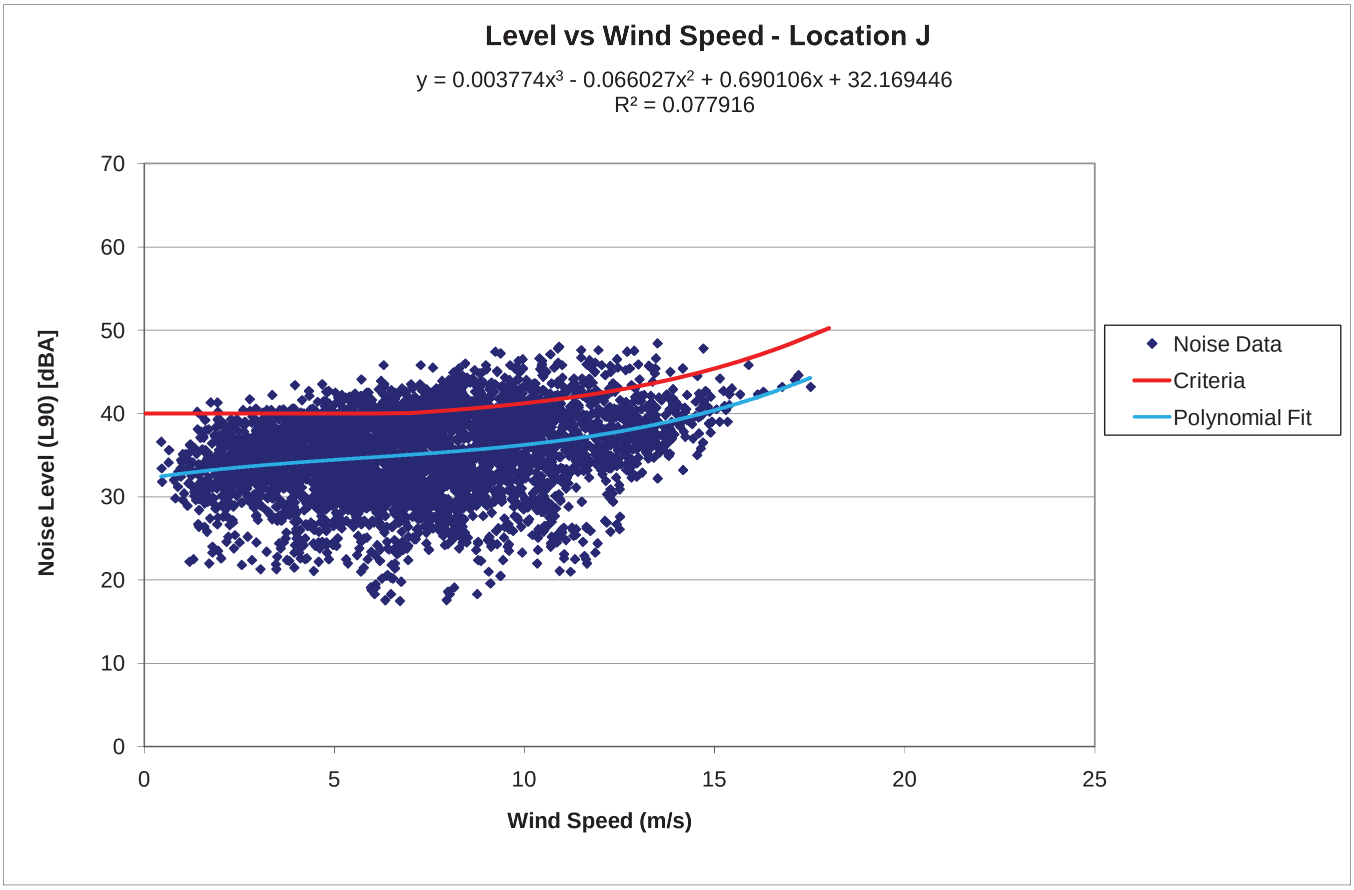
Figure 27 – Location CF

Appendix C

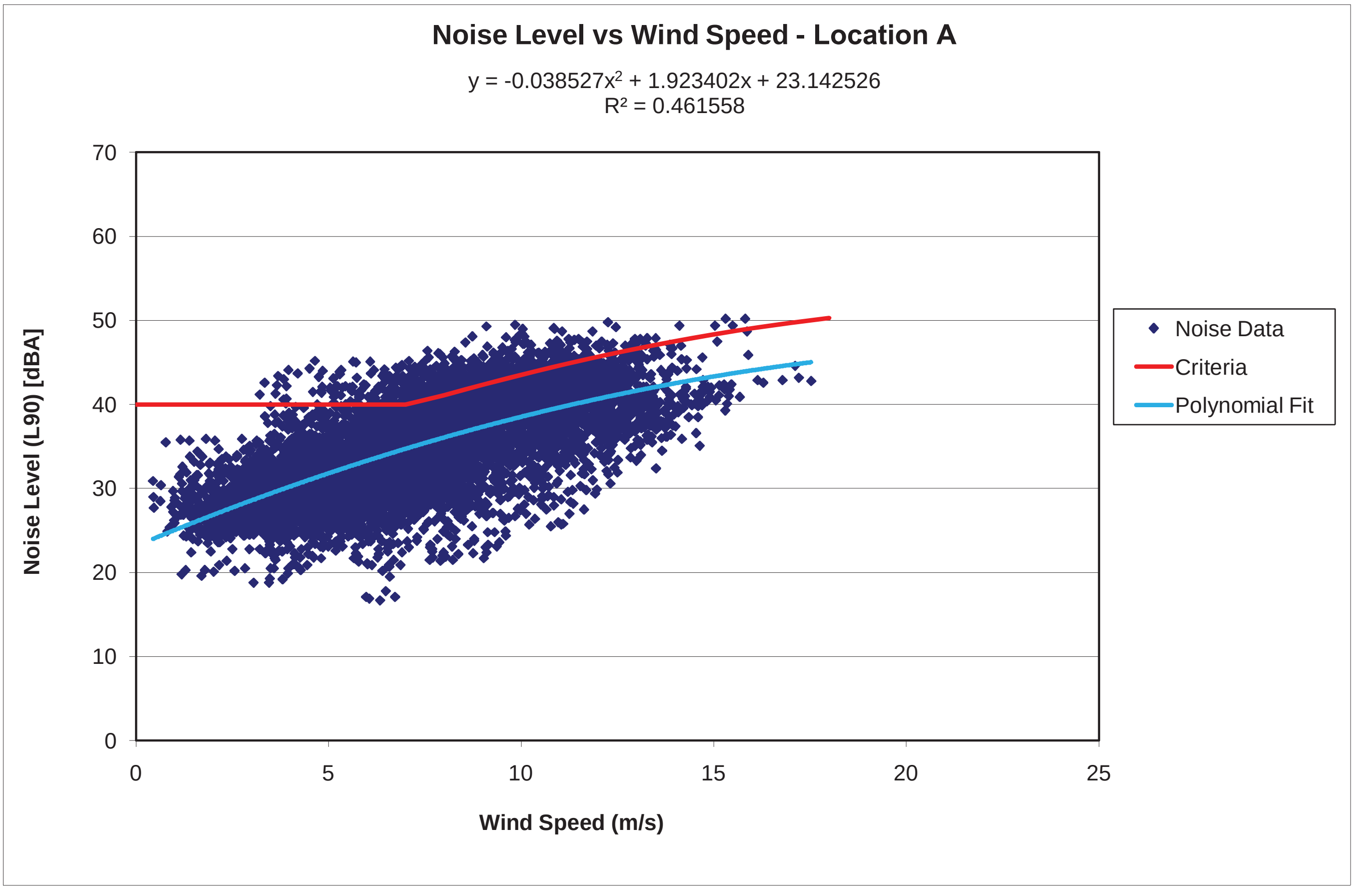
Noise Regression Curves


Noise Level vs Wind Speed - Location C
y = 0.069873x² - 0.442270x + 33.871463
R² = 0.255072
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit

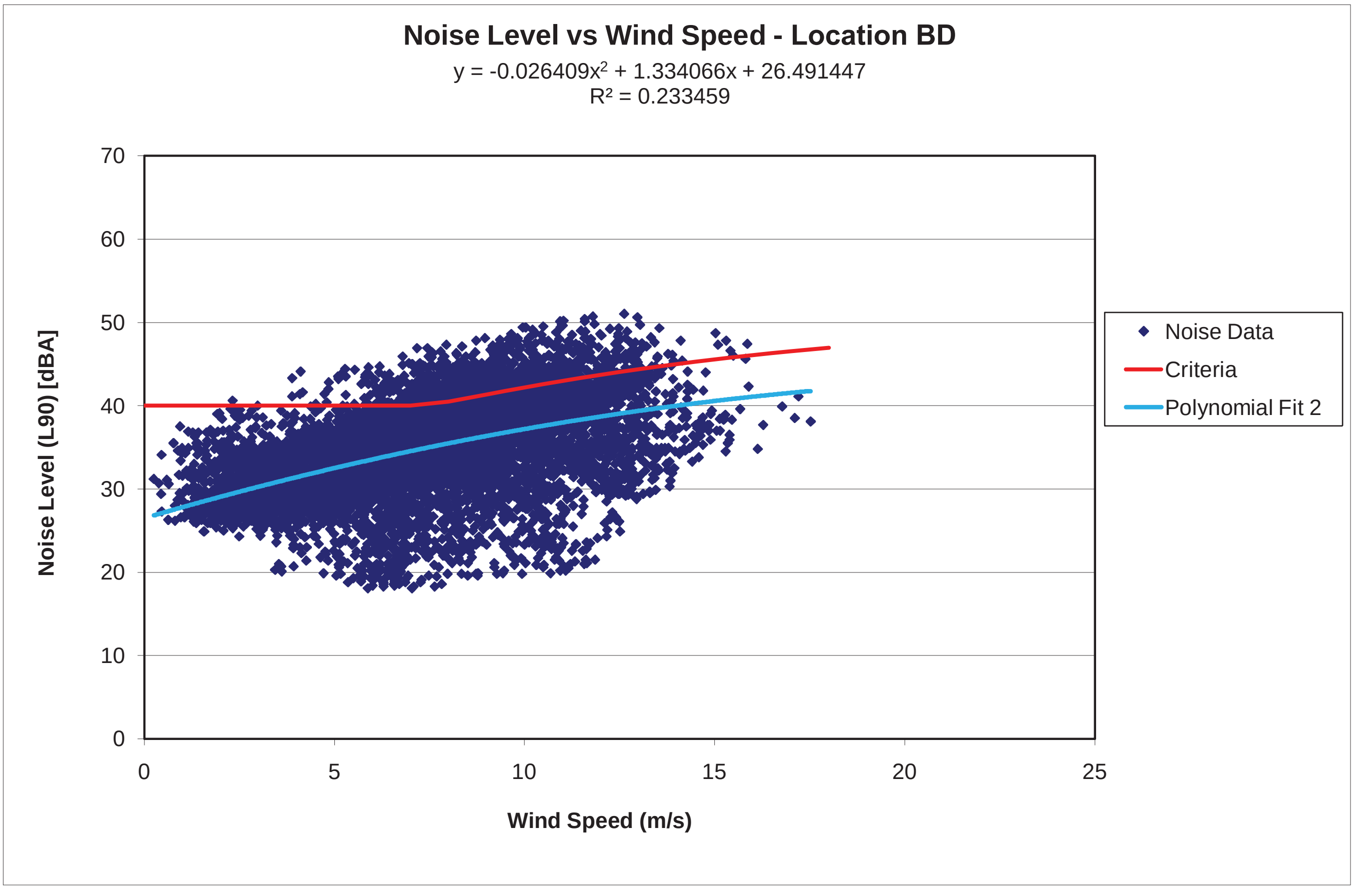

Noise Level v's Wind Speed - Location F
y = -0.058200x² + 2.012591x + 22.448574
R² = 0.275820
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit 2

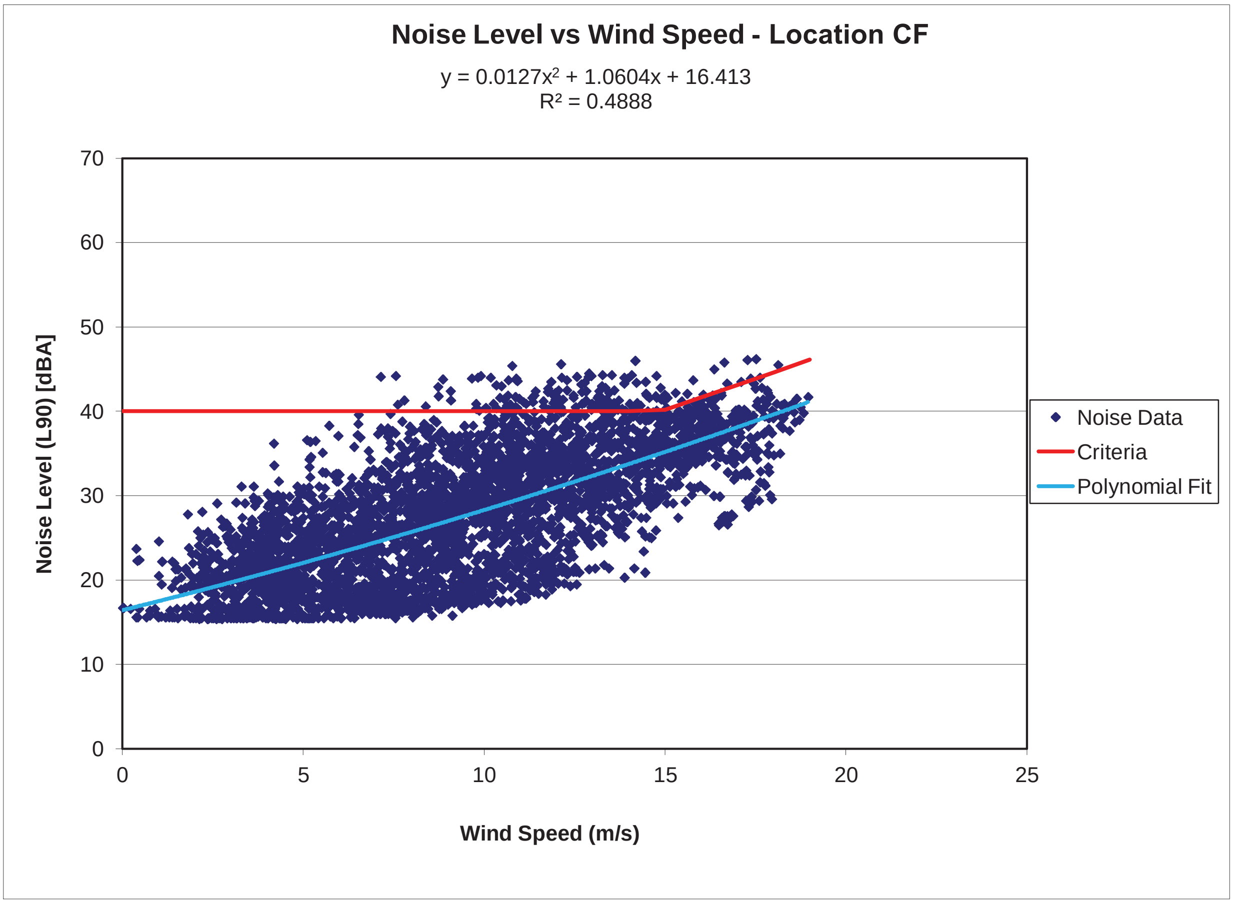


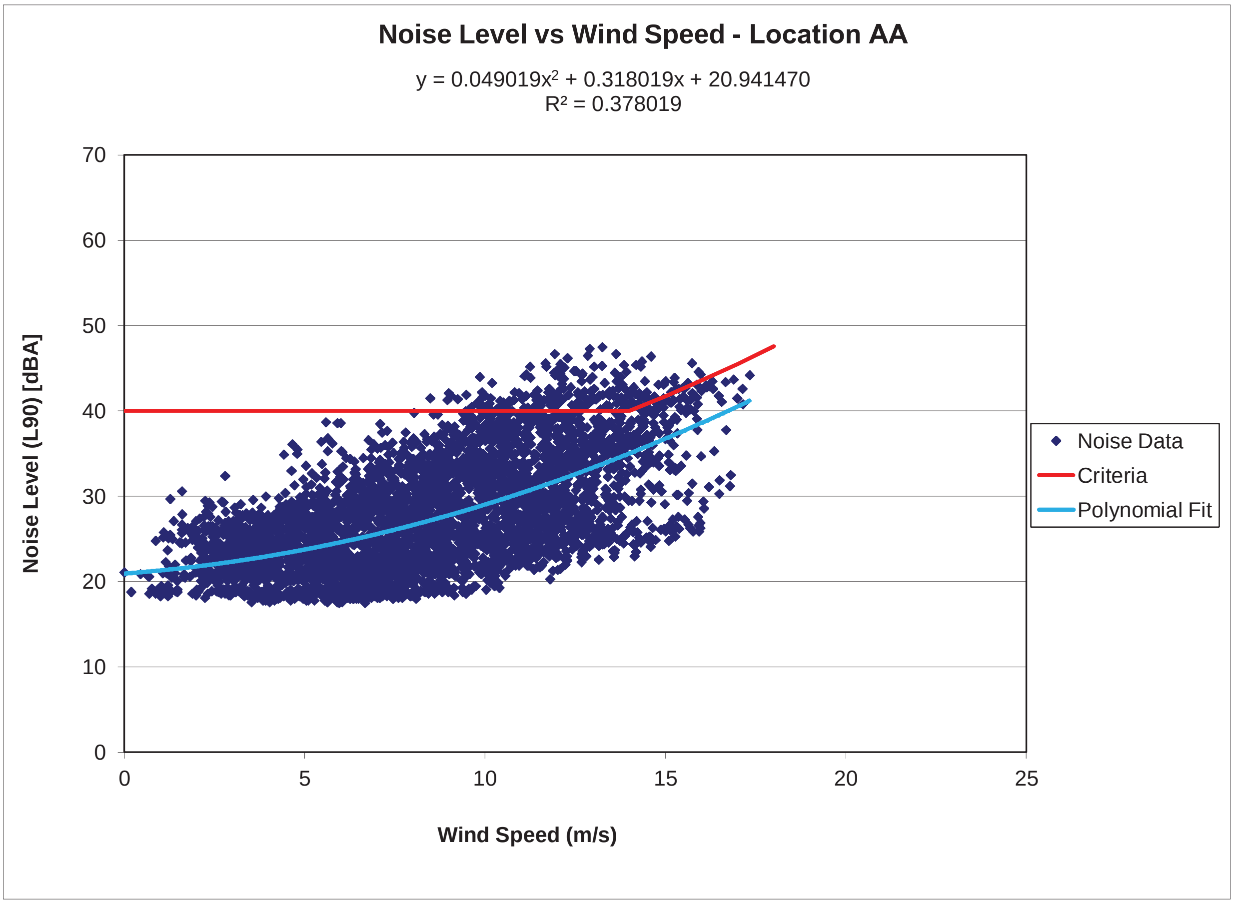
Level vs Wind Speed - Location J
y = 0.003774x³ - 0.066027x² + 0.690106x + 32.169446
R² = 0.077916
Noise Level (L90) [dBA]
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit



