2. Industrial noise trigger levels

Industrial noise can have a significant effect on noise-sensitive receivers surrounding the premises. This draft guideline sets out the procedure to determine the **project noise trigger levels** relevant to a particular industrial development. The project noise trigger level applies to existing noise-sensitive receivers.

If it is predicted that the development is likely to cause the project noise trigger level to be exceeded at **existing noise-sensitive receivers**, management measures need to be considered to reduce the **predicted noise level**.

2.1 Project noise trigger level

The project noise trigger level provides a benchmark or objective for assessing a proposal or site. It is not intended for use as a mandatory requirement. The project noise trigger level is a level that, if exceeded, would indicate a potential noise impact on the community, and so ‘trigger’ a management response; for example, further investigation of mitigation measures.

The project noise trigger level, reasonable and feasible mitigation and consideration of residual noise impacts are used together to assess noise impact and manage the noise from a proposal or site. It is the combination of these elements that is designed to ensure that acceptable noise outcomes are determined by decision makers.

The trigger level is tailored for each specific circumstance to take into account a range of factors that may affect the level of impact, including:

- the receiver’s background noise environment
- the time of day of the activity
- the character of the noise
- the type of receiver and nature of the area.

The scientific literature indicates that both the increase in noise level above background levels (i.e. intrusiveness of a source), as well as the absolute level of noise are important factors in how a community will respond to noise from industrial sources. The project noise trigger level established in this guideline addresses each of these components of noise impact.

The project noise trigger level for a project is the lower (i.e. the most stringent) value of the **intrusiveness noise level** and **amenity noise level** determined in Sections 2.3 and 2.4.

The intrusiveness noise level aims to protect against significant changes in noise levels, whilst the amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited and amenity is protected and that no single industry can unacceptably change the noise level of an area.

The worked case studies in Fact Sheet E show how both components are used to determine the project noise trigger level.

Typically, the intrusiveness level will inform the project noise trigger level in areas with little industry (and/or ambient noise levels) whereas the amenity level will inform the project noise trigger level in areas with higher existing background noise levels.

Intrusive noise levels are only applied to residential receivers (residences). For other receiver types identified in Table 2.1, only the amenity levels apply.

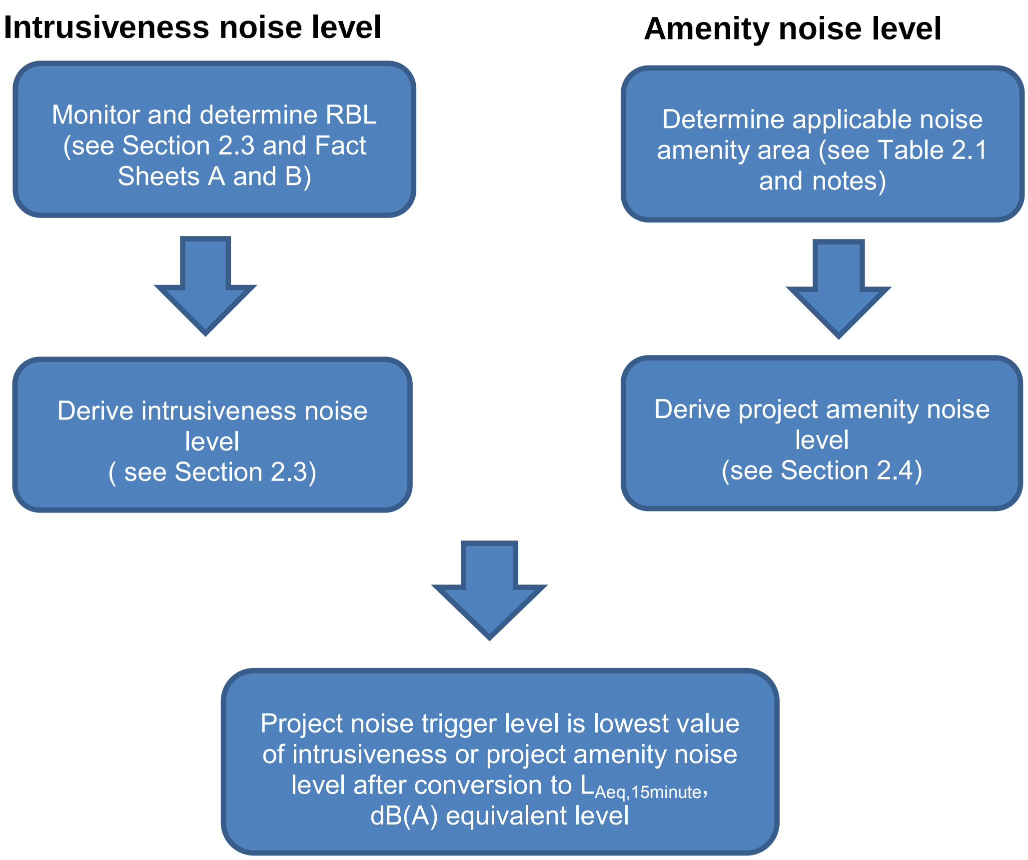

Figure 1: Determining the project noise trigger level. RBL = rating background noise level.

2.2 Noise descriptors

The noise levels in this guideline differentiate between noise impacts during the day, evening and night. More stringent levels are applied for evening and night-time. It is widely accepted that noise is generally more disturbing in the evening and night because more noise-sensitive activities occur at those times (e.g. socialising, relaxing and sleeping). Also, most residents are typically at home and noise is more intrusive due to lower background levels during the evening and at night.

L_{Aeq} descriptor

The **L_{Aeq} descriptor** is used for both the intrusiveness noise level and the amenity noise level. This descriptor represents the level of average noise energy over the relevant period of measurement and takes account of peak noise levels as well as the degree of noise fluctuation. This unit is most widely correlated with the subjective effect of noise (Miedema and Vos, 2004).

The L_{Aeq} is determined over a 15-minute period for the intrusiveness noise level and over an assessment period (day, evening and night) for the amenity noise level. To standardise the time periods for the intrusiveness and amenity noise levels, this guideline assumes that the **$L_{Aeq,15\ minute}$** will be taken to be equal to the **$L_{Aeq,\ period}$ + 2 dB** unless robust evidence is provided for an alternative approach for the project.

All project noise trigger levels and limits derived in this guideline will be expressed as $L_{Aeq,15\ minute}$ values except as otherwise expressed in Section 2.8.

L_{A90} descriptor

The **L_{A90} descriptor** is used to measure the background noise level. This descriptor represents the noise level that is exceeded for 90% of the time over a relevant period of measurement.

This guideline describes a process to derive a **rating background noise level** (RBL) that provides a single figure that represents the background noise level for assessment purposes.

L_{Amax} descriptor

The L_{Amax} descriptor is used to measure and quantify maximum noise level events. The L_{Amax} is the maximum fast time weighted sound level of an event measured with a sound level meter satisfying AS IEC 61672.1-2004.

2.3 Intrusiveness noise level

The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the **L_{Aeq} descriptor**), measured over a 15-minute period, does not exceed the background noise level by more than 5 dB(A). This level seeks to limit the degree of change a new noise source introduces to an existing environment.

To account for the temporal variation of background noise levels, the method outlined in Fact Sheet A is required for determining the background noise level or rating background noise level (RBL) to be used in the assessment. The outcome of this approach aims to ensure that the intrusive noise level is being met for at least 90% of the time periods over which annoyance reactions can occur (taken to be periods of 15 minutes).

The intrusiveness noise level is determined as follows:

LAeq, 15 minute = rating background level + 5dB

where:

$L_{Aeq, 15\ minute}$	represents the equivalent continuous (energy average) A-weighted sound pressure level **of the source** over 15 minutes. This is to be assessed at the reasonably most-affected point on or within the **residential** property boundary—or, if that is more than 30 metres from the residence, at the reasonably most-affected point within 30 metres of the residence.

and

Rating background level	represents the background level to be used for assessment purposes as determined by the method outlined in Fact Sheet A.

In some rural situations, the RBL may be the same for the day and night. In these cases, it is recognised that excursions of noise above the intrusiveness criterion during the day would not usually have the same impact as they would at night. This is due to the more sensitive nature of activities likely to be disturbed at night (for example, sleep and relaxation).

Minimum assumed RBLs apply in this guideline. These result in minimum intrusiveness noise levels as follows:

Time of day	Minimum assumed rating background noise level (dB(A))	Minimum intrusiveness noise levels ($L_{Aeq,15minutes}$ dB(A))
Day	35	40
Evening	30	35
Night	30	35

The objective of carrying out long-term background noise monitoring at a location is to determine existing background noise levels that are indicative of levels during the entire year. However, the RBL for evening or night periods calculated from long-term unattended background noise monitoring can sometimes be higher than the RBL for the daytime period. This situation can arise due to increased noise from, for example, insects or frogs during the evening and night in the warmer months or due to temperature inversion conditions during winter.

In determining project-specific noise levels from RBLs, the community's expectations also need to be considered. The community generally expects greater control of noise during the more sensitive evening and night-time periods than during the less sensitive daytime period. Therefore, in determining project-specific noise levels for a particular development, it is generally recommended that the intrusive noise level for evening be set at no greater than the intrusive noise level for daytime. The intrusive noise level for night-time should be no greater than the intrusive noise level for day or evening. Alternative approaches to these recommendations may be adopted if appropriately justified.

2.4 Amenity noise levels and project amenity noise levels

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from **all** industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.1 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance.

The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004). They have been subjectively scaled to reflect the perceived differential expectations and ambient noise environments of rural, suburban and urban communities for residential receivers. They are based on protecting the majority of the community (90%) from being highly annoyed by industrial noise.

The recommended amenity noise levels represent the objective for **total** industrial noise at a receiver location whereas the **project amenity noise level** represents the objective for noise from a **single** industrial development at a receiver location.

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a **project amenity noise level** applies for each new source of industrial noise as follows:

Project amenity noise level for industrial developments = recommended amenity noise level minus 5 dB(A)

There are exceptions to this for areas with high traffic noise levels where the level of traffic noise is considered in deriving the project amenity noise level (Section 2.4.1) and for development in major industrial clusters, for example ports and industrial complexes where many co-located industrial premises occur (Section 2.4.2).

Where the project amenity noise level applies and it can be met, no additional consideration of cumulative industrial noise is required. However, in circumstances where this level cannot be feasibly and reasonably met, an assessment of existing industrial noise, and the combined resulting noise level from existing and the proposed industries, is required so the impact of the residual noise levels can be determined.

Table 2.1: Amenity noise levels

Receiver	Noise amenity area	Time of day	L_{Aeq}, dB(A)
(see Table 2.2)			**Recommended amenity noise level**
Residence	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day.
School classroom – internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Hospital ward internal external	 All All	 Noisiest 1-hour Noisiest 1-hour	 35 50
Place of worship – internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

Notes: The recommended amenity noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

For residences, the amenity noise levels apply at the reasonably most-affected point on or within the residential property boundary or, if this is more than 30 metres from the residence, at the reasonably most-affected point within 30 metres of the residence. This requirement should not be read to infer that the noise limit **only** applies at the 'reasonably worst affected location'.

In assessing amenity noise levels at commercial or industrial premises, the noise level is to be assessed at the reasonably most-affected point on or within the property boundary. Again, this requirement should not be read to infer that the noise limit **only** applies at the 'reasonably worst affected location'.

Where internal amenity noise levels are specified, they refer to the noise level at the centre of the habitable room that is most exposed to the noise and apply with windows opened sufficiently to provide adequate ventilation except where alternative means of ventilation complying with the Building Code of Australia are provided. In cases where the gaining of internal access for monitoring is difficult, then external noise levels 10 dB(A) above the internal levels apply.

In assessing amenity noise levels at passive and active recreational areas, the noise level is to be assessed at the most-affected point within the area that is reasonably expected to be used by people, for example picnic areas, walking tracks etc.

Types of receivers are defined as follows:

- rural residential – see Table 2.2
- suburban residential – see Table 2.2
- urban residential – see Table 2.2
- industrial interface – an area that is in close proximity to existing industrial premises and that extends out to a point where the existing industrial noise from the source has fallen by 5 dB or an area defined in a planning instrument. Beyond this region the amenity noise level for the applicable category applies. This category may be used only for existing situations (further explanation on how this category applies is outlined in Section 2.6).
- commercial – commercial activities being undertaken in a planning zone that allows commercial land uses
- industrial – an area defined as an industrial zone on a local environment plan, for isolated residences within an industrial zone the industrial amenity level would usually apply.

Time of day is defined as follows:

- day – the period from 7 am to 6 pm Monday to Saturday or 8 am to 6 pm on Sundays and public holidays
- evening – the period from 6 pm to 10 pm
- night – the remaining periods.

(These periods may be varied where appropriate, for example, see A3 in Fact Sheet A.)

In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$.

Table 2.2 is designed to provide guidance in assigning residential receiver noise categories; however, careful judgement based on site-specific circumstances and consultation with the relevant planning/licensing authority may be required in some circumstances.

Table 2.2: Determining which of the residential receiver categories applies

Receiver category	Typical planning zoning – standard instrument*	Typical existing background noise levels	Description
Rural residential	RU1 – primary production RU2 – rural landscape RU4 – primary production small lots R5 – large lot residential	Daytime RBL <40 dB(A) Evening RBL <35 dB(A) Night RBL <30 dB(A)	**Rural** – an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic noise and generally characterised by low background noise levels (except in the immediate vicinity of industrial noise sources). Settlement patterns would be typically sparse.
Suburban residential	RU5 – village RU6 – transition R2 – low density residential R3 – medium density residential	Daytime RBL<45dB(A) Evening RBL<40dB(A) Night RBL <35dB(A)	**Suburban** – an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.
Urban residential	R1 – general residential R4 – high density residential B1 – neighbourhood centre (boarding houses and shop top housing) B2 – local centre (boarding houses)	Daytime RBL>45dB(A) Evening RBL>40dB(A) Night RBL >35dB(A)	**Urban** – an area with an acoustical environment that: is dominated by ‘urban hum’ or industrial source noise has through traffic with characteristically heavy and continuous traffic flows during peak periods is near commercial districts or industrial districts has any combination of the above or where ‘urban hum’ means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources.

Notes: * As cited in Standard Instrument – Principal Local Environmental Plan, New South Wales Government, Version 15 August 2014. RBL = rating background level.

2.4.1 Amenity noise levels in areas of high traffic noise

The level of transport noise, road traffic noise in particular, may be high enough to make noise from an industrial source effectively inaudible, even though the L_{Aeq} noise level from that industrial noise source may exceed the project amenity noise level. In such cases the project amenity noise level may be derived from the $L_{Aeq,\ period(traffic)}$ minus 15 dB(A).

High traffic project amenity noise level for industrial developments = $L_{Aeq,\ period(traffic)}$ minus 15 dB(A)

General and more specific case studies showing how the high-traffic criterion works are included in Fact Sheet E.

This high traffic project amenity noise level may be applied only if all the following apply:

- traffic noise is identified as the dominant noise source at the site
- the existing traffic noise level (determined using the procedure outlined in A2, Fact Sheet A (i.e. measuring traffic instead of industrial noise) is 10 dB(A) or more above the recommended amenity noise level for the area
- it is highly unlikely traffic noise levels will decrease in the future

The applicability of these traffic noise provisions needs to be determined for each assessment period (i.e. day, evening and night).

2.4.2 Amenity noise levels in areas near an existing or proposed cluster of industry

The recommended amenity noise level from Table 2.1 represents the **total** industrial noise level from all sources (new and proposed) that is sought to be achieved using feasible and reasonable controls.

The approach of deriving the project amenity noise level resulting from a new development on the basis of the recommended amenity noise level minus 5 dB(A) is based on a receiver not being impacted by more than three to four individual industrial noise sources.

Where an existing cluster of industry, for example an industrial estate, is undergoing redevelopment and/or expansion and the development constitutes a single premises addition or expansion, with no other redevelopment planned in the foreseeable future, the project amenity noise level approach procedure in Section 2.4 can be applied.

