Dear Madam,

NOISE ASSESSMENT FOR PROPOSED ANIMAL SANCTUARY (INCLUDING DOG KENNELS)
LAND AT LITTLE BROUGHTON, COCKERMOUTH, CUMBRIA

1.00 INTRODUCTION

1.01 Environmental Noise Solutions (Limited) have been commissioned by Jennifer Hubbard (Town Planning Consultant), on behalf of ‘Animal Concern’ to carry out a desk based noise assessment for a proposed animal sanctuary (including the provision of 16 no. dog kennels, up to 20 no. dogs) at land at Little Broughton, Cockermouth.

1.02 It is understood that a planning application for a proposed animal sanctuary was submitted to Allerdale Borough Council in February 2011 (Reference 2/2011/0098). Determination was not made however as the application was subsequently withdrawn. Notwithstanding this, the following consultation response dated 22 March 2011 was provided by Sian Tranter, Specialist Environmental Health Officer (Pollution) to the Planning South Team at Allerdale Borough Council.

We have no objection in principle to the above proposal, however in order to protect the surrounding amenity I would make the following comments:

Noise mitigation

Discussions have been held with the applicant/agent in respect of earth bunds to prevent line of sight from the kennel building to the nearest noise sensitive uses. Taking account of current site levels, the earth bund will be approximately 3m in height which will equate to the height of the first floor bedroom window of the closest property. The onus would rest with the applicant to demonstrate to the satisfaction of the planning authority how the proposal will operate and protect the surrounding amenity.

All external runs/exercise areas will need to be on an elevation not facing properties taking into account predominant wind directions. Any ventilation to the building would also need to be addressed so as not to cause any noise to escape from the building i.e. the legal impact of other legislation regarding animal welfare, may affect the design and layout.

We would suggest at this stage that a noise impact assessment is submitted by the applicants which would consider all the issues mentioned above. We would recommend that the scheme is designed to meet noise criteria whereby the noise emanating from the premises shall not exceed the existing background noise levels by 5 dBA at the nearest noise sensitive use.

In addition details of all noise control measures shall be submitted to and approved by the planning authority and shall be in place prior to the development being brought into use.

1.03 This noise assessment has been prepared to identify the layout (internal and external), construction materials, screening measures and management controls required to ensure that the proposed animal sanctuary (including 16 no. dog kennels, up to 20 no. dogs) should not lead to any unacceptable loss of noise amenity at the nearest residential dwellings.
2.00 PROPOSED DEVELOPMENT AND SITE SETTING

2.01 The proposed development is to include 16 no. dog kennels (up to 20 no. dogs) in a ‘U’ shaped building. The sleeping area to each kennel is to be located within the building, whilst the exercise area to each kennel is to be located partly under the roof structure and partly outside.

2.02 The proposed kennel building is ‘U’ shaped. The (significantly) longest ‘wing’ of the building runs north west to south east with (significantly) shorter returns at the end(s). The open aspect of the ‘U’ shape is therefore facing north east.

2.03 For reference, the nearest residential dwellings are Glen Cottage and Rose Cottage, which are located circa 240 metres to the south west of the proposed kennel building (i.e. upwind of the proposed kennel building under prevailing westerly / south westerly wind conditions). The nearest residential dwellings to the north east (i.e. downwind) are circa 1,500 metres away.

2.04 In accordance with best practice for the control of noise from kennels, the following noise mitigation and control measures are recommended:

- Full height block work separating walls between: indoor kennel areas; indoor and outdoor kennel areas; and (up to height of at least 1.5 metres above ground level but preferentially full height) outdoor kennel (exercise) areas
- Solid door with vision panel or glazed doors between circulation corridor and indoor kennel areas
- Insulated sliding doors with draft seals between indoor and outdoor kennel areas
- ‘End’ gates to each kennel outdoor exercise area in galvanised steel (mesh)
- Roof structure to kennel building to be confirmed but assumed to be mono pitch roof consisting of 18 mm exterior grade plywood (mass per unit area ≥10 kg/m$^2$) with bituminous water proof felt over supported by roof joists / trusses with insulation between joists and a plasterboard or plywood ceiling (note; roof line assumed to slope downwards from west to east)
- All glazing including roof lights to be double glazed
- For the purpose of the barrier calculation, the roof level to the (inside of the ‘U’ shaped kennel building i.e. facing east) is assumed to be at least 2.4 metres above ground floor level (note: no concerns over a sloping roof structure such that the roof is higher to the west (residential) than the east (open fields))
- Visiting times restricted to set and limited periods during the day (to be determined/agreed)
- Access to outdoor exercise areas to be prohibited between 2000 and 0800 hours (to be determined/agreed)

3.00 NOISE ASSESSMENT CRITERIA

3.01 There is no specific national guidance or recommended noise level standards relating to kennels. In the absence of such guidance, reliance must be placed upon proven methods of measurement and assessment published elsewhere. A glossary of acoustic terms is contained in Appendix 1 for reference.