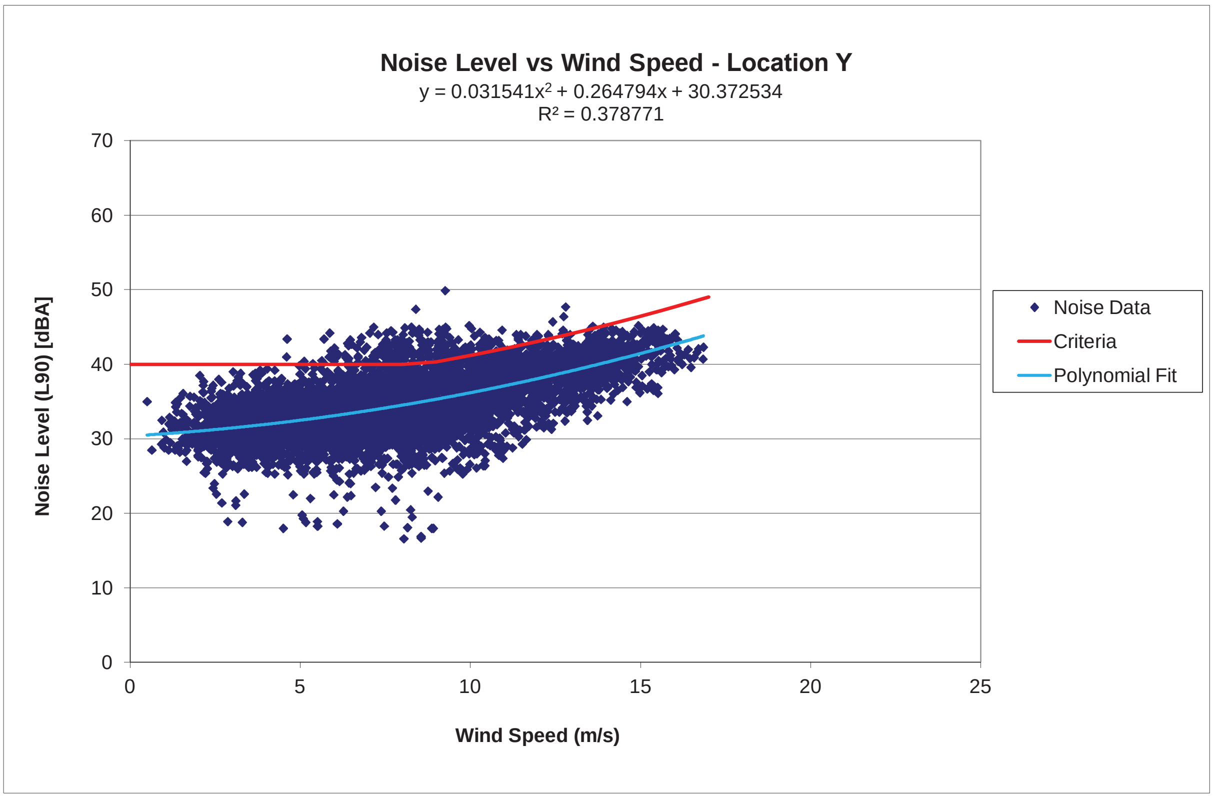
Noise Level vs Wind Speed - Location A
y = -0.038527x² + 1.923402x + 23.142526
R² = 0.461558
Noise Level (L90) [dBA]
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit


Noise Level vs Wind Speed - Location BD
y = -0.026409x² + 1.334066x + 26.491447
R² = 0.233459
Noise Level (L90) [dBA]
0
10
20
30
40
50
60
70
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit 2

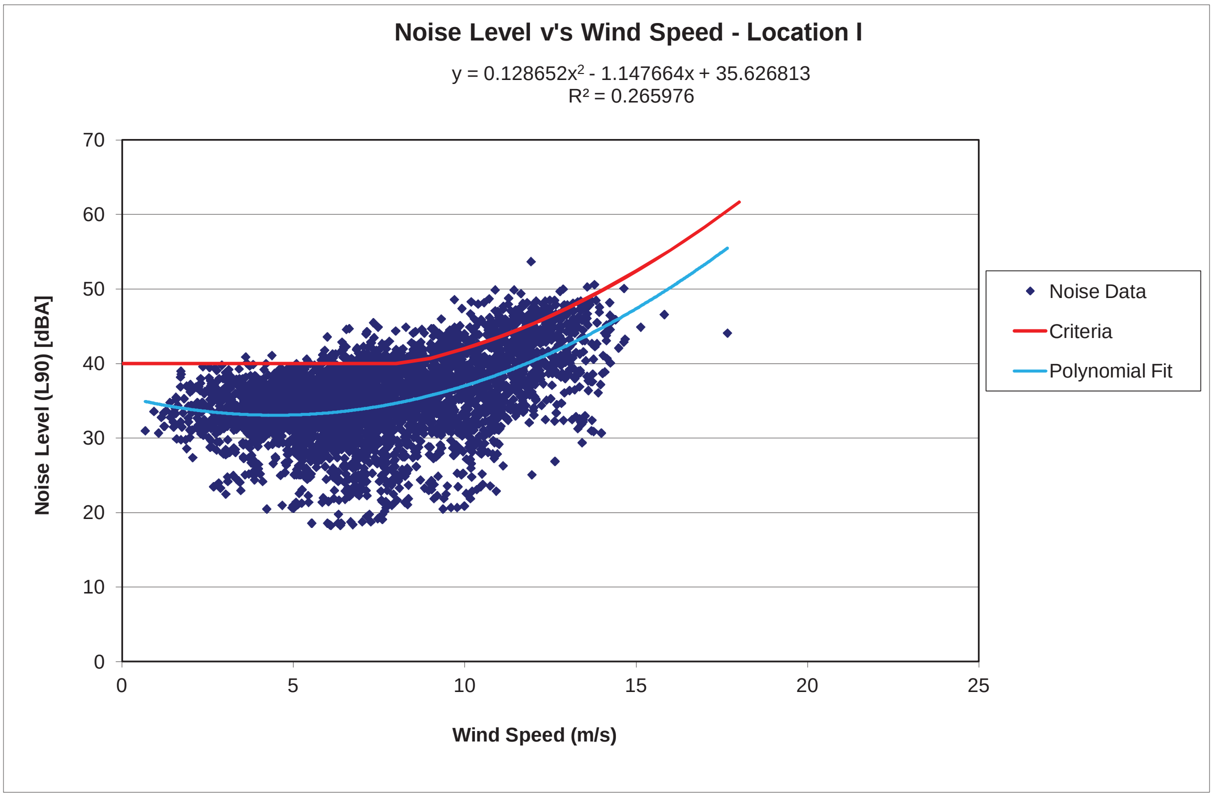

Noise Level vs Wind Speed - Location CF
y = 0.0127x² + 1.0604x + 16.413
R² = 0.4888
Noise Level (L90) [dBA]
0
10
20
30
40
50
60
70
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit

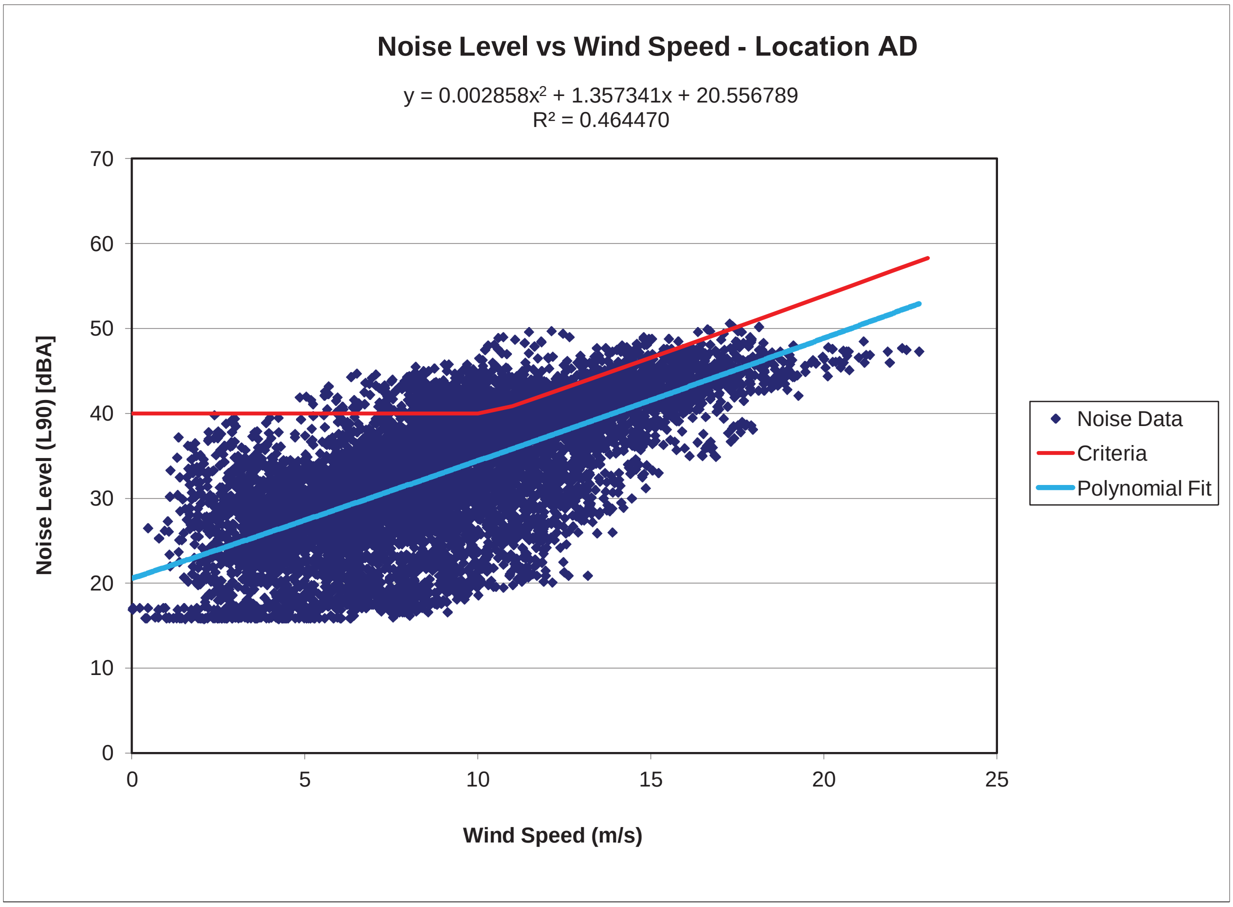


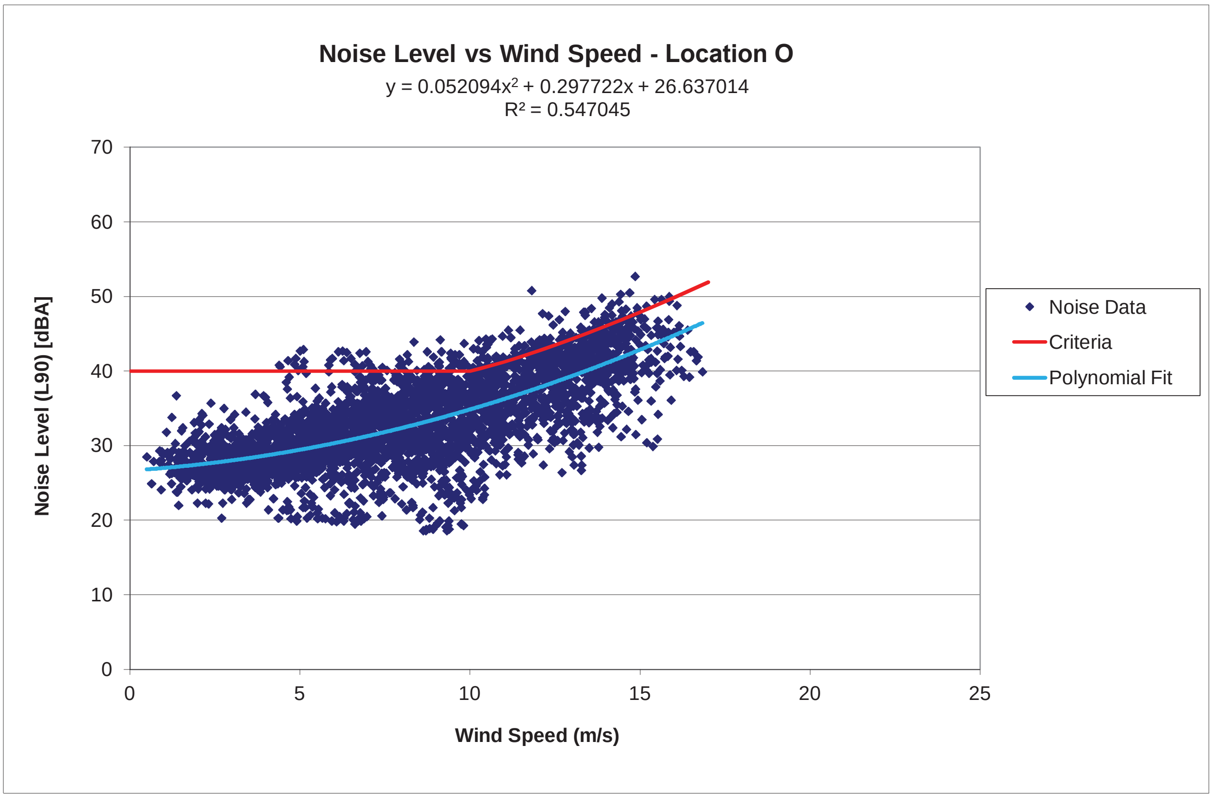
Noise Level vs Wind Speed - Location AA
y = 0.049019x² + 0.318019x + 20.941470
R² = 0.378019
Noise Level (L90) [dBA]
Wind Speed (m/s)
0
10
20
30
40
50
60
70
0
5
10
15
20
25
Noise Data
Criteria
Polynomial Fit

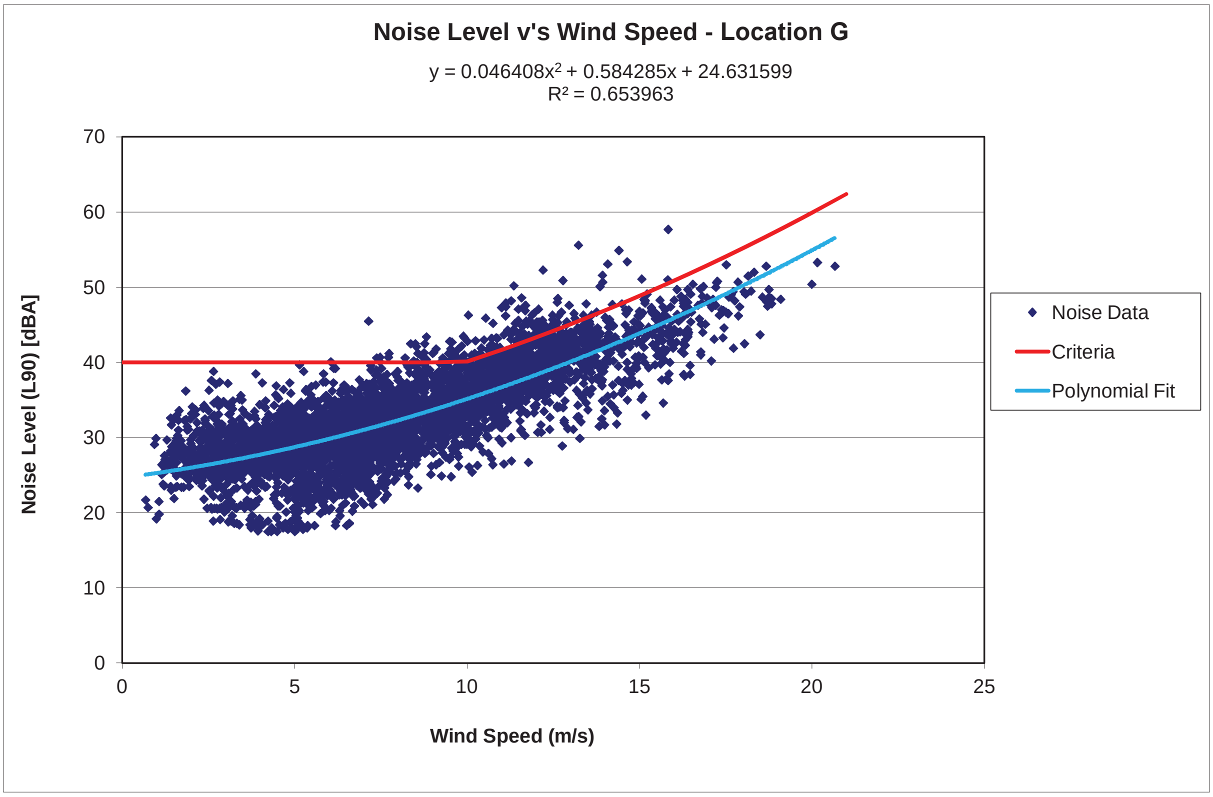


Noise Level vs Wind Speed - Location Y
y = 0.031541x² + 0.264794x + 30.372534
R² = 0.378771
Noise Level (L90) [dBA]
Wind Speed (m/s)
0
10
20
30
40
50
60
70
0
5
10
15
20
25
Noise Data
Criteria
Polynomial Fit


Noise Level v's Wind Speed - Location I
y = 0.128652x² - 1.147664x + 35.626813
R² = 0.265976
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit


Noise Level vs Wind Speed - Location AD
y = 0.002858x² + 1.357341x + 20.556789
R² = 0.464470
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit


Noise Level vs Wind Speed - Location O
y = 0.052094x2 + 0.297722x + 26.637014
R² = 0.547045
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit


Noise Level v's Wind Speed - Location G
y = 0.046408x2 + 0.584285x + 24.631599
R² = 0.653963
Noise Level (L90) [dBA]
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Wind Speed (m/s)
Noise Data
Criteria
Polynomial Fit

Appendix D

Calibration Certificates

Certificate Of Calibration

Certificate No.: **SLM 36777**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00276273
Microphone Type:	UC-52	**Serial No:**	112905
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: Noise Measurement Services Pty Ltd
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 996 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 41 %RH ±5% RH

Date of Calibration: 17/03/2009 **Issue Date:** 18/03/2009

Checked by: AH **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA World Recognised Accreditation
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37365**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00365350
Microphone Type:	UC-52	**Serial No:**	107753
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: Noise Measurement Services
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 1012 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 31 %RH ±5% RH

Date of Calibration: 26/02/2010 **Issue Date:** 26/02/2010

Acu-Vib Test Procedure: AVP05 (SLM)

Checked by: ... **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA World Recognised Accreditation
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

RION CO., LTD.

3-20-41 Higashimotomachi Kokubunji Tokyo 185-8533
Phone:042(359)7888, Facsimile:042(359)7442

Certificate of Calibration

Name	: Sound level meter		
Model	: NL-21	S/No. :	00598492
Microphone	: UC-52	S/No. :	125464
Preamplifier	: NH-21	S/No. :	30254
Date of Calibration	: May, 26, 2009		

We hereby certify that the above product was tested and calibrated according to the prescribed Rion procedures, and that it fulfills specification requirements.

The measuring equipment and reference devices used for testing and calibrating this unit are managed under the Rion traceability system and are traceable according to official Japanese standards and official standards of countries belonging to the International Committee of Weights and Measures.

RION CO., LTD.

N. Takeda

Manager, Quality Control Department

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 37424

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	01277353
Microphone Type:	UC-52	**Serial No:**	116930
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: Noise Measurement Services
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 1005 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 49 %RH ±5% RH

Date of Calibration: 22/03/2010 **Issue Date:** 22/03/2010

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: ...AH **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION

Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37848**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00676782
Microphone Type:	UC-52	**Serial No:**	114116
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: AECOM
540 Wickham Street
Fortitude Valley QLD 4006

Ambient Pressure: 1005 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 59 %RH ±5% RH
Date of Calibration: 21/10/2010 **Issue Date:** 22/10/2010
Acu-Vib Test Procedure: AVP05 (SLM)
Checked By: .... **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
World Recognised Accreditation
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37478**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00187446
Microphone Type:	UC-52	**Serial No:**	116545
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: AECOM
Level 7, 3 Forrest Place
Perth, WA 6000

Ambient Pressure: 1010 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 52 %RH ±5% RH
Date of Calibration: 16/04/2010 **Issue Date:** 16/04/2010
Acu-Vib Test Procedure: AVP05 (SLM)
Checked By: .... **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
World Recognised Accreditation
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 36778

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 00276274

Microphone Type: UC-52 **Serial No:** 12909

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: Noise Measurement Services Pty Ltd
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 996 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 41 %RH ±5% RH

Date of Calibration: 17/03/2009 **Issue Date:** 18/03/2009

CHECKED BY: AH **AUTHORISED SIGNATORY:** Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION

Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

RTA TECHNOLOGY PTY LTD

Level 9, 418A Elizabeth Street., Surry Hills NSW 2010 AUSTRALIA
Ph: (02) 9281 2222 Fax: (02) 9281 2220 Email: rtatech@rtagroup.com.au
Website: www.rtagroup.com.au ABN 56 003 290 140

Certificate of Calibration
Sound Level Meter

Calibration Date 7/07/2010 **Job No** RA770 **Operator** AL
Client Name ALPHA ACOUSTICS
Client Address 7 PYLARA CR, FERNY HILLS, 4055

Test Item

Instrument Make	Rion	**Model**	NL-21	**Serial No**	#00487669
Microphone Make	Rion	**Model**	UC-52	**Serial No**	#118311
Preamplifier Make	Rion	**Model**	NH-21	**Serial No**	#26795
Ext'n Cable Make	Nil	**Model**	N/A	**Serial No**	N/A
Accessories	Nil				

SLM Type	2
Filters Class	N/A

Temp deg C	23.0
RH %	41.0
Bar Pressure hPa	1018

Applicable Standards:
Australian Standard AS1259.1 1990 "Sound Level Meters Part 1: Non-integrating"
Australian Standard AS1259.2 1990 "Sound Level Meters Part 2: Integrating-averaging"

Applicable Work Instruction:
RWI-08 SLM Verification.doc

Traceability:
The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to Australian national standards of measurement. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
Unless otherwise stated, the uncertainty of measurement is +/-0.14dB. The uncertainty is stated at a confidence level of 95% using a k factor of 2.