However, where a greenfield or redevelopment of an existing cluster of industry consisting of **multiple new** noise generating premises is proposed, the approach for determining the project amenity noise level in Section 2.4 is not applicable and the approach below should be applied.

Equation 1: New multiple premises or redevelopment of existing clusters of industry

Individual project amenity noise level = $10\text{Log}\ (10^{(ANL - 5\ dB/10)}/N)$

where:

ANL = relevant recommended amenity noise level from Table 2.1

N = number of proposed additional premises.

Where a greenfield development is proposed and it can be demonstrated that existing levels of industrial noise are lower than the relevant recommended amenity noise level, equation 1 can be modified to reflect ‘amenity noise level’ in lieu of ‘amenity noise level – 5 dB(A)’.

2.4.3 Effects of changing land use

When land uses in an area are undergoing significant change, for example residential subdivisions for new suburbs with associated development of local and regional roads, the background noise levels would be expected to change, sometimes significantly. In these cases, assessments of noise sources for control purposes should be made against the recommended amenity noise level for the modified land use.

2.5 Maximum noise level event assessment

The potential for sleep disturbance from maximum noise level events from a premises during the night-time period needs to be considered.

Where the subject development can satisfy the following two maximum noise level event trigger levels no additional assessment or evaluation of sleep disturbance is required:

- a night-time project noise trigger level of $L_{Aeq,15minutes}$ 40 dB(A), and
- a maximum noise level screening criteria of L_{Amax} 52 dB(A) when assessed or predicted at 1 metre from the façade of a residence containing a window.

Where the night-time noise levels are predicted to exceed one or both of the maximum event noise trigger levels above, a detailed analysis should be undertaken.

The detailed analysis should cover the maximum noise level, the extent to which the maximum noise level exceeds the background level (RBL) and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy.

Other factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events will occur
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the subject development
- whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods)
- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

Maximum noise level event assessments should be based on the L_{Amax} descriptor on an event basis under 'fast' time response.

The detailed assessment should consider all feasible and reasonable noise mitigation measures with a goal of achieving the above trigger levels.

2.6 Industrial interface

The industrial interface assessment recognises that the availability of noise mitigation measures might be limited where residences are close to existing major clusters of industry or critical infrastructure, for example a port.

The industrial interface assessment generally applies only for existing situations (that is, an existing receiver near an existing industry) and generally only for those receivers in the immediate area surrounding the existing industry (that is, the region that extends from the boundary of the existing industry to the point where the noise level of the existing industry (measured at its boundary) has fallen by 5 dB(A)).

Beyond the interface region (that is, beyond the point where noise has fallen by 5 dB) the recommended amenity noise level relevant to the receiver category that most describes the area (rural, suburban or urban) would apply.

For new developments of a limited nature such as an extension to **existing** process or plant, or replacement of part of an **existing** process or plant with new technology, the industrial interface assessment applies.

However, where a new development on an existing site is of a substantial nature (for example demolition of the existing plant and replacement with current technology or different type of plant) and where replacement of the existing plant has a realistic potential to significantly reduce receiver noise levels through using feasible and reasonable noise mitigation (i.e. where the existing plant is the dominant or a significant contributor to receiver noise levels) then the applicable noise level for the new development is the appropriate (rural, suburban or urban) amenity noise level for the location.

In most cases the situation will be apparent but in some cases careful judgement will be required to determine whether the new development is of sufficient magnitude to effectively replace the existing plant. In situations where no clear conclusion on the magnitude of change created by the new development is possible, then the industrial interface assessment should apply.

In all cases, however, the proponent/licensee is required to demonstrate that all feasible and reasonable noise mitigation measures are being applied before the industrial interface criteria is adopted.

2.7 Noise management precincts

2.7.1 What is a noise management precinct?

A **noise management precinct** allows for new development without causing further noise impacts in areas where noise levels might already be above desired levels. It also has the potential to be used to manage legacy noise issues associated with industrial land that is close to residential areas.

The precinct approach has the following objectives:

- to ensure that noise impacts are not exacerbated in residential areas close to a nominated industrial precinct
- to provide a mechanism that will allow noise impacts to be managed over time
- to allow nominated industrial precinct to be fully utilised in a cost effective and efficient manner.

The precinct approach allows noise from multiple sites to be managed as a single site by giving the operator of an activity or proposed activity the flexibility to take action to reduce noise in another nearby location, or work with others to take action to reduce noise on their behalf.

While a new noise source always adds to existing noise levels, the precinct approach ensures any nominal increase from a single development is not significant and not detectable by the community. By maintaining the requirement to implement the usual suite of reasonable and feasible mitigation options, there is also potential for noise levels to be reduced over time.

Within a precinct the source of the noise affecting receivers is managed as a single site. When a new development is proposed, the responsible landowner or entity can use any available method to ensure the precinct meets the recommended amenity noise level. For example, it might be possible to re-locate a new activity in a different area to the original proposal or to reduce noise levels at other sources in order to accommodate the new activity.

In all cases, the principle that all reasonable and feasible means of mitigating noise impacts must be undertaken will remain.

3.2 Community engagement

The management of industrial noise impacts requires effective public involvement and communication strategies to help everyone understand the impact of industrial noise on the community. This is best approached by proponents/owners of industrial premises providing the community with:

- information about proposed industrial developments that may affect surrounding receivers
- the opportunity, where appropriate, for input and/or involvement in developments and activities that may affect it
- a means of ongoing communication once industrial activities begin (i.e. complaint and response mechanisms).

The Guidelines for Major Project Community Consultation (DoP, 2007) provides advice on community and stakeholder consultation for major projects.

Noise-mitigation planning for industrial projects is greatly assisted by effective community consultation throughout the environmental assessment process. This includes the formal public exhibition phase, which invites written submissions in line with the requirements of the EP&A Act. These processes allow the community to participate in any mitigation selection process in a transparent, equitable and consistent way. Effective community involvement is particularly needed where impact assessment finds there will still be noise impacts even after applying all feasible and reasonable mitigation measures.

It is equally important for land-use planning authorities to ensure that existing and proposed industrial developments are considered when making and/or determining land-use planning instruments. This includes rezoning proposals and residential development applications.

3.3 Predicting noise levels and determining impacts

3.3.1 Identifying noise parameters

The important parameters for predicting noise are listed below. These will set the boundaries of the noise prediction process. They need to be determined and clearly identified for noise impacts to be predicted adequately. The parameters are:

- all noise sources related to the proposed development, including vehicles that operate on site
- source noise levels, site location and effective height of the noise source – references should be provided for all source noise levels used in the assessment (for example, direct measurement, previous Environmental Impact Statement, manufacturer's specifications etc.)
- annoying characteristics of the noise sources that may be experienced at receiver locations (e.g. tonality, low frequency, intermittency etc; see Fact Sheet C)
- all stages of project development
- all receivers potentially affected by the development
- meteorological conditions applicable to the site (from Fact sheet D) to determine the meteorological conditions that should be adopted for the noise impact assessment
- site features (including natural and constructed, development and surrounding land uses) that affect noise propagation
- operating times of the development.

3.3.2 Noise prediction

To quantify the noise impact, the noise levels from the source at all potentially affected receivers should be predicted, taking account of the parameters identified in Section 3.3.1.

The noise levels predicted should be on the basis of $L_{Aeq,15minute}$ values as project noise trigger levels are expressed using this descriptor (see Section 2.2 for converting the project amenity noise level) and the L_{Amax} level for assessing the potential for sleep disturbance (Section 2.5).

For small or simple projects, the predicted noise level from the source may be calculated manually, taking into account the distance from the source to receiver and any shielding between the source and receiver.

For large or difficult projects, noise is generally predicted through the use of computer noise models. Such models generally take account of noise attenuation due to distance, atmospheric absorption, barriers, and effects of intervening ground types and weather conditions. They use information about source noise levels, location of sources, topography between source and receiver and weather conditions to calculate overall noise levels at a receiver location.

The model selected should be capable of considering the standard and noise-enhancing meteorological conditions identified in Fact Sheet D.

Evidence of the suitability of the noise propagation model to accurately predict noise under Australian conditions should be referenced in any noise impact assessment, for example peer reviewed publications. All user-adjusted variables in a noise model should be identified and justified at the project level. Noise predictions should be presented in both point to point outputs and noise contours for larger projects in 5 dB(A) increments.

Prediction approaches that present a statistical distribution of noise levels based on a range of prevailing meteorological conditions are useful in explaining to the community the range of noise levels that could result from a development. However, it is the proponent's responsibility to present a noise level that can be met under the meteorological conditions that apply to the site based on Fact Sheet D.

Where the proposed development is expected to produce annoying noise characteristics, adjustments are to be applied to the predicted noise levels as outlined in Fact Sheet C to arrive at a final predicted level that will be compared with the project noise trigger levels.

3.3.3 Determining impacts

The noise impact of the development can be determined by comparing the predicted noise levels at the receiver with the corresponding project noise trigger levels that have been derived for that particular location. The development is considered to cause a noise impact if the predicted noise level at the receiver exceeds the corresponding project noise trigger level. The extent of noise impact from the development is defined by the extent the predicted noise level exceeds the project noise trigger level.

3.4 Mitigating noise from industrial developments

Where the project noise trigger levels are exceeded, feasible and reasonable noise mitigation measures should be evaluated with the aim of reducing noise to the project noise trigger levels.

This section gives a broad overview of ways to mitigate noise from industrial activities. It is not intended to be prescriptive guidance. It will be the responsibility of the proponent to demonstrate the selected mitigation measures are appropriate, and to justify any mitigation measures proposed (or disregarded) as part of a noise impact assessment. This advice provides useful guidance to developers of industrial activities to consider during the early stages of planning and design. The aim of this process is to evaluate what mitigation measures are both feasible and reasonable and the effect these will have on noise outcomes if applied.

Measures for reducing noise impacts from industrial activities follow three main control strategies:

- reducing noise at the source
- reducing noise in transmission to the receiver
- reducing noise at the receiver.

These control strategies should be considered in a hierarchical way so that all the measures that reduce noise for a large number of receivers (i.e. source controls) are exhausted before more localised mitigation measures are considered.

The scope for applying feasible and reasonable mitigation measures to existing industrial activities is generally more limited and potentially more costly than for new greenfield developments. Implementing effective noise management strategies is an integral part of the planning phase for industrial developments and is potentially a cost saving approach compared to retrospective mitigation.

When determining whether noise mitigation is 'feasible and reasonable', the starting point is identifying mitigation measures that would result in achieving the relevant project noise trigger levels and then identifying why particular measures may not be either feasible or reasonable.

3.4.1 Reducing noise at the source

Best management practice

Best management practice (BMP) is the adoption of particular operational procedures that minimise noise while retaining productive efficiency.

When an appropriate mitigation strategy that incorporates expensive engineering solutions is being considered, the extent to which cheaper, non-engineering-oriented BMP can contribute to the required reduction of noise should be taken into account.

Application of BMP includes the following types of practice:

- using the quietest plant that can do the job
- in open-cut mines, restricting movement of trucks on ridgelines and exposed haul routes where their noise can propagate over a wide area, especially at night – this could potentially mean restricting night-time movement of spoil to areas shielded by barriers or mounds, and reserving large-scale spoil movement for daytime
- scheduling the use of noisy equipment at the least sensitive time of day
- not operating, or reducing operations at night
- siting noisy equipment behind structures that act as barriers, or at the greatest distance from the noise-sensitive area; or orienting the equipment so that noise emissions are directed away from any sensitive areas, to achieve the maximum attenuation of noise
- where there are several noisy pieces of equipment, scheduling operations so they are used separately rather than concurrently
- keeping equipment well maintained and operating it in a proper and efficient manner
- employing 'quiet' practices when operating equipment, for example, positioning idling trucks in appropriate areas
- running staff-education programs and regular tool box talks on the effects of noise and the use of quiet work practices
- fitting and maintaining noise reduction packages on plant and equipment.

Best available technology economically achievable

Allied with BMP is 'best available technology economically achievable' (BATEA). With BATEA, equipment, plant and machinery that produce noise incorporate the most advanced and affordable technology to minimise noise output. Affordability is not necessarily determined by the price of the technology alone. Increased productivity may also result from using more advanced equipment, offsetting the initial outlay; for example, using 'quieter' equipment that can be operated over extended hours. Often old or badly designed equipment can be a major source of noise.

Where BMP fails to achieve the required noise reduction by itself, the BATEA approach should then be considered. Most of the noise-control measures listed in Section 3.4.5 belong to this approach. Examples of uses of BATEA include:

- considering alternatives to tonal reversing alarms (where work, health and safety is appropriately considered)
- using equipment with efficient muffler design
- using quieter engines, such as electric instead of internal combustion
- using efficient enclosures for noise sources
- using vibratory piling in place of impact piling
- using high-pressure hydraulic systems to split rock, instead of hydraulic or pneumatic hammers
- damping or lining metal trays or bins
- active noise control.

3.4.2 Controlling noise in transmission

Barriers

Barriers are more effective if they are near the source or the receiver. Their effectiveness is also determined by their height, the materials used (absorptive or reflective), and their density. The relationship of these design features to attenuation is well documented.

Barriers can take a number of forms including free standing walls between a source and a receiver, grass or earth mounds or bunds, and trenches or cuttings within which noise sources are sited. They are employed when source and receiver control is either impractical or too costly.

The use of noise barriers should be carefully considered as they can have negatives such as unattractive visual impacts or be associated with unwanted behaviours such as graffiti or littering, particularly when poorly sited or designed.

3.4.3 Controlling noise at the receiver

Noise controls at the receiver are expensive when many receivers require treatment, but may be attractive and cost-effective where only a few receivers would be affected by noise and the alternatives are even more expensive source controls. Cost effectiveness is also determined by the increase in the number of future potential receivers where residential land is being developed near the noise source.

The two major controls are insulation and upgraded glazing of windows. For these to be effective, the residence needs alternative means of ventilation to enable windows to be maintained in the closed position so that noise amelioration measures are not compromised. Providing a comfort benefit (i.e. air conditioning as well as ventilation) may be considered a reasonable trade-off for the reduced internal amenity associated with closed windows.

In some circumstances other trade-offs for benefits that are acceptable to all parties may be appropriate. For example:

- a structure that provides shielding to the residence, for example a shed or courtyard wall
- additional landscaping designed to provide visual screening and provide masking noise when windy (note: vegetation will not normally provide a significant reduction in noise levels).

The most extreme control is property acquisition. Receiver treatments, including the extreme case of acquisition, are normally only applicable for isolated residences in rural areas.

3.4.4 Noise mitigation strategies

Selecting an appropriate strategy for a proposed development or alterations to an existing development involves the following steps:

- determining the noise reduction required to achieve the project noise trigger levels
- identifying the specific characteristics of the industry and the site that would indicate a preference for specified measures
- examining the mitigation strategy chosen by similar industries on similar sites with similar requirements for noise reduction, and considering that strategy’s appropriateness for the subject development
- considering the range of noise-control measures available (as generically suggested in this chapter)
- considering community preferences for particular strategies. This is especially important when the community has particular sensitivities to noise.

The preference ranking (from most preferred to least preferred) for particular strategies is:

- **Land-use controls** – essentially separating noise-producing industries from sensitive areas, which avoids more expensive short-term measures.
- **Control at the source**, **BMP and BATEA** used in conjunction – these strategies are the best after land-use planning, as they serve to reduce the noise output of the source so that the surrounding environment is protected against noise.
- **Control in transmission** – the next best strategy to controlling noise at the source as it serves to reduce the noise level at specific receivers but not necessarily the broader environment surrounding the source.
- **Receiver controls** – the least-preferred option, as it protects only the internal environment of specific receivers and not the external noise environment.

Proponents will take into account the cost-effectiveness of strategies in determining how much noise reduction is affordable. A proponent’s choice of a particular strategy is likely to have unique features due to the economics of the industry and site-specific technical considerations.

The above steps and the range of measures described in the chapter can be used as a guide in assessing the strength of the proponent’s mitigation proposals.

