ADC ACOUSTICS
PO Box 1030, Warrington, Cheshire WA4 9FJ
t. 01925 723333 www.adcacoustics.co.uk

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The Welsh Government

Assessment of noise impact of proposed commercial development at Plot 3, Parc Bryn Cegin, Bangor, LL57 4 BG

Prepared for :-

The Welsh Government
c/o SP Projects
Unit 7B
Wilkinson Business Park
Wrexham
LL13 9AE

Prepared by :-

Andrew Raymond

CONTENTS

1.0 SUMMARY

The general noise climate was dominated throughout by traffic on the A5 and A55. There was also some low level noise occasionally audible from a nearby building site.

Overall modelled levels are based on fairly extreme worst cases. A very busy simulated 1-hour period is assumed to persist throughout the entire day. Predicted levels give a BS 4142 *"initial estimate"* of *"low Impact depending on the context"*. The context is a busy area dominated by the traffic, which is the main noise likely to be generated by the site. The Impact is expected to be negligible.

-------------------------------------- A R Raymond

-------------------------------------- P J Durell

2.0 INTRODUCTION

ADC was instructed to carry out an independent assessment of the above site with regards to its suitability from a noise perspective for the development of commercial units.

This report begins by summarising assessment standards and, where appropriate, discusses alternative interpretations.

After a brief statement of survey details we discuss basic results and the resulting assessment. The impact is discussed along with any recommendations for mitigation.

3.0 ASSESSMENT STANDARDS

3.1 Technical Advice Note (Wales), Noise

This document provides general advice on how to minimise the impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. It is intended for assessing proposed new residential development but can also be useful for understanding general noise levels.

Development Control

The following extracts are from TAN 11:-

Development Control

Noise generating development

8. Local planning authorities must ensure that noise generating development does not cause an unacceptable degree of disturbance. They should also bear in mind that if subsequent intensification or change of use results in greater intrusion, consideration should be given to the use of appropriate conditions.

9. Noise characteristics and levels can vary substantially according to their source and the type of activity involved. In the case of industrial development, for example, the character of the noise should be taken into account as well as its level. Sudden impulses, irregular noise or noise which contains a distinguishable continuous tone will require special consideration. In addition to noise from aircraft landing and taking off, noise from aerodromes is likely to result from engine testing as well as ground movements. The impact of noise from sport, recreation and entertainment will depend to a large extent on frequency of use and the design of facilities. Advice on assessing noise and on factors to consider in relation to the major noise sources including roads, railways, airports, industrial and recreational noise and their measurement is given in Annex B.

Noise-sensitive development

10. Local planning authorities should consider whether proposals for new noise-sensitive development would be incompatible with existing activities, taking into account the likely level of noise exposure at the time of the application and any increase that may reasonably be expected in the foreseeable future. Such development should not normally be permitted in areas which are, or are expected to become, subject to unacceptably high levels of noise and should not normally be permitted where high levels of noise will continue throughout the night.

For Residential Development, TAN 11 sets out Noise Exposure Categories (NECs) in Annex A as follows:-

TABLE 1: NOISE EXPOSURE CATEGORIES	
A	Noise need not be considered as a determining factor in granting planning permission, although the noise level at the high end of the category should not be regarded as desirable.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example, because there are no alternative quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

Table 2: RECOMMENDED NOISE EXPOSURE CATEGORIES FOR NEW DWELLINGS NEAR EXISTING NOISE SOURCES

Noise Levels[1] corresponding to the Noise Exposure Categories for New Dwellings $L_{Aeq,T}$dB

Noise Source		Noise Exposure Category			
		A	B	C	D
road traffic	0700-2300	<55	55-63	63-72	>72
	2300-0700[2]	<45	45-57	57-66	>66
rail traffic	0700-2300	<55	55-66	66-74	>74
	2300-0700[2]	<45	45-59	59-66	>66
air traffic[3]	0700-2300	<57	57-66	66-72	>72
	2300-0700[2]	<48	48-57	57-66	>66
mixed sources[4]	0700-2300	<55	55-63	63-72	>72
	2300-0700[2]	<45	45-57	57-66	>66

Notes
[1] ***Noise levels:*** *the noise level(s) ($L_{Aeq,T}$) used when deciding the NEC of a site should be representatives of typical conditions.*
[2] ***Night-time noise levels (2300-0700):*** *sites where individual noise events regularly exceed 82dBL_{Amax} (S time weighting) several times in any hour should be treated as being in NEC C, regardless of the $L_{Aeq,8H}$ (except where the $L_{Aeq,8H}$ already puts the site in NEC D).*
[3] ***Aircraft noise:*** *daytime values accord with the contour values adopted by the Department of Transport which relate to levels measured 1.2m above open ground. For the same amount of noise energy, contour values can be up to 2 dB(A) higher than those of other sources because of ground reflection effects.*
[4] ***Mixed sources:*** *this refers to any combination of road, rail, air and industrial noise sources. The "mixed source" values are based on the lowest numerical values of the single source limits in the table. The "mixed source" NECs should only be used where no individual noise source is dominant.*
To check if any individual noise source is dominant (for the purposes of this assessment) the noise level from the individual sources should be determined and then combined by decibel addition (remembering first to subtract 2 dB(A) from any aircraft noise contour values). If the level of any one source then lies within 2 dB(A) of the calculated combined value, that source should be taken as the dominant one and the site assessed against the appropriate NEC for that source, rather than using the "mixed source" NECs. If the dominant source is industrial noise see paragraph B17 of Annex B.
If the contribution of the individual noise sources to the overall noise level cannot be determined by measurement and/or calculation, then the overall measured level should be used and the site assessed against the NECs for "mixed sources".

3.2 BS8233 and WHO

BS 8233 is primarily intended for new buildings, but the criteria are routinely referred to for putting general noise climates into context.