NATA WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 8th July 2010

Template Document Name: RQT-02 (rev 40) SLM Verification

RTA TECHNOLOGY PTY LTD

Level 9, 418A Elizabeth Street., Surry Hills NSW 2010 AUSTRALIA
Ph: (02) 9281 2222 Fax: (02) 9281 2220 Email: rtatech@rtagroup.com.au
Website: www.rtagroup.com.au ABN 56 003 290 140

Certificate of Calibration
Sound Level Meter

Calibration Date 7/07/2010 **Job No** RA770 **Operator** AL
Client Name ALPHA ACOUSTICS
Client Address 7 PYLARA CR, FERNY HILLS, 4055

Test Item

Instrument Make Rion	**Model** NL-21	**Serial No** #00487697
Microphone Make Rion	**Model** UC-52	**Serial No** #118961
Preamplifier Make Rion	**Model** NH-21	**Serial No** #26823
Ext'n Cable Make Nil	**Model** N/A	**Serial No** N/A
Accessories Nil		

SLM Type	2
Filters Class	N/A

Temp deg C	23.0
RH %	41.0
Bar Pressure hPa	1019

Applicable Standards:
Australian Standard AS1259.1 1990 "Sound Level Meters Part 1: Non-integrating"
Australian Standard AS1259.2 1990 "Sound Level Meters Part 2: Integrating-averaging"

Applicable Work Instruction:
RWI-08 SLM Verification.doc

Traceability:
The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to Australian national standards of measurement. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
Unless otherwise stated, the uncertainty of measurement is +/-0.14dB. The uncertainty is stated at a confidence level of 95% using a k factor of 2.

NATA WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 8th July 2010

Template Document Name: RQT-02 (rev 40) SLM Verification

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 37044

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00776886
Microphone Type:	UC-52	**Serial No:**	114983
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: Noise Measurement Services Pty Ltd
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 1005 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 35 %RH ±5% RH
Date of Calibration: 10/08/2009 **Issue Date:** 10/08/2009

CHECKED BY: .... **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No: 11169

Equipment Tested: Sound Level Calibrator

Manufacturer: Rion
Type No: NC-74 **Serial No:** 34483785
Owner: AECOM
Level 3, 49 Park Road
Milton. QLD 4064

Tests Performed: Measured output sound pressure level was found to be:
Before adiustment: 94.13 dB re 20 uPa at 1001.0 Hz THD< 1%.
After adiustment: 94.13 dB re 20 uPa at 1001.0 Hz THD< 1%.

Uncertainty (at 95% c.l.) k=2: Output ±0.11dB
Freq. ±0.05 Hz

Condition Of Test:

Ambient Pressure: 1006 hPa ±1.5 hPa **Relative Humidity:** 63 % RH ±5% RH
Temperature: 23 °C ±2° C
Date of Calibration: 15/04/2010 **Issue Date:** 16/04/2010
Acu-Vib Test Procedure: AVP02 (Calibrators)
Test Method: AS IEC 60942 - 2004
Checked By: ...... **Authorised Signatory:** ....
Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS
HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
Web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37442**

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 00187447

Microphone Type: UC-52 **Serial No:** 109046

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: AECOM
Level 1, 21 Stokes Street
Townsville, QLD 4810

Ambient Pressure: 1005 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 61 %RH ±5% RH

Date of Calibration: 30/03/2010 **Issue Date:** 30/03/2010
Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable
Checked By: ..AH.. **Authorised Signatory:** ....
Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS
HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37521**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00187448
Microphone Type:	UC-52	**Serial No:**	116615
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: AECOM
Level 11, 44 Market Street
Sydney NSW 2000

Ambient Pressure: 995 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 41 %RH ±5% RH
Date of Calibration: 11/05/2010 **Issue Date:** 12/05/2010
Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable
Checked by: AH **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Certificate Of Calibration

Certificate No.: **SLM 37272**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00265112
Microphone Type:	UC-52	**Serial No:**	108046
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		

Owner: AECOM
91 King William Street
Adelaide SA 5000

Ambient Pressure: 994 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 32 %RH ±5% RH
Date of Calibration: 20/01/2010 **Issue Date:** 20/01/2010
Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable
Checked by: AH **Authorised Signatory:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 37480**

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 00465445

Microphone Type: UC-52 **Serial No:** 108056

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: AECOM
Level 28, 91 King William Street
Adelaide SA 5000

Ambient Pressure: 1011 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 38 %RH ±5% RH

Date of Calibration: 19/04/2010 **Issue Date:** 19/04/2010

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: A.H. **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 37668**

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 00765699

Microphone Type: UC-52 **Serial No:** 109044

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: AECOM
Level 9, 8 Exhibition Street
Melbourne VIC 3000

Ambient Pressure: 1000 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 65 %RH ±5% RH

Date of Calibration: 31/07/2010 **Issue Date:** 02/08/2010

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: A.H. **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

Page 1 of 2
AVCERT1 Rev.2.4 03.06.09

RTA TECHNOLOGY PTY LTD

Level 9, 418A Elizabeth Street., Surry Hills NSW 2010 AUSTRALIA
Ph: (02) 9281 2222 Fax: (02) 9281 2220 Email: rtatech@rtagroup.com.au
Website: www.rtagroup.com.au ABN 56 003 290 140

Certificate of Calibration
Sound Level Meter

Calibration Date 7/07/2010 **Job No** RA770 **Operator** AL
Client Name ALPHA ACOUSTICS
Client Address 7 PYLARA CR, FERNY HILLS, 4055

Test Item

Instrument Make	Rion	**Model**	NL-21	**Serial No**	#00487697
Microphone Make	Rion	**Model**	UC-52	**Serial No**	#118961
Preamplifier Make	Rion	**Model**	NH-21	**Serial No**	#26823
Ext'n Cable Make	Nil	**Model**	N/A	**Serial No**	N/A
Accessories	Nil				

SLM Type	2
Filters Class	N/A

Temp deg C	23.0
RH %	41.0
Bar Pressure hPa	1019

Applicable Standards:
Australian Standard AS1259.1 1990 "Sound Level Meters Part 1: Non-integrating"
Australian Standard AS1259.2 1990 "Sound Level Meters Part 2: Integrating-averaging"

Applicable Work Instruction:
RWI-08 SLM Verification.doc

Traceability:
The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to Australian national standards of measurement. This document shall not be reproduced, except in full.

Scope:
This certificate is issued on the basis that the instrument complies with the manufacturer's specification. See "Sound Level Meter Verification - Summary of Tests" page for an itemised list of results for each test.

Uncertainty:
Unless otherwise stated, the uncertainty of measurement is +/-0.14dB. The uncertainty is stated at a confidence level of 95% using a k factor of 2.

NATA Accredited Laboratory
Number 14966

Authorized Signatory:

Print Name: Renzo Tonin Date: 8th July 2010

Template Document Name: RQT-02 (rev 40) SLM Verification

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 36777

Equipment Description: Sound Level Meter
Manufacturer: Rion
Model No: NL-21 **Serial No:** 00276273
Microphone Type: UC-52 **Serial No:** 112905
Filter Type: - **Serial No:** -
Comments: All tests passed for type 2.

Owner: Noise Measurement Services Pty Ltd
Suite 2, 90 Vulture Street
West End QLD 4101

Ambient Pressure: 996 hPa ±1.5 hPa
Temperature: 23 °C ±2° C **Relative Humidity:** 41 %RH ±5% RH
Date of Calibration: 17/03/2009 **Issue Date:** 18/03/2009
CHECKED BY: AH **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 36778**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00276274
Microphone Type:	UC-52	**Serial No:**	12909
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		
Owner:	Noise Measurement Services Pty Ltd Suite 2, 90 Vulture Street West End QLD 4101		
Ambient Pressure:	996 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	41 %RH ±5% RH
Date of Calibration:	17/03/2009	**Issue Date:**	18/03/2009
CHECKED BY:	....	**AUTHORISED SIGNATORY:**	.... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 37365**

Equipment Description:	Sound Level Meter		
Manufacturer:	Rion		
Model No:	NL-21	**Serial No:**	00365350
Microphone Type:	UC-52	**Serial No:**	107753
Filter Type:	-	**Serial No:**	-
Comments:	All tests passed for type 2.		
Owner:	Noise Measurement Services Suite 2, 90 Vulture Street West End QLD 4101		
Ambient Pressure:	1012 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	31 %RH ±5% RH
Date of Calibration:	26/02/2010	**Issue Date:**	26/02/2010
Acu-Vib Test Procedure:	AVP05 (SLM)		
CHECKED BY:		**AUTHORISED SIGNATORY:**	.... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 107025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 38129**

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 01043718

Microphone Type: UC-52 **Serial No:** 128992

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: Noise Measurement Services
18 Lade Street
Enoggera QLD 4051

Ambient Pressure: 1008 hPa ±1.5 hPa

Temperature: 23 °C ±2° C **Relative Humidity:** 54 %RH ±5% RH

Date of Calibration: 18/04/2011 **Issue Date:** 18/04/2011

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: AH **AUTHORISED SIGNATORY:** .... Jack Kielt

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA WORLD RECOGNISED ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

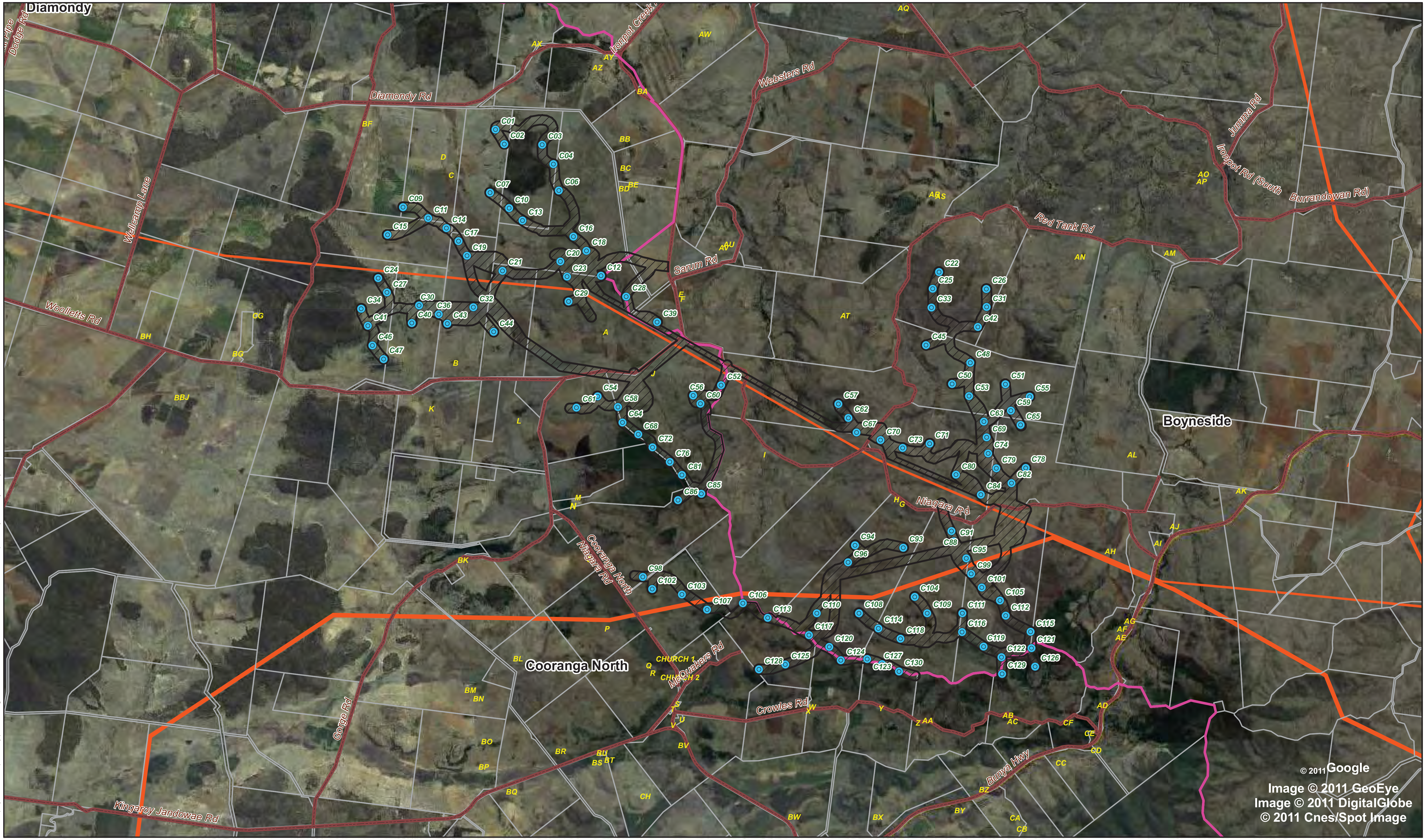
ACU-VIB ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

D R A F T

Appendix E

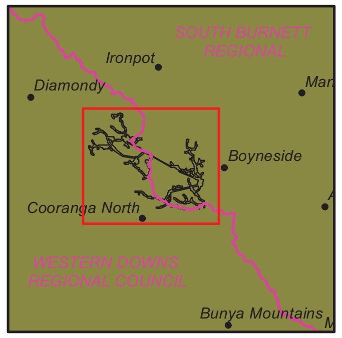
Wind Turbine and Receiver Locations



N

AECOM
www.aecom.com

Energy in action. AGL



LEGEND

- Proposed CID Corridor
- Nominal Turbine Locations
- LGA Boundary
- A Receiver Locations
- Existing High Voltage Transmission Line Easement
- Cadastre
- Roads

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 2
Kilometres

1:75,000 (when printed at A3)

Data Sources:
1. Proposed CIC Corridor & Turbines © 2011 AECOM Australia Pty Ltd.
2. Copyright 2011 Google Earth Pro Image captured on 21/2/2011.
3. Dwellings, Access Roads, Transmission Lines © AGL 2011.
4. Roads © StreetPro 2011.
5. Towns © Copyright [2011], MapData Sciences Pty Ltd, PSMA.
6. Local Government Area (LGA) boundaries © Australia Bureau of Statistic (ABS), 2011.
7. DCDB © The State of Queensland, The Department of Environment and Resource Management, 2011.
8. Watercourses © GeoScience Australia, 2011.

Disclaimer:
StreetPro © 2011 Pitney Bowes Software Pty Ltd. All rights reserved

Watercourses © Copyright Commonwealth of Australia (Geoscience Australia) 2011. The Commonwealth gives no warranty regarding the accuracy, completeness, currency or suitability for any particular purpose.MA.

© The State of Queensland, The Department of Environment and Resource Management, 2011. Based on or contains data provided by the State of Queensland Department of Environment and Resource Management) [2008]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

COOPERS GAP WIND FARM PROJECT

Turbine and Receiver Locations CID area - Rev AA

PROJECT ID	60162856
CREATED BY	CS
LAST MODIFIED	CS - 4 March 2011
VERSION:	1

AECOM does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. AECOM shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

Appendix F

Predicted Noise Levels

D R A F T

Appendix F Predicted Noise Levels

Eastings and Northings are defined based on the GDA 1994 Projection MGA Zone 56 co-ordinate system.

Location		Receiver	Wind Speed (m/s)													
			4.3		5		6		7		8		9		10	
Eastings	Northings	Name	Criteria	Predicted	Criteria	Predicted	Criteria	Predicted	Criteria	Predicted	Criteria	Predicted	Criteria	Predicted	Criteria	Predicted
340083.64	7046383.86	A	45	32	45	34	45	36	45	39	45	41	45	43	45	44
346821.92	7038249.71	AA	40	28	40	29	40	32	40	34	40	37	40	39	40	40
348509.69	7038355.60	AB	45	31	45	32	45	34	45	37	45	39	45	41	45	42
348599.93	7038225.88	AC	45	30	45	31	45	33	45	36	45	38	45	40	45	41
350481.39	7038561.88	AD	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
350862.40	7040011.31	AE	40	<25	40	<25	40	<25	40	28	40	30	40	32	40	33
350894.08	7040160.02	AF	40	<25	40	<25	40	26	40	28	40	31	40	33	40	34
351062.79	7040332.81	AG	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
350644.44	7041787.89	AH	40	<25	40	<25	40	<25	40	27	40	30	40	32	40	33
351635.32	7041956.19	AI	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
351992.86	7042313.99	AJ	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
353390.57	7043055.32	AK	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
351111.69	7043812.29	AL	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
351892.88	7048035.24	AM	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
350015.20	7047959.02	AN	40	<25	40	<25	40	<25	40	27	40	30	40	32	40	33
352602.51	7049683.82	AO	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
352560.01	7049534.07	AP	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
346316.43	7053162.12	AQ	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
346966.60	7049264.78	AR	40	<25	40	<25	40	27	40	29	40	32	40	34	40	35
347091.79	7049224.13	AS	40	<25	40	<25	40	27	40	30	40	32	40	34	40	36
345095.26	7046725.81	AT	40	26	40	28	40	30	40	32	40	35	40	37	40	38
342660.62	7048215.92	AU	40	<25	40	<25	40	<25	40	27	40	30	40	32	40	33
342553.63	7048149.04	AV	40	<25	40	<25	40	25	40	28	40	31	40	32	40	34
342159.14	7052618.47	AW	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
338631.89	7052421.85	AX	40	<25	40	<25	40	25	40	28	40	31	40	32	40	34
340135.10	7052136.15	AY	40	<25	40	<25	40	<25	40	26	40	28	40	30	40	32
339907.17	7051919.07	AZ	40	<25	40	<25	40	<25	40	27	40	30	40	32	40	33
336940.46	7045734.76	B	45	33	45	34	45	37	45	39	45	42	45	44	45	45
340849.52	7051426.78	BA	40	<25	40	<25	40	<25	40	26	40	29	40	31	40	32
340477.95	7050425.25	BB	40	26	40	27	40	29	40	32	40	34	40	36	40	38
340491.29	7049759.71	BC	40	27	40	28	40	31	40	33	40	36	40	38	40	39
340462.52	7049386.33	BD	40	29	40	30	40	32	40	35	40	37	40	39	40	40

D R A F T

340649.28	**7049465.31**	**BE**	40	27	40	29	40	31	40	34	40	36	40	38	40	39
335084.09	**7050742.34**	**BF**	40	<25	40	<25	40	26	40	29	40	32	40	33	40	35
332375.03	**7045921.47**	**BG**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
330442.93	**7046291.91**	**BH**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
331115.75	**7045011.26**	**BI**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
331254.77	**7045013.42**	**BJ**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
337093.08	**7041604.18**	**BK**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
338340.07	**7039540.20**	**BL**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	26
337241.91	**7038885.32**	**BM**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
337414.98	**7038704.73**	**BN**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
337588.74	**7037802.70**	**BO**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
337518.69	**7037277.65**	**BP**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
338111.03	**7036755.87**	**BQ**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
339132.34	**7037598.68**	**BR**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
339984.92	**7037397.75**	**BS**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
340046.98	**7037449.32**	**BT**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
339999.63	**7037566.91**	**BU**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	26
341701.82	**7037728.37**	**BV**	40	<25	40	<25	40	<25	40	<25	40	27	40	29	40	30
344024.32	**7036226.39**	**BW**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
345776.44	**7036220.81**	**BX**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
347491.69	**7036362.89**	**BY**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
348008.24	**7036796.91**	**BZ**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
336840.43	**7049667.48**	**C**	45	33	45	35	45	37	45	40	45	42	45	44	45	45
348654.18	**7036210.06**	**CA**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
348791.81	**7035972.58**	**CB**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
349614.72	**7037357.79**	**CC**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
350349.72	**7037619.18**	**CD**	40	<25	40	<25	40	<25	40	<25	40	26	40	28	40	30
350211.44	**7037982.86**	**CE**	40	<25	40	<25	40	<25	40	<25	40	26	40	27	40	29
349762.98	**7038200.97**	**CF**	40	26	40	28	40	30	40	32	40	35	40	37	40	38
332797.68	**7046721.75**	**CG**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
340905.84	**7036659.63**	**CH**	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25	40	<25
341470.88	**7039535.19**	**CHURCH 1**	40	28	40	29	40	32	40	34	40	37	40	39	40	40
341636.49	**7039151.32**	**CHURCH 2**	40	27	40	28	40	30	40	33	40	35	40	37	40	38
336677.10	**7050047.03**	**D**	45	31	45	32	45	35	45	37	45	40	45	42	45	43
341658.46	**7047167.51**	**E**	45	30	45	32	45	34	45	36	45	39	45	41	45	42
341691.40	**7047075.28**	**F**	45	31	45	32	45	34	45	37	45	39	45	41	45	42
346234.30	**7042890.46**	**G**	45	34	45	35	45	37	45	40	45	42	45	44	45	45
346167.61	**7042874.88**	**H**	45	33	45	35	45	37	45	40	45	42	45	44	45	45