Where a proposed mitigation strategy will not achieve the desired noise reduction and leaves a residual noise impact, the significance of the impact needs to be assessed.

3.4.5 Generic noise control measures

Typical noise sources on industrial sites include:

- engines
- exhausts
- fans
- transport of materials, such as on conveyors and trucks
- milling and stamping (metal works)
- sawing and debarking (wood mills)
- processors such as crushing and separating plant
- pumps and compressors
- whistles and alarms
- material dumping and scraping
- electrical transformers and switching equipment.

The choice of noise control measures depends on both the degree of mitigation required and the undesirable characteristics of the noise source that need to be controlled. The actual measures chosen will also depend on site factors, such as the ability of the site to accommodate particular engineering measures relative to other measures and their site costs.

A generic set of noise-control measures is set out below, with additional measures shown that respond to particular developments.

Generic list of mitigation measures

Noise-source controls include:

- selecting quieter equipment
- enclosing the source—the design of the enclosure and materials used to absorb sound will affect the attenuation achieved
- silencing exhausts—muffler design and noise barrier systems
- active noise control, effective on a limited range of noise sources
- times of operation.

Controls along the sound-transmission path include:

- noise barriers—more effective if near source or receiver; effectiveness also controlled by materials used (reflective or absorptive) and by height
- mounds and bunds
- site design to maximise the distance from the critical noise source to the receiver, and with intervening buildings to act as barriers.

Controls at the noise receiver include:

- insulation
- upgraded glazing of windows and use of mechanical ventilation and/or air conditioning
- other mutually accepted trade-offs for benefits
- acquisition.

Additional mitigation measures for extractive industries

Noise mitigation measures for on-site transport of materials include:

- selecting vehicles with minimum noise output, including tyre noise, exhaust and compressor/fan noise
- using rolling stock with quiet couplings and brakes
- using locomotives with components that do not emit tonal or low-frequency noise
- using trenches, cuttings, tunnels and barriers for transport routes
- restricting times for truck operations on ridgelines and in locations that are line-of-sight with receivers
- giving preference to haul routes with low grades
- using conveyor systems with low noise output, paying particular attention to rollers
- enclosing conveyors where necessary
- maintaining plant and equipment to ensure that the designers' noise-output specifications continue to be met
- using 'smart' reversing alarms.

Noise mitigation measures for mine and quarry operation include:

- locating materials processing in the least noise-sensitive area, or enclosing it if necessary
- dumping spoil and waste behind barriers
- using reactive management systems that allows for operations to be modified under adverse meteorological conditions.

Additional mitigation measures for sites with specific noise characteristics

Noise mitigation measures for piling:

- using piling shrouds or vibratory piling instead of impact piling to control impulsive noise.

Noise mitigation measures for milling and metal works include:

- using efficient enclosures, where needed, to reduce the impact of impulsive noise from metal stamping
- reducing the impact or output of tonal noise from cutting equipment and saws, by using enclosures or through equipment redesign.

Noise mitigation methods for pumps, transformers and machinery producing low-frequency or tonal noise include:

- where low frequency noise is difficult to isolate, seeking specialist advice about machinery redesign and restricted operating times
- reducing tonal noise through machinery redesign, enclosure, or restricted operating times, or by applying active noise control.

Noise mitigation for sites producing intermittent noise during night-time operations:

- control may be specific to the way the noise source is designed or how it fits in to the overall industrial process. Using barriers, enclosing or redesigning the source, or changing the operation to provide for a more continuous output, are possible measures.

Proponents may wish to utilise the following matrix, or develop a similar decision-making tool, to determine and justify what mitigation measures are feasible and reasonable. This may be taken into account by the planning authority.

Table 3.1: Example of 'Feasible and Reasonable' mitigation decision-making matrix for inclusion within an environmental impact assessment

Mitigation option	Feasible mitigation test	Reasonable mitigation test	Justification for adopting or disregarding this option
Mitigation at the source **Option 1** **Option 2 etc.**	Comment on whether the option under consideration is feasible. Refer to Fact Sheet F for further advice.	Comment on whether the option under consideration is reasonable. Refer to Fact Sheet F for further advice.	Provide details why the particular option under consideration will be included or disregarded, based on: • the noise impacts with and without the option • the noise mitigation benefits • the cost effectiveness of noise mitigation • community views. Refer to Fact Sheet F for further advice.
Mitigation in the transmission path to the receiver **Option 1** **Option 2 etc.**	As above	As above	As above
Mitigation at the receiver **Option 1** **Option 2 etc.**	As above	As above	As above

4. Determining the significance of residual noise impacts

4.1 Residual noise impacts

A residual noise impact may exist where the best achievable noise level from a development, when assessed at a sensitive receiver location, remains above the project noise trigger levels.

Residual noise impacts are identified **after** all source and pathway feasible and reasonable noise mitigation measures have been considered. The significance of the residual impact and the need to assess receiver-based treatment options may need to be considered as part of an authority's determination/approval process.

As set out in Section 2, the project noise trigger level is the lowest value of intrusiveness or project amenity noise level after conversion to $L_{Aeq,15minute}$, dB(A) equivalent level.

Determining the significance of any residual noise impact is an essential component of the noise assessment process to ensure that effective and appropriate mitigation measures are taken in each case.

4.2 Guide to the acceptability of residual noise impacts

Planning decisions for proposed developments take into account social, economic and environmental factors. Noise impact is one factor taken into account and decisions can be made that result in residual noise impacts (i.e. noise levels above the project noise trigger level). In these cases, a consent may include an obligation on proponents to undertake noise mitigation at receiver locations.

The types of receiver-based noise control options are outlined in Section 3.4.3. Receiver treatment, including the extreme case of acquisition, is normally only applicable for isolated residences in rural areas. The purpose of this component of the guideline is to identify the significance of the residual noise impact. Weighing this against the broader social, economic and environmental considerations is the role of the planning system.

As a general guide, where all source and pathway feasible and reasonable noise mitigation measures have been applied, the significance of residual noise levels (i.e. noise levels above the project noise trigger level) will be considered as outlined in Table 4.1.

Table 4.1 Significance of residual noise impacts

If the predicted noise level minus the project noise trigger level is	And the total cumulative industrial noise level is	Then the significance of residual noise level is
≤ 2dB (A)	≤ recommended amenity noise level or > recommended amenity noise level, but the increase in recommended amenity noise levels resulting from the development is less than 1dB	Negligible
≤ 2dB (A)	> recommended amenity noise level and the increase in amenity noise levels resulting from the development is more than 1dB	Marginal
≥ 3 but ≤ 5dB (A)	< recommended amenity noise level or > recommended amenity noise level, but the increase in recommended amenity noise level resulting from the development is less than 1dB	Marginal
≥ 3 but ≤ 5dB (A)	> Recommended amenity noise level and the increase in recommended amenity noise levels resulting from the development is more than 1dB.	Moderate
>5dB (A)		Significant

Note: This approach is designed for new and substantially modified developments and should be applied with caution to assessments of existing operations.

Examples of noise mitigation at a residence that may be required by planning authorities to mitigate residual noise impacts are outlined in Table 4.2.

Table 4.2: Examples of receiver based treatments to mitigate residual noise impacts

Significance of residual noise level	Example of potential treatment
Negligible	The exceedances would not be discernible by the average listener and therefore would not warrant receiver based treatments or controls
Marginal	Provide mechanical ventilation / comfort condition systems to enable windows to be closed without compromising internal air quality / amenity.
Moderate	As for marginal but also upgraded façade elements like windows, doors, roof insulation etc. to further increase the ability of the building façade to reduce noise levels.
Significant	Offers of acquisition

5. Consent and licence conditions

5.1 What is included in the planning approval/licence

A planning approval or licence condition arrived at through the process described in this guideline will have taken the following issues into account:

- the assessed noise impact, which includes the impact of the noise source and any additional impact caused by meteorological conditions
- mitigation measures required to achieve the project noise trigger level
- identification of a practical (achievable) noise level
- the significance of any residual noise impacts and the number of receivers affected
- consideration of trade-offs
- whether the final noise level proposed is acceptable.

It is important to note that the agreed limits in the planning approval or licence apply under the meteorological conditions determined by the guideline to be relevant to the assessment site.

Compliance with noise limits will not always safeguard against complaints because it is not possible to protect the whole range of individual sensitivities in a community to noise.

5.2 Specifying meteorological conditions in the consent/licence

Noise limits derived from this guideline should be based on the following broad principles:

- they should be based on noise levels that have been demonstrated to be achievable and should apply at specific locations (consideration should be given to nominating co-ordinates to identify the location at which limits apply)
- they should apply under either standard or noise-enhancing metrological conditions (see Fact Sheet D) depending on the significance of occurrence of noise-enhancing conditions
- inversion conditions will be identified using Pasquill–Gifford stability categories as opposed to stipulating temperature lapse rates in degrees per 100 metres
- for meteorological conditions outside of the range of meteorological conditions noted in the consent/licence limit, excursions of greater than 5 dB above the limit will be determined as a non-compliance regardless of the meteorological conditions prevailing at the time (i.e. a cap on noise emissions will apply)
- the distinction between when monitoring should not occur versus when limits apply needs to be identified. That is, while measurements should not be undertaken when wind at microphone heights exceeds 5 metres per second or during rain, that does not mean that the limits do not apply under those conditions
- the location and method for determining prevailing meteorological conditions will be clearly stated in noise conditions.

6. Applying the guideline to existing industrial premises

The principles and approaches to assessing and managing noise in this guideline can be applied to existing sites using a noise reduction program. This approach recognises that existing activities are established based on agreed performance requirements and is designed to allow established industries to adapt to changes in the noise expectations of the community where needed.

The need to establish achievable noise limits and implement a noise reduction program may be triggered by actions such as:

- the site becoming the subject of serious and persistent noise complaints
- a proposal to upgrade or expand the site
- the site having no formal consent or licence conditions and management wishing to clarify their position
- the owner or occupier choosing to initiate a noise reduction program.

This approach provides a formal structured program to reduce high existing noise levels to acceptable levels over time by applying feasible and reasonable control measures. It establishes certainty through an agreed process to achieve noise reduction, while providing flexibility in the choice of noise reduction measures.

6.1 Applying the guideline to existing sites

Many existing industrial sources were designed for higher noise emission levels than the project noise trigger levels outlined in this guideline. In other cases industries may have been in existence before neighbouring noise-sensitive developments and even before noise-control legislation was introduced. The range of mitigation measures available for these sites can be limited or costly.

Applications for extensions to existing premises often provide an opportunity to redress issues that relate to the whole site. The need for reduced noise from existing sites must be weighed against the wider economic, social and environmental considerations. Where noise emissions from the site exceed the project noise trigger levels, the regulatory authorities and the noise-source manager will negotiate achievable noise limits for the site. The project noise trigger levels should not be applied as mandatory noise limits. The project noise trigger levels supply the initial target levels and drive the process of assessing all feasible and reasonable control measures. Achievable noise limits result from applying all feasible and reasonable noise control measures. For sites with limited mitigation measures, the achievable noise limits may generally be above the project noise trigger levels.

In many instances the site will be required to reduce its noise emissions progressively to achieve the specified noise limits by specified dates. This will require noise to be managed as an integral part of site upgrades. However, the development of formal operating practices to reduce noise generation often need not be linked to site upgrades, and where feasible these operating practices should be applied at the earliest opportunity. The measures required to achieve the noise limits would usually be set out in a noise reduction program, with mitigation measures staged over time. The noise reduction program would typically be attached as a licence condition. Efforts should be aimed at achieving a reduction in noise in a manner that provides the greatest benefit to residents without undue impact on the existing business. This may be accomplished by prioritising the various noise-control measures.

6.1.1 Steps in the process

This process may be triggered by a proposal to partly upgrade a site, or by serious noise complaints. Where these occur the usual process is:

- Measure and determine existing background noise levels in accordance with Fact Sheets A and B. Determine project noise trigger levels from intrusive and project amenity noise levels.
- Measure/predict the noise levels produced by the source in question, having regard to meteorological effects such as wind and temperature inversions. Noise from both the whole premises and the upgraded section in isolation should be presented.
- Compare the measured/predicted noise level with the project noise trigger levels.
- Where the project noise trigger levels are exceeded, assess feasible and reasonable noise mitigation strategies.
- Negotiation between the regulator and the noise source manager to agree to achievable noise limits that will likely become goals for pollution reduction programs for the site (this may involve consultation with the community). Regulatory authorities and the noise-source manager need to consider the technical practicalities and cost of noise-reduction measures, how long it will take to implement these measures along with the environmental consequences of exceeding the project-specific noise trigger levels.
- Measures to achieve the limits by specified dates may be set out in a noise reduction program.
- Monitor compliance with the noise reduction program, and review and amend the program as required.

An example showing how this process works is contained in Fact Sheet E.

6.2 Noise reduction programs

The noise reduction program is reached through agreement between proponent and regulator and will typically have a statutory basis through conditions on a licence or notice. It will document the actions required to achieve the noise limits.

The measures will generally be source- and site-specific, but could include the following elements:

- the aim and scope of the program
- identification of noise levels and targets for the site
- an upper limit for new equipment
- an upper limit for partial upgrades of the site
- plans to eliminate problematic characteristics that have been identified, such as tonal and low frequency noise
- a sound power limit for relevant sections of the site
- operating practices to reduce noise emissions
- training and awareness initiatives
- an ongoing monitoring program to evaluate noise-emission levels
- communicating with the affected community via one or more of a complaints handling process, liaison group, newsletters etc.

6.3 Noise reduction strategies for existing sites

The range of noise reduction strategies for existing situations is generally more limited than those available for new development at the planning stage. For example spatial separation between the source and receiver is not an option for existing situations. The initial focus for existing sites should be operational procedures and cost-effective measures that can minimise noise with minimal impact on site operations and productivity.

The applicability, effectiveness and cost of particular mitigation measures often depend strongly on site variables. Section 3.4 provides advice on a range of typical mitigation strategies, and is a useful guide in deciding suitable mitigation measures for a particular site.

The significance of residual noise impacts should be addressed on a case-by-case basis. The guidance contained in Table 4.1 should be applied with caution to existing situations.

7. Monitoring performance

Determining compliance with a noise limit can range from a simple exercise to a technically complex process. This section presents a range of compliance assessment techniques that may be used individually, or in combination, to provide a means of determining compliance with a noise limit. At times, the best available compliance assessment methodology will only allow for a **balance of probabilities** type determination of compliance.

A noise limit applies to noise from a particular development/activity and not to general ambient noise. Therefore it is often necessary to use techniques to attempt to separate the noise from a facility versus noise from other sources. There is often no easy way to do this, and professional judgement and multiple techniques are sometimes required in combination to give the necessary level of confidence in the results.

7.1 Monitoring environmental noise

7.1.1 Options for noise monitoring

Direct measurement at a receiver location

The preferred method of determining compliance with a noise limit is operator attended direct measurement of noise at a location identified for compliance using a sound level meter. Where the compliance location is dominated by noise from the industrial premises under investigation, this can be an effective and simple exercise. However, most locations are seldom ever controlled by a single noise source and techniques, including professional judgement, are often needed to determine the level of noise from the source under investigation.

Some examples of techniques used to isolate the noise from a facility include:

- pausing the sound level meter during extraneous noise events, for example when a dog is barking or road traffic noise is clearly audible and affecting the measurements
- using frequency filtering techniques where certain frequencies of noise are excluded from the measurements. For example, local insect noise can be excluded by using a low pass filter on a sound level meter
- using other descriptors such as the L_{A90} to filter extraneous noise events where the noise under consideration is continuous and the difference between the L_{Aeq} and L_{A90} is expected to be small
- turning the source noise on and off or waiting for times when extraneous noise is low – this is not always practical, but sometimes can be effectively used, especially when dealing with a source that is intermittent, for example a gas fired power station
- using directional noise measuring instrumentation where noise from only a given direction is measured, thereby removing extraneous noise from other directions.