The criteria in Table 4 of BS 8233 are based on WHO guidance and give the desirable criteria for indoor ambient noise levels for dwellings as follows:-

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,8hour}$	30 dB $L_{Aeq,8hour}$

Note that the standard accepts the widely used rule of thumb that, for a partly open window, the levels just outside will be 15dB higher than those just inside. This brings us to an external equivalent of the above table, as follows:-

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	50 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	55 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	50 dB $L_{Aeq,8hour}$	45 dB $L_{Aeq,8hour}$

It goes on to state that, where necessary, the criteria can be relaxed by up to 5 dB and still achieve reasonable conditions.

Note that the new version does not explicitly state criteria for bedroom noise in terms of dB L_{Amax} but the WHO Guidelines for Community Noise (or similar) are widely used with a recommendation that the noise inside bedrooms should not typically exceed 45 dB L_{Amax}, for instance no more than 10 to 15 times a night.

Garden area criteria are unchanged with 50 dB L_{Aeq} and 55 dB L_{Aeq} being considered desirable and reasonable respectively.

Note that the new version of BS8233 more explicitly specifies the assessment periods as 16 hour and 8 hour for daytime and night time respectively.

3.3 BS 4142

BS 4142 was updated in November 2014. The standard is very complicated but, basically, it describes methods for rating and assessing sound of an industrial and/or commercial nature, which includes:

a) sound from industrial and manufacturing processes

b) sound from fixed installations which comprise mechanical and electrical plant and equipment

c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises

d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site.

The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

Characteristics and Context

Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, we need to add a character correction to the specific sound level to obtain the rating level.

These features can include tonality, impulsivity and intermittency with corrections typically ranging potentially from 0dB to 9 dB. Corrections at the higher end would represent characteristics which are highly perceptible in the context of the ambient noise as a whole. Corrections at the lower end would represent characteristics which are just perceptible in the presence of the ambient noise as a whole,

The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context.

Assessment

We obtain an *initial estimate* of the impact of the specific sound by subtracting the measured background sound level from the rating level and considering the following.

a) Typically, the greater this difference, the greater the magnitude of the impact.

b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.

d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

Where the initial estimate of the impact needs to be modified due to the context, pertinent factors need to be taken into consideration, including the following.

1) The absolute level of sound.

   For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.

Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.

Where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts, and the margin by which the rating level exceeds the background might simply be an indication of the extent to which the specific sound source is likely to make those impacts worse.

2) The character and level of the residual sound compared to the character and level of the specific sound.

   We need to consider whether it would be beneficial to compare the frequency spectrum and temporal variation of the specific sound with that of the ambient or residual sound, to assess the degree to which the specific sound source is likely to be distinguishable and will represent an incongruous sound by comparison to the acoustic environment that would occur in the absence of the specific sound. Any sound parameters, sampling periods and averaging time periods used to undertake character comparisons should reflect the way in which sound of an industrial and/or commercial nature is likely to be perceived and how people react to it.

3) The sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions.

3.4 <u>Local Authority</u>

We are not aware of any criteria proposed by the local Authority.

4.0 GUIDE TO CALCULATIONS AND MODELLING

We have used the well-established CadnaA modelling software which calculates noise propagation based on the processes of *ISO 9613 : Acoustics – Attenuation of sound during propagation outdoors*. Obviously, modelling software is reliant on the inputs and assumptions. The key ones are:-

1. The ground is a mixture of soft and reflective (an absorption coefficient of 0.5 assumed).

2. Calculations are based on two orders of reflections.

3. The proposed site buildings and the surrounding buildings are assumed to be mainly reflective (0.5 dB loss on reflection assumed).

4. The surrounding trees and vegetation will provide a small degree of absorption but this has been neglected.

5. Where acoustic fences are used, they are also assumed to be reflective the same as the buildings, unless specified otherwise.

6. There are three main components to the modelling – vehicle movements, internal noise breakout, and mechanical equipment.

7. For each of these source groups, the continuous source levels are corrected for their durations in a busy 1 hour period. More detail is given below.

Appendix 2 shows the full calculations for the assessment and the figures which are input to the model.

4.1 Visitor Numbers

We have assumed that each and every car parking space for each unit is filled and emptied in a single 1 hour period, and that this continues every hour for the entire day. The vehicles using the parking spaces are mainly cars but, for each unit, two of them are assumed to be LGVs (medium vans).

We have also assumed that the turning areas for each unit, are each visited by one OGV every hour. We have assumed that this will be an equal mix of OGV1s (large rigid lorries) and OGV2s (large articulated HGVs). This is assumed to persist every hour through the entire day.

4.2 Vehicle Movements

Vehicle movements are based on a series of 20 to 25m segments which include a vehicle pulling forwards from a standstill, accelerating to 15 km/hr, and slowing to a stop. The source of the noise data was from our own database and includes an “average” of various cars, all measured at 10m from the drive-past centre over hard ground. Each segment takes about 12 seconds. The figures are almost identical to a steady 40 to 50 km/hr drive past and so cover the steady and stop/start scenarios. Within the model, the source data is entered as a Sound Power Level per meter and calibrated to give the exact measured level at 10m from a 25m long line source. The actual line source entered can then be any length with the same Sound Power per meter. We then enter adjustments for the duration of the source data and for the number of vehicles per hour. There are of course different values for vehicle numbers using the access roads, car parks and petrol pumps. In the case of the latter, the total number of vehicles for fuel is split evenly across all pumps.

Where applicable, LGVs (eg. Vans) are approximately 5 dB louder, OGV1s (eg. Rigid Lorries) 10 dB louder and OGV2s (eg. Articulated HGVs) are approximately 12 dB louder at these speeds.

The derivation of these corrections is shown in Appendix 2.

4.3 Loading/Unloading

This is entered as point sources near the loading bays. It is based on past measurements of typical activity. We have assumed that loading will take place at each bays for half an hour each throughout the day. Each OGV is also assumed to have reversing alarms for each visit.