BS 4142

3.02 In general a noise is liable to provoke complaints whenever it exceeds the background noise level by a certain margin or when it attains a certain absolute level. Noise levels at or below the existing background level are unlikely to give rise to complaints. This fundamental acoustic principle underpins the guidance contained in British Standard 4142 ‘Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas’ (1997).
3.03 BS 4142 describes methods for determining, at the outside of a building, noise levels from factories or industrial premises and a method for assessing whether the noise is likely to give rise to complaints from people residing in the building. BS 4142 is typically used for the introduction of new industrial sources into an existing noise environment, or, to assess whether existing industrial use is impacting on existing residential or other noise-sensitive development.

3.04 BS 4142 considers that the likelihood of complaints is dependent on the difference between the rating level and background noise level; the greater this difference the greater the likelihood of complaints. Further, it suggests that a difference of around +10 dB or more indicates that complaints are likely, a difference of around +5 dB is of marginal significance and if the rating level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.

3.05 The rating level is described as the specific noise level (the equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference period) plus any adjustment for the characteristic features of the noise. If the noise contains a distinguishable, discrete, continuous note, or if there are distinct impulses in the noise, or if the noise is irregular enough in character to attract attention, then a 5 dB penalty should be added to the specific noise level. Only a single 5 dB correction is made even if more than one of the above characteristics is present.

3.06 The background noise level is the A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 percent of a given time interval, T, measured using time weighting ‘F’ and quoted to the nearest whole number of decibels. The reference time interval for a BS 4142 assessment is one hour during the daytime (7:00 am to 11:00 pm) and five minutes during the night time (11:00 pm to 07:00 am).

World Health Organisation Guidelines for Community Noise

3.07 As an additional assessment tool, consideration has been given to World Health Organisation (WHO) Guidelines for Community Noise (1996, revised 2000), which gives absolute internal guideline levels as opposed to the relative assessment methodology used in BS 4142.

3.08 The WHO guidelines state: “During the daytime, few people are seriously annoyed by activities with \(L_{Aeq}\) levels below 55 dB; or moderately annoyed with \(L_{Aeq}\) levels below 50 dB. Sound pressure levels during the evening and night should be 5–10 dB lower than during the day. Noise with low frequency components require even lower levels. It is emphasized that for intermittent noise it is necessary to take into account the maximum sound pressure level as well as the number of noise events.”

3.09 The WHO guidelines consider that to avoid sleep disturbance, indoor guideline values for bedrooms are 30 dB \(L_{Aeq}\) (23:00–07:00) for continuous noise and 45 dB \(L_{AFmax}\) (23:00–07:00) for single sound events. At night, sound pressure levels at the outside façades of dwellings should not exceed 45 dB \(L_{Aeq}\) and 60 dB \(L_{AFmax}\) so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 decibels.

3.10 The WHO guidance on the relationship between maximum noise levels and sleep disturbance is reiterated within British Standard 8233 ‘Sound Insulation and Noise Reduction for Buildings – Code of Practice’ (1999). For a reasonable standard in bedrooms at night, BS 8233 states: “individual noise events should not normally exceed 45 dB \(L_{AFmax}\)”.

South Holland District Council Guidance

3.11 Given that BS 4142 and the WHO Guidelines have not been specifically designed to assess noise from dog kennels, South Holland District Council in Lincolnshire carried out detailed research on this topic during the late 1990s. This research culminated in the publication of Supplementary Planning Guidance entitled ‘Location of Premises for the Boarding and Breeding of Dogs and Other Animals – Noise Issues’ in December 1999.
3.12 This guidance states “the objective shall be that the specific noise level does not exceed the background noise level”. It should be noted that unlike BS 4142, the kennel guidance does not advocate an acoustic correction penalty of +5 dB. The information contained within the kennel guidance is primarily used to evaluate the noise emitted from open air runs. Under the development proposals, the open air runs are screened from the nearest residential dwellings by the kennel building itself and, as a consequence, allowance should be made for screening by the building.