Direct measurement at alternative or intermediate location/s

Where direct measurement of noise at a compliance location is not practical because of poor signal to noise ratios (i.e. extraneous noise is louder than the noise under investigation), or where access to the location has been denied or is unavailable, measurements at intermediate locations between the source and the receiver location, where signal to noise ratios are higher, may be a viable option. For this approach to be effective there needs to be well established theoretical and/or empirical relationships between the intermediate location and the receiver location in terms of noise exposure. Noise modelling may be one option to establish this relationship. The techniques above under the section entitled Direct measurement at a receiver location, would also be relevant in terms of quantifying the level of noise from the source at the intermediate location(s).

Where this technique is relied upon, it is the responsibility of the proponent to demonstrate a robust acoustic relationship between the compliance location and the intermediate location.

Unattended monitoring

Unattended monitoring using remote instrumentation should not generally be used as the sole means to determine compliance with a noise limit. This is because of the added difficulty in isolating the noise under investigation from ambient noise not related to the subject noise source.

Unattended continuous noise monitoring is however being effectively used as a noise management tool for many mining projects. It generally involves the deployment of continuous noise monitoring equipment at intermediate locations where relationships with noise at compliance locations has been established. These instruments are configured to send alert messages to mine managers when a noise limit is likely to be approached. They allow remote access so that mine managers can listen to audio to determine whether the mine is the likely reason for the alert. Under these circumstances the mine managers are able to alter operations so that a noise limit exceedance is avoided.

The results from unattended monitoring may be used to supplement conclusions reached from attended monitoring campaigns; however, they should not be relied upon as a definitive measure of compliance, or otherwise, because of a lack of operator attended observations and conclusions about the origin and accuracy of the measured noise levels.

Modelling

In some cases it will be impossible to determine whether a development is satisfying noise limits using direct measurement at a compliance location or intermediate locations. An extreme example would be a facility located in an industrial estate with co-located, but separate, noise-producing developments that all impact a particular sensitive receiver location. In these cases, noise modelling techniques may be the only way of determining compliance with noise limits. This may involve on-site measurement of noise-producing plant and equipment to determine (or confirm) the source noise level (sound power level). The sound power levels may then be used in a noise model to determine the level of noise at a sensitive receiver location from the operation of the individual development.

These modelling techniques could range from simple manual distance attenuation calculations to complex noise modelling that considers intervening terrain and structures, meteorological conditions, attenuation factors (distance, atmospheric absorption, ground effects etc.). Modelling methods should only be used where it has been demonstrated that direct measurement techniques are not viable.

Models should be calibrated and validated to produce accurate results under Australian conditions. The use of intermediate location as a means of model validation or calibration can be a useful technique.

7.1.2 Notes on noise monitoring

Items to be monitored

To check compliance with the consent/licence condition, the following items require monitoring:

- noise levels from the development at locations specified in the condition, or at the nearest affected receivers where no locations are specified. During monitoring the meter should be generally set as follows:
  - for L_{eq} measurements the meter should be set to linear averaging
  - where frequency analysis is required the meter should be set to Z frequency weighting

- where statistical descriptors or maximum noise levels are measured (e.g. L_{Amax}, L_{A90}), the meter should be set to fast time response and exponential averaging
- the frequency weighting selected should align with the frequency weighting of the limit/criteria being assessed

- the wind speed and direction
- the meteorological conditions prevailing during the monitoring as required by the condition
- the operational condition of the noise source/emitter (i.e. not operating, at full capacity, at some percentage capacity etc).

7.1.3 Noise test reports

The results of a noise monitoring test should be clearly reported and forwarded to the relevant authority (if requested), or kept on file for reference. The following items are to be included in a noise monitoring report:

- the type of monitoring test conducted
- the development noise limits on the consent/licence
- the monitoring location – where this is a sensitive receiver, this should be at the reasonably most affected point at or within the receiver's boundary or, if that is more than 30 metres from the receiver's premises, at the most affected point within 30 metres of the premises
- the noise instrumentation used (the instrumentation specifications required for compliance monitoring are the same as those required for background noise monitoring set out in Fact Sheet A)
- the weather instrumentation used (the instrumentation specifications are the same as those set out in Fact Sheet D)
- the weather conditions during noise monitoring and the location of the weather monitoring station used
- the time(s) and duration(s) of monitoring, including dates. In the case of receiver complaints, these should coincide with the time that the noise is considered to be most intrusive. In the case of development-stage monitoring, these should cover the full cycle of activity
- the results of noise monitoring at each monitoring location, including a comparison with the development limits
- a statement outlining the development's compliance or non-compliance with the limit
- where non-compliances or a breach of noise limits are found, the reasons for non-compliance should be stated and strategies for management identified
- where the noise exceedance is due to excessive noise levels from the development, the strategies to be used to manage the noise exceedance should be identified and stated.

In addition to the above requirement, section 66(6) of the POEO Act requires that pollution monitoring data that is required to be collected by a licence condition must also be published by the licensee in accordance with the written requirements issued by the EPA as set out in Requirements for publishing pollution monitoring data (EPA, 2013).

7.1.4 Compliance justification

Where a proponent is required by a consent or regulatory authority to demonstrate compliance with a noise limit, the methodology relied upon to establish the operational noise levels shall be clearly identified. As a minimum this will involve the techniques used to quantify the noise contribution from the development/activity under consideration, together with the parameters under which the noise limits apply, for example the meteorological conditions prevailing at the time of compliance assessment.

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Glossary

Term	Definition
Above ground level (AGL)	Above ground level.
A-weighted	See dB(A).
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Amenity noise level	See the fourth column of Table 2.1.
Annoyance	An emotional state connected to feelings of discomfort, anger, depression and helplessness. It is generally measured by means of the ISO15666 defined questionnaire (EEA, 2010).
Assessment period	The period in a day over which assessments are made: day (7 am to 6 pm), evening (6 pm to 10 pm) or night (10 pm to 7 am).
Assessment background level (ABL)	The single-figure background level representing each assessment period: day, evening and night (i.e. three assessment background levels are determined for each 24-hour period of the monitoring period). Its determination is by the tenth percentile method described in Fact Sheet B.
Background noise	The underlying level of noise present in ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
Best available technology economically achievable (BATEA)	Equipment, plant and machinery incorporating the most advanced and affordable technology available to minimise noise output.
Best management practice (BMP)	Adoption of particular operational procedures that minimise noise while retaining productive efficiency.
Breach	Any exceedance of a consent/licence limit is considered a breach. However, the type of regulatory action taken by a regulatory authority will depend on a number of factors in accordance with the authority’s prosecution policies and guidelines.
C-weighted	C-weighting is an adjustment made to sound-level measurements which takes account of low-frequency components of noise within the audibility range of humans.
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context
Construction activities	Activities that are related to the establishment phase of a development and that will occur on a site for only a limited period of time.
Cumulative industrial noise level	The total level of noise from all industrial sources
Day	The period from 7 am to 6 pm (Monday to Saturday) and 8 am to 6 pm (Sundays and Public Holidays).
Decibel (dB)	A measure of sound level. The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage or intensity or other parameters. In the case of sound pressure it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared.

Term	Definition
decibel (A-weighted) (dB(A))	Unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
EP&A Act	*Environmental Planning and Assessment Act 1979.*
Evening	Refers to the period from 6 pm to 10 pm.
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
Feasible and reasonable mitigation	As defined in Fact Sheet F.
Greenfield site	Undeveloped land.
High traffic amenity level	See Section 2.4.1.
Impulsive noise	Noise with a high peak of short duration, or a sequence of such peaks.
Industrial noise sources	As defined in Section 1.4.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 decibels. The intrusiveness level is set out in Section 2.3.
L_{A90}	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise.
L_{Aeq}	The time-averaged sound pressure level. The value of the A-weighted sound pressure level of a continuous steady sound that, with a measurement time interval T, has the same mean square sound pressure level as a sound under consideration with a level that varies with time. (AS1055.1-1997).
Low frequency	Noise containing major components in the low-frequency range (10 Hz to 250 Hz) of the frequency spectrum.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street. (Bies and Hansen 1996).
Median	The middle value in a number of values sorted in ascending or descending order. Hence, for an odd number of values, the value of the median is simply the middle value. If there is an even number of values the median is the arithmetic average of the two middle values.
Meteorological conditions	Wind and temperature-inversion conditions.
Noise impact assessment (NIA)	The component of an Environmental Impact Statement, Environmental Assessment, Statement of Environmtal Effects, license application etc that considers the impacts of noise resulting from a development or activity.
Noise limits	Enforceable noise levels that appear in conditions on consents and licences. The noise limits are based on achievable noise levels which the proponent has predicted can be met during the environmental assessment. Exceedance of the noise limits can result in the requirement for either the development of noise management plans or legal action.
Night	The period from 10 pm to 7 am (Monday to Saturday) and 10 pm to 8 am hours (Sundays and Public Holidays).

Term	Definition
Noise-sensitive land uses	Land uses that are sensitive to noise, such as residential areas, churches, schools and recreation areas.
Non-compliance	See breach.
Non-mandatory	In this guideline this means not required by legislation. The guideline specifies project noise trigger levels to be strived for, but the legislation does not make these levels compulsory. However, the guideline will be used as a guide to setting statutory (legally enforceable) limits for licences and consents.
Operator	Noise-source manager.
Performance-based goals	Goals specified in terms of the outcomes/performance to be achieved, but not in terms of the means of achieving them.
Project noise trigger levels	Target noise levels for a particular noise-generating facility. They are based on the most stringent of the intrusiveness level or the project amenity noise level.
Proponent	The developer of the industrial noise source.
POEO Act	*Protection of the Environment Operations Act 1997*
Rating background noise level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). This is the level used for assessment purposes. It is defined as the median value of: • all day assessment background levels over the monitoring period for the day • all the evening assessment background levels over the monitoring period for the evening, or • all the night assessment background levels over the monitoring period for the night.
Residence	A lawful and permanent structure erected in a land-use zone that permits residential use (or for which existing use rights under the EP&A Act apply) where a person/s permanently reside and is not, nor associated with, a commercial undertaking such as caretakers quarters, hotel, motel, transient holiday accommodation or caravan park.
Reasonably most affected location	Locations that experience (or will experience) the greatest noise impact from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source location(s), distance from source (or proposed source) to receiver, and any shielding between source and receiver. This should not be construed to mean that limits **only** apply at the worst most affected location.
Receiver	The noise-sensitive land use at which noise from a development can be heard.
Significant meteorological effects	In relation to temperature inversions, means at least 30% of the total night-time during the winter months. In relation to wind speeds this means at least 30% of the time or more in any assessment period (day, evening, night) in any season.
Sleep disturbance	Awakenings and disturbance to sleep stages.
Spectral characteristics	The frequency content of noise.
Temperature inversion	An atmospheric condition in which temperature increases with height above the ground.
Temporal variation of noise	Variation in noise levels over time.
Tenth percentile method	See Fact Sheet B.

Term	Definition
Time of maximum impact	The time during which the difference between the background noise level and the source noise is expected to be greatest.
Tonality	Noise containing a prominent frequency and characterised by a definite pitch.
Transportation	Includes road, rail and air traffic.

Fact Sheet A: Determining existing noise levels

A1 Determining background noise for the intrusiveness criterion

The background noise level is defined here as ‘the underlying level of noise present in ambient noise when all unusual extraneous noise is removed’. Sound levels contributing to background levels can include sound from nearby traffic (see Section A1.3), birds, insects, animals, machinery and similar sources if these sounds are a normal feature of the location. The background noise level is considered to be represented by the $L_{A90,15\ minute}$ descriptor when undertaking short term monitoring. In comparison, the rating background level (as defined in Section A1.2) is the single-figure background noise level derived from monitoring over a representative period of time, typically one full week. The rating background level is used for assessment purposes.

Background noise levels need to be determined before intrusive noise can be assessed. The background noise levels to be measured are those that are present at the time of the noise assessment and generally without the subject development operating.

For the assessment of modifications to an existing development, the noise from the existing development should generally be excluded from background noise measurements. However, where a development has been operating continuously for a significant period of time and is considered a normal part of the acoustic environment, it may, under certain circumstances be included in the background noise assessment. The factors that need to be considered for this to occur are as follows:

- the development must have been operating for a period in excess of ten (10) years
- the development must be operating in accordance with noise limits and requirements imposed in a consent or license and/or be applying best practice.

Note: This is acknowledging the true purpose of the intrusiveness criterion, which is to limit significant change in the acoustic environment. It will not result in undue ‘background noise creep’, as the project amenity noise level will moderate against that.

When assessing a new development, it is important to undertake sufficient monitoring of background noise to allow intrusive noise to be assessed adequately. However, when assessing noise levels in response to complaints, the background noise level during the period of the complaint is of interest, and monitoring over a shorter length of time may be appropriate.

Before embarking on a noise-monitoring program, the potential for the development/activity to cause noise annoyance, and the need for accurate noise assessment, should be considered. Two measurement regimes are presented below. The first is a definitive method to be used when assessing developments with the potential for significant noise impact. The second is a shorter method that can be used for complaint-assessment purposes.

A1.1 Methods of determining background noise

Table A1 summarises the two procedures for determining background noise: the long-term method to be used at the planning and approval stage, and the short-term method for complaint and compliance assessment purposes. The long-term method involves a two-step process to determine the rating background level. The short-term method involves only one step. Fact Sheet B gives a detailed description of instrumentation requirements, and procedures for measurement and analysis for each method.

The long-term method for determining background noise (summarised in Table A1*)* is designed to ensure that the criterion for intrusive noise will be achieved for approximately 90% of the time periods over which annoyance reactions may occur (taken to be periods of 15 mins).

Definitions and technical considerations to help users interpret and apply the methods are set down in the following sections.

Table A1: Methods for determining background noise

Features	Method	
	Long term	**Short term**
When to use	During planning and approval stage where there is significant potential for noise impact, e.g. extractive industries and industrial developments	During complaint assessments, compliance checks, when determining the effect of background noise on a source noise measurement and for low risk developments
Type of monitoring	Continuous sampling accompanied by periods of operator-attended monitoring	Individual sampling, operator-attended measurements
Length of monitoring	Equivalent to one week's worth of valid data covering the days and times of operation of the development (see Section A5)	15-minute measurements covering the times of operation of the development
Conditions for monitoring	Average wind speed < 5 m/s[1], no rain, no extraneous noise (see Sections A1.2 and A4)	Average wind speed < 5 m/s[1], no rain, no extraneous noise (see Sections A1.2 and A4)
Monitoring location	Reasonably most or potentially most affected noise-sensitive location(s)	Reasonably most affected noise-sensitive location and/or location of complaint
Assessment time periods	Day (7 am–6 pm) Evening (6 pm–10 pm) Night (10 pm–7 am) (see Section A3 for exceptions)	Times when maximum impacts occur
Base measure	$L_{A90,15\ minute}$	$L_{A90,15\ minute}$
Analysis method	Determine the assessment background level for each day, evening and night by using the tenth percentile method[2]. The rating background level is the median assessment background level over all days for each period. NOTE: Current generation noise logging instrumentation with high sampling rates and increased storage capabilities allows for the calculation of $L_{A90,Fast\ (day/evening/night)}$ dB(A) noise levels. These period L_{A90} levels may be adopted as the ABL for the purposes of calculating the rating background noise level.	The rating background level is the measured $L_{A90,15\ minute}$ value, or, where a number of measurements have been made, the lowest $L_{A90,\ 15\ minute}$ value.

Notes: 1. Refers to the wind speed at the microphone height. 2. See Fact Sheet B for how to determine the assessment background level using the tenth percentile method.

A1.2 Definitions to support methodologies

Extraneous noise – noise due to activities that are not typical of the area. These activities might include construction, changes in road, rail or air traffic due to holiday periods, and special events such as concerts or sporting events. Normal daily road traffic and other transportation noise are not considered to be extraneous noise. Where an industry in an industrial estate wishes to extend its operations, the measured background noise level may include the general hum of industries nearby, but should not include any noise from the site itself or noise from any intrusive sources nearby that could affect the $L_{A90,15\ minute}$ value with the exception of circumstances outlined in Section A1. As a reasonable guide, any extraneous noise present for at least half of a 15-minute monitoring period, and having the potential to affect the $L_{A90,15\ minute}$ value, should be excluded.