4.4 Mechanical Equipment

We cannot know exactly what equipment will be installed and so, for illustrative purposes, we have used 2 x Mitsubishi PUHZ-RP250YKA units all on the roller shutter door sides of all of the units. Sound power levels from the manufacturer are entered and assumed to run on full load through the day.

4.5 Internal Noise Break-Out

To illustrate what is likely to be a fairly extreme worst case, we have assumed that the internal noise in the building is 80 dB L_{Aeq} and that it persists through the entire day. This level would represent the lower action value of the Control of Noise at Work Regulations, at which action to reduce exposure is likely to be required. We have assumed that the building is made from basic Kingspan-type cladding and that the roof lights are just single skin polycarbonate with very little sound insulation. These are entered as area sources. We have also assumed that the roller shutter doors are open through the day. These are entered as vertical area sources.

5.0 SURVEY DETAILS

5.1 Site Times and Personnel

The site surveys were carried out by Mark Pimlett of ADC Acoustics from shortly before 08:00 to shortly after 12:00. The times were chosen to include rush hour and what is likely to be a quieter time of day.

5.2 Instrumentation

Instrumentation used was a Rion NL-52. This is a Class I sound level meter which holds a current calibration certificate and which was field-calibrated as necessary. The meter was set up to measure continuous 5 minute samples of the noise climate.

All measurements have been gathered in terms of dB L_{eq}, dB L_{max} and dB L_{90} in overall A-weighted terms, and in octave bands across the frequency range. See Definition of Acoustic Terms in Appendix 1.

5.3 Measurement Positions

The main measurement position was as shown by the yellow star on the following plan.

The microphone was 1.3 m above ground and well away from other reflecting surfaces.

5.4 Survey Conditions

Weather conditions were as follows :-

Rain	:	none, dry roads
Cloud	:	0%
Temperature	:	14 Celsius
Wind	:	negligible

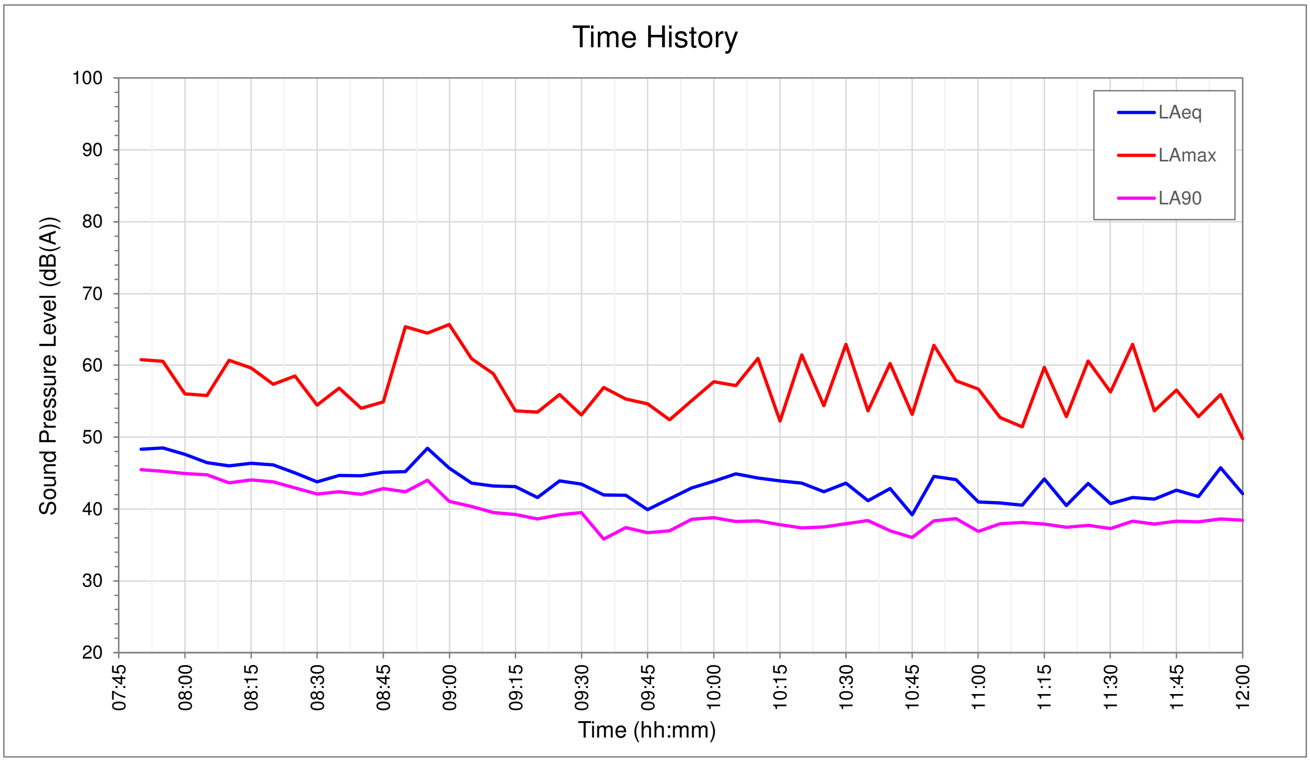
The general noise climate appeared to be normal and representative.

6.0 RESULTS AND DISCUSSIONS

6.1 Noise Survey Results

The general noise climate was dominated throughout by traffic on the A5 and A55. There was also some low level noise occasionally audible from a nearby building site.