DRAFT

D R A F T

343404.32	**7043808.64**	**I**	40	29	40	30	40	32	40	35	40	37	40	39	40	40
341073.20	**7045511.15**	**J**	45	34	45	35	45	37	45	40	45	42	45	44	45	45
336432.29	**7044775.95**	**K**	40	27	40	29	40	31	40	34	40	36	40	38	40	39
338266.78	**7044523.41**	**L**	40	26	40	28	40	30	40	32	40	35	40	37	40	38
339498.09	**7042915.85**	**M**	40	27	40	28	40	30	40	33	40	35	40	37	40	39
339485.10	**7042871.99**	**N**	40	27	40	28	40	30	40	33	40	35	40	37	40	38
339739.18	**7041619.48**	**O**	40	27	40	28	40	31	40	33	40	36	40	38	40	39
340106.34	**7040162.19**	**P**	45	27	45	28	45	30	45	33	45	35	45	37	45	39
340984.42	**7039395.20**	**Q**	40	26	40	27	40	29	40	32	40	34	40	36	40	38
340958.42	**7039353.94**	**R**	40	26	40	27	40	29	40	32	40	34	40	36	40	37
341571.10	**7038592.50**	**S**	40	<25	40	<25	40	27	40	30	40	32	40	34	40	35
341484.23	**7038469.54**	**T**	40	<25	40	<25	40	26	40	29	40	31	40	33	40	35
341675.20	**7038266.34**	**U**	40	<25	40	<25	40	26	40	29	40	31	40	33	40	34
341567.49	**7038197.28**	**V**	40	<25	40	<25	40	25	40	28	40	30	40	32	40	34
344403.18	**7038524.56**	**W**	45	31	45	32	45	35	45	37	45	40	45	42	45	43
344325.97	**7038445.75**	**X**	45	31	45	32	45	34	45	37	45	39	45	41	45	42
345841.15	**7038503.08**	**Y**	40	32	40	33	40	36	40	38	40	41	40	43	40	44
346681.96	**7038195.69**	**Z**	40	28	40	30	40	32	40	34	40	37	40	39	40	40

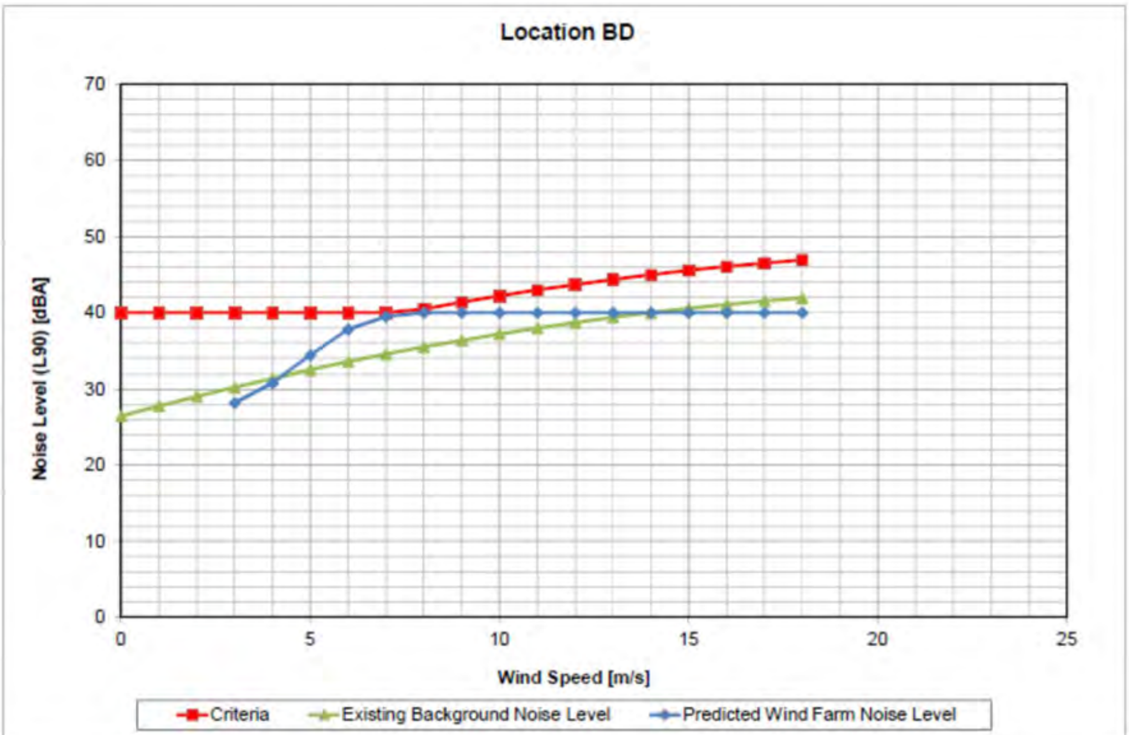
DRAFT

Appendix G

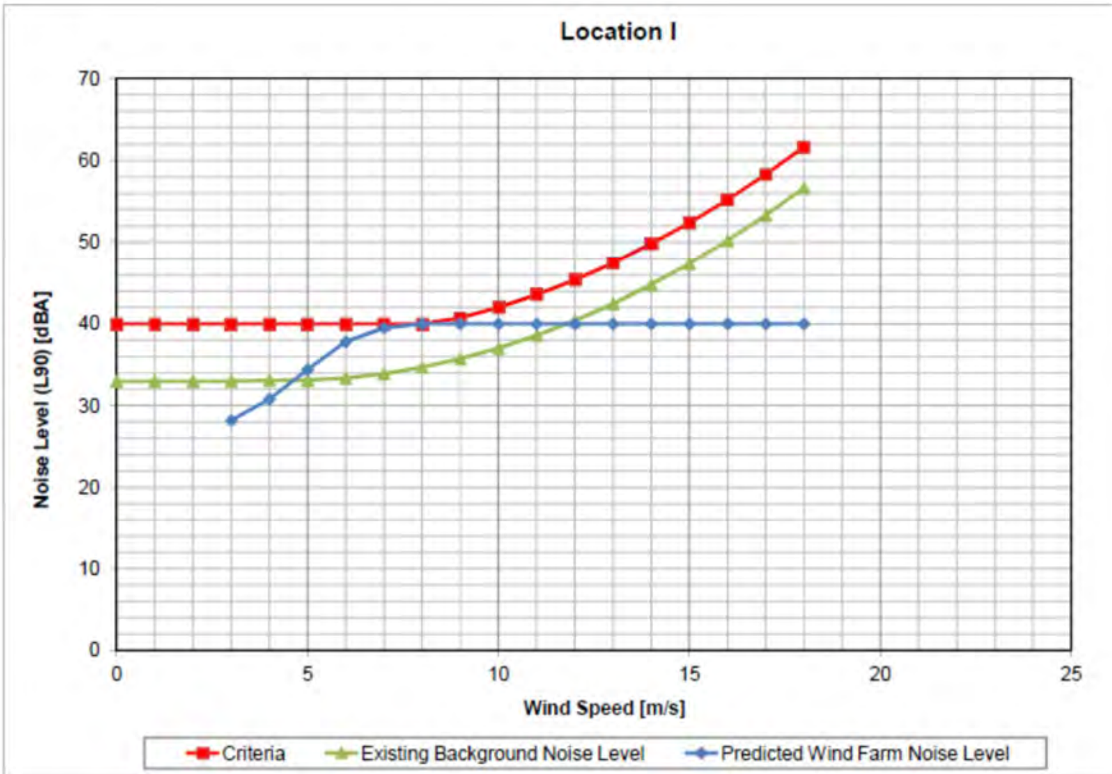
Predicted Noise Levels Based on Wind Speed

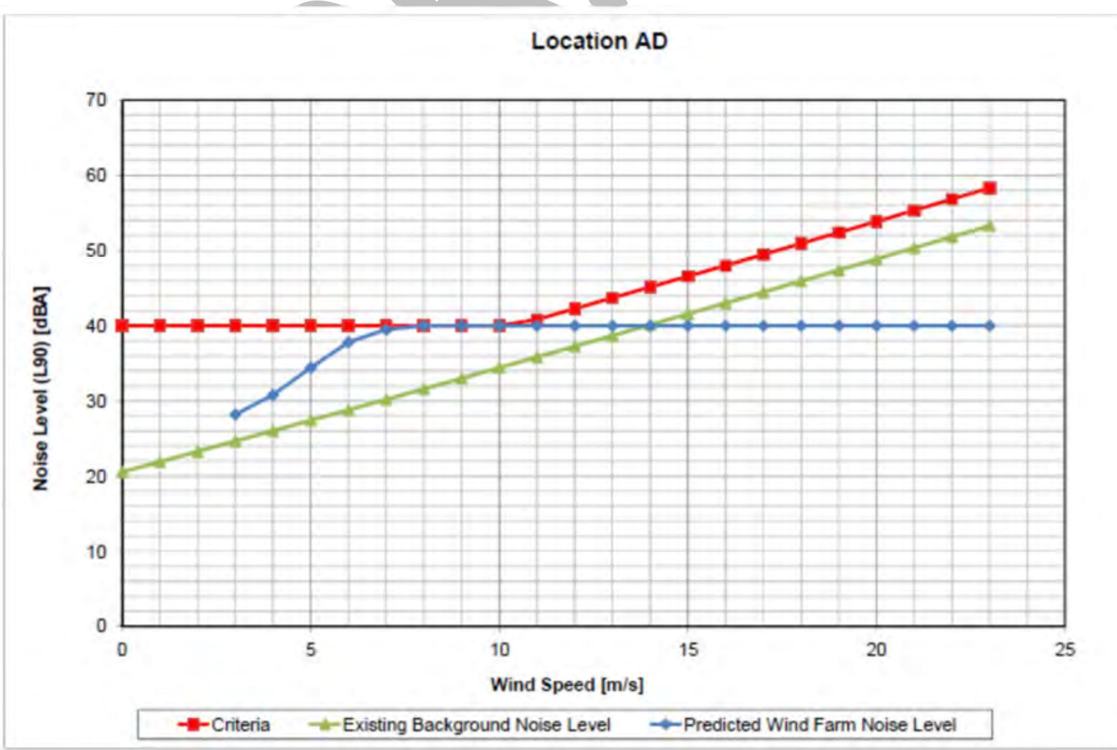
DRAFT

Appendix G Predicted Noise Levels Based on Wind Speed

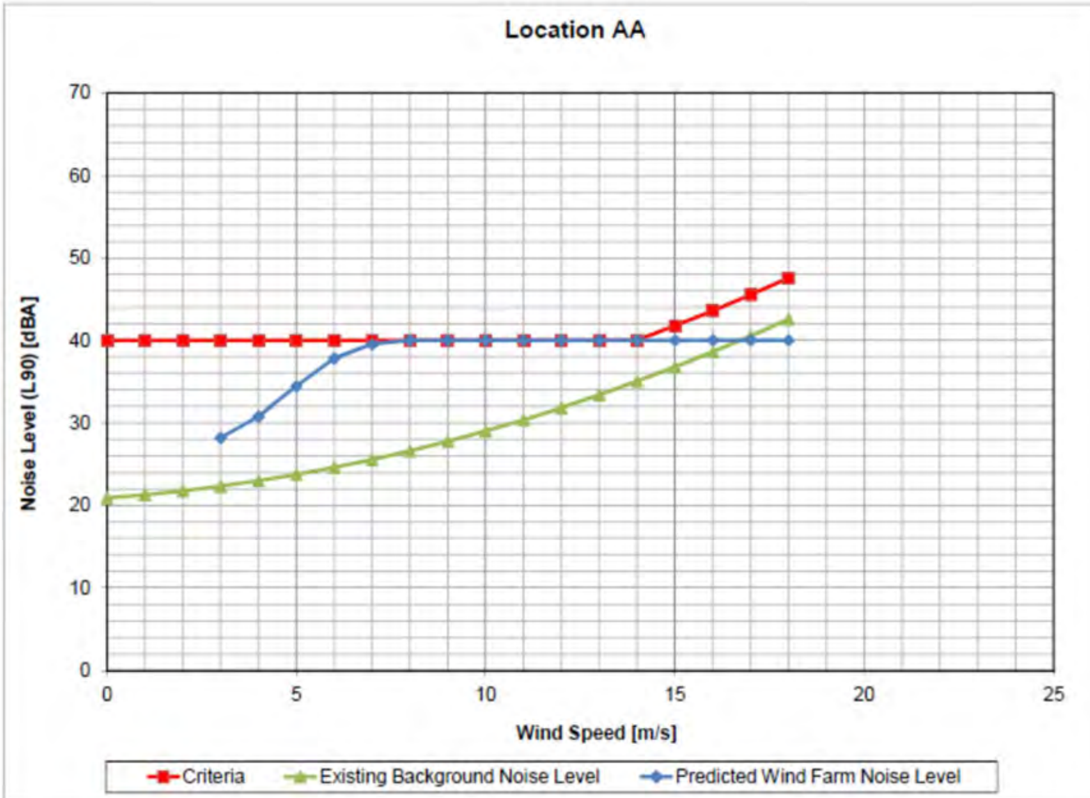


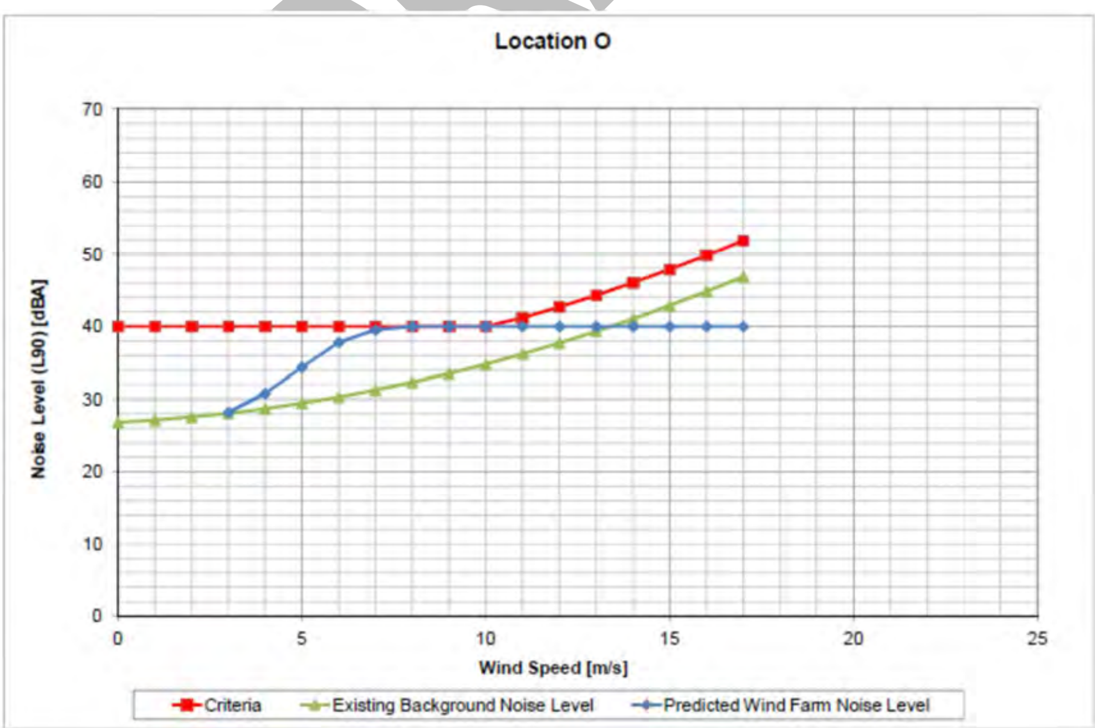
D R A F T


Location I
70
60
50
40
30
20
10
0
Noise Level (L90) [dBA]
0
5
10
15
20
25
Wind Speed [m/s]
Criteria
Existing Background Noise Level
Predicted Wind Farm Noise Level


Location AD
70
60
50
40
30
20
10
0
Noise Level (L90) [dBA]
0
5
10
15
20
25
Wind Speed [m/s]
Criteria
Existing Background Noise Level
Predicted Wind Farm Noise Level

D R A F T

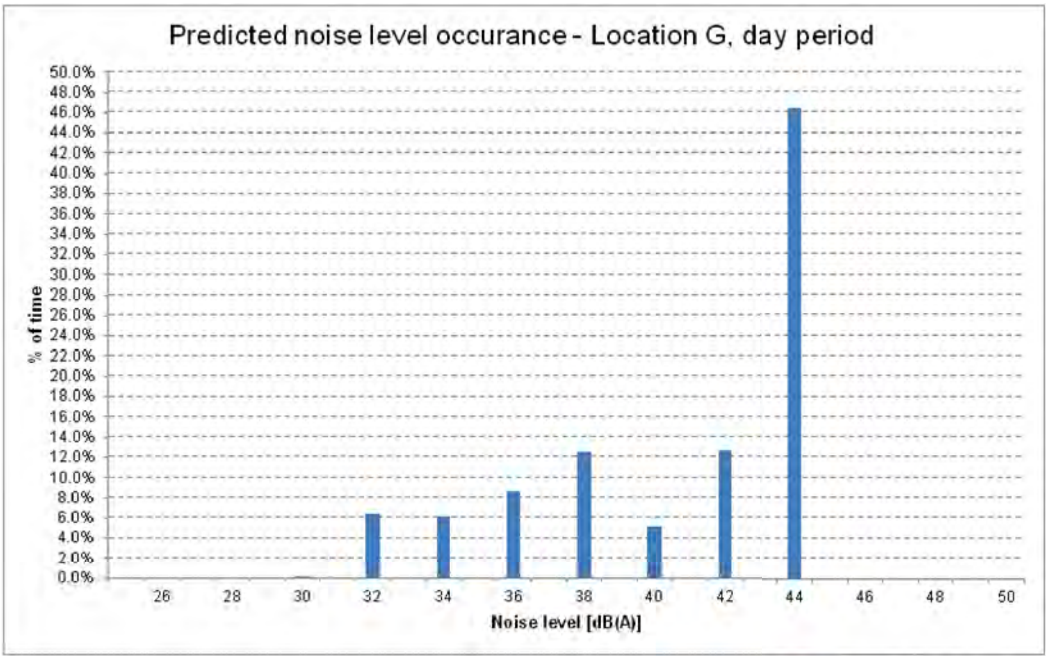

Location AA
70
60
50
40
30
20
10
0
Noise Level (L90) [dBA]
0
5
10
15
20
25
Wind Speed [m/s]
Criteria
Existing Background Noise Level
Predicted Wind Farm Noise Level