Special care needs to be taken when doing short-term measurements to ensure that the measurements reflect the time of maximum impact. For example, in a residential neighbourhood short-term noise measurements should not be taken when there are other noisy activities going on such as lawn-mowing, idling vehicles, neighbourhood chatter and vehicle movements that may not be a characteristic of the whole assessment period of interest (see A1.3). When in doubt about whether an activity is typical of the area, it is best to exclude data affected by noise from that activity.

Noise-sensitive location(s) – residential premises.

Reasonably most affected location(s) – locations that are reasonably most affected (or that will be most affected) by noise from the source under consideration as per Note 2 in Section 2.4. In determining these locations, the following need to be considered: existing background levels, noise source location(s), distance from source(s) (or proposed source(s)) to receiver, and any shielding (e.g. building, barrier) between source and receiver. Often several locations will be affected by noise from the development. In these cases, locations that can be considered representative of the various affected areas should be monitored.

Time of maximum impact – the time during which the difference between the background noise level and the source noise is expected to be the greatest.

Assessment background level (ABL) – the single-figure background level representing each assessment period—day, evening and night (that is, three assessment background levels are determined for each 24-hour period of the monitoring period). Determination of the assessment background level is by the tenth percentile method described in Fact Sheet B. Alternatively the ABL may be calculated on the basis of $L_{A90,F,period(day/evening/night)}$ dB(A) noise levels. **Only those days and assessment periods that are applicable to the times of operation of the proposed development are required to be assessed.**

$L_{A90,F,period(day/evening/night)\ dB(A)}$ noise level – The A-weighted sound pressure level, obtained by using fast time weighting that is equal to or exceeded for 90% of the day, evening and night periods (as defined in this guideline) for each 24-hour period.

Rating background noise level (RBL) – the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). The rating background level is the level used for assessment purposes. **Where the rating background level is found to be less than 30 dB(A), then it is set to 30 dB(A) for evening and night and 35 dB(A) for day**.

For the short-term method the rating background level is simply the measured $L_{A90,15\ minute}$ level. For the long-term method, the rating background level is defined as the median value of:

- all the day assessment background levels over the monitoring period for the day
- all the evening assessment background levels over the monitoring period for the evening, or
- all the night assessment background levels over the monitoring period for the night.

Median – is the middle value in a number of values. For an odd number of values, the value of the median is simply the middle value in a number of values ranked in ascending or descending order. For an even number of values, the median is the arithmetic average of the two middle values.

A1.3 Transportation noise in background noise measurements

Transportation noise (air, road and rail) may be included in background noise measurements, except when there is a reasonable expectation that flows are not representative of normal conditions (e.g. traffic during school holidays). Air, road and rail traffic during these times are usually considered to be extraneous.

Where the period of measurement is limited (that is, with a short-term measurement), care is needed to ensure that the time at which the measurements are made reflects the period when the highest noise impacts are likely to occur. For example, where there is only intermittent traffic, the short-term noise measurement should not include transportation noise, otherwise incorrect high readings will result. However, where the traffic is constant and continuous, transportation may be included in the short-term measurement to ensure that the noise environment is adequately represented.

A2 Determining existing industrial noise levels when required

Existing industrial noise levels need to be determined when the project amenity noise level cannot be satisfied.

In determining the existing L_{Aeq} noise level from industry, it is important to obtain a representative level. Hence, assessing the existing L_{Aeq} noise level from industry is ideally as defined in Table A2 for assessing different noise risk developments.

Table A2: Determining existing industrial noise levels

Risk of noise impact	Measurement period[1]	Definition of existing level
Low risk	One day, covering the defined day/evening/night periods relevant to the periods the proposed development would operate.	The logarithmic average[2] of individual $L_{Aeq,15\ minute}$ levels for each day/evening/night assessment period over the measurement period.
High risk	One week, covering the defined day/evening/night periods the proposed development would operate.	

Notes: 1. It is recommended that the L_{Aeq} be measured on a 15-minute basis. 2. Logarithmic average = $10 \times \log_{10}((\sum_{i=1\ to\ n} 10^{(L_{Aeq,15\ min,i}/10)})/n)$, where n = number of $L_{Aeq,15\ min}$ values in each assessment period over the measurement period.

However, in many cases the direct measurement of noise from industrial sources will be difficult, if not impossible, due to extraneous noise. In these circumstances the use of ambient noise levels that contain both the existing industrial noise contribution and extraneous noise may be used to estimate cumulative industrial noise as a screening test. Where this approach suggests cumulative industrial noise levels will remain below the relevant 'amenity noise levels' in Table 2.1, no additional assessment of cumulative impacts is required.

However, where the screening approach suggests total industrial noise above the relevant 'amenity noise level' in Table 2.1, attempts to better quantify existing industrial noise levels are required. Professional judgement will often be needed to effectively quantify/estimate the level of noise from existing industry. In some cases reference to data contained in compliance assessments and/or environmental impact assessment documentation for existing industrial sources will be needed.

A3 Dealing with 'shoulder' periods

There will be situations that call for different assessment periods. For example, where early morning (5 am to 7 am) operations are proposed, it may be unduly stringent to expect such operations to be assessed against the night-time project noise trigger levels – especially if existing background noise levels are steadily rising in these early morning hours. In these situations, appropriate noise level targets may be negotiated with the regulatory/consent authority on a case-by-case basis. As a rule of thumb and for the purposes of deriving the intrusiveness noise level only, it may be appropriate to assign a shoulder period rating background level as the mid-point value between the rating background levels of the two assessment periods that are on either side of the shoulder period.

The objective is to achieve environmental amenity in a feasible and reasonable manner. In an assessment of the likely level of noise impact, the time of day is only one of several relevant factors, such as noise level and character, and the activities affected by the noise. Noise of a lower level, and with no intrusive characteristics such as tones and impulses, can often be more acceptable over a longer period of the day than noise at a high level and/or with intrusive characteristics.

A4 Meteorological conditions for background noise monitoring

Wind and rain conditions

Noise monitoring should not be conducted (or the data should be excluded) when average wind speeds (over 15-min periods or shorter) at microphone height are greater than 5 metres per second, or when rainfall occurs. Exceptions to this rule are allowed provided the proponent is able to show that the wind-induced noise on the microphone, and sound levels due to rain, are at least 10 dB below the noise levels (that is, background and/or ambient) under investigation.

Where high wind speeds are a feature of the area, monitoring may be permitted during higher wind speeds, provided the proponent is able to show that these wind speeds are a site feature and that the wind-induced noise on the microphone (contamination) is at least 10 dB below the noise levels under investigation. High performance wind screens can be used to reduce the amount of data that may need to be excluded due to contamination. Specifications of the wind screen used and the data exclusions rules developed shall be stated in any noise impacts assessment.

Wind blowing through leaves can raise the environmental noise levels, even at speeds less than 5 metres per second. To avoid this effect, take care to select monitoring locations that are as far away as possible from vegetation while still being representative of the subject site.

Temperature inversions

The noise levels determined using the methods just described are considered to represent the season in which they have been monitored. For this reason, monitoring may be conducted during temperature inversion conditions to ensure that the noise environment at a site is adequately represented. However, care is needed when doing short-term measurements to ensure that the measured noise level results in an adequate assessment of impacts. For instance, measurement of short-term background noise should exclude any data collected during temperature inversions where these inversions are infrequent and are not a feature of the area. Otherwise, assessment applying the intrusiveness noise level will not adequately assess the noise impact.

Seasonal variations

The EPA recognises that background noise levels may vary due to seasonal changes in weather conditions and wildlife activity (for example, insects, birds and other fauna) and also as a result of changes in operational activities on surrounding developments. As far as is practicable, these potential changes should be considered and addressed in a qualitative manner in the noise assessment report to ensure that noise impacts during other seasons are not ignored.

Such changes may be accounted for by excluding the season-related noise levels from the background noise measurements by filtering or other means (for example, in the case of seasonal operational activities, by monitoring in a similar location not affected by the development in question). In other cases these variations may be discounted on the basis of local knowledge in the area, but the discounting should still be justified in the noise assessment report.

A5 Duration of monitoring

Screening tests may be performed before any monitoring to assess whether monitoring is required. For example, if a minimum background noise level outlined in Section 2.3 is assumed as the rating background level and the assessment shows no impact, then there is no need for background noise monitoring, as this represents a conservative and limiting case.

Typically, one week's worth of valid data covering the days and times of operation of the proposed development is required to meaningfully determine the existing noise environment. However, the duration of monitoring should be determined by taking into account the circumstances of the particular situation. The cyclic or random nature of ambient noise levels can affect the duration required.

Any variations from the specified monitoring duration in Table A1 should be fully justified in the noise assessment report.

Fact Sheet B: Methods for determining background noise

B1 Determining background noise using long-term noise measurements

The long-term background noise measurement procedure should be used during the planning and consent stage for developments that have the potential to cause significant noise nuisance. Both the type of development and its proximity to noise-sensitive locations are important elements to be considered in deciding whether the long-term method is the most appropriate.

Some examples of developments that may present a high risk of noise impact include:

- extractive industries (for example, mines and quarries)
- industrial developments (for example, bitumen plants, coal works, crushing and grinding works, drum re-conditioning, power stations, refineries and timber mills)

Essentially, the procedure for determining long-term background noise involves two components:

- determining a representative background noise level for each day/evening/night of the monitoring period. This level is termed the assessment background level (ABL) and is a single figure representing each day/evening/night for each monitoring site required for a particular project.
- determining an overall level representing the day, evening and night assessment periods over the entire monitoring period. This level is termed the rating background noise level (RBL) and is determined based on the individual day/evening/night ABLs as outlined in Section B1.3.

The rating background levels are used in determining the intrusiveness criterion.

B1.1 Instrumentation requirements and siting

Background noise levels should be measured with a noise data logger that has an accuracy at least equivalent to the specifications of a Type 2 meter as stated in AS IEC 61672.1 – 2004 Electroacoustics – Sound level meters, Part 1: Specifications. The data logger should be fitted with a windshield and should have a current laboratory calibration certificate or label in accordance with calibration requirements outlined in AS IEC 61672.1 and AS2659. Equipment should also be calibrated in the field in accordance with these standards.

Site the data logger(s) at the most- (or potentially most-) affected noise-sensitive location(s). If this is impractical, site the logger(s) at locations with a similar acoustical environment. Be careful to choose sites that are truly representative of the noise environment at the noise-sensitive receivers; for example, do not choose positions screened from dominant background noise sources such as road traffic if sensitive receivers are not screened from such sources. Locate the microphone 1.2 to 1.5 metres above the ground and, where practicable, at least 3 to 5 metres from walls, buildings and other reflecting surfaces. **Data loggers should be sited as far away from trees as practicable to avoid noise produced by wind blowing through foliage, unless this is representative of the exposure of the receiver location.**

During monitoring, set the meter to ‘Fast’ time weighting and ‘A’ frequency weighting.

A weather monitor that continuously monitors wind and rainfall data should be positioned within 5 metres of the data logging equipment, ideally in a place that is not shielded from the wind. The effect of weather on the instrumentation is of interest here, so the height of the monitor should reasonably correspond to that of the noise logging equipment. Where multiple monitoring sites are required for a particular project, it is best to have simultaneous weather monitoring at each noise logger location or at locations that are demonstrated to be indicative of a number of locations. The weather monitor should record average wind speed (accuracy to within ± 0.5 metres per second) at least over 15 minute periods (corresponding to the noise measurement interval) and record the time intervals of rainfall.

Monitoring should not be conducted (or monitoring data are to be excluded) when average wind speeds are greater than 5 metres per second at microphone height or during rain. Exceptions to this rule are allowed, provided the proponent is able to show that the wind-induced noise on the microphone and sound levels due to rain are at least 10 dB(A) below the background noise levels under investigation. For sites where high wind speeds are a feature of the area, monitoring may be permitted during higher wind speeds provided that the proponent is able to show that these wind speeds are a site feature and that the wind-induced noise on the microphone is at least 10 dB(A) below the noise levels under investigation.

B1.2 Measurement procedure

The steps involved in monitoring background noise levels for planning purposes are:

- Calibrate the noise monitoring equipment in the field.
- Monitor the background noise and meteorological conditions continuously for each day of the week the proposed development will be operating and over the proposed operating hours.
- Note dominant and background noise sources present at the site throughout the monitoring period. Simultaneous data logging and audio capture of noise levels and operator-attended measurements may be made at the site to support the identification and occurrence of noise sources.
- Do a field calibration check at the end of the monitoring period in accordance with AS IEC 61672.1 – 2004 and AS2659. Re-monitoring may be required if there is a calibration drift greater than that allowed by the standards.

B1.3 Analysis procedure (tenth percentile method)

1. Remove any data that are affected by adverse weather conditions and/or extraneous noise. Check that the number and pattern of excluded $L_{A90,15\ minute}$ samples complies with the rules specified in Figure B1. If it does not, re-monitor the background noise following steps 1 to 4, but only for the affected assessment period in the corresponding day of the week. The underlying idea is to ensure that any patterns that occur are accounted for. These are often seen temporally throughout a day, diurnally, and from weekday to weekend.

   Exception: re-monitoring may not be required where monitoring contains weather-affected data if it can be ascertained that the affected samples are not within the expected 'quieter' times of an assessment period (day/evening/night); that is, those time periods where the lowest tenth percentile background noise level might occur. In this case it should be fully justified in the noise-assessment report that the weather-affected data would not affect the lowest tenth percentile background noise level. This could be done through the clear identification of set daily noise patterns of ‘quiet’ periods exhibited by the measured data from the non-affected days. There should be enough non-affected data available for the assessor to be confident that any pattern identified is valid. For these cases the affected samples need **not** be removed from the data set before the tenth percentile is determined in Step 2.

1. For every 4 consecutive values (-) there should be no more than 2 samples missing (x), for example:

   Single invalid 15-minute samples: - - - x - - - x - - - x - - - or

   - - x - - x - - x - - x - - or

   - x - x - x - x - x - x -

   Double invalid 15-minute samples: - - x x - - x x - - x x - -

2. Where the maximum number of invalid samples (x) is greater than 8, 2 or 4 for day, evening and night respectively, then the corresponding period (day/evening/night) should be monitored again.

3. Where there are more than two consecutive invalid (x) samples, only one occurrence of the following pattern is allowed before re-monitoring is required.

   Triple invalid 15-minute samples: - - - x x x - - -

Figure B1: Data exclusion rules.

2. Determine an assessment background level for each day (7 am to 6 pm), evening (6 pm to 10 pm) and night (10 pm to 7 am), using the tenth percentile method (essentially represents the lower tenth per cent value). The tenth percentile method may be determined automatically using a spreadsheet package, or manually by applying the method shown in Table B1.

Table B1: Method for determining the tenth percentile

Step 1	Sort the $L_{A90,15\ minute}$ data in each assessment period in **ascending** order.
Step 2	Work out the tenth per cent **position** of the number of samples in the assessment period. This can be calculated by multiplying the number of $L_{A90,\ 15\ minute}$ values in the assessment period by 0.1.
Step 3	Determine the tenth percentile (essentially the lowest tenth per cent value): If the tenth per cent **position** (from Step 2) is an integer, then the tenth percentile is determined by taking the arithmetic average of the value of the $L_{A90,\ 15\ minute}$ at the tenth per cent position and the next highest value. If the tenth per cent **position** (from Step 2) is not an integer, then the tenth percentile is the next highest $L_{A90,\ 15\ minute}$ value above the value at the tenth per cent position. Examples: For a data set of size 40, the tenth per cent position is 4 (i.e. 0.1 x 40). As this is an integer, the tenth percentile is the average of the values at the 4th position and the 5th position, counting from the lowest value of the sorted data (from Step 1). For a data set of size 44, the tenth per cent position is 4.4 (i.e. 0.1 x 44). As this value is not an integer, the tenth percentile is the value at the 5th position counting from the lowest value of the sorted data (from Step 1).