Results of existing noise measurements are presented graphically as follows:-



A summary of the lowest 15 minute periods (lowest in terms of the dB L_{A90} index) is as follows:-

Time Period	*Index*	***dB(A)***
Lowest 15 Minutes	Leq	**41**
	Lmax	**56**
	L90	**37**

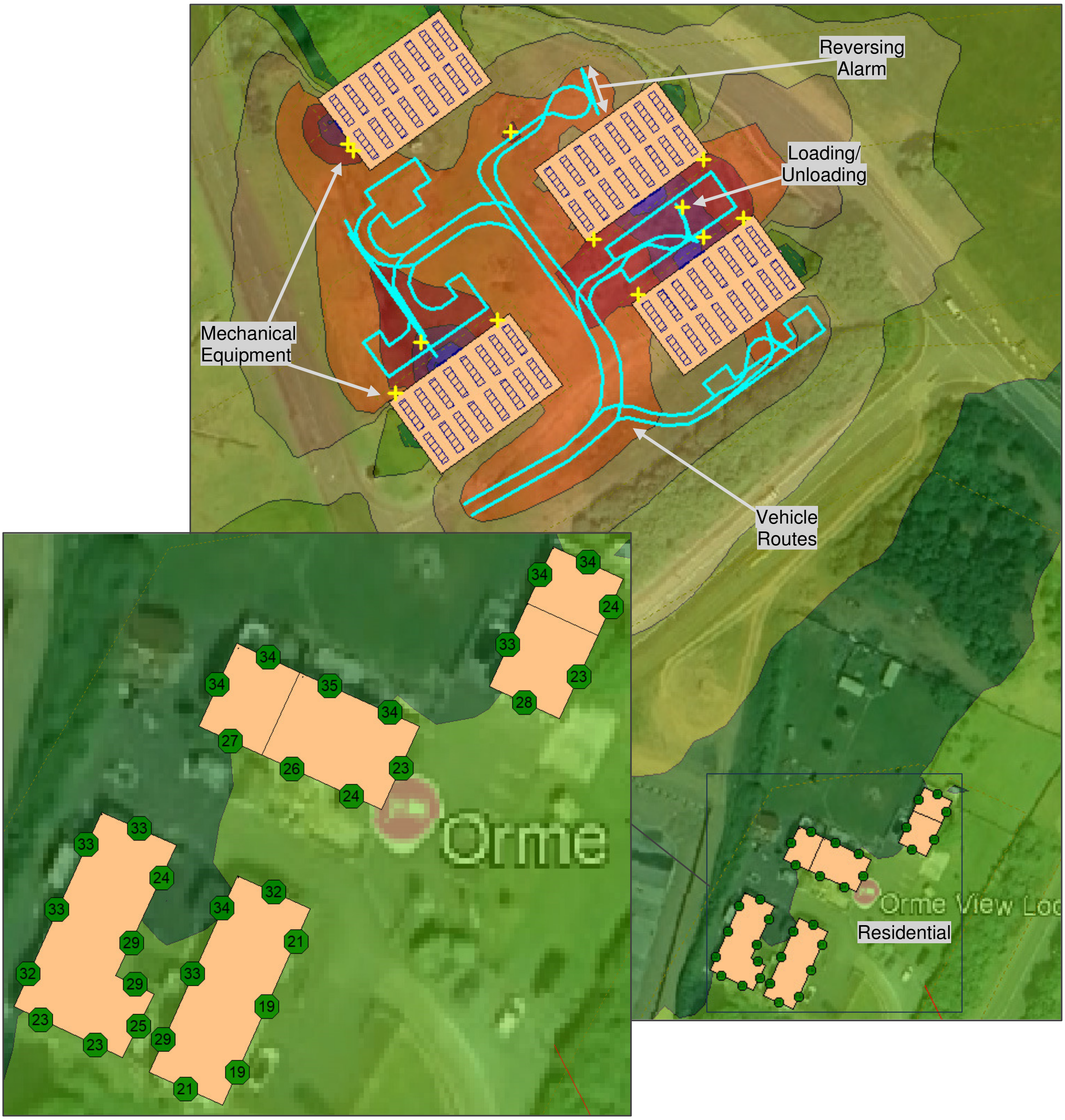
Very importantly, BS 4142 does not require the lowest measurements to be used as the representative Background Sound Level. However, we have used the lowest 15 minute periods here as a means of assuming a worst case, for instance to mitigate for variations on different days.

The highest 15 minute period is briefly referred to in 6.6below. A summary of the highest 15 minute periods (highest in terms of the dB L_{Aeq} index) is as follows:-

Time Period	*Index*	***dB(A)***
Highest 15 Minutes	Leq	**48**
	Lmax	**60**
	L90	**45**

6.2 Results of Modelling

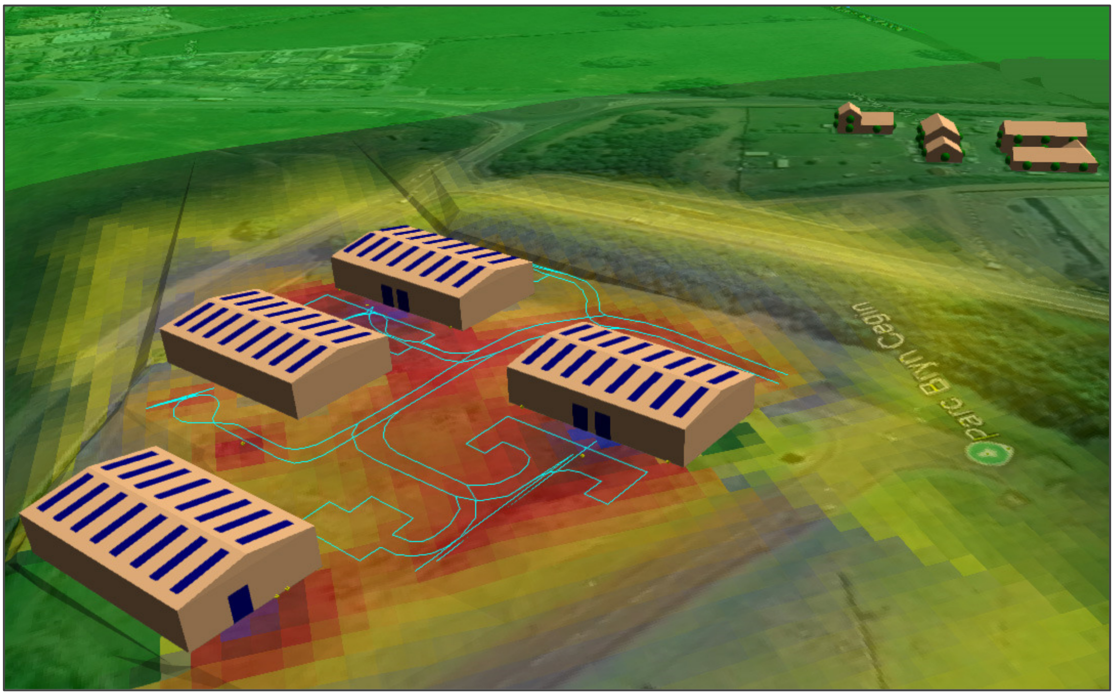
Full details of sources are given in Appendix 2 and methods and assumptions described in Section 4.0 above. The results of the modelling of the busiest 1-hour daytime period is as shown below.