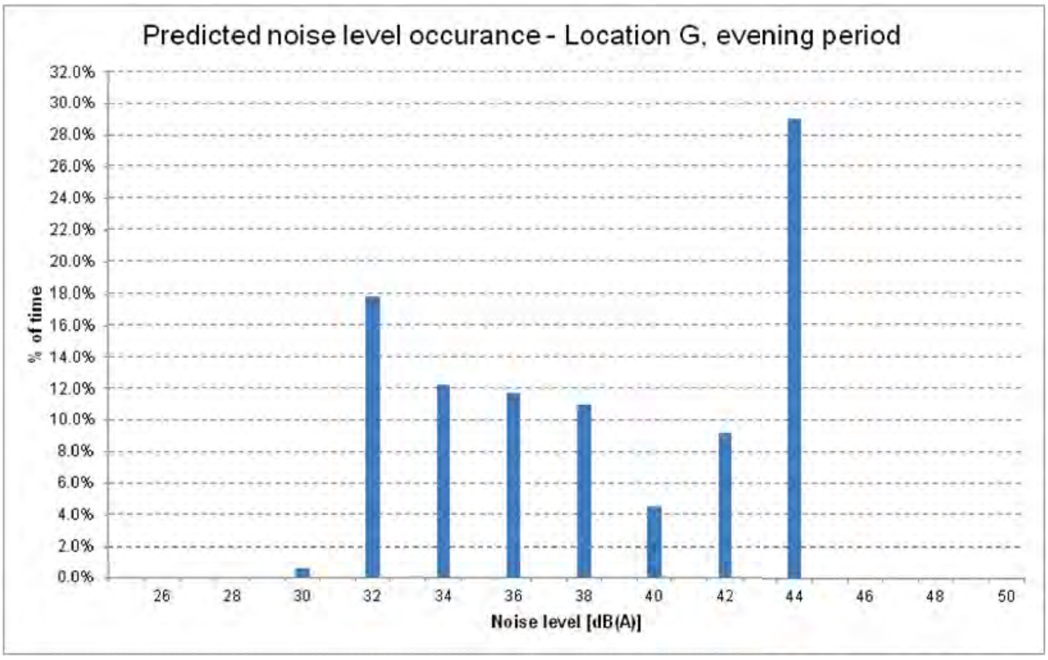

Location O
70
60
50
40
30
20
10
0
Noise Level (L90) [dBA]
0
5
10
15
20
25
Wind Speed [m/s]
Criteria
Existing Background Noise Level
Predicted Wind Farm Noise Level

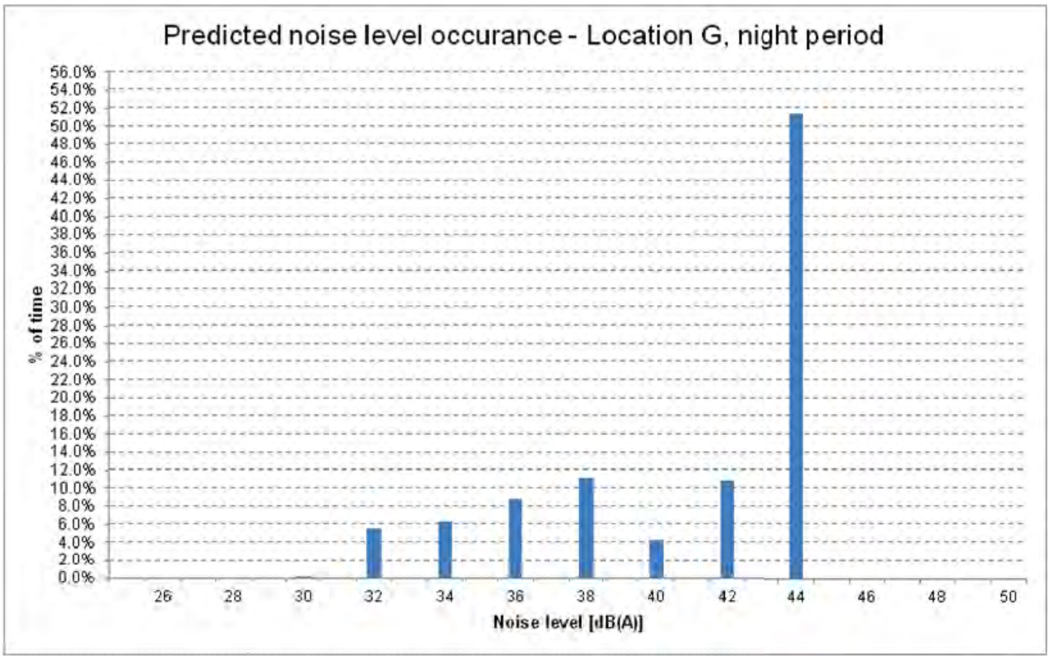
D R A F T

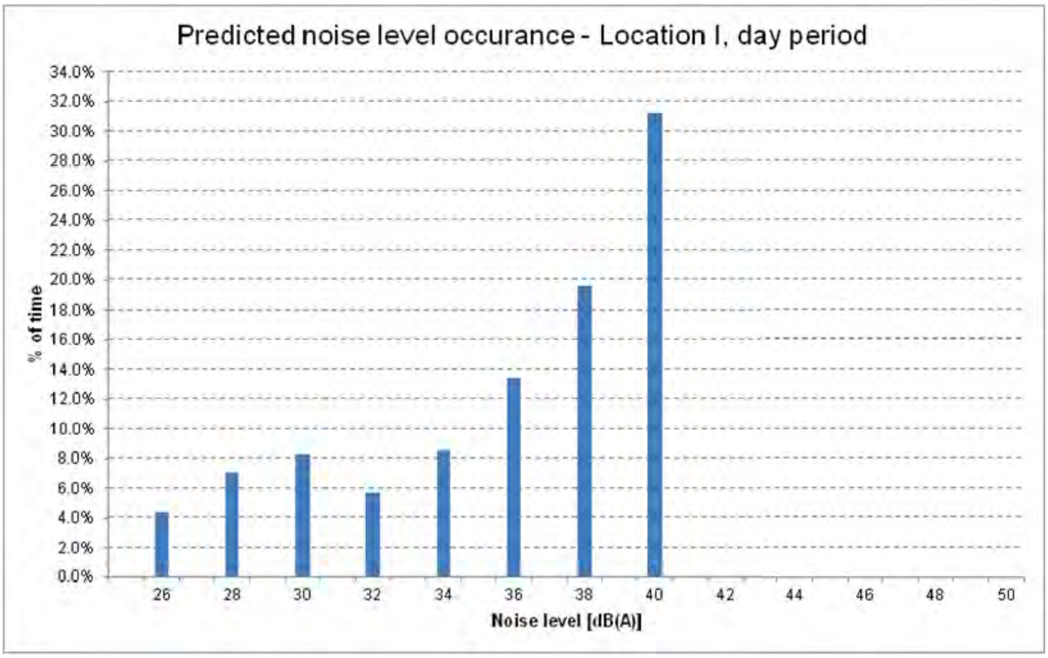
Appendix H

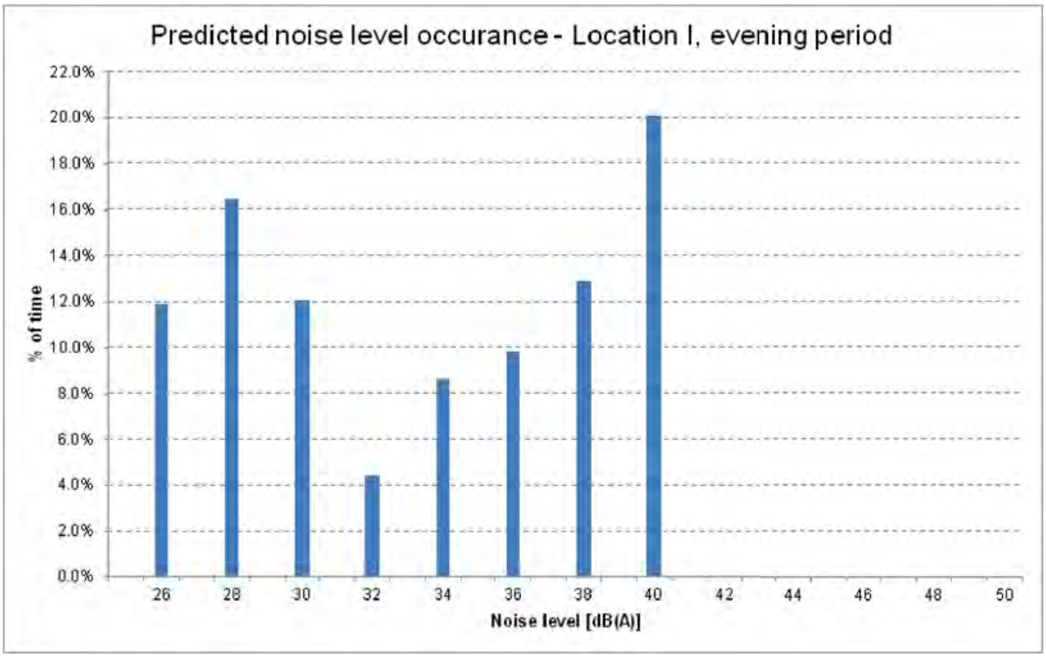
Wind Frequency Analysis

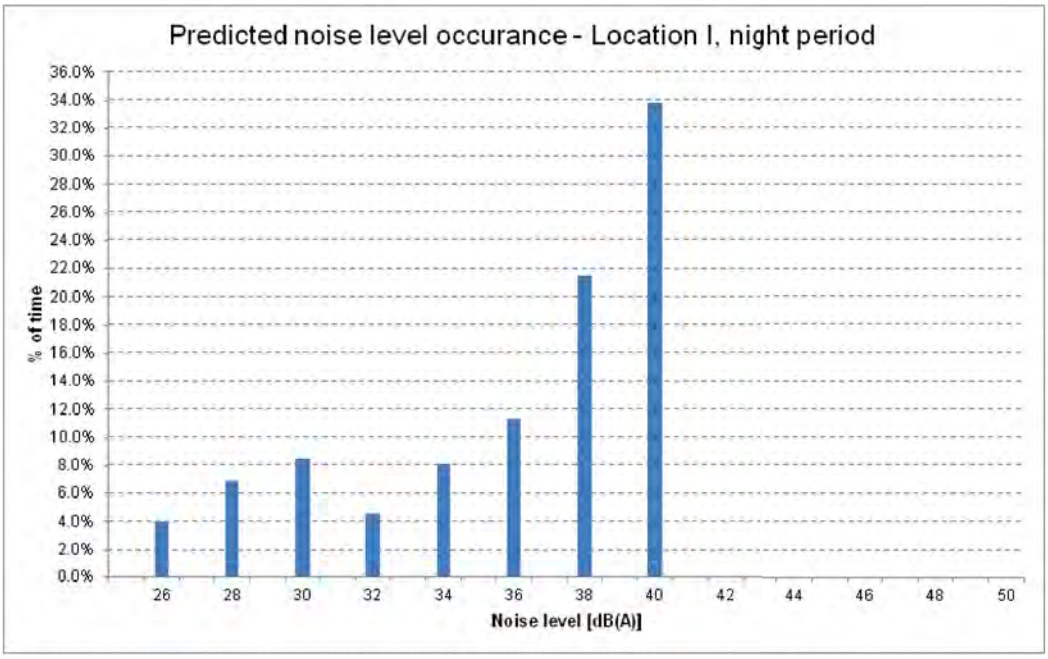

Predicted noise level occurance - Location G, day period
% of time
Noise level [dB(A)]

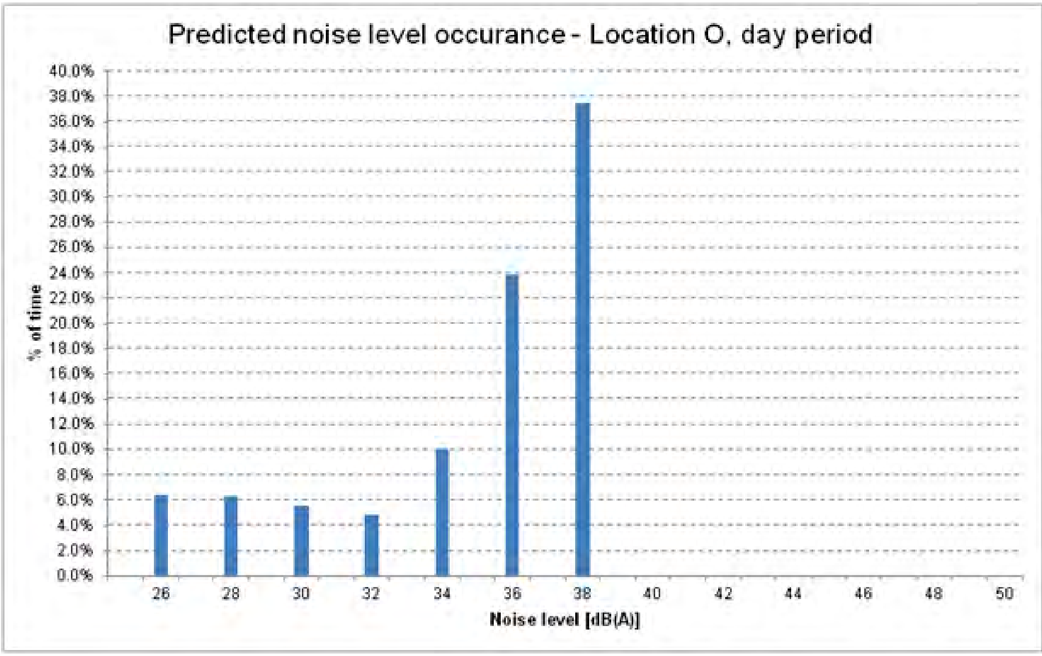

Predicted noise level occurance - Location G, evening period
% of time
Noise level [dB(A)]

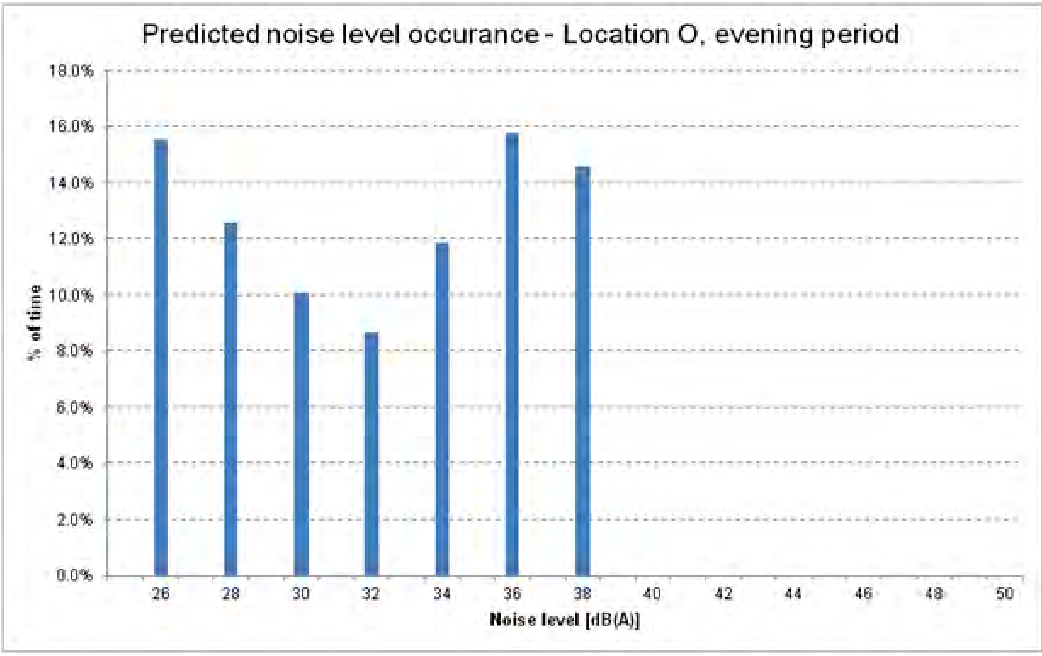

Predicted noise level occurance - Location G, night period
% of time
Noise level [dB(A)]

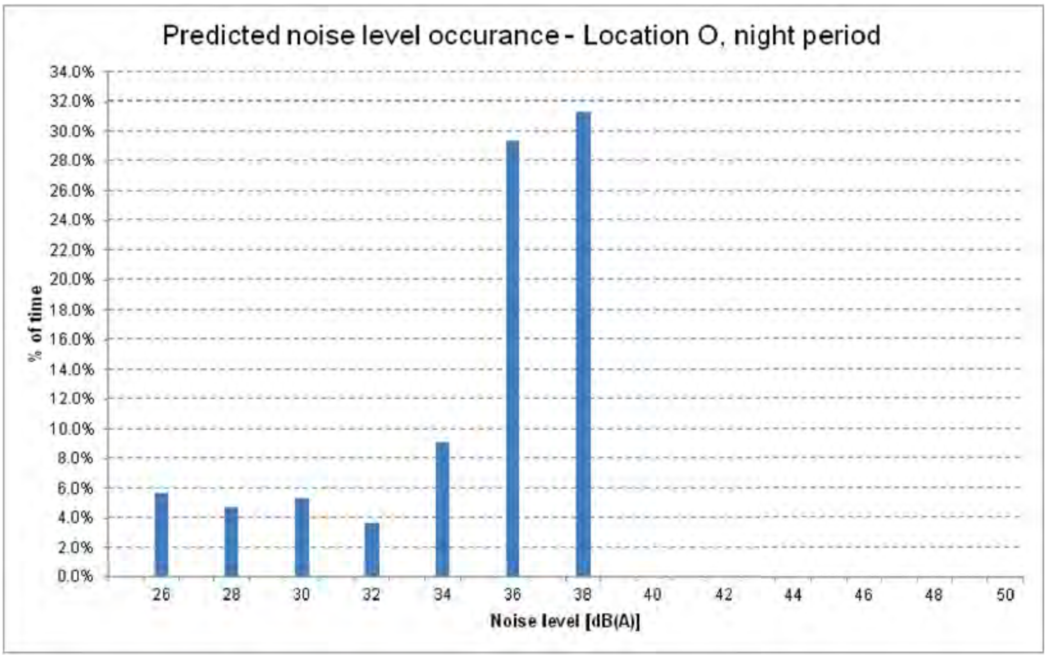

Predicted noise level occurance - Location I, day period
% of time
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

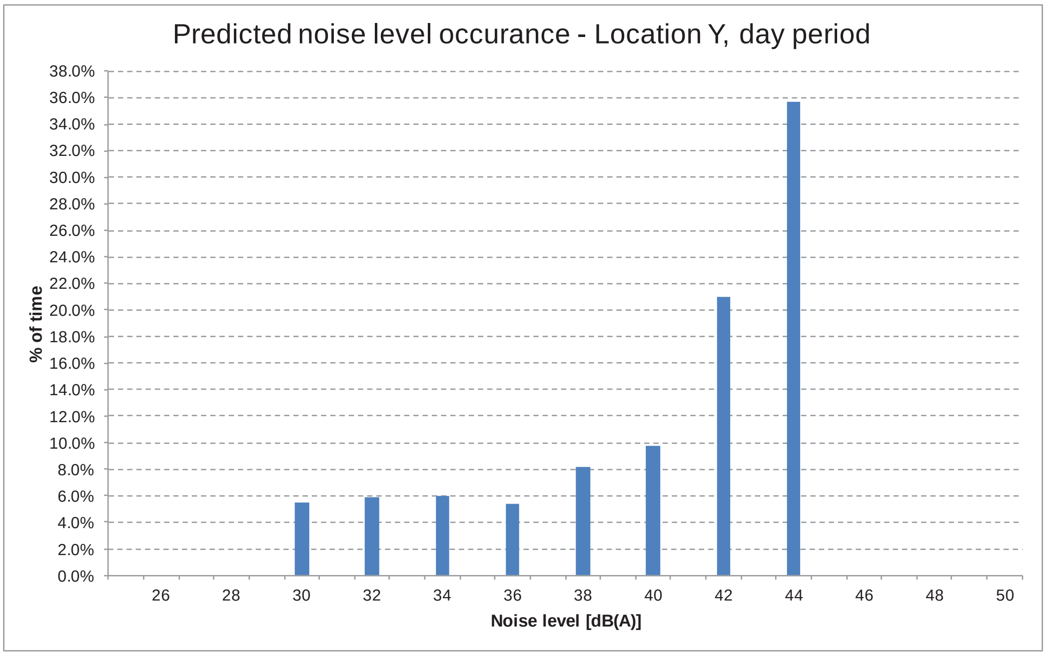

Predicted noise level occurance - Location I, evening period
% of time
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