3. Determine the rating background level to be used for assessment purposes. This is taken to be the median value of the corresponding day/evening/night assessment background levels. For example, for a week's worth of monitoring, the evening rating background level is the median of the seven evening assessment background levels; that is, the fourth highest (or lowest) value. Where this level is found to be less than 30 dB(A), the rating background level is set to 30 dB(A) for the evening and night periods and 35 dB(A) for the day period.

B1.4 Analysis procedure ($L_{A90,F,period(day/evening/night)\ dB(A)}$ noise level)

Data should be excluded for further analysis for conditions outlined in Fact Sheet A4. Where the amount of invalid data exceeds 18%, 13% or 11% of the day, evening or night period respectively, then the corresponding period should be monitored again.

B2 Determining background noise using short-term noise measurements

The short-term method is the more appropriate background noise monitoring technique for:

- establishing the difference between the background noise level and the source being measured
- checking the noise compliance of a development
- determining the effect of background noise on a source-noise measurement.

B2.1 Instrumentation requirements and siting

To measure background noise levels, use a sound-level meter that meets the specifications of a precision (Class 1) or general-purpose (Class 2) sound-level meter as stated in AS IEC 61672.1. Fit a windshield over the microphone before taking any measurements. The equipment should have a current laboratory calibration certificate or label in accordance with the calibration requirements outlined in AS IEC 61672.1 and AS2659. Equipment should also be calibrated in the field in accordance with the standards. Use a portable sound-level calibrator (in current calibration) for field-checking purposes.

Wind speed during monitoring should be less than 5 minutes per second (equivalent to number 3 on the Beaufort wind scale; that is, leaves and small twigs in constant motion; wind extends small flag).

Take the background noise measurement at the reasonably most affected noise-sensitive location. If responding to a noise complaint, take the measurement as close as practicable to where the noise impact is alleged to occur.

Measure the background noise in the absence of both the noise under investigation and any extraneous noise not typical of the area. If it is not possible to exclude the source under investigation, then measure the background noise at a remote location judged to have a similar noise environment.

Hold the sound-level meter at arm's length or set it up on a tripod so the microphone is 1.2 to 1.5 metres above the ground and at least 3 to 5 metres from walls, buildings and other reflecting surfaces. During monitoring, set the meter to 'Fast' time weighting and 'A' frequency weighting. Do not take measurements when it is raining or when the average wind speed at microphone height exceeds 5 metres per second.

B2.2 Measurement procedure

1. During the period of the day for which the noise source is expected to operate, determine the time when the greatest impact is likely to occur and take measurements at this time. (Note: This is often when the difference between the measured background noise and the noise level generated by the new or existing development is greatest.)
2. Field-calibrate the noise monitoring equipment.
3. Measure the background noise level continuously for 15 minutes, excluding all distinct extraneous noises. (Because of the short period over which the background noise is being measured, distinct extraneous noises, including noise from transportation, conversation, birds and insects, should be ex cluded from the measurements.) If extraneous noise is present, pause the meter when this noise occurs or choose another measuring time or location.

The rating background level to be used for assessment purposes is the $L_{A90,\ 15\ minute}$ level produced by a statistical meter.

4. Check the field calibration at the end of the monitoring period in accordance with AS IEC 61672.1 and AS2659. Re-monitoring may be required if there is a calibration drift greater than that allowed by the standards.
5. If two or more valid measurements of background noise are recorded at the one location, adopt the lowest level as the background level.

Note: If the measured background level is less than 30 dB(A), then the rating background level is considered to be 30 dB(A) for the evening and night periods and 35 dB(A) for the day period.

B3 Reporting requirements

Include the following items in a report to support the determined rating background level:

B3.1 Long-term method

To support the determined rating background level, include:

- details of equipment used (include latest calibration date), equipment settings and sampling rate of the logger used
- a statement justifying the choice of monitoring site, including the procedure used to choose the site, having regard to the definitions of 'noise-sensitive location(s)' and 'reasonably most-affected location(s)' described in A1.2
- details of the exact location of the monitoring site and a description of land uses in surrounding areas
- a brief description of where the equipment was positioned
- a description of the dominant and background noise sources at the site
- a record of periods of affected data (due to adverse weather and extraneous noise) and statement indicating the need for any re-monitoring under Step 1 in Section B1.3
- day, evening and night assessment background levels for each day of the monitoring period
- the final RBL value
- daily logger graphs presenting $L_{Amax(15min)}$; $L_{A1(15min)}$, $L_{A10(15min)}$; $L_{A90(15min)}$ and $L_{Aeq(15min)}$.

B3.2 Short-term method

To support the determined rating background level, include:

- details of equipment used (include latest calibration date), equipment settings and the sampling rate of the meter
- a statement justifying the choice of monitoring site and period, including the procedure used to choose the site, having regard to the definitions of 'noise- sensitive location(s)' and 'reasonably most-affected location(s)' described in A1.2
- a description of the dominant and background noise sources at the site
- a record of weather conditions during monitoring
- the measured background noise levels.

Fact Sheet C: Adjustments for annoying noise characteristics

C1 Introduction

Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level. On the other hand, some sources may cause less annoyance where only a single event occurs for a limited duration. This section outlines the correction factors to be applied to the source noise level at the receiver before comparison with the project noise trigger levels specified in Section 2 to account for the additional annoyance caused by these modifying factors.

The modifying factor corrections should be applied having regard to:

- the contribution noise level from the premises when assessed / measured at a receiver location, and
- the nature of the noise source and its characteristics (as set out in this fact sheet).

Table C1 sets out the corrections to be applied. The corrections specified for tonal, intermittent and low-frequency noise are to be added to the measured or predicted noise levels at the receiver before comparison with the project noise trigger levels. The adjustments for duration are to be applied to the criterion.

Table C1: Modifying factor corrections (see definitions in Section C2)

Factor	Assessment/ measurement	When to apply	Correction[1]	Comments
Tonal noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method (ISO1996.2-2007 – Annex D)	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5dB or more if the centre frequency of the band containing the tone is in the range 500Hz to 10,00KHz • 8dB or more if the centre frequency of the band containing the tone is in the range 160Hz to 400Hz • 15dB or more if the centre frequency of the band containing the tone is in the range 25Hz to 125Hz	5 dB[2]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements.
Low frequency noise	Measurement of overall C-weighted and A-weighted level and one-third octave measurements in the range 10–160Hz	Measure/assess C- and A-weighted Leq,T levels over same time period. Correction to be applied where the C-A level exceeds 15dB and: • where any of the 1/3 octave noise levels in Table C2 are exceeded by up to 5dB and cannot be mitigated, a 2 dB(A) positive adjustment to measured/predicted A weighted levels applies for the evening/night period. • where any of the 1/3 octave noise levels in Table C2 are exceeded by more than 5dB and cannot be mitigated, a 5 dB(A) positive adjustment to measured/predicted A weighted levels applies for the evening/night period and a 2dB positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse et al, 2011 for DEFRA fluctuating low frequency noise criteria with corrections to reflect external assessment locations.
Intermittent noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.	5 dB	Adjustment to be applied for **night-time only**.
Duration	Single-event noise duration may range from 1.5 min to 2.5 h.	One event in any assessment period	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise. (see Table C3)
Maximum adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10 dB(A)2 (excluding duration correction)	

Notes: 1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion. 2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range.

C2 Definitions to support the modifying factor corrections

Tonal noise: noise containing a prominent frequency and characterised by a definite pitch.

Low-frequency noise: noise containing major components within the low frequency range (10 Hz–160 Hz) of the frequency spectrum.

Table C2: One-third octave low frequency noise thresholds

Hz/dB(Z)	One-third octave $L_{Zeq,15minute}$ threshold level												
f,Hz	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB(Z)	92	89	86	77	69	61	54	50	50	48	48	46	44

Note: dB(z) = decibel (Z-weighted); f,Hz = frequency in Hertz; Hz/dB(Z) = hertz per decibel (Z-weighted). For the assessment of low frequency noise, care should be taken to select a wind screen that has wind-induced noise characteristics at least 10 dB below the threshold values in Table C2 for wind speeds up to 5 metres per second. It is likely that high performance larger diameter wind screens (nominally 175 mm) will be required to achieve this performance (Hessler et.al. 2008). In any case, the performance of the wind screen and wind speeds at which data will be excluded needs to be stated.

Low frequency noise shall be assessed under the meteorological conditions under which noise limits would apply.

Measurements should be made between 1.2 and 1.5 metres above ground level unless otherwise approved through a planning instrument (consent/approval) or Environment Protection Licence and at locations nominated in the development consent or license.

Intermittent noise: noise where the level suddenly drops/increases several times during the assessment period, with a noticeable change in source noise level of at least 5 dB(A); for example, equipment cycling on and off. The intermittency correction is not intended to be applied to changes in noise level due to meteorology.

Adjustment for duration: this is applied where a single-event noise is continuous for a period of less than two and a half hours in any assessment period. The allowable exceedance of the $L_{Aeq,15minute}$ equivalent noise criterion is shown in Table C3 for the duration of the event. This adjustment is designed to account for unusual and one-off events, and does not apply to regular and/or routine high-noise level events.

Table C3: Adjustment for duration

Allowable duration of noise (one event in any 24-hour period)	Allowable exceedance of $L_{Aeq,15minute}$ equivalent project noise trigger level at receptor for the period of the noise event, dB(A)	
	Daytime and evening (7 am–10 pm)	Night-time (10 pm–7 am)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
less than 1.5 minutes	20	10

Note: Where the duration of the noise event is smaller than the duration of the noise criterion (i.e. less than 15 minutes) the allowable adjustment to the criterion will need to be calculated as follows: Adjusted $L_{Aeq,15minute}$ equivalent project noise trigger level = $10\text{Log}((10^{\text{criterion}/10} \times (X/900s)) + (10^{(\text{criterion + allowable exceedance})/10} \times (Y/900s)))$ where: X = 900s minus duration of event, and Y = duration of event.

Maximum adjustment: the maximum correction to be applied to the predicted or the measured level where two or more modifying factors are present. The maximum adjustment is 10 dB(A) where the noise contains two or more modifying factors (excluding the duration correction).

Fact Sheet D: Accounting for noise-enhancing weather conditions

Certain meteorological/weather conditions may increase noise levels by focusing sound-wave propagation paths at a single point. Such refraction of sound waves will occur during temperature inversions (atmospheric conditions where temperatures increase with height above ground level) and where there is a wind gradient (that is, wind velocities increasing with height) with wind direction from the source to the receiver.

Meteorological conditions need to be considered for both the impact assessment phase (pre-operation) and compliance assessment phase (post-operation) for an industrial activity. Compliance against noise requirements in consents and licences needs to be able to be determined under a range of meteorological conditions.

Standard meteorological conditions and **noise-enhancing meteorological conditions** have been defined in Table D1 for the purposes of this guideline.

Table D1: Standard and noise-enhancing meteorological conditions

Meteorological conditions	Meteorological parameters
Standard meteorological conditions	Day/evening/night: stability categories A–E wind speed up to 0.5 m/s at 10 m AGL.
Noise-enhancing meteorological conditions	Daytime/evening: stability categories A–E with light winds (0.5–3 m/s). Night-time: stability categories A–E with light winds (0.5–3 m/s) and stability category F.

Notes: m/s = metres per second; m = metres; AGL = above ground level; Where a range of conditions is nominated, the meteorological condition delivering the highest predicted noise level should be adopted for assessment purposes. However, feasible and reasonable noise limits in consents and licences derived from this process would apply under the full range of meteorological conditions nominated under standard or noise-enhancing conditions as relevant. All wind speeds are referenced to 10 m AGL.

Two options are available to a proponent to consider meteorological effects:

1. Simply adopt by default the **noise-enhancing meteorological conditions** for the assessment without an assessment of how often these conditions occur – a conservative approach; or

2. Determine the significance of noise-enhancing conditions based on a significance threshold of occurrence of 30% determined in accordance with the provisions in the guideline. Where **noise-enhancing meteorological conditions** occur for less than 30% of the time, **standard meteorological conditions** may be adopted for the assessment.

   Notes:

   - When determining the significance of F class stability category, F and G class conditions should be assessed and the combined occurrence used.
   - Where F class conditions are relevant for the assessment, any wind vectors that can occur while F class conditions are maintained should be considered. Where a condition of consent or licence identifies that limits apply under F class conditions, the limits will apply under any wind vector that can be maintained under F class stability category.

Where an environmental assessment has either adopted by default noise-enhancing conditions or identified noise-enhancing conditions as significant, predicted noise levels under these meteorological conditions should be compared to the relevant project noise trigger level for impact assessment purposes.

Where noise-enhancing meteorological conditions have been identified as not significant, predicted noise levels under standard meteorological conditions should be compared to the relevant project noise trigger level for impact assessment purposes.

Where appropriate, feasible and reasonable noise limits should be derived for consents and licences and should apply under the meteorological conditions use in the environmental assessment process. For all meteorological conditions outside the conditions used in the assessment process a limit based on ‘limit plus 5 dB(A)’ will apply. In this way a development is subject to noise limits under all meteorological conditions.

D1 Method for determining the frequency of temperature inversions

D1.1 Background

An important part of the assessment of noise enhancement due to inversions involves determining whether inversions occur frequently enough to warrant inclusion in the assessment.

The frequency of occurrence of temperature inversions may be determined either by direct measurement of inversion parameters, or by using indirect methods that allow the prediction of wind and temperature profiles to within a moderately narrow range using readily available meteorological data. The direct-measurement method will result in actual temperature gradients and drainage-flow-wind speeds from which the percentage occurrence of inversions may be determined. The indirect methods, on the other hand, allow the susceptibility of an area to inversions to be determined through the use of the relationship developed by the US Atomic Energy Commission between atmospheric stability categories and inversions. The relationship shown in Table D2 outlines the range of temperature gradients that can be expected within each stability category. Hence, if a stability category is known, then the range of possible temperature gradients may be inferred.

A positive temperature gradient signifies a temperature inversion; hence, from the table below, inversions occur during E, F and G stability categories. These three categories are considered to represent weak, moderate and strong inversions respectively. For noise assessment purposes, only moderate and strong inversions are considered significant enough to require assessment.

Table D2: Stability categories based on DT/DZ

Stability category	Range of vertical temperature gradient (degrees Celsius/100 metres)
A	DT/DZ < –1.9
B	–1.9 ≤ DT/DZ < –1.7
C	–1.7 ≤DT/DZ < –1.5
D	–1.5 ≤ DT/DZ < –0.5
E	–0.5 ≤ DT/DZ < 1.5
F	1.5 ≤ DT/DZ < 4
G	4 ≤ DT/DZ

Three basic schemes may be used to determine the occurrence of different stability classes at a particular site based on the following combinations of meteorological parameters:

- direct measurement of temperature lapse rate over a height interval range of 50 metres minimum with the lower height a minimum of 10 metres, and wind speed at 10 metres height
- cloud cover, wind speed and solar elevation (Pasquill–Gifford scheme and Turner scheme)
- measurements of sigma-theta (the standard deviation of wind direction), wind speed and time of day.

All methods involve analysing three months of meteorological data collected in winter, the season during which most inversions occur. Wind measurements are to comply with AS 3580.14-2011: Methods for sampling and analysis of ambient air. Meteorological monitoring for ambient air quality monitoring applications (Standards Australia 2011).

D1.2 Direct measurement of temperature lapse rate

This method involves the measurement of temperature gradient and wind speed at hourly intervals over the three winter months. The temperature gradient measurement involves measuring the temperature at two elevated levels, the lower height a minimum of 10 metres above ground and a 50-metre height interval minimum to determine the temperature difference. Where temperature is not measured at 10 metres and 60 metres the actual measurement heights need to be stated. The temperature gradient is then the temperature difference (that is, the temperature at the higher elevation minus the temperature at the lower elevation) multiplied by a fraction that is calculated as 100 divided by the height difference. The wind speed should be measured at a height of 10 metres. Care should be taken to ensure that measurement procedures comply with relevant standards (NSW EPA, 2014).