Note that:-

- The beige shapes are surrounding buildings and the application site building in its proposed form.
- Vehicle routes, including reversing alarms, are the pale blue lines
- The yellow crosses are point sources (pumps, unloading, mechanical equipment, intercoms, idling, etc)
- The dark blue hatched areas are the area sources of the roof lights.
- The dark blue lines are the vertical area sources of the open roller shutter doors. They are difficult to see in plan view and can be seen better in the 3D view below.
- The coloured numbers are the noise levels at the residential facades. Note that the software is set up to present the noisiest floor level.
- Note that the noise contours are shown for guidance as to how the noise propagates. The contours are at a height of 4 m.

The following main 3D view should help to visualise the model.



As described in section 4 above, the figures represent the busy 1-hour period which is assumed to persist throughout the entire day. It should represent a significant worst case.

6.3 <u>Mitigation</u>

There is no mitigation built into the modelling and none is proposed.

6.4 <u>Overall Assessment</u>

The BS 4142 assessment is presented as follows:-

Specific Sound Level:	35 dB L_{Aeq}
Feature Corrections[1]	
tonality:	0 dB L_{Aeq}
impulsivity:	0 dB L_{Aeq}
intermittency:	0 dB L_{Aeq}
other:	0 dB L_{Aeq}
Rating Level:	35 dB L_{Ar}
Background Sound Level:	37 dB L_{A90}
Rating Level Excess re. Background	-2 dB

This is below what a BS 4142 *"initial estimate"* rates as *"low impact depending on the context".*

The context of course is one of a busy area already dominated by traffic noise. Vehicle movements represent by far the biggest component of the predicted noise and it is likely to be aurally indistinguishable from the

[1] The noise is clearly not impulsive or tonal. Vehicle movements will be intermittent at source but unlikely to be even audible at the houses, and certainly not distinguishable from the existing traffic noise. The Therefore, no character/feature corrections apply.

general traffic. We have used numerous worst case assumptions, and also set the predicted levels against the quietest 15 minute background level and the impact is likely to be negligible.

6.5 Discussion of Uncertainty

BS 4142 requires us to:

"Consider the level of uncertainty in the data and associated calculations. Where the level of uncertainty could affect the conclusion, take reasonably practicable steps to reduce the level of uncertainty".

The measurements of Background/Residual Sound were chose to include what was likely to be a quieter time of day, ie. outside of rush hour. We have no reason to believe that the conditions were anything other than representative of normal conditions. BS 4142 does not state what would be a representative background noise but there is certainly no suggestion that it should be lowest, and indeed it states, *"…the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods"*. However, in order to allow for the possibility of variation in levels, we have used the lowest 15 minute respective periods.

Source data taken for the vehicles, etc. can of course vary but is based on a lot of measurements and we would expect this uncertainty to be compensated for by the numerous worst case assumptions listed throughout the report.

6.6 Other Issues

We were asked to provide a brief assessment of the possibility of external noise affecting future occupants of the commercial units.

Section 6.1 shows the highest 15 minute ambient level as 48 dB L_{Aeq}. If we add in the levels predicted by the modelling, we have levels at the various office windows of around 55 to 60 dB L_{Aeq}. If windows were partly open, then we could expect internal levels of around 40 to 45 dB L_{Aeq} for a small, furnished, but unoccupied office.

Table 6 of BS 8233 provides some guidance:-

Table 6 Typical noise levels in non-domestic buildings

Activity	Location	Design range dB $L_{Aeq,T}$
Speech or telephone communications	Department store Cafeteria, canteen, kitchen	50 – 55
	Concourse Corridor, circulation space	45 – 55
Study and work requiring concentration	Library, gallery, museum	40 – 50
	Staff/meeting room, training room	35 – 45
	Executive office	35 – 40
Listening	Place of worship, counselling, meditation, relaxation	30 – 35

Note that these are typical ranges and not criteria as such. However, they are often used as guideline values, for instance in a BREEAM Assessment.

We can see that predicted levels exceed typical executive office values, but meet the staff/meeting room and training room range. We would suggest that most of the accommodation in the commercial unit are a closer fit to the latter.

With windows closed, the levels can be expected to be much lower and well within the range, even for an executive office.

7.0 CONCLUSIONS/RECOMMENDATIONS

Overall modelled levels are based on fairly extreme worst cases. A very busy simulated 1-hour period is assumed to persist throughout the entire day. Predicted levels give a BS 4142 *"initial estimate"* of *"low Impact depending on the context"*. The context is a busy area dominated by the traffic, which is the main noise likely to be generated by the site. The Impact is expected to be negligible.

As the exact details of mechanical equipment is not set, it may be necessary to submit details, although the impact is likely to be negligible whatever is proposed.

Our only recommendation is that you issue this report to planners and we invite Officers to contact us directly with any queries.

Appendix 1

Definition of Acoustic Terms

The Decibel

The decibel is the basic unit of noise measurement and is denoted dB. Technically, it is a means of expressing the difference in noise level between the measured noise and a standard level of noise. Most often the threshold of human hearing is used as the standard reference but is really should be stated. The threshold of human hearing is a sound pressure of 20µPa or a sound power of 1pW.