3.13 The South Holland District Council guidance is considered equally applicable with regards to potential noise breakout from the proposed dog kennels during the night time period.

**Guidance on the Control of Noise from Clay Target Shooting**

3.14 The sudden nature, duration and the character of barking dogs has an aural similarity with the noise from gunshots at a distance. The Chartered Institute of Environmental Health published in January 2003 ‘Guidance on the Control of Noise from Clay Target Shooting’. This guidance is largely based on measurement and social survey work completed by Building Research Establishment (BRE) during 1997 and papers presented at the Institute of Acoustics conference during that year provides a basis for guidance on acceptable noise limits to be applied in the vicinity of residential premises. The guidance measures noise from clay target shooting using the Shooting Noise Level (SNL) index (the logarithmic average of the loudest 25 shots measured as dB L\text{A\text{fMax}} in a 30 minute period).

3.15 The BRE research suggests that there is no fixed shooting noise level at which annoyance starts to occur. Annoyance is less likely to occur at a SNL below 55 dB(A) and highly likely to occur at a SNL above 65 dB(A). The likelihood of annoyance at levels within this range will depend upon local circumstances.

3.16 The research work by BRE found that there was a need for further study of the effect of background noise on annoyance due to shooting. BRE found no effect from background noise in their data but most of the measurements were made in situations where the shooting noise levels were well in excess of background. Closer examination of sites with relatively higher background levels is necessary before the role of background noise in relation to annoyance can be better understood.

3.17 To quote directly from the research conclusions: “For a given exposure level, community annoyance was found to vary significantly between shoots, but no particular shoot characteristics or socio-demographic variables were seen to be associated with the degree of annoyance. There is some suggestion in the data that different sensitivities exist in different communities and that this affects annoyance, but the causes of differing sensitivities are not clear. At shooting noise levels below the mid 50’s dB(A) there is little evidence of significant levels of annoyance at any site, whereas for levels in the mid to high 60’s, significant annoyance is engendered in a majority of sites. For levels in between however, the extent of the annoyance varies considerably from site to site. Thus a level of, say, 60 dB(A) may be deemed acceptable at one site, but not at another.”

3.18 Furthermore, Appendix 5 of the ‘Guidance on the Control of Noise from Clay Target Shooting’ states that “Planning permission should not normally be granted for a major shoot if the mean SNL exceeds 55 dB where the background level is less than 45 dB. … A major shoot may be taken as operating on more than one day a week.”

3.19 It should be stressed that noise ‘annoyance’ is not the same as noise ‘nuisance’ and that the assessment of whether the noise experienced at noise sensitive properties is a nuisance will be a judgment based on a number of factors. However, the level of noise experienced will usually be an important factor in any assessment of noise nuisance.
4.00 NOISE IMPACT PREDICTION METHODOLOGY

4.01 The predicted noise level at the nearest noise sensitive receptor will be dependent on:

- The noise level associated with dogs barking;
- The number of dogs;
- The sound insulation properties of the dog kennels;
- The attenuation provided by any buildings and boundary screening; and
- The distance to the dog kennels.

4.02 The noise impact of the proposed dog kennels on the nearest noise sensitive receptor is dependent upon:

- The predicted noise level associated with the dog kennels; and
- The background noise level.

4.03 For assessment purposes, the baseline source data used in the guidance published by South Holland District Council is given as one medium size dog in the open air barking for a cumulative period of 10 minutes in any hourly period at a distance of 10 metres away. The baseline noise level from this event is stated as 65.6 dB $L_{Aeq, 1 \ hour}$; no guidance is provided on the associated maximum noise levels.

4.04 Frequency analysis of a dog barking is provided however, which illustrates that the sound energy is concentrated in the mid to high frequency range from 500 to 2,000 Hertz. This is particularly relevant to the attenuation afforded by any barrier structures (fences, buildings, changes in topography (based on the topographical survey), etc) as the effectiveness of such structures increases with the frequency.

4.05 In order to assess the basic accuracy of the noise level data published by South Holland District Council, ENS undertook noise measurements associated with two very noisy dogs barking at a distance of 5 metres from the microphone. These measurements were considered representative of an open situation and the noise level was 84 dB $L_{Aeq}$ (1 minute) and typically 96 dB $L_{AFMax}$.