Inversion strengths calculated by extrapolation of the difference between temperatures measured at the same or different heights above ground level, but where one measurement is laterally displaced on elevated terrain, may give reasonable accuracy. The accuracy should be established by comparison of the calculated values against measurements from a campaign of direct measurements, such as by tethersonde.

Once all data have been collected, the percentage occurrence of each stability category may be determined. A step-by-step guide to the analysis procedure is given in Table D3.

Table D3: Step procedure for determining wind speed used in the assessment

Step	Procedure
1.	Sort the night-time (period between 1 hr before sunset to 1 hr after sunrise taken to be 6 pm to 7 am) temperature gradients with associated wind speed in ascending order for the whole winter period.
2.	Convert the temperature gradients into their corresponding stability categories according to Table D2.
3.	If F or G stability categories occur for a period of 30% of the total night-time or more, either separately or in combination, then temperature inversions are considered to be a significant feature of the area and need to be assessed.

D1.3 Classifications of stability category based on cloud cover

The most widely used stability classification scheme is that developed by Pasquill (1961). This is based on observations of cloud cover, wind speed and solar elevation. This scheme was modified by Turner (1964) to create an alternative scheme that is more amenable to application with computer-based databases. Both schemes are discussed below.

D1.3.1 Pasquill–Gifford scheme

The Pasquill–Gifford scheme, outlined in Table D4 below, essentially determines Pasquill stability categories based on hourly or three-hourly wind-speed and cloud-cover measurements. Once these are known, the percentage frequency of temperature inversions over the three winter months may be predicted using the relationship in Table D3. The following data are required for the analysis collected over the three winter months:

- hourly or three-hourly wind speed and direction at 10 metres (the wind direction is not required to determine the Pasquill stability category but is required for the noise analysis)
- hourly or three-hourly cloud cover measurements

- times of sunrise and sunset recorded on a daily basis (these times are required to define the night-time period) or assumed to be 7 am and 6 pm, respectively.

The required data may be obtained from the Bureau of Meteorology from data collected at the closest monitoring station. The parameters needed are available from selected Bureau of Meteorology stations across NSW. Wind speeds and wind directions are subject to considerable local variation. However, cloud cover is generally not subject to such strong spatial variations and, consequently, data from a station some distance away may be acceptable. Whether or not data apply to a particular site needs to be critically assessed. For cloud cover, distance from the coast and ground elevation will have an important bearing on the cloudiness. In general, data collected from weather-monitoring stations are considered relevant for a radius of 30 kilometres from the station, provided the surrounding area is in the same topographical basin as the station.

If representative cloud data is not available from a nearby station, it is advisable to use the sigma-theta method outlined below instead to determine stability categories. This is because the numerous individual observations needed to measure cloud cover for the Pasquill–Gifford method are often not feasible.

Table D4: Key to Pasquill stability categories[1]

Hourly average wind speed at 10 metres per second	Daytime stability categories	Stability categories based on night cloud cover[(2)] (night = 6 pm to 7 am)	
		Thinly overcast or ≥ 4/8 low cloud	≤ 3/8 cloud
< 2	A–D	G	G
2–3		E	F
3–5		D	E
5–6		D	D
> 6		D	D

Source: Adapted from Pasquill (1961). Notes: 1. In dispersion modelling, stability class is used to categorise the rate at which a plume will disperse. In the Pasquill–Gifford stability class assignment scheme (as used in this study) there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. Class F relates to stable conditions, such as those that occur when the sky is clear, the winds are light and an inversion is present. The intermediate classes B, C, D and E relate to intermediate dispersion conditions. A seventh class, G, has also been defined to accommodate extremely stable conditions such as might be found in arid rural areas. 2. The neutral category D should be used for overcast conditions regardless of wind speed.

D1.3.1.1 Determining the frequency of occurrence of inversions

Once the stability categories have been determined for all the data collected during the period from 6 pm to 7 am, the percentage occurrence of moderate and strong inversions occurring during F and G stability categories, respectively, may then be determined. The percentage occurrence required here is the total percentage occurrence for the night periods over the three months of winter. The Pasquill–Gifford scheme assumes that moderate and strong inversions do not occur during the daytime hours (considered here to be from 7 am to 6 pm).

Where the sum total of F and G inversions occur for at least 30% of the total night-time in winter, the project area is considered to be significantly affected by inversions warranting noise assessment. Current generation noise modelling software does not allow for the modelling of G class stability categories. Therefore modelling should be undertaken using F class conditions. Where direct temperature lapse rates are able to be selected in a noise model, the upper bounds of F class should be selected, that is, 4 degrees Celsius per 100 metres.

D1.3.2 Turner scheme

The Turner scheme recognises that stability near the ground depends mainly on net radiation and wind speed, with net radiation being a function of cloud cover and the height of the cloud ceiling. This scheme determines stability categories based on hourly or three-hourly wind measurements of cloud cover, cloud-ceiling height, wind speed and wind direction. As with the previous scheme, the percentage occurrence of temperature inversions over the three winter months may be predicted using the relationship in Table D3. The following data need to be collected over the three winter months for analysis:

- hourly or three-hourly wind speed and direction at 10 metres (wind direction is not required to determine the Pasquill stability category, but is required for the noise analysis)
- hourly or three-hourly cloud cover measurements
- hourly or three-hourly cloud ceiling-height measurements
- daily records of time of sunrise and sunset (needed to define the night-time period) or assumed to be 6 pm to 7 am, respectively.

Similarly, the required data may be obtained from the Bureau of Meteorology from data collected at the closest monitoring station (see Section D1.3.1 regarding considerations relating to the applicability of data to a site).

If representative cloud data are not available from a nearby station, it is advisable to use the sigma-theta method outlined in Section D1.4 instead to determine stability categories. This is because the large number of individual observations needed to measure cloud cover for the Turner scheme may not be feasible.

Table D5 gives the stability class as a function of wind speed and net radiation. The net radiation index for the night period ranges from –1 to –2 (negative radiation is radiation directed away from the earth). **Note that the Turner scheme assumes that moderate and strong inversions do not occur during daytime hours (considered here to be the period from 7 am to 6 pm).**

Note also that in the specifications for this scheme cloud-cover data are assumed to be available in 1/10ths. Usually data from the Bureau of Meteorology are reported in 1/8ths, so some conversion will be needed.

The net radiation index to be used in Table D5 is:

- If the total cloud cover is 10/10 and the ceiling is less than 7000 feet, use net radiation index equal to 0 (whether day or night).
- For night-time (from 6 pm to 7 am):

  a) If total cloud cover ≤ 4/10, use net radiation index equal to –2.

  b) If total cloud cover >4/10, use net radiation equal to –1.

Table D5: Stability class as a function of net radiation and wind speed

Wind speed		Net radiation index		
Knots	**m/s**	**0**	**–1**	**–2**
0–1	0–0.7	D	F	G
2–3	0.8–1.8	D	F	G
4–5	1.9–2.8	D	E	F
6	2.9–3.3	D	E	F
7	3.4–3.8	D	D	E
8–9	3.9–4.8	D	D	E
10	4.9–5.4	D	D	E
11	5.5–5.9	D	D	D
≥ 12	≥ 6.0	D	D	D

Note: m/s = metres per second.

Follow the procedure outlined in Section D1.3.1.1 to determine the percentage occurrence of temperature inversions once the stability-category classifications have been made.

D1.4 Use of sigma-theta data

The sigma-theta method, developed by the US EPA, refers to observations of sigma-theta, wind speed and time of day. With this method the Pasquill stability categories may be determined by using a relationship between stability categories and the standard deviation of the horizontal wind direction fluctuations (σ_A in degrees). The scheme is applied in one step to determine the daytime stability category and two steps to determine the night-time stability category as follows:

- the daytime (from 7 am to 6 pm) stability category may be determined directly from σA data using Table D6.
- the night-time (from 6 pm to 7 am) stability category may be determined in two steps:
  - determine the stability category from σ_A data using Table D6.
  - modify this stability category based on prevailing wind speed using Table D7.

Sigma-theta data may be measured on an hourly or three-hourly basis and should be collected as specified in AS 3580.14-2011: Methods for sampling and analysis of ambient air. Meteorological monitoring for ambient air quality monitoring applications.

Note: Table D6 strictly applies only when the σ_A measurements are made in an area where the surface roughness is 0.15 metres. To apply the scheme using σ_A data collected in an area where the surface roughness is different, the limit in the table should be modified by multiplying it by:

$$(z_o/15\text{ cm})^{0.2} \text{ where } z_o = \text{the surface roughness of the area in centimetres.}$$

For example, if the surface roughness is 0.20 metres, the first limit in Table D6 (that is, 22.5º) should be changed to 23.8º (i.e. $22.5º \times (20/15)^{0.2}$).

Table D8 shows the typical surface roughness that applies for a range of surfaces.

Table D6: Wind fluctuation criteria for estimating Pasquill–Gifford stability categories for non-arid areas in NSW[1,2]

Pasquill stability category	Standard deviation of the horizontal wind direction fluctuations[3,4] (σ_A in degrees (º))
A	$\sigma_A \geq 22.5^o$
B	$17.5^o \leq \sigma_A < 22.5^o$
C	$12.5^o \leq \sigma_A < 17.5^o$
D	$7.5^o \leq \sigma_A < 12.5^o$
E	$3.8^o \leq \sigma_A < 7.5^o$
F	$2.1^o \leq \sigma_A \leq 3.8^o$
G[5]	$\sigma_A \leq 2.1^o$

Adapted from: Irwin (1980) and US EPA (1987). Notes: 1. These criteria are appropriate for steady-state conditions, a measurement height of 10 metres for level terrain, and an aerodynamic surface roughness length of 15 centimetres. Ensure that the wind sensor is responsive enough for use in measuring wind direction fluctuations (US EPA 1987). 2. The NSW EPA recommends that the sigma-theta method not be used for arid or semi-arid areas (US EPA 1987). 3. For areas with surface roughness different from 15 centimetres, the **table** values should be modified by multiplying by the surface roughness factor of $(z_o/15\text{ cm})^{0.2}$, where z_o is the average surface roughness in centimetres within a radius of 1 to 3 kilometres of the source. Note that this factor, while theoretically sound, has not been subjected to rigorous testing and may not improve the estimates in all circumstances. A table of z_o values that may be used as a guide to estimating surface roughness is given in Smedman–Hogstrom and Hogstrom (1978). 4. These criteria are from an NRC proposal (NRC 1972). It would seem reasonable to restrict the possible categories of A through D during daytime hours with a restriction that, for 10-metre above ground level wind speeds above 6 metres persecond, conditions are neutral. Likewise, during the night-time hours, some restrictions (as in Table CA2.6 in the NRC document*)* are needed to preclude occurrences of categories A through C. 5. Supplemented by data from Mitchell and Timbre (1979) and US EPA (1980).

Table D7: Night-time[1] Pasquill–Gifford stability categories based on σ_A from table D6

If the σ_A stability category is:	And the wind speed at 10-metre AGL is (m/s)	Then the pasquil stability category is:
A	<2.9 2.9-3.5 >=3.6	F E D
B	<2.4 2.4-2.9 >=3	F E D
C	<2.3 >=2.4	E D
D	ANY	D
E	<4.9 >=5	E D
F	<3 3-5 >=5	F E D
G	<2 2-3 3-5 >=5	G F E D

Adapted from Irwin (1980) and US EPA (1987). Notes: AGL = above ground level. 1. Night-time is considered to be from 6 pm to 7 am. 2. The original Mitchell and Timbre (1979) table had no wind speed restrictions. However, the original Pasquill criteria suggest that, for wind speeds greater than or equal to 5 metres per second (m/s), the D category would be appropriate; and for wind speeds between 3 m/s and 5 m/s, the E category should be used. For wind speeds between 2 m/s and 3 m/s, the F category should be used, and for wind speeds less than 2 m/s, the G category should be used.

Table D8: Aerodynamic roughness of various surfaces

Surface	Comments	Roughness (z_o) (metres)
Water	Still, open sea	0.1–10.0x10^{-5}
Sand, open desert		0.0003
Open soil		0.001–0.01
Grass	Mown lawn: 0.02–0.10 metres high Rough pasture: 0.25–1 metres high	0.003–0.01 0.04–0.10
Short scrub, long grass and most field crops		0.05–0.10
Forest		0.6–2
Suburban area		0.6
City		0.6–2

D1.5 Discussion

In summary, the above discussion outlines three independent ways that readily-available or easily-collected meteorological data can be analysed to estimate the frequency with which atmospheric stability categories of different classes occur.

It is envisaged that consultants assessing the susceptibility of an area to inversions would either accept the noise-enhancing meteorological parameters, or undertake their own analyses using one of the schemes outlined above to establish whether inversions are a significant feature of the area.

In order of preference, the schemes available to determine stability category are:

- direct measurements of temperature gradient at two heights with the lower height being a minimum of 10 metres over a height interval of at least 50 metres, with simultaneous measurements of wind speed and wind direction at 10 metres
- the sigma-theta method
- the Pasquill–Gifford scheme and Turner scheme (equally preferred).

Other methods are detailed in the US EPA's documents (1987 and 2000), On-Site Meteorological Program Guidance for Regulating Modelling Applications.

D2 Method for determining the frequency of winds

The following methods may be used to determine the frequency of winds:

- For individual sites, the NEWA method on the EPA website should be used, or other methods demonstrated to be equally suitable.
- Wind roses with 16 cardinal directions may be used. To determine the significance of a wind vector in accordance with this guideline, the direction plus or minus 45o must be taken into account. Therefore the most relevant cardinal direction, plus the arithmetic sum of the adjoining two cardinal directions either side of the primary, should be used as a first estimate of percentage frequency of occurrence.
- Other methods justified and accepted by the relevant regulatory authority can also be used.

Note: At least one year's worth of meteorological data shall be used in the analysis.

Fact Sheet E: Worked case studies

E1 General application case study

This case study aims to highlight the main aspects of the policy, and can be referred to in a number of different assessment situations.

Situation: New major development proposal near an urban residential area

A major development is proposed in an existing industrial area with a residential area located nearby. Apart from the site in question, the industrial area is fully developed. The noise impact of the proposed development needs to be assessed. The development is proposed to operate 24 hours a day seven days per week.

Main assessment steps

1. Preliminary site investigation

Visit the site and surrounds to determine relevant information for a noise assessment including:

- the physical relationship between the industrial site and the residential area
- the nature of the acoustic environment at the residential area, and the number of acoustic monitoring locations that may be needed to characterise the noise environment
- information to assist in determining the residential receiver category (ING – Table 2.2) including general observations of the noise environment and its dominant sources (i.e. transportation, industry, natural sources etc).

2. Determine existing noise levels

Acoustic monitoring instrumentation was deployed at a single location deemed representative of the residential area for a full week. The main information required at this stage of the assessment is the rating background noise levels. However, the existing industrial noise levels may be needed if the project amenity noise levels cannot be met. Therefore, to avoid any duplication the instrument was programed to record all relevant acoustic parameters including sample audio data.

The monitoring location was also visited by the acoustic practitioner during the day, evening and night periods to make observations about the acoustic environment, including the general noise sources that are audible.

The rating background noise levels were determined to be:

- daytime: 45 dB(A)
- evening: 42 dB(A)
- night-time: 36 dB(A).

3. Determine residential receiver category

The residential area is zoned R4 High Density Residential. The noise in the area is dominated by traffic noise due to main roads and some industrial noise was audible for all assessment periods. The land zoning, the subjective assessment of the acoustic environment in the area and the acquired background noise levels would support an urban residential land-use category with reference to Table 2.2 in the ING.

4. Determine project noise trigger levels (PNTLs)

The amenity and intrusiveness noise levels were determined as shown in Table E1.1.