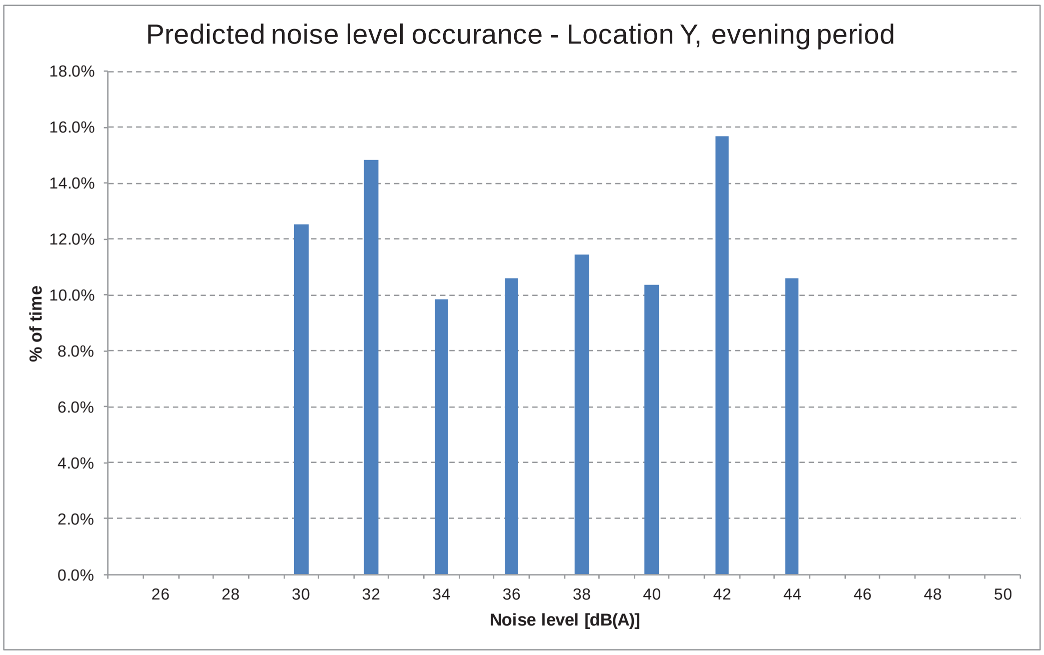

Predicted noise level occurance - Location I, night period
% of time
36.0%
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

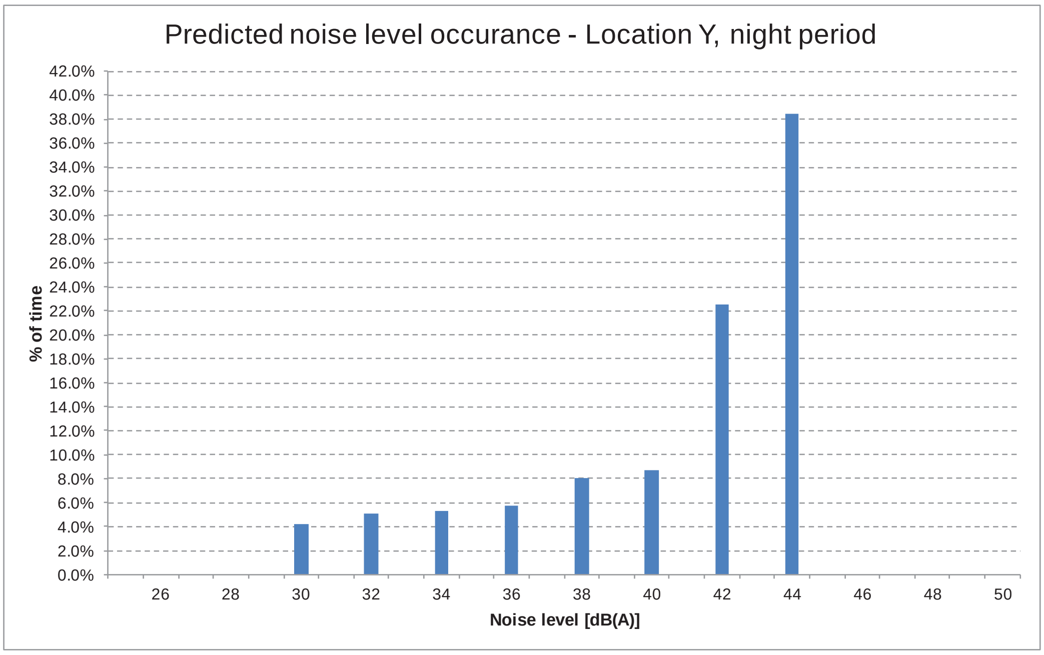

Predicted noise level occurance - Location O, day period
% of time
Noise level [dB(A)]

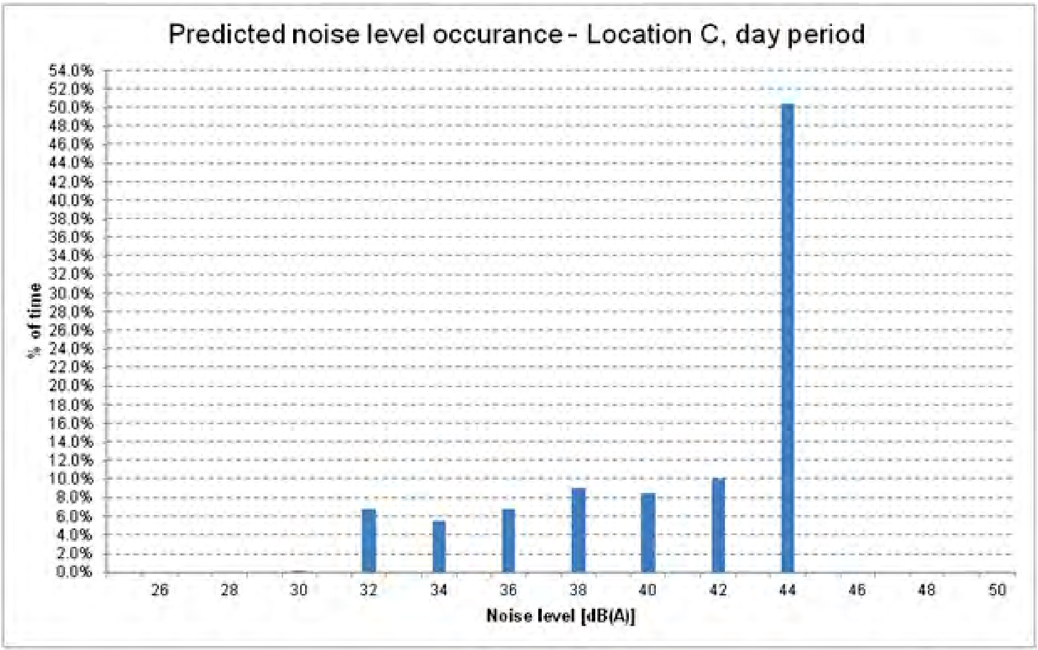

Predicted noise level occurance - Location O, evening period
% of time
Noise level [dB(A)]


Predicted noise level occurance - Location O, night period
% of time
Noise level [dB(A)]

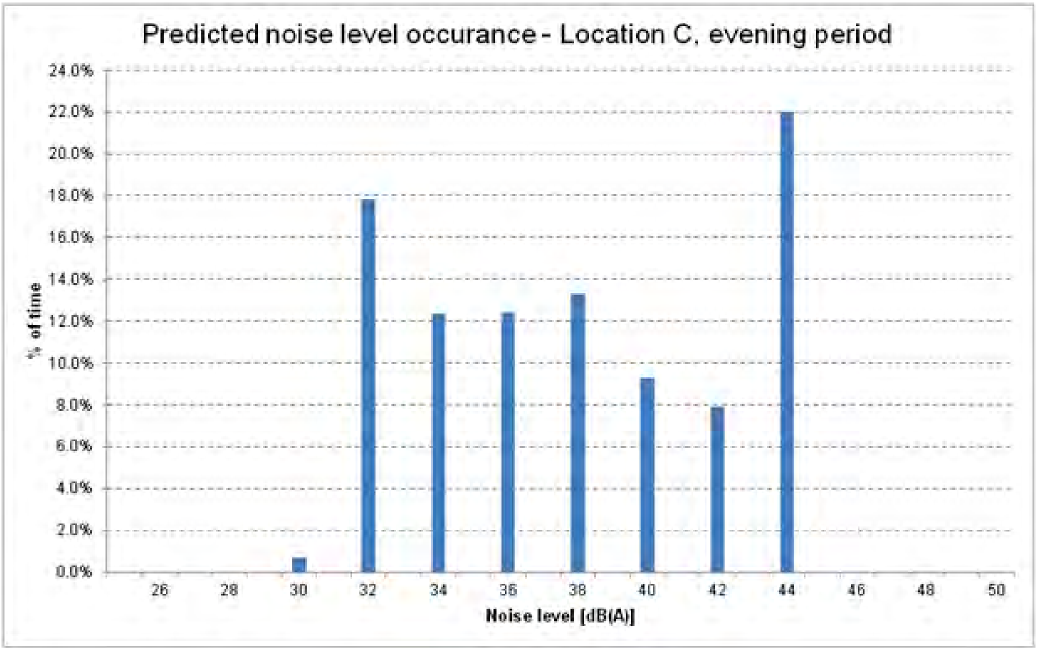

Predicted noise level occurance - Location Y, day period
% of time
38.0%
36.0%
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]


Predicted noise level occurance - Location Y, evening period
% of time
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

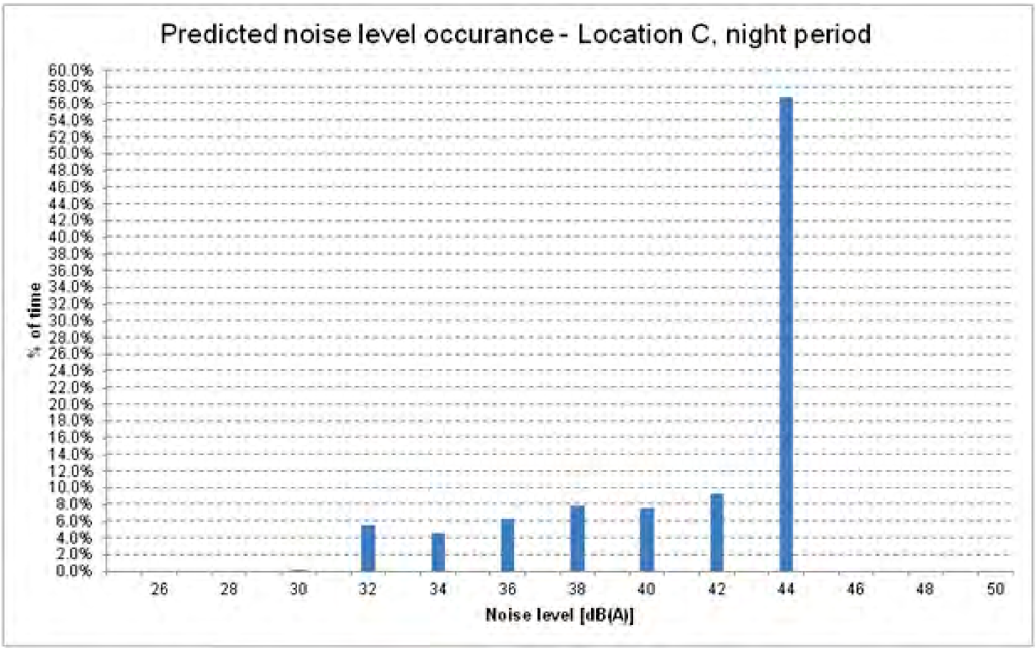

Predicted noise level occurance - Location Y, night period
% of time
42.0%
40.0%
38.0%
36.0%
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]



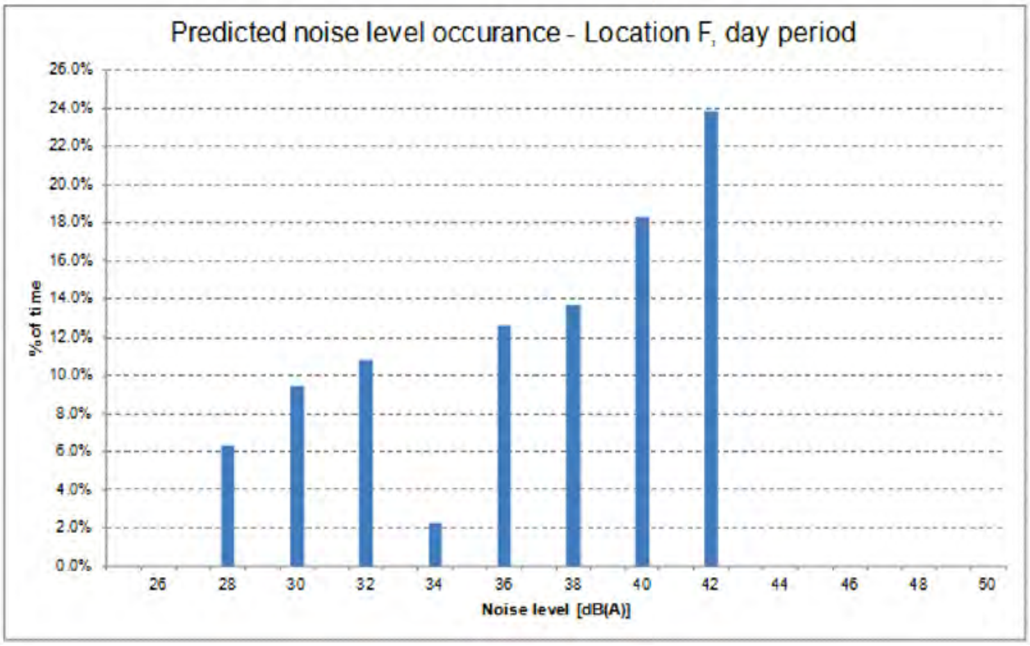
Predicted noise level occurance - Location C, day period
% of time
Noise level [dB(A)]



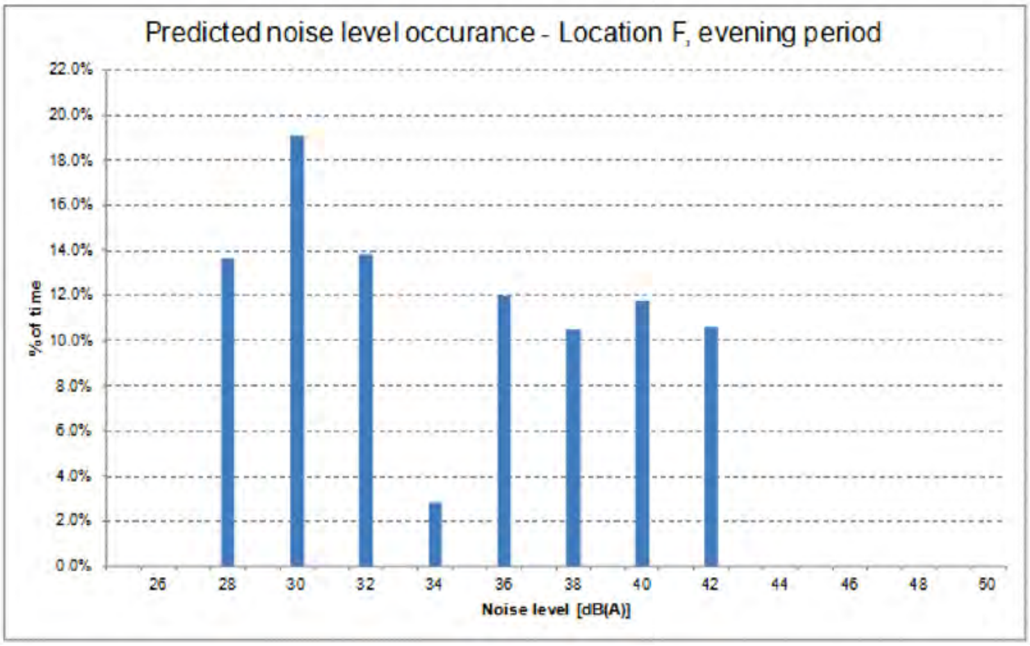
Predicted noise level occurance - Location C, evening period
% of time
Noise level [dB(A)]



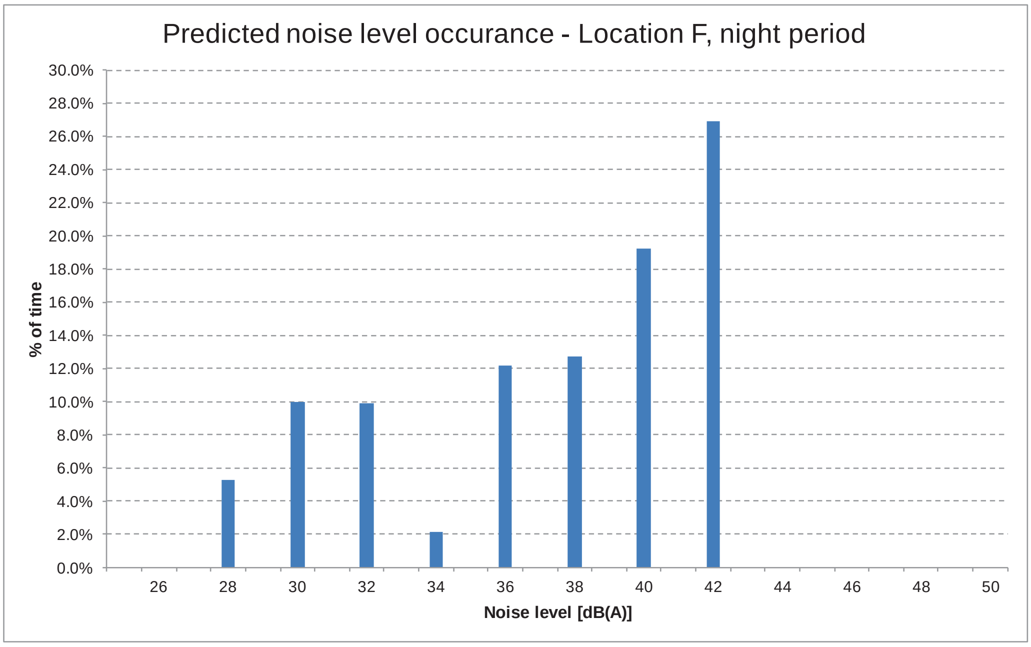
Predicted noise level occurance - Location C, night period
% of time
Noise level [dB(A)]



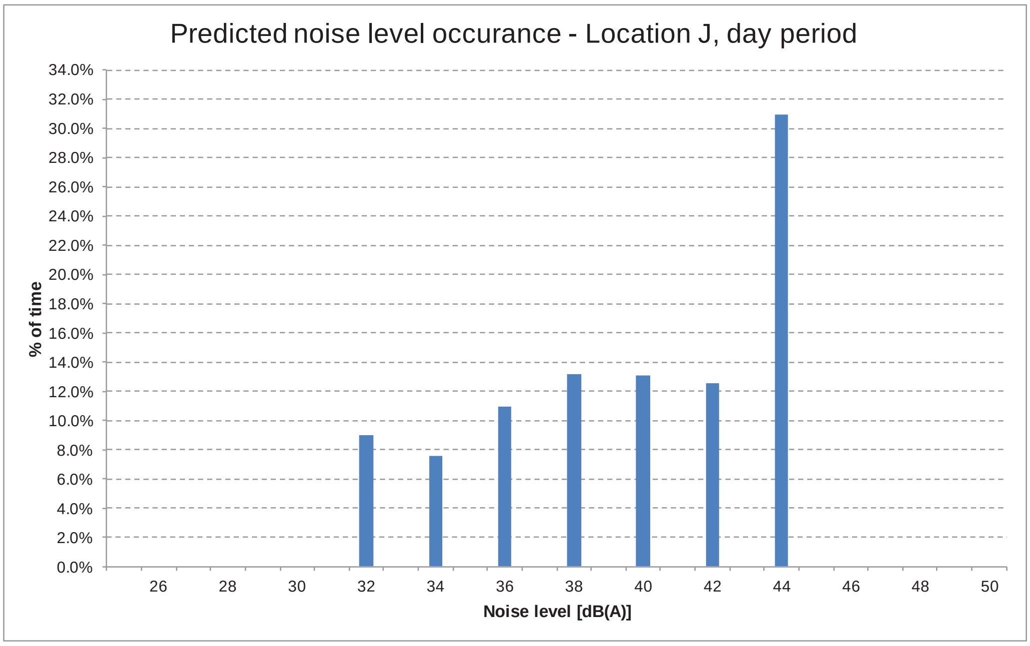
Predicted noise level occurance - Location F, day period
% of time
Noise level [dB(A)]