A sound pressure level or SPL should be expressed in dB(re. 20µPa). A sound power level or SWL should be expressed in dB(re. 1pW). If the reference levels are omitted, it will often (but not always) be safe to assume that they are referenced to the threshold of human hearing.

A-Weighting and dB(A)

The human hearing system responds differently to different frequencies. The A-weighting system takes account of this by emphasising mid and high frequencies more than low frequencies to give an overall level. An A-Weighted noise level, therefore, reflects the way normal, healthy hearing would perceive the overall level of the noise. The basic unit is dB(A), although other systems of expressing an A-weighted levels are discussed below.

Other weighting systems, such as C-Weighting, denoted dB(C), reflect the human hearing system's response at higher noise levels.

NR and NC Levels

NR curves and NC curves are a series of curves representing noise levels across the frequency range. A given noise climate has an NR level or NC level if it equals a point on the curve at any frequency. They are particularly, although by no means exclusively, used as a means of specifying noise limits in an indoor environment, for instance from mechanical services or traffic noise break-in from the outside. They are typically expressed as NR or NC followed by a number, e.g. NR40, NC55, etc.

Equivalent Continuous Sound Level, L_{eq}

This can be simplistically described as a way of expressing the average noise level.

The unit is dB L_{eq}. For A-weighted levels the unit is dB(A) L_{eq} or, in more modern units, dB L_{Aeq}.

Maximum Level, L_{max}

This is the maximum level reached (usually for a fraction of a second) in the measurement period.

The unit is dB L_{max}. For A-weighted levels the unit is dB(A) L_{max} or, in more modern units, dB L_{Amax}.

Statistical (Percentile) Levels, L_n

During a measurement of fluctuating noise, it is often useful to establish the levels exceed for a percentage of the time. L_n is the index representing the level exceeded for n% of the measurement period.

The unit is dB L_n. For A-weighted levels, the unit is dB(A) L_n or, in more modern units, dB L_{An}.

Common examples are as follows :-

dB L_{A90} is the A-weighted level exceeded for 90% of the time and is often used to describe the underlying background noise.

dB L_{A50} is the A-weighted level exceed for 50% of the time. Mathematically, it is the median, another kind of average.

dB L_{A10} is the A-weighted level exceeded for 10% of the time and has traditionally been used to describe the intermittent highs in the noise climate such as passing cars or aircraft.

Frequency Analysis

Here the audible frequency range is divided up into bands and the noise level is expressed in each frequency band from low pitches to high pitches.

Octave Band analysis is where the frequency range is divided into 8 bands from 63 Hz to 8kHz, or sometimes into 10 bands from 31.5 Hz to 16kHz.

1/3 Octave Band analysis provides more detailed subdivision into 24 bands from 50 Hz to 10kHz, or sometimes into 30 bands from 20Hz to 20kHz.

Narrow Band analysis takes this further with the possibility of many thousands of bands, possibly only 1Hz wide, or even less.

In all types of frequency analysis, the level in each band can be expressed in terms of L_{eq}, L_{max}, L_n, etc. as defined above.

Sound Insulation

Sound insulation is best expressed across the frequency range in octave bands or third octave bands. Often, however, in known environments such as domestic sound insulation and speech privacy, it is simpler to express the sound insulation as a single figure. A higher value means better sound insulation.

The most common ways are dB D_{nTw}, dB R_w and dB$_{(mean\ 100\text{-}3150Hz)}$. The first two are ways of expressing average sound insulation, weighted to account for speech frequencies. The third is simply an un-weighted mean value.

The Building Regulations Approved Document E (ADE) routinely refer to D_{nTw} $+C_{tr}$ The C_{tr} term is a negative number which is used to modify the D_{nTw} value for the insulation properties at lower frequencies.

ADE also uses the L_{nTw} index for impact sound transmission. It is a measure of the level of noise in the room below a room in which a standard tapping machine is being used. It represents the impact sound transfer such as footfall noise, scraping chairs, washing machines, etc. A lower value means better insulation.

Reverberation Time

The most common measure of Reverberation Time is, effectively the time taken for sound from a steady source to decay by 60 dB after it has been abruptly cut off. In practice it is often difficult to measure a 60 dB decay and so decays of 30 dB, 20 dB, or even 10 dB are often used and adjusted pro rata, although the exact measure is not quite the same.

Reverberation Time is generally expressed as RT in seconds. We may, if we are being precise, add subscripts 60, 30, etc. to show whether the basis of the measure is 60 dB decay, 30 dB decay, etc. E.g. the RT_{60} = 0.52s, the RT_{30} = 0.49s, etc.

RT can be expressed in octave bands or 1/3 octave bands across the frequency range, or at central frequencies such as 500 Hz or 1kHz.