Table E1.1: Project noise trigger levels

Period	Intrusiveness noise level[1]	Project amenity noise level[2]
Daytime	50 dB $L_{Aeq,15\ minute}$ (45 + 5)	57 $L_{Aeq,15minutes}$ (60 –5 + 2)
Evening	47 dB $L_{Aeq,15\ minute}$ (42 + 5)	47 $L_{Aeq,15minutes}$ (50 –5 + 2)
Night-time	41 dB $L_{Aeq,15\ minute}$ (36 + 5)	42 $L_{Aeq,15minutes}$ (45 –5 + 2)

Notes: dB = decibel; dB(A) = decibel (A-weighted); RBL = rating background noise level. 1. Intrusiveness noise level is $L_{Aeq,15\ minute}$ ≤ RBL + 5 (Section 2.1). 2. Project amenity noise level (ANL) is urban ANL (Table 2.1) minus 5 dB(A) plus 2 dB(A) to convert from a period level to a 15 minute level.

The project noise trigger level is the lower (i.e. the most stringent) value of the intrusiveness and amenity noise levels. Therefore the PNTLs are as follows:

- daytime: $L_{Aeq,15minutes}$ 50 dB(A)
- evening: $L_{Aeq,15minutes}$ 47 dB(A)
- night-time: $L_{Aeq,15minutes}$ 41 dB(A).

5. Predict/measure level of noise and determine impact

The proponent chose to adopt the noise-enhancing meteorological conditions outlined in Fact Sheet D without an assessment of how often these conditions occur, which is acceptable under the guideline.

Table E1.2: Assessment meteorological conditions

Period	Meteorological conditions
During noise-enhancing meteorological conditions	Daytime/evening: stability categories A–E with light winds (0.5–3 m/s). Night-time: stability categories A–E with light winds (0.5–3 m/s) and stability category F.

Note: m/s = metres per second.

Noise modelling was undertaken for the project using the above meteorological parameters. Relevant details provided in the assessment included all matters outlined in *Section 3* of the ING.

The following noise levels were predicted for the day, evening and night-time period.

- daytime: $L_{Aeq,15minutes}$ 49 dB(A)
- evening: $L_{Aeq,15minutes}$ 49 dB(A)
- night-time: $L_{Aeq,15minutes}$ 46 dB(A)

The predicted noise levels exceed the evening PNTL by 2 dB(A) and the night-time PNTL by 5dB(A). Consideration of noise mitigation is therefore required.

The proponent demonstrated that a three-metre high solid barrier on the northern boundary of the premises and the acoustic enclosure of a compressor would reduce noise levels by between 5 and 7 dB(A) at the residential location. These measures were determined to be both feasible and reasonable and were proposed to be adopted by the proponent. With these measures incorporated, the following revised noise predictions were made.

- daytime: $L_{Aeq,15minutes}$ 42 dB(A)
- evening: $L_{Aeq,15minutes}$ 42 dB(A)

- night-time: $L_{Aeq,15minutes}$ 41 dB(A)

With the proposed noise mitigation measures incorporated, unacceptable noise impacts are not expected.

6. Monitor performance

Suitable conditions were placed in the consent/environment protection licence based on achieving the project noise trigger level under the meteorological conditions (i.e. noise-enhancing conditions) used in the assessment. An upper limit of +5 dB(A) was also included to apply during extreme meteorological conditions.

E2 High traffic noise case study

This case study aims to highlight the high traffic noise level amenity provisions of the policy.

Situation: New major development proposal near an urban residential area

A major development is proposed in an existing industrial area with a residential area located across a major highway from the facility. Apart from the site in question, the industrial area is fully developed. The noise impact of the proposed development needs to be assessed. The development is proposed to operate during daytime and evening hours, six days per week.

Main assessment steps

1. Preliminary site investigation

Visit the site and surrounds to determine relevant information for a noise assessment including:

- the physical relationship between the industrial site and the residential area
- the nature of the acoustic environment at the residential area, including the amount of traffic noise, and the number of acoustic monitoring locations that may be needed to characterise the noise environment
- information to assist in determining the residential receiver category (ING – Table 2.2) including general observations of the noise environment and its dominant sources (i.e. transportation, industry, natural sources etc.).

2. Determine existing noise levels

Acoustic monitoring instrumentation was deployed at a single location deemed representative of the residential area for a full week. During deployment of the monitoring instrument the acoustician undertaking the assessment noted that road traffic noise was the only audible source of noise at the monitoring location.

The main information required at this stage of the assessment is the rating background noise levels and the level of road traffic noise for the daytime and evening period. However, the existing industrial noise levels may be needed if the default amenity trigger levels cannot be met. Therefore to avoid any duplication the instrument was programed to record all relevant acoustic parameters, including sample audio data.

The monitoring location was also visited by the acoustic practitioner several times during the monitoring period to make observations about the acoustic environment, including the general noise sources that are audible, and to confirm that road traffic noise is the dominant source of noise.

The rating background noise levels and $L_{Aeq,traffic}$ for the daytime and evening period were determined as follows.

Table E2.1: RBLs and $L_{Aeq,traffic}$ levels

Period	RBL, dB(A)	$L_{Aeq,traffic}$,dB(A)
Daytime	62	71
Evening	60	68

3. Determine residential receiver category

The residential area is zoned R4 High Density Residential. The noise in the area is dominated by traffic noise due to main roads for the day and evening periods. The land zoning, the subjective assessment of the acoustic environment in the area and the acquired background noise levels would support an urban residential land-use category with reference to *Table 2.2* in the ING.

However, for the purposes of deriving the amenity trigger level, the acoustician confirmed, through attended and unattended monitoring, that:

- traffic noise is the dominant source of noise at the receiver location
- the existing traffic noise level is 10 dB(A) or more above the ANL for the area
- it is highly unlikely that traffic noise will reduce over time.

Therefore the high traffic noise provisions in the ING Section 2.4.1 were adopted to derive the default amenity trigger levels.

4. Determine project noise trigger levels

The amenity and intrusiveness noise levels were determined as shown in Table E2.2.

Table E2.2: Project noise trigger levels

Period	Intrusiveness noise level[1]	High traffic project amenity noise level[2]
Daytime	67 dB $L_{Aeq,15\ minute}$ (62 + 5)	58 $L_{Aeq,15minutes}$ (71 –15 + 2)
Evening	65 dB $L_{Aeq,15\ minute}$ (60 + 5)	55 $L_{Aeq,15minutes}$ (68 –15 + 2)

Notes: Intrusiveness noise level is $L_{Aeq,15\ minute} \leq$ RBL + 5 (Section 2.1). High traffic project amenity noise level is existing traffic levels minus 15 dB(A) plus 2 dB(A) to convert from a period level to a 15-minute level.

The project noise trigger level is the lower (i.e. the most stringent) value of the intrusiveness and amenity noise levels. Therefore the PNTLs are as follows:

- daytime: $L_{Aeq,15minutes}$ 58 dB(A)
- evening: $L_{Aeq,15minutes}$ 55 dB(A)

5. Predict/measure level of noise and determine impact

The proponent chose to adopt the noise-enhancing meteorological conditions outlined in Fact Sheet D of the Industrial Noise Guideline without an assessment of how often these conditions occur, which is acceptable under the guideline.

Period	Meteorological conditions
During noise-enhancing meteorological conditions	Daytime/evening: stability categories A–E with light winds (0.5–3 m/s), Night-time: stability categories A–E with light winds (0.5–3 m/s) and stability category F.

Note: m/s = metres per second.

Noise modelling was undertaken for the project. Relevant details provided in the assessment included all matters outlined in Section 3 of the ING.

The following noise levels were predicted for the day and evening periods.

- daytime: $L_{Aeq,15minutes}$ 53 dB(A)
- evening: $L_{Aeq,15minutes}$ 53 dB(A)

The predicted noise levels satisfy the PNTL by 5 dB(A) for the daytime and 2 dB(A) for evening period. On that basis unacceptable noise impacts are not expected.

6. Monitor performance

Suitable conditions were placed in the consent/environment protection license based on achieving the project noise trigger level under the deemed meteorological conditions outlined above. The conditions included a requirements for a not greater than 5 dB(A) excursion above the noise limits for meteorological conditions more extreme that the deemed meteorological conditions, for example G class stability category or wind speeds greater than 3 metres per second @ 10 metres AGL during the daytime.

E3 Extractive industry proposed for quiet rural area (significance of meteorological assessment)

This case study aims to highlight the assessment of an extractive industry in a quiet rural location with consideration of the significance of noise-enhancing meteorology.

Situation: New major extractive industry proposed near isolated rural residential locations

A major extractive industry is proposed in a quiet rural location with isolated rural residential locations potentially affected by noise from the development. The noise impact of the proposed development needs to be assessed. The development is proposed to operate 24 hours seven days per week.

Main assessment steps

1. Preliminary site investigation

Visit the site and surrounds to determine relevant information for a noise assessment including:

- the physical relationship between the industrial site and the residential area
- the nature of the acoustic environment at the residential area, including the amount of traffic noise, and the number of acoustic monitoring locations that may be needed to characterise the noise environment
- information to assist in determining the residential receiver category (Industrial Noise Guideline (ING) – Table 2.2) including general observations of the noise environment and its dominant sources (i.e. transportation, industry, natural sources etc.).

2. Determine existing noise levels

Acoustic monitoring instrumentation was deployed at a single location deemed representative of the isolated residential locations for a full week.

The main information required at this stage of the assessment is the rating background noise levels. However, the existing industrial noise levels may be needed if the default amenity trigger levels cannot be met. Therefore to avoid any duplication the instrument was programed to record all relevant acoustic parameters, including sample audio data.

The monitoring location was also visited by the acoustic practitioner several times during the monitoring period to make observations about the acoustic environment.

The rating background noise levels for the daytime, evening and night period were determined as shown in Table E3.1.

Table E3.1: Rating background noise levels

Period	RBL, dB(A)
Daytime	35[1] (Actual 27)
Evening	30[1] (Actual 26)
Night-time	30[1] (Actual 25)

Note: RBL = rating background noise level. 1. Actual RBLs are below assumed policy minimums; therefore adopt assumed minimums.

3. Determine residential receiver category

The residential area is zoned RU1 Primary Production. The noise in the area is dominated by natural sounds. The land zoning, the subjective assessment of the acoustic environment in the area and the acquired background noise levels would support a rural residential land-use category with reference to Table 2.2 in the ING.

4. Determine project noise trigger levels

The amenity and intrusiveness noise levels were determined as follows:

Table E3.2: Project noise trigger levels

Period	Intrusiveness noise level[1]	Project amenity noise level[2]
Daytime	40 dB $L_{Aeq,15\ minute}$ (35 + 5)	47 $L_{Aeq,15minutes}$ (50 –5 + 2)
Evening	35 dB $L_{Aeq,15\ minute}$ (30 + 5)	42 $L_{Aeq,15minutes}$ (45 –5 + 2)
Night-time	35 dB $L_{Aeq,15\ minute}$ (30 + 5)	37 $L_{Aeq,15minutes}$ (40 –5 + 2)

Notes: 1. Intrusiveness noise level is $L_{Aeq,15\ minute} \leq$ RBL + 5 (section 2.1). 2. Project amenity noise level is Rural ANL minus 5 dB(A) plus 2 dB(A) to convert from a period level to a 15 minute level.

The project noise trigger level is the lower (i.e. the most stringent) value of the intrusiveness and amenity noise levels. Therefore the PNTLs are as follows:

- daytime: $L_{Aeq,15minutes}$ 40 dB(A)
- evening: $L_{Aeq,15minutes}$ 35 dB(A)
- night-time: $L_{Aeq,15minutes}$ 35 dB(A).

5. Predict/measure level of noise and determine impact

The proponent elected to determine the percentage occurrence of noise-enhancing meteorological conditions in accordance with the guideline. It was determined that F class stability category occurred for more than 30% of winter nights and was therefore determined to be a significant feature of the area. Light source to receiver winds (0.5–3 m/s) were also identified as a significant feature of the area. Therefore the noise-enhancing meteorological conditions outlined below were adopted for impact assessment purposes.

Period	Meteorological conditions
During noise-enhancing meteorological conditions	Daytime/evening: stability categories A–E with light winds (0.5–3 m/s). Night-time: stability categories A-E with light winds (0.5–3 m/s) and stability category F.

Note: m/s = metres per second.

Noise modelling was undertaken for the project. Relevant details provided in the assessment included all matters outlined in Section 3 of the ING.

The following noise levels were predicted for the day, evening and night-time periods at the nearest most affected receiver:

- daytime: $L_{Aeq,15minutes}$ 38 dB(A)
- evening: $L_{Aeq,15minutes}$ 38 dB(A)
- night-time: $L_{Aeq,15minutes}$ 40 dB(A).

The predicted noise levels satisfy the PNTL by 2 dB(A) for the daytime and exceed the PNTL for the evening and night by 3 and 5 dB respectively. On that basis noise mitigation measures need to be considered to seek to achieve the PNTL.

The proponent correctly started by identifying the mitigation measures that would be needed to satisfy the PNTL and they consisted of:

- fully enclosing coal handling preparation plant (CHPP)
- partially enclosing the rail load out facility
- selecting noise abated haul trucks.

The measures were subsequently analysed in terms of whether they were both feasible and reasonable. The analysis indicated that full enclosure of the CHPP was not feasible due to access requirements; however, a partial enclosure, and the partial enclosure of the load out facility and noise abated haul trucks were both feasible and reasonable.

With these measures adopted, noise from the facility was predicted at the nearest most affected receiver as:

- daytime: $L_{Aeq,15minutes}$ 35 dB(A)
- evening: $L_{Aeq,15minutes}$ 35 dB(A)
- night-time: $L_{Aeq,15minutes}$ 36 dB(A).

The proponent supplied sufficient information to enable the decision maker to conclude that the mitigated noise levels represented the best achievable outcome. The 1 dB(A) residual noise level was deemed to represent a negligible impact and was adopted as an acceptable performance benchmark for the facility in the consent and environment protection licence.

6. Monitor performance

Suitable conditions were placed in the consent/environment protection licence based on the predicted noise levels with feasible and reasonable mitigation measures considered. The limits were required to be met under the deemed meteorological conditions. The conditions included a requirements for a not greater than 5 dB(A) excursion above the noise limits for meteorological conditions more extreme that the deemed meteorological conditions; for example, G class stability category or wind speeds greater than 3 metres per second @ 10 metres AGL during the daytime.

Fact Sheet F: Feasible and reasonable mitigation

'Feasible' and 'reasonable' mitigation is defined as follows:

A **feasible** mitigation measure is a noise mitigation measure that can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements. It may also include options such as amending operational practices (e.g. changing a noisy operation to a less sensitive period or location) to achieve noise reduction.

Selecting **reasonable** measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. To make such a judgement, consider the following:

- Noise impacts:
    - existing and future levels, and projected changes in noise levels
    - level of amenity before the development; for example the number of people affected or annoyed
    - the amount by which the triggers are exceeded.
- Noise mitigation benefits:
    - the amount of noise reduction expected, including the cumulative effectiveness of proposed mitigation measures; for example, a noise wall/mound should be able to reduce noise levels by at least 5 decibels
    - the number of people protected.
- Cost effectiveness of noise mitigation:
    - the total cost of mitigation measures
    - noise mitigation costs compared with total project costs, taking into account capital and maintenance costs
    - ongoing operational and maintenance cost borne by the community, for example running air conditioners or mechanical ventilation.
- Community views:
    - engage with affected land users when deciding about aesthetic and other impacts of noise mitigation measures
    - determine the views of all affected land users, not just those making representations, through early community consultation
    - consider noise mitigation measures that have majority support from the affected community.

Take into account the above considerations when determining the mitigation measures proposed to be incorporated into the development. In practice, the detail of the mitigation measures applied will largely depend on project-specific factors. These are the measures that minimise, as far as practicable, the local impacts of the project. Project approval conditions that flow from this process should be achievable. They need to provide clarity and confidence for the proponent, local community, regulators and the ultimate operator that the proposed mitigation measures can achieve the predicted level of environmental protection.