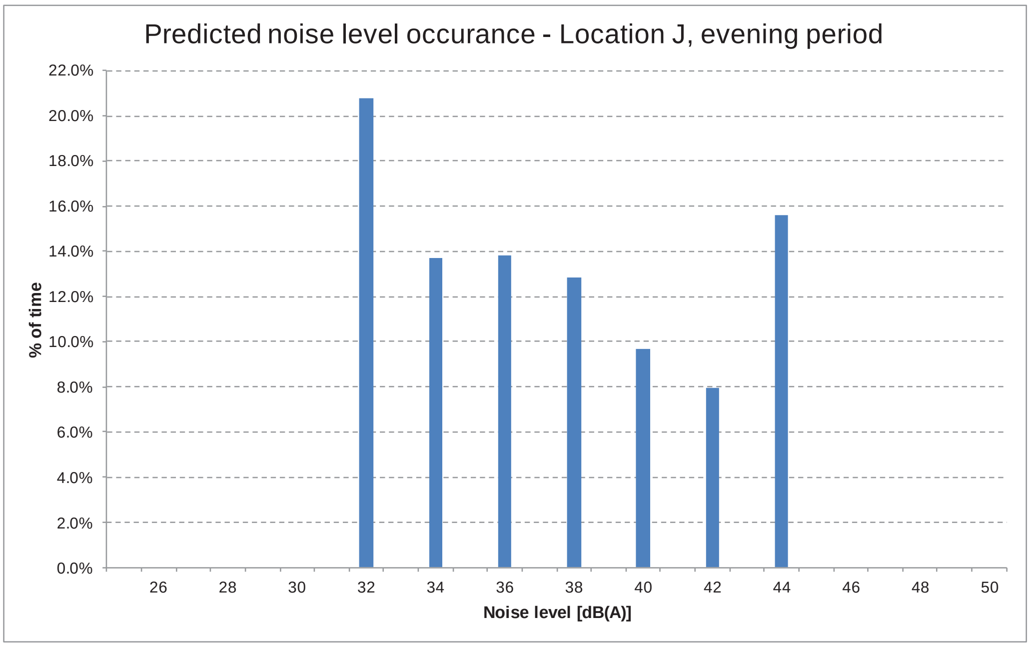


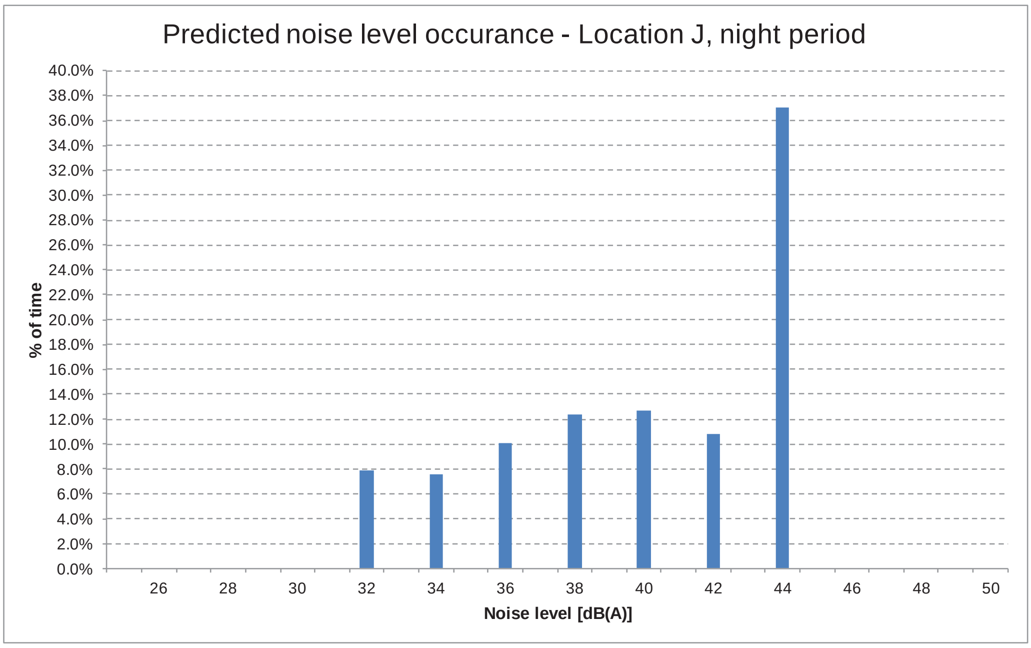
Predicted noise level occurance - Location F, evening period
% of time
Noise level [dB(A)]

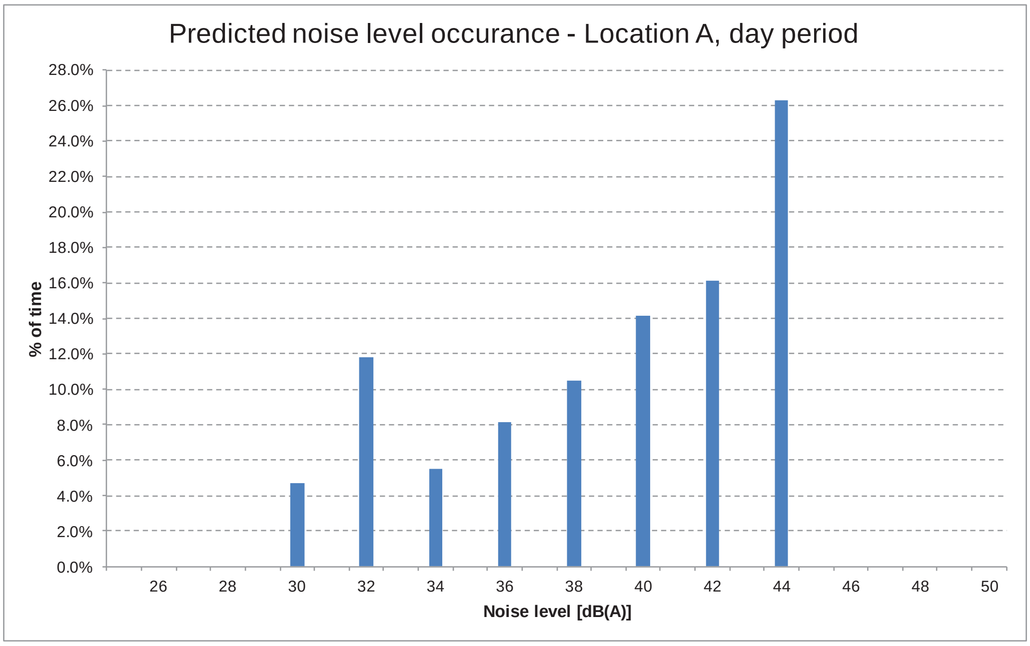


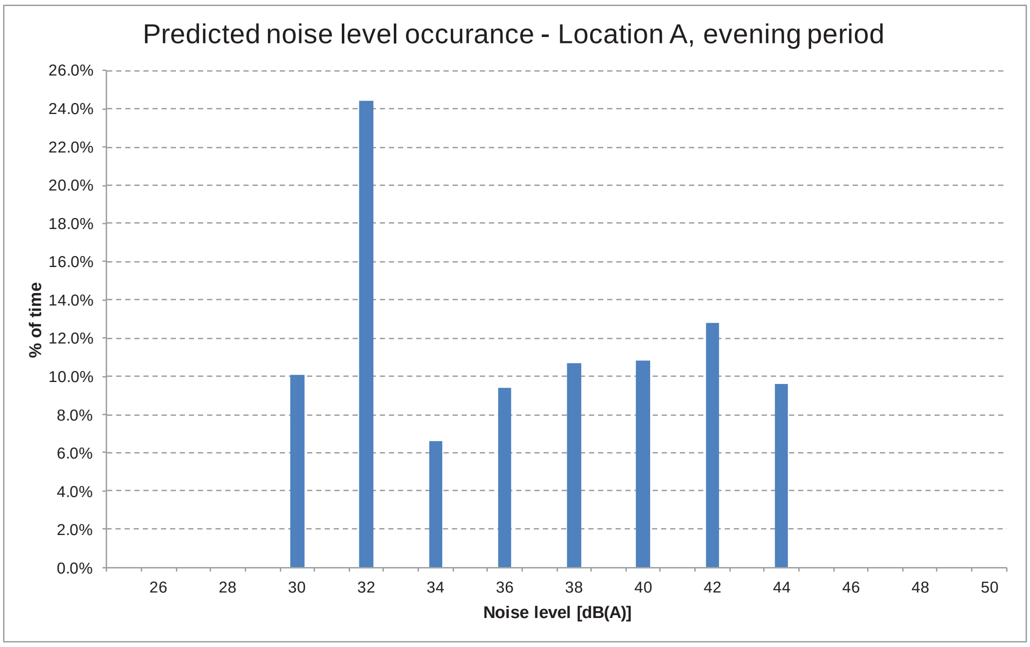
Predicted noise level occurance - Location F, night period
% of time
Noise level [dB(A)]

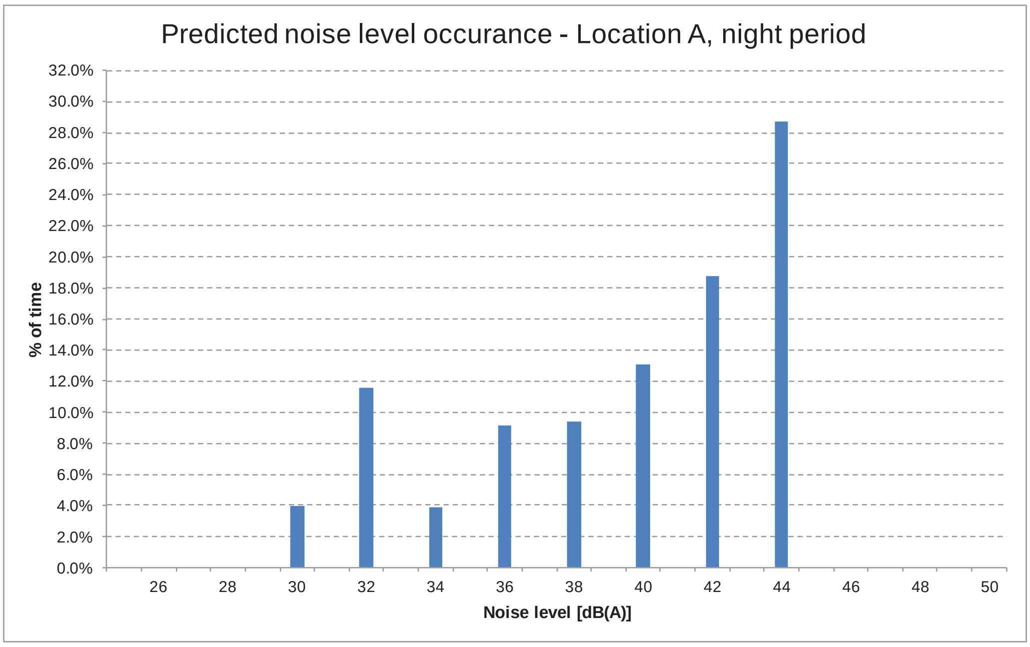

Predicted noise level occurance - Location J, day period
% of time
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

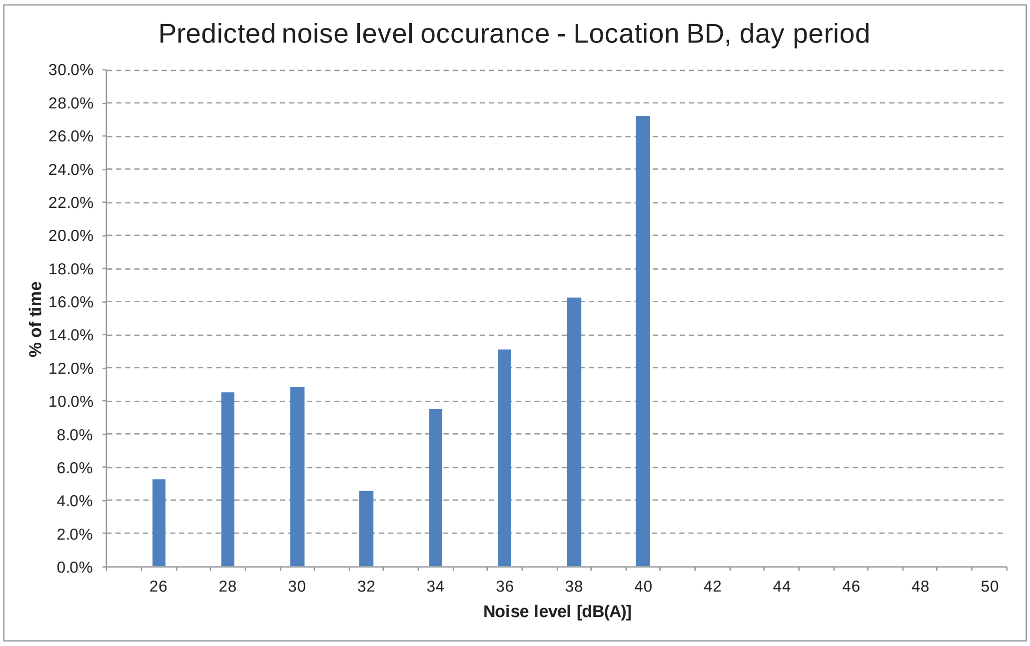

Predicted noise level occurance - Location J, evening period
% of time
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

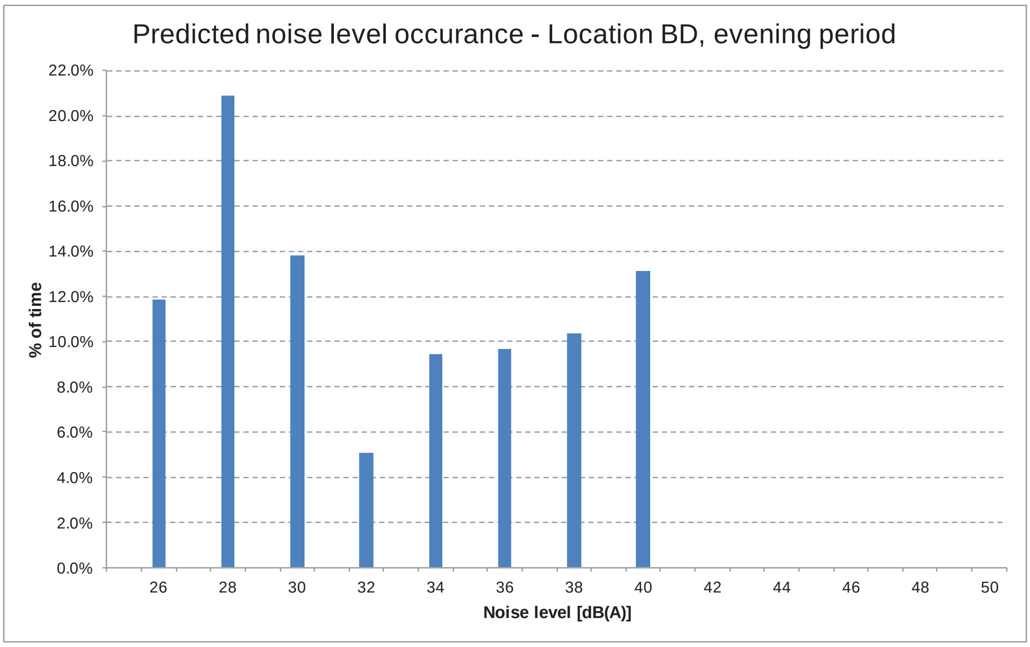

Predicted noise level occurance - Location J, night period
% of time
40.0%
38.0%
36.0%
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

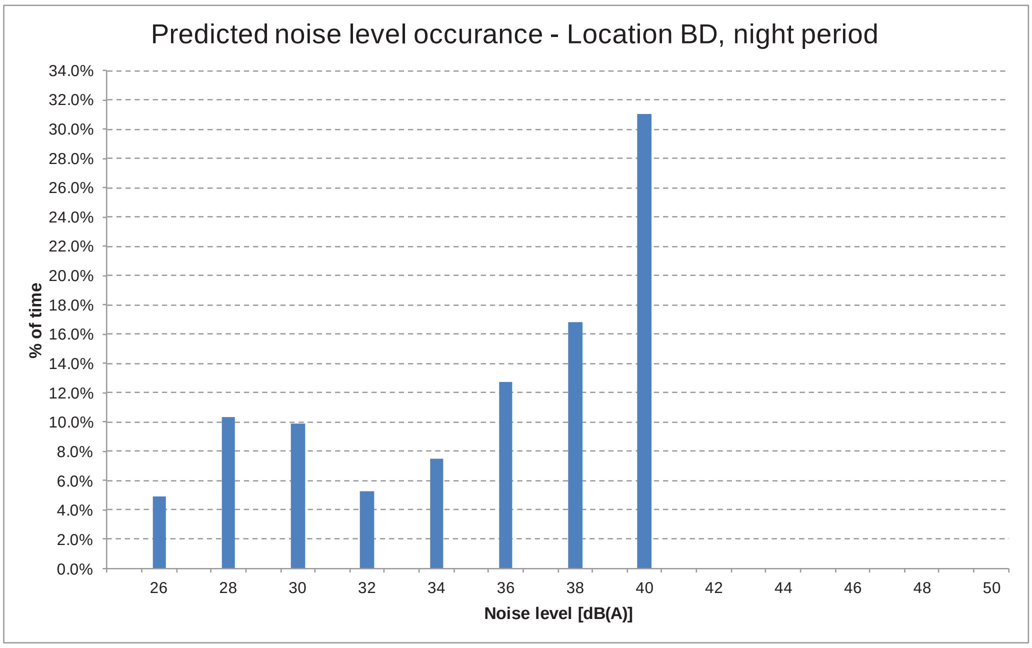

Predicted noise level occurance - Location A, day period
% of time
Noise level [dB(A)]
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%
14.0%
16.0%
18.0%
20.0%
22.0%
24.0%
26.0%
28.0%
26
28
30
32
34
36
38
40
42
44
46
48
50

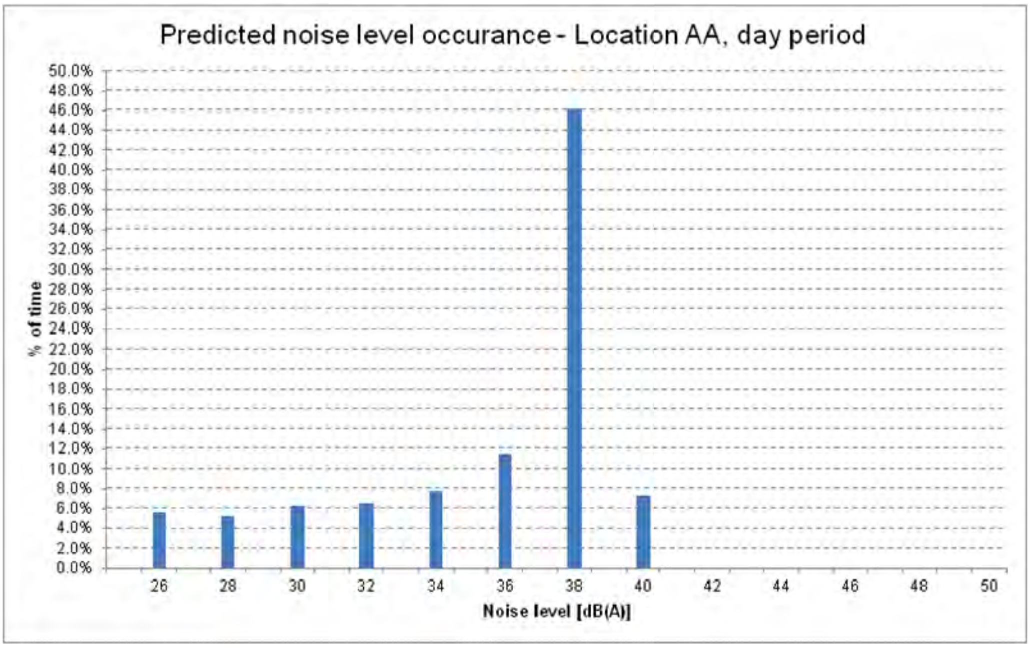

Predicted noise level occurance - Location A, evening period
% of time
Noise level [dB(A)]
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%
14.0%
16.0%
18.0%
20.0%
22.0%
24.0%
26.0%
26
28
30
32
34
36
38
40
42
44
46
48
50