Appendix 2

Measurements in Full

Time Period	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
07:50	Leq	**48**	68	52	40	42	45	37	27	23
	Lmax	**61**	76	69	63	56	52	52	46	47
	L90	**45**	57	47	35	40	44	35	20	14
07:55	Leq	**49**	69	53	43	42	45	37	32	27
	Lmax	**61**	75	65	64	56	49	46	53	48
	L90	**45**	59	48	35	39	43	34	20	14
08:00	Leq	**48**	67	52	38	41	45	36	24	17
	Lmax	**56**	75	64	53	53	50	45	40	33
	L90	**45**	55	45	35	39	43	34	20	14
08:05	Leq	**46**	57	49	39	42	45	36	24	17
	Lmax	**56**	69	66	54	49	50	48	39	34
	L90	**45**	53	44	34	40	43	34	20	14
08:10	Leq	**46**	58	48	36	41	44	35	26	32
	Lmax	**61**	69	58	44	48	50	58	49	53
	L90	**44**	53	45	33	38	42	33	20	14
08:15	Leq	**46**	57	48	39	41	44	36	35	30
	Lmax	**60**	72	68	61	54	51	49	51	49
	L90	**44**	53	45	35	39	42	33	20	14
08:20	Leq	**46**	57	48	38	41	44	36	28	24
	Lmax	**57**	66	58	51	52	51	51	48	48
	L90	**44**	54	44	33	38	42	33	19	14
08:25	Leq	**45**	56	48	36	39	43	35	26	29
	Lmax	**59**	68	59	49	45	51	44	52	56
	L90	**43**	52	43	32	37	41	33	18	14
08:30	Leq	**44**	56	46	35	38	42	33	22	23
	Lmax	**54**	67	61	52	48	48	43	36	51
	L90	**42**	53	42	31	36	41	32	18	14
08:35	Leq	**45**	58	49	37	39	42	35	24	17
	Lmax	**57**	65	62	52	58	48	44	43	38
	L90	**42**	54	44	33	36	41	32	19	14
08:40	Leq	**45**	56	47	36	39	43	34	29	20
	Lmax	**54**	64	57	50	48	49	44	47	40
	L90	**42**	53	44	33	36	40	32	20	14
08:45	Leq	**45**	57	47	37	39	43	36	27	21
	Lmax	**55**	67	59	49	48	51	47	44	40
	L90	**43**	53	43	34	37	41	33	19	14
08:50	Leq	**45**	57	51	40	38	42	37	29	21
	Lmax	**65**	66	64	50	46	51	62	60	52
	L90	**42**	54	45	33	36	41	32	20	14
08:55	Leq	**48**	59	53	42	40	44	44	33	27
	Lmax	**65**	69	61	53	50	55	62	47	46
	L90	**44**	54	49	37	38	42	35	24	15

Time Period	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
09:00	Leq	**46**	57	48	37	37	42	41	29	23
	Lmax	**66**	67	59	51	46	53	64	53	46
	L90	**41**	53	44	31	34	39	31	17	14
09:05	Leq	**44**	58	51	38	36	41	34	25	18
	Lmax	**61**	71	74	62	46	50	50	51	46
	L90	**40**	54	45	32	33	38	30	18	14
09:10	Leq	**43**	58	49	35	35	40	37	24	17
	Lmax	**59**	67	61	44	55	56	50	42	33
	L90	**40**	53	44	31	32	38	29	17	13
09:15	Leq	**43**	59	50	38	34	40	35	26	17
	Lmax	**54**	69	61	50	41	46	49	43	35
	L90	**39**	52	43	30	31	38	29	18	14
09:20	Leq	**42**	56	47	35	33	39	32	27	22
	Lmax	**53**	66	59	46	39	45	46	48	44
	L90	**39**	52	44	30	31	37	29	16	14
09:25	Leq	**44**	65	49	37	34	40	34	22	15
	Lmax	**56**	73	57	51	46	52	49	40	35
	L90	**39**	55	45	32	31	37	29	17	13
09:30	Leq	**43**	66	50	36	33	38	32	27	20
	Lmax	**53**	72	59	48	45	43	44	47	41
	L90	**39**	59	46	32	30	36	29	18	14
09:35	Leq	**42**	63	50	36	30	36	29	34	25
	Lmax	**57**	74	64	48	41	42	43	54	45
	L90	**36**	53	45	30	28	32	25	17	14
09:40	Leq	**42**	63	49	35	30	37	33	27	19
	Lmax	**55**	73	63	48	40	45	50	46	42
	L90	**37**	53	44	31	29	35	27	17	13
09:45	Leq	**40**	57	48	35	31	37	30	21	14
	Lmax	**55**	64	63	48	43	49	50	36	26
	L90	**37**	53	43	30	29	34	26	15	13
09:50	Leq	**41**	62	50	36	31	36	31	23	20
	Lmax	**52**	72	59	47	44	47	45	35	40
	L90	**37**	54	45	31	28	34	27	17	14
09:55	Leq	**43**	64	52	39	32	37	34	24	20
	Lmax	**55**	73	61	51	45	50	49	42	40
	L90	**39**	59	49	34	29	34	27	16	14
10:00	Leq	**44**	64	53	40	34	39	34	28	18
	Lmax	**58**	73	67	55	49	54	47	46	38
	L90	**39**	58	48	34	30	34	27	17	14
10:05	Leq	**45**	68	52	41	34	38	33	27	22
	Lmax	**57**	75	62	58	48	49	44	51	42
	L90	**38**	59	47	33	29	34	27	17	14
10:10	Leq	**44**	68	50	36	33	38	34	22	15
	Lmax	**61**	80	71	52	49	56	52	40	32
	L90	**38**	60	45	32	29	34	27	17	14
10:15	Leq	**44**	68	50	35	31	37	30	24	29
	Lmax	**52**	74	59	50	41	43	42	39	44
	L90	**38**	58	46	32	29	34	27	18	14
10:20	Leq	**44**	64	49	36	32	39	36	29	26
	Lmax	**61**	75	65	54	47	57	56	48	51
	L90	**37**	54	44	32	29	35	27	18	14
10:25	Leq	**42**	59	51	41	33	38	34	25	16
	Lmax	**54**	73	65	55	46	48	44	38	29
	L90	**38**	54	45	33	30	34	28	19	14
10:30	Leq	**44**	60	53	40	32	38	37	30	20
	Lmax	**63**	70	70	64	52	50	57	56	47
	L90	**38**	54	44	31	29	35	28	18	14
10:35	Leq	**41**	57	47	35	32	38	33	25	18
	Lmax	**54**	65	57	44	43	47	49	44	37
	L90	**38**	53	44	31	29	36	29	18	14
10:40	Leq	**43**	57	56	36	30	37	31	22	16
	Lmax	**60**	68	75	55	43	52	44	43	31
	L90	**37**	53	43	30	28	35	27	16	14
10:45	Leq	**39**	56	45	34	30	36	30	27	17
	Lmax	**53**	64	60	52	45	45	45	47	34
	L90	**36**	52	41	30	28	34	26	16	14
10:50	Leq	**45**	58	50	46	40	40	34	22	15
	Lmax	**63**	69	66	67	55	58	53	42	29
	L90	**38**	53	44	34	31	36	28	17	14
10:55	Leq	**44**	58	51	42	42	40	33	20	15
	Lmax	**58**	70	67	56	56	52	45	43	35
	L90	**39**	54	44	33	31	36	29	16	14