4.06 Applying corrections to this measured level for:

- A single dog rather than two dogs (correction $=10 \log (1/2) = 3$ dB), not required for consideration of maximum noise levels.
- A distance of 10 metres rather than 5 metres ($=20 \log (5/10) = 6$ dB); and
- An on-time of 10 minutes in an hour ($=10 \log (10/60) = 8$ dB), note: not required for consideration of maximum noise levels.

4.07 The predicted noise level for one very noise dog in the open air barking for a cumulative period of 10 minutes in any hourly period at a distance of 10 metres away is 67 dB $L_{Aeq, 1 \ hour}$ (and due to corrections for distance alone, a ‘peak’ noise level of 90 dB $L_{AFMax}$). This correlates closely with the baseline noise level of 65.6 dB $L_{Aeq, 1 \ hour}$ at a distance of 10 metres as quoted in the guidance provided by South Holland District Council (which is based on more extensive research).

4.08 For the purpose of this assessment, the baseline noise level associated with a dog in the open air barking for a cumulative period of 10 minutes in any hourly period at a distance of 10 metres away is taken as 66 dB $L_{Aeq, 1 \ hour}$ and 90 dB $L_{AFMax}$. 
5.00  NOISE IMPACT ASSESSMENT

5.01 There are two scenarios which require consideration:

- Noise associated with the outdoor areas during the daytime; and
- Noise associated with the main kennel building during the night time.

**Noise Associated With The Outdoor Areas During Daytime**

5.02 During the daytime, it is considered that the potential noise impact associated with the proposed dog kennels is associated with the intermittent barking of dogs within the outdoor areas.

5.03 For the purpose of the assessment, although access may be more restricted, it has been assumed that kennelled dogs may access the outdoor exercise areas between 0800 and 2000 hours. The maximum occupancy of the proposed kennels is 20 no. dogs (in 16 no. kennels). It is assumed that the proposed layout will allow for 12 no. kennels (16 no. dogs) on the east elevation and 2 no. kennels (2 no. dogs) on each of the north and south elevations.

5.04 On the basis of the supplementary planning guidance published by South Holland District Council, for the purpose of the noise impact assessment, the number of dogs barking at the site at any time is 0.6 x the total number of dogs. The corresponding base noise level for 0.6 x (up to) 20 dogs at 10 metres is therefore calculated at 76.4 dB L_{Aeq,1 hour} (termed SPL). This is considered a robust estimate since no allowance has been made for the significant benefits associated with the solid masonry dividing walls between kennels, which should significantly reduce interaction between kennelled dogs (and hence the propensity to bark).

5.05 In order to predict the noise level at the nearest noise sensitive receptor, adjustments are made for distance attenuation and the screening effects of barriers (primarily the kennel building itself). The distance between the outdoor areas and the residential properties to the west is approximately 240 metres, hence distance correction is 28 decibels (20 * log (240/10)).

5.06 The kennel building itself will provide significant screening between the kennel outdoor areas and the residential properties to the south west. British Standard 5228:2009 'Code of Practice for Noise and Vibration Control on Construction and Open Sites' (BS 5228) advises that if there is a barrier or other topographic feature between the source (in this case dog(s) in outdoor exercise area(s) during the daytime) and receiving position (in this case residential properties 240 metres to the south west) the approximate attenuation will be: 5 decibels when the top of the noise source is just visible to the receiver over the noise barrier; at least 10 decibels when the noise screen completely hides the sources from the receiver; and high topographical features and/or specifically designed and positioned noise barriers could provide greater attenuation.

5.07 On the basis of the screening effects of barriers (solid masonry walls / timber roof structure), under similar circumstances in terms of the noise source being located close to the ground and the barrier being located in close proximity to the noise source, and also the noise source being mid to high frequency (barriers are particularly effective at mid to high frequency), it is considered that at least a 15 decibel correction for screening effects is wholly reasonable.