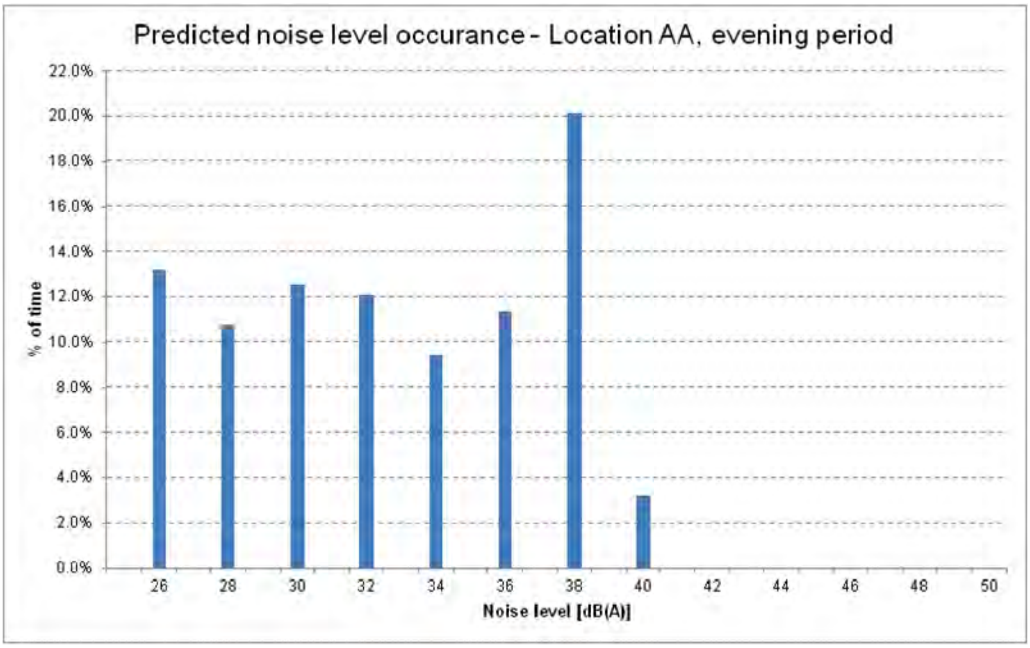

Predicted noise level occurance - Location A, night period
% of time
Noise level [dB(A)]
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
12.0%
14.0%
16.0%
18.0%
20.0%
22.0%
24.0%
26.0%
28.0%
30.0%
32.0%
26
28
30
32
34
36
38
40
42
44
46
48
50

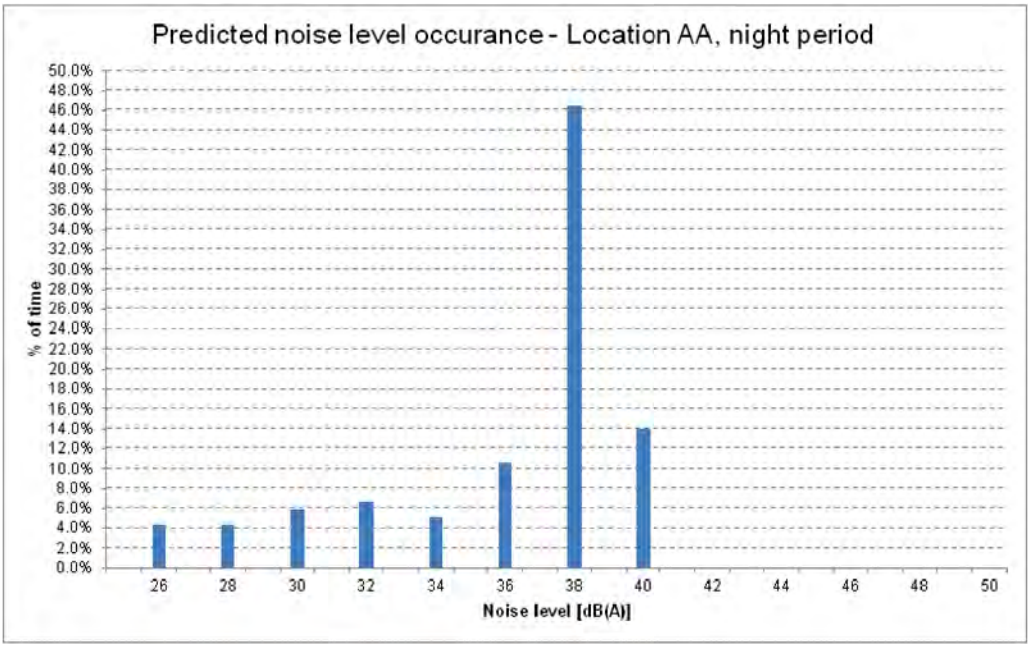

Predicted noise level occurance - Location BD, day period
% of time
Noise level [dB(A)]

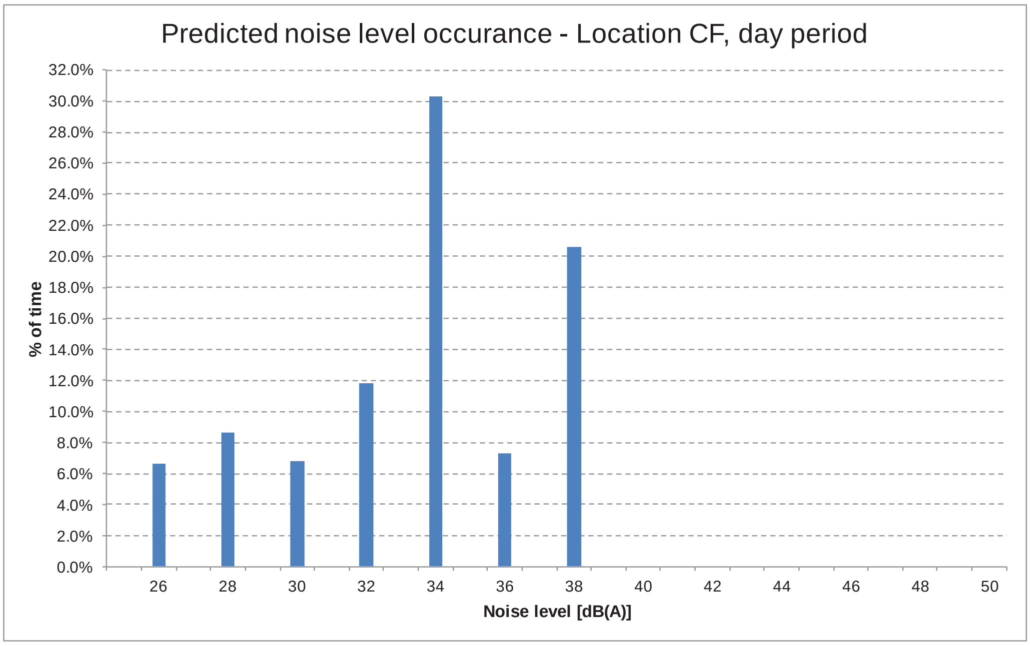

Predicted noise level occurance - Location BD, evening period
% of time
Noise level [dB(A)]

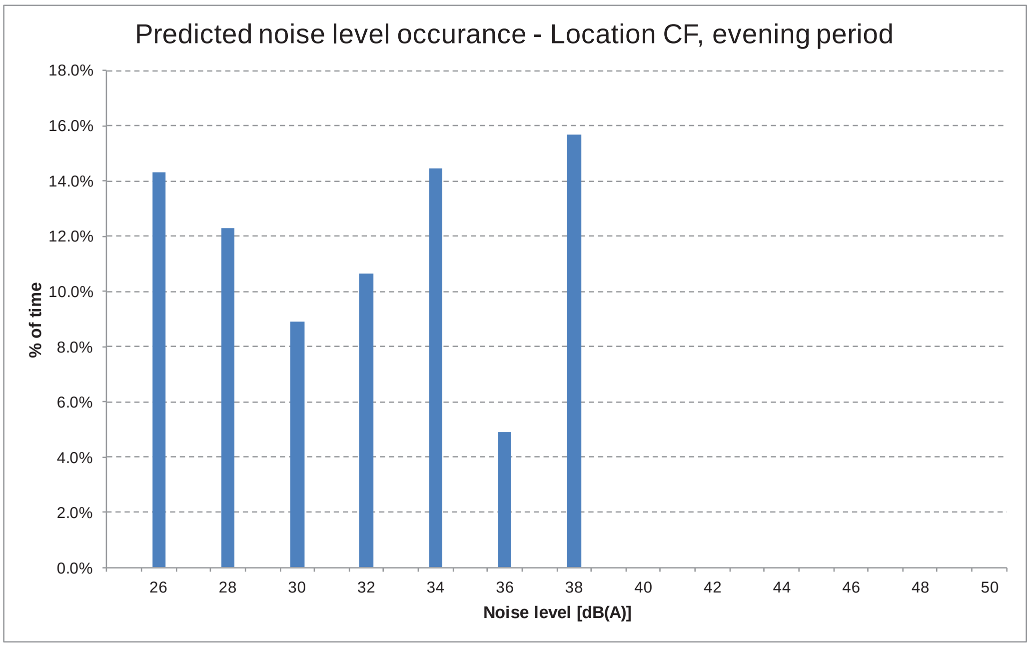

Predicted noise level occurance - Location BD, night period
% of time
Noise level [dB(A)]

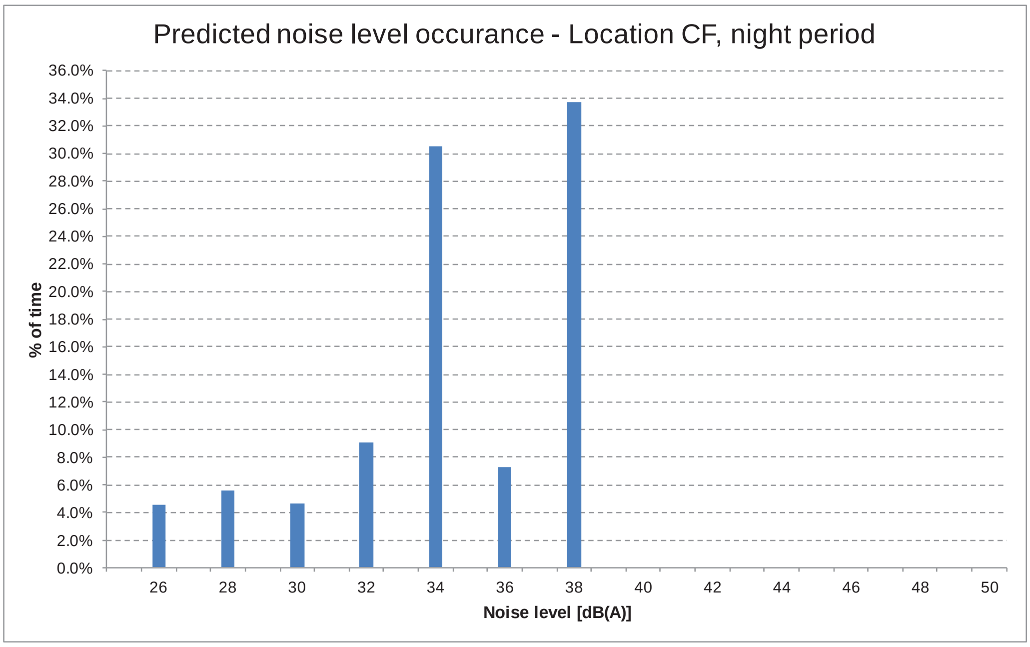

Predicted noise level occurance - Location AA, day period
% of time
Noise level [dB(A)]


Predicted noise level occurance - Location AA, evening period
% of time
Noise level [dB(A)]


Predicted noise level occurance - Location AA, night period
% of time
Noise level [dB(A)]


Predicted noise level occurance - Location CF, day period
% of time
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]


Predicted noise level occurance - Location CF, evening period
% of time
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]


Predicted noise level occurance - Location CF, night period
% of time
36.0%
34.0%
32.0%
30.0%
28.0%
26.0%
24.0%
22.0%
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
26
28
30
32
34
36
38
40
42
44
46
48
50
Noise level [dB(A)]

Appendix I

Facade Attenuation Review

D R A F T

Appendix I Facade Attenuation Review

Internal noise goals are often recommended for environmental noise emission with the aim of preserving the health and wellbeing and the ability to sleep for building occupants. These internal noise goals are generally translated into external noise level goals for a number of reasons:

- To avoid the need to take compliance measurements indoors (which can be intrusive);
- To provide consistency in the criteria between different building types, when otherwise a different external noise level could be allowed depending on the type of building design; and,
- To provide consistency in the criteria over time – i.e. so that the external noise level does not need to change if a building is altered through, for example, upgrading windows, adding extensions, providing air conditioning, etc.

To nominate an external noise criterion based on internal noise level goals requires a reasonable estimate of the expected reduction of sound through a typical façade. This estimate may vary in different climatic reasons, as the typical facade material changes, and the size of windows and window openings also varies. For climates like Queensland, the reduction across a facade typically considers a scenario with windows wide open or partially open to allow for natural ventilation.

This appendix summarises a review of the available literature on facade sound reduction to provide a basis for determining the appropriateness of external noise criteria.

When sound energy hits a facade, the energy is either transmitted through the facade into the house, absorbed into the building materials themselves or reflected back towards the source. The relative proportions of these vary with different materials – concrete will tend to reflect most sound; wood will absorb some, reflect some and transmit some; whereas sound hitting an open area will be completely transmitted into the building. The amount of sound transmitted through an opening will generally be much more significant than the sound partially transmitted through the rest of the facade. As such, for a typical Queensland home, the sound reduction provided by a facade will generally be controlled by any openings in the facade.

After the sound energy travels through an opening, the energy then spreads out to fill the room. The amount of sound that is transmitted into the room depends on the size of the opening - how big the windows are, whether they are fully open, partially open or closed, and the type of window - a sliding window provides a much greater open area relative to the window size than an awning window, for instance.

The resultant sound pressure level (or ‘loudness’ of the sound) in the room depends on the room itself – the size of the room (or how big a space the sound has to fill) and the finishes of the room (i.e. the area of surfaces in the room that absorb sound), as well as the location of the occupant relative to the window (and therefore how much direct sound they are exposed to). This is analogous to a water sprinkler operating near a window – only a portion of the water hitting the house will enter in an open window, most will hit the rest of the facade.

For these reasons, there are a range of values that are used to estimate the reduction of noise levels through the facade of a dwelling. Values of up to 25 dB(A) are used in some areas (particularly Europe) where smaller, partially open windows are common. Lower values are typically used in Australia, where larger, more open windows are common and beds are often located close to the window.

In Australia the sound attenuation of noise from outside to inside provided by a building façade with an open window is generally assumed to be between 10 and 15 dB(A). The actual reduction varies depending on a number of factors including size of windows, percentage of open area, type of window, size of rooms, finishes of room and location of sensitive receivers in relation to the window. These factors are often a function of house type and climate, and for that reason guideline values adopted for ‘typical’ reductions often vary between regions.

Review of Guidance Documents

The table below provides a summary of typical sound reduction values quoted in commonly used guidance documents. The documents include international and Australian state planning and environmental noise assessment documents.

DRAFT

Table 21 - Summary of values for sound reduction (through an open window) in commonly used guidance documents

Guidance Document	Sound Level Reduction
International	
Building Bulletin 93 (BB93): Acoustic Design of Schools (2003) (Department of Education and Skills, UK)	R_W 10 - 15
British Standard BS 8233:1999: Sound insulation and noise reduction for buildings - Code of Practice	10 to 15 dB
European Standard EN 12354-3:1999: Building acoustics - Estimation of acoustic performance of buildings from the performance of products, Part 3: Airborne sound insulation against outdoor sound	R_W 10 - 15
Guidelines for Community Noise (1999) (World Health Organisation)	10 - 15 dB(A)
Planning Policy Guidance PPG 24 (1994) (Department for Communities and Local Government, UK)	10 - 15 dB(A)
BRE Digest 338 (1988) (Building Research Establishment, UK)	D_w 15
Design Bulletin 26 (1972) (Department of the Environment, UK)	5 - 15 dB(A)
Australian	
Australian Standard AS 3671 - 1989: Acoustics - Road Traffic Noise Intrusion - Building siting and construction	10 dB(A)
Ecoaccess Guideline: Noise (Department of Environment and Resource Management, QLD): Planning for Noise Control	5 – 10 NR dB(A)
Noise Impact Assessment Planning Scheme (Brisbane City Council)	5 dB(A)
Environmental Protection (Noise) Policy 2008 (Department of Environment and Resource Management, QLD)	15 - 20 dB(A)
Interim Construction Noise Guidelines 2009 (Department of Environment and Climate Change NSW)	10 dB
NSW Industrial Noise Policy 2000 (Environmental Protection Authority)	10 dB
Environmental Protection (Noise) Regulations 1997 (Department of Environmental Protection, WA)	10 dB
Environmental Protection Policy (Noise) 2009 (Department of Environment, Parks, Heritage and the Arts, TAS)	15 dB(A)

DRAFT

Different studies used different descriptors to present a single figure reduction for the measured reduction across the frequency range. These descriptors are:

- Rw - Weighted Sound Reduction Index – Laboratory test measurement procedure that provides a single number indication of the acoustic performance of a partition or single building element. The higher the RW, the greater the noise isolation between spaces.
- Dw - Weighted Level Difference – Single number that represents the noise reduction in sound between two adjoining enclosed spaces. The result includes the actual noise reduction for the installed partition and ceiling systems. The higher the D_W, the greater the noise isolation between spaces.
- NR – Noise Reduction – The difference between the sound levels in the source space and the other (receiving) space.

For the purposes of this review we have assumed that the various parameters are roughly equal.

Review of Field and Laboratory Studies

A number of field and laboratory studies have been reviewed to determine if the guideline values summarised above are consistent with what has been found in the field.

The most significant study findings are summarised in the table below.

D R A F T

Table 22 – Summary of values for sound reduction for a facade with open windows – field studies

Research Study	Open Area on Facade	Noise Attenuation (dB)
General Noise (i.e. typically up to 4 kHz)		
NANR116 (2007)	0.20 m^2	≥ 10 (in 97% of cases)
		15 (average)
Quirt (1982)	0.28 m^2	≥ 9 (in 99% of cases)
		12 (average)
Mackenzie and Williamson (1972 – 73)	0.36 m^2	11 (average)
Lawrence and Burgess (1983 – 85) (Australian)	5%	10 (average)
	10%	8 (average)
Carter et. Al. (1992) (Australian)	Up to 15cm opening	11 – 13 dB
Ryan et. Al. (2011) (Australian)	0.2 – 1.6 m^2	11 (average)

The majority of studies were from cooler climates (e.g. Europe, Canada, etc.) where smaller, partially open windows are common. The three studies from Australia assessed greater open areas of windows. These Australian studies support the assumption that a 10 dB reduction is appropriate.

Natural Ventilation Requirements in Australia

The Building Code of Australia (BCA) (2011) is the minimum standard of building for all new buildings in Australia. Whilst it does not apply to existing dwellings, it provides useful guidance on acceptable levels of natural ventilation requirements for existing and any future dwellings.

The BCA 2011 specifies that natural ventilation;

"*... must consist of permanent openings, windows, doors or other devices which can be opened-*

- *(a) With an aggregate opening or openable size not less than 5% of the floor area of the room*
- *(b) open to—*
  - *(i) suitably sized court, or space open to the sky; or*
  - *(ii) an open verandah, carport, or the like; or*
  - *(iii) an adjoining room (with sufficient ventilation).*

On this basis, the *total* area of all windows, doors, etc. within a room should be equal to, or greater than, 5% of the floor area of the room itself.

We have used the earlier research results and the BCA natural ventilation requirements to assess the reduction of a 'typical' facade in Australia. We have assumed that adjoining rooms may not have sufficient ventilation and that the ventilation requirements must be provided by the windows opening to the outside alone. For a master bedroom or living room with typical dimensions of 5m x 5m (a floor area of 25 m^2) would require an open area of 1.25 m^2 for natural ventilation under the BCA. Assuming a ceiling height of 2.7m, an open window area of 1.25 m^2 (assuming all ventilation is provided by windows opening to the outside alone) is equivalent to 9.3% of the façade.

A small to medium sized bedroom with typical dimensions of 3m x 3m (a floor area of 9 m^2) would require an open area of 0.45 m^2. Assuming the same conditions as those listed above, the open window area of 0.45 m^2 would equate to 5.6% of the façade.

These approximate areas and percentages can then be compared to the studies that specifically detailed the percentage or area of open facade values outlined in Table 22 above. Based on these studies, a 10 dB(A) reduction can be expected from the a typical ventilation area in line with current BCA requirements. As an example, the study undertaken in 2011 by Ryan et. Al. found that for every dwelling tested with an open area of 10% or less, the attenuation was greater than 10 dB(A).

DRAFT

D R A F T

Effect of Dwelling Construction

The Ryan et. Al. study compared the difference between the measured and theoretical attenuation of timber, brick veneer and double brick residences. The paper states that:

> *It has also determined that whilst theoretically slightly weaker acoustically than the masonry residences, the traditional Queenslander style timber facade dwellings measured in this test are still capable of providing noise attenuation at a level comparable to those measured at the more solid double brick and brick veneer residences.*

As discussed above, this result is not unexpected as the sound reduction provided by a facade will generally be controlled by openings in the facade.

DRAFT