Time Period	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
11:00	Leq	**41**	56	46	36	31	37	35	26	19
	Lmax	**57**	63	56	49	44	49	53	48	38
	L90	**37**	53	43	30	28	34	28	17	14
11:05	Leq	**41**	57	50	36	31	37	33	23	16
	Lmax	**53**	66	64	45	42	47	45	40	36
	L90	**38**	54	44	32	29	35	29	18	14
11:10	Leq	**41**	56	48	35	32	37	33	23	17
	Lmax	**51**	63	59	43	42	46	45	43	37
	L90	**38**	53	45	32	30	35	29	19	14
11:15	Leq	**44**	60	51	42	39	40	35	25	21
	Lmax	**60**	69	61	58	55	55	54	46	46
	L90	**38**	54	45	33	30	35	28	17	14
11:20	Leq	**40**	57	47	35	33	37	32	22	21
	Lmax	**53**	67	55	52	47	49	45	34	40
	L90	**37**	52	43	32	30	35	28	17	14
11:25	Leq	**44**	57	54	43	32	37	34	33	27
	Lmax	**61**	66	69	62	46	50	53	54	46
	L90	**38**	54	45	33	29	35	28	18	14
11:30	Leq	**41**	56	47	35	32	38	32	21	15
	Lmax	**56**	66	61	51	49	54	46	43	28
	L90	**37**	52	42	32	29	35	28	16	14
11:35	Leq	**42**	57	46	36	33	39	33	27	21
	Lmax	**63**	73	63	56	51	57	56	58	47
	L90	**38**	53	42	32	30	36	29	18	14
11:40	Leq	**41**	57	48	37	32	38	33	22	16
	Lmax	**54**	67	62	57	44	45	44	42	40
	L90	**38**	52	43	32	30	36	29	18	14
11:45	Leq	**43**	56	53	38	33	38	34	23	16
	Lmax	**57**	62	66	51	46	49	52	42	37
	L90	**38**	53	44	32	30	36	29	17	14
11:50	Leq	**42**	56	49	41	35	37	34	24	19
	Lmax	**53**	63	58	52	45	48	45	42	43
	L90	**38**	53	45	34	30	35	29	18	14
11:55	Leq	**46**	58	54	46	42	41	33	24	20
	Lmax	**56**	68	64	57	53	51	41	39	34
	L90	**39**	53	45	35	32	36	29	18	15
12:00	Leq	**42**	55	49	42	37	38	32	23	20
	Lmax	**50**	62	57	50	45	46	39	36	34
	L90	**38**	52	45	35	32	36	29	18	15

Time Period	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Lowest 15 Minutes	Leq	**41**	61	49	35	30	36	31	30	22
	Lmax	**56**	72	64	48	41	46	48	50	42
	L90	**37**	53	44	30	28	34	26	16	13

Time Period	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Highest 15 Minutes	Leq	**48**	68	52	41	42	45	37	29	24
	Lmax	**60**	75	66	62	55	50	49	49	46
	L90	**45**	57	47	35	39	44	35	20	14

Appendix 3

Modelling Inputs

Visitor Based Source Data

Continuous Source Inputs

Description	*Index*	***dB(A)***	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Car Drive Past 25m/12s long - pull away, pass at 10m, and stop	Leq	**53**	70	53	53	50	46	43	39	34
	Lmax	**57**	73	60	59	53	50	47	44	38
LGV (eg. Van) Drive Past 25m/12s long - pull away, pass at 10m, and stop	Leq	**58**	75	58	58	55	51	48	44	39
	Lmax	**62**	78	65	64	58	55	52	49	43
OGV1 (eg. Rigid Lorry) Drive Past 25m/12s long - pull away, pass at 10m, and stop	Leq	**63**	80	63	63	60	56	53	49	44
	Lmax	**67**	83	70	69	63	60	57	54	48
OGV2 (eg. Articulated HGV) Drive Past 25m/12s long - pull away, pass at 10m, and stop	Leq	**65**	82	65	65	62	58	55	51	46
	Lmax	**69**	85	72	71	65	62	59	56	50

Commercial Units

Length of Vehicle Source Segment 25 m
Duration of Vehicle Segment 12 s
Correction for the Duration of a Segment -25 dB
Assumed DT percentage of total 50 %

Description	*Unit A*	*Unit B*	*Unit C*	*Unit D*
Number of Cars per hour	10.00	20.00	6.00	10.00
Correction for number of Cars (dB)	10	13	8	10
Overall Correction for Cars (dB)	**-15**	**-12**	**-17**	**-15**
Number of LGVs per hour	2.00	2.00	2.00	2.00
Correction for number of LGVs (dB)	3	3	3	3
Overall Correction for LGVs (dB)	**-22**	**-22**	**-22**	**-22**
Overall Correction for Cars and LGVs (dB)	**-13**	**-11**	**-14**	**-13**
Number of OGV1s per hour	0.50	0.50	0.50	0.50
Correction for number of OGV1s (dB)	-3	-3	-3	-3
Overall Correction for OGV1s (dB)	**-28**	**-28**	**-28**	**-28**
Number of OGV2s per hour	0.50	0.50	0.50	0.50
Correction for number of OGV2s (dB)	-3	-3	-3	-3
Overall Correction for OGV2s (dB)	**-28**	**-28**	**-28**	**-28**
Overall Correction for All OGVs (dB)	**-24**	**-24**	**-24**	**-24**