5.08 Based on the topographical survey (reproduced in Appendix 2 for reference), a Maekawa barrier calculation has been undertaken based on the following input parameters:

- Horizontal separation distance source to barrier = 3.0 metres (dog to external wall)
- Vertical separation distance source to barrier = 1.9 metres (dog to roof line)
- Horizontal separation distance receptor to barrier = 240.0 metres (house to roof line)
- Vertical separation distance receptor to barrier = 6.2 metres (1st floor window to roof line)
- Horizontal separation distance source to receptor = 243.0 metres (dog to house)
- Vertical separation distance source to receptor = 8.1 metres (dog to 1st floor window)
- Spectrum characteristics from barking dogs measured by ENS

5.09 The Maekawa barrier calculation (reproduced in Appendix 3 for reference) illustrates that the attenuation due the kennel building is of the order of 19 decibels.
5.10 The resultant noise level at the nearest noise sensitive property (SPL₂) is therefore calculated from the equation:

\[
SPL₂ = SPL₁ - \text{Distance Attenuation} - \text{Barrier Attenuation}
\]

\[
SPL₂ = 76 - 28 - 19 = 29 \text{ dB } L_{\text{Aeq}, 1 \text{ hour}}
\]

\[
SPL₂ = 90 - 28 - 19 = 43 \text{ dB } L_{\text{AFMax}}
\]

5.11 It is considered that the predicted noise levels represent a robust worst case scenario as no allowance has been made for: a) the solid masonry walls between kennels and outdoor runs (up to a minimum height of 1.5 metres but preferably full height) which will significantly reduce the visual stimulation and thus propensity of dogs to bark; or b) the nearest residential dwellings being upwind of the proposed dog kennels.

5.12 Considering the rural setting, based on experience from other sites, the background noise level at the nearest residential properties is assumed to be in the range 30 to 35 dB L₉₀₀–₂₀₀₀ during the daytime (when dogs have access to their outdoor runs).

5.13 The predicted noise level (robustly) associated with the proposed kennels is less than the assumed background noise level and is also relatively low. On this basis it is considered that no unacceptable loss of amenity will occur.

5.14 In terms of peak noise levels, the noise level associated with dogs barking in the outdoor areas (with the provision of solid masonry walls between areas) is (robustly) predicted to be no greater than 43 dB L_{\text{AFMax}} at the nearest residential properties to the south west.

5.15 With respect to the CIEH ‘Guidance on the Control of Noise from Clay Target Shooting’, the ‘peak’ noise level is significantly below the 55 dB(A) threshold at which ‘annoyance is less likely to occur’. It should be noted that clay target shooting generally takes place within rural areas where the background noise level would be commensurate with that at the application site. On this basis, it is considered that the ‘peak’ noise levels associated with dogs barking (during 0800 to 2000 hours) should not cause any unacceptable degree of disturbance to the residential properties to the south west (subject to the management controls outlined in the following sections of this assessment).

**Noise Associated with the Main Kennel Building During the Night Time**

5.16 In terms of the night time period, it is understood that access to all outdoor areas will not be permitted between 20:00 and 08:00 hours and therefore at night all kennelled dogs will be contained within an insulated building of traditional construction. Since kennels normally show a clear diurnal pattern (with high levels at peak times during the working day and relatively low levels overnight), the potential for a significant adverse noise impact is considered to be relatively low.

5.17 Notwithstanding this, as a worst case scenario, it is assumed that the kennelled dogs may bark during the night time period. Based on experience, the (short term) noise level associated with a significant number of dogs barking within a kennel building has been taken as 100 dB L_{\text{Aeq}, 5 \text{ min}} and 105 dB L_{\text{AFMax}}. The primary route for noise break out would be via the double glazed windows / roof lights (weighted sound reduction index taken as 30 dB R_r). For the assessment, it has been assumed that each kennel has a 1m² roof light (i.e. 16 m² roof lights in total).

5.18 The noise level at the residential properties to the south west is calculated by the following equation (assuming intervening soft ground):

\[
SPL₂ = SPL₁ - R + 10 \log S_p - 25 \log r + 2 - 14
\]

\[
SPL₁ = 100 \text{ dB } L_{\text{Aeq}, 5 \text{ min}} \text{ or } 105 \text{ dB } L_{\text{AFMax}}
\]

\[
R = \text{sound reduction index of roof lights} = 30 \text{ dB}
\]

\[
S_p = \text{surface area of roof lights} = 16 \text{ m}²
\]

\[
R = \text{separation distance} = 240 \text{ metres}
\]
5.19 The above equation is more commonly referred to as “Woods Formulae” (modified for soft ground attenuation) and is used to calculate the resultant noise level at a distance $r$ from a building façade when the internal noise level and the area and sound reduction index of the weakest element of the façade are known.

5.20 Processing the above equation, the resultant noise level outside the residential properties to the south west of the application site associated with dogs barking within the kennel building at night has been calculated at 11 dB $L_{Aeq}$ (5 min) and 16 dB $L_{AFMax}$. Such levels should not cause any unacceptable loss of amenity.

5.21 There is no justification for the (proposed) earth bund if double glazed windows / roof lights are provided.

6.00 MANAGEMENT CONTROLS

6.01 Access to all outdoor kennel areas will not be permitted between 20:00 and 08:00 hours.

6.02 The hours of operation (in terms of arrivals / departures) should be limited to 08:00 to 18:00 hours, Monday to Sunday. This will reduce the propensity of dogs barking during the evening and night time periods.

I trust the foregoing is to your satisfaction. If you have any queries please do not hesitate to contact me.

Yours sincerely

Jonathan Rigg
For Environmental Noise Solutions Ltd

cc File
APPENDIX 1
GLOSSARY OF ACOUSTIC TERMS

Sound Pressure Level ($L_p$)
The basic unit of sound measurement is the sound pressure level. As the pressures to which the human ear responds can range from 20 µPa to 200 Pa, a linear measurement of sound levels would involve many orders of magnitude. Consequently, the pressures are converted to a logarithmic scale and expressed in decibels (dB) as follows:

$$L_p = 20 \log_{10}(p/p_0)$$

Where $L_p$ = sound pressure level in dB; $p$ = rms sound pressure in Pa; and $p_0$ = reference sound pressure (20 µPa).

A-weighting Network
A frequency filtering system in a sound level meter, which approximates under defined conditions the frequency response of the human ear. The A-weighted sound pressure level, expressed in dB(A), has been shown to correlate well with subjective response to noise.

Equivalent continuous A-weighted sound pressure level, $L_{Aeq, T}$
The value of the A-weighted sound pressure level in decibels of continuous steady sound that within a specified time interval, $T$, has the same mean-square sound pressure as a sound that varies with time. $L_{Aeq, 16h}$ (07:00 to 23:00 hours) and $L_{Aeq, 8h}$ (23:00 to 07:00 hours) are used to qualify daytime and night time noise levels.

$L_{A10, T}$
The A-weighted sound pressure level in decibels exceeded for 10% of the measurement period, $T$. $L_{A10, 18h}$ is the arithmetic mean of the 18 hourly values from 06:00 to 24:00 hours.

$L_{A90, T}$
The A-weighted sound pressure level of the residual noise in decibels exceeded 90% of a given time interval, $T$. $L_{A90}$ is typically taken as representative of background noise.

$L_{A,F, max}$
The maximum A-weighted noise level recorded during the measurement period. The subscript ‘F’ denotes fast time weighting, slow time weighting ‘S’ is also used.

Sound Exposure Level (SEL or $L_{AE}$)
The energy produced by a discrete noise event averaged over one second, no matter how long the event actually took. This allows for comparison between different noise events which occur over different lengths of time.

Weighted Sound Reduction Index ($R_w$)
Single number quantity which characterises the airborne sound insulation properties of a material or building element over a defined range of frequencies ($R_w$ is used to characterise the insulation of a material or product that has been measured in a laboratory).
## Calculation of Approximate Attenuation of a Thin Rigid Barrier

<table>
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<th>Octave band centre frequencies (Hz)</th>
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<th>125</th>
<th>250</th>
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<th>2000</th>
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</table>

**Broadband level at receptor (dB L_Aeq)** 65.7 18.8 Barrier Attenuation

* A formula based on work by Maekawa can be used to give the approximate attenuation produced by a thin rigid barrier between the source of sound and the receiver. Attenuation, $E_b = 10 \log_{10} (3 + 40.\delta/\lambda)$ dB

where: $\lambda$ = wavelength of the sound and $\delta$ = path difference of the sound travelling over the barrier and directly.

### Inputs

<table>
<thead>
<tr>
<th></th>
<th>Horizontal</th>
<th>Vertical</th>
<th>Slant</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>3.00</td>
<td>1.90</td>
<td>3.55</td>
</tr>
<tr>
<td>b</td>
<td>240.00</td>
<td>6.20</td>
<td>240.08</td>
</tr>
<tr>
<td>c</td>
<td>243.00</td>
<td>8.10</td>
<td>243.13</td>
</tr>
</tbody>
</table>

0.50