Arup**Acoustics**

Strategic Sites

Waterfront Quarter Huddersfield

Environmental Noise Assessment

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Environmental Noise Assessment

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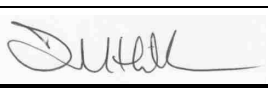
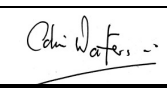
		Signature			

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Executive Summary

It is proposed to redevelop the Huddersfield Waterfront Quarter, the area bounded by Manchester Road, Chapel Hill Road and the River Colne, Huddersfield. The development is proposed to be mixed use, including residential dwellings, a technical college and commercial areas (e.g. offices, cafés etc). There is also a public square at the heart of the development.

This report presents an assessment of noise and vibration issues and their mitigation in support of the planning application. Separate sections set out the assessment and mitigation of: potential environmental noise impact of the development on the surrounding area; existing noise on the development site (and how this might affect the proposed residential and office buildings); and potential noise issues within the development.

An environmental noise survey has been undertaken to establish the existing noise climate on the site and at existing noise sensitive receptors around the site. The methodology was discussed in advance with the Environmental Health team of the local council.

Effect of noise from the development on existing receptors

The potential environmental noise sources associated with the development are generated road traffic and fixed mechanical plant as part of the office development. Road traffic is potentially a direct effect (from new traffic on the development site) and an indirect effect (intensification of existing roads).

The traffic impact assessment has shown that whilst the development will give rise to additional traffic the volume will be small compared with the flows on existing roads. Furthermore, the small volume of traffic on the site, combined with the distances to the nearest receptor and the relatively high current ambient noise at the receptors mean that it is highly unlikely that onsite road traffic will give rise to noise impacts or effects at existing receptors.

With appropriate selection, location and, where necessary, suppression of fixed plant it is possible to mitigate any potential noise impacts from these sources. The results of the survey have been used to define proposed limits for fixed plant noise at receptors around the site that will ensure that the development will not give rise to noise impact.

Effect of existing noise sources on the development

The noise survey has been used to assess the site according to Planning Policy Guidance note (PPG24). Noise on the site is dominated by the two main roads that border the northern and eastern boundaries. Whilst the noise levels along the northern and eastern edges of the development site were found to fall, just, within Noise Exposure Category D, for which the PPG24 advises that planning permission should normally be refused, noise levels on the remainder of the site are lower, especially furthest from the roads along the bank of the River Colne where levels are within exposure category B. On average the site falls into exposure category C.

There is extensive precedence in urban redevelopment for planning permission being granted on urban 'brown field' sites categorised in exposure categorises C and D where there is a demonstrable need, as there is in this case. From successful experience, appropriate noise control can be developed during detailed design through a mix of detailed spatial planning and design of high sound insulation facades (and ventilation) for the aspects of buildings facing the two main roads to achieve acceptable internal and external levels across the development.

Intra-development noise

No substantive intra-development noise or vibration issues have been identified. Detailed matters, such as the appropriate mitigation of noise sources to protect new noise sensitive receivers (especially residential property) will need to be considered as part of detailed design.

1 Introduction

Arup Acoustics has been engaged to carry out a noise assessment for the proposed Waterfront Quarter mixed use development in Huddersfield.

In addition to assessment of the potential impact of the scheme upon the local area, this report also addresses the effects of existing noise sources on the proposed development, and the impact of potential noise sources within the development upon noise sensitive receivers within the development.

A noise survey has been carried out to determine the existing noise levels around the development site. Appendix A provides a description of the acoustic terminology used in this report. The results of the noise survey are included in Appendix B.

2 Proposed Development

The proposed development is located in Huddersfield, the site being bounded by Manchester Road, Chapel Hill Road and the River Colne.

The development will be mixed use consisting of three residential buildings, four office buildings and a new building for Huddersfield Technical College.

A number of the buildings will incorporate car parking at lower levels, which will be accessed via two new access roads. There will also be underground parking below the Public Square. Building F is likely to include surface car parking.

At the centre of the scheme will be a public square. Building M, adjacent to the Square, may contain A1 to A5 uses.

A plan of the proposed development is presented in Figure 1.

3 Baseline Environmental Noise Survey

An environmental noise survey has been carried out to quantify the existing baseline ambient and background noise levels around the site of the proposed buildings. Table 1 describes the measurements undertaken and the purpose of these measurements.

Measurement locations are presented as Figure 1.

Measurements	Time (hrs)	Location	Purpose
Daytime afternoon	13:30 – 16:30	1, 2, 3	To determine daytime noise levels at proposed residential buildings
Afternoon rush hour	16:30 – 18:30	4, 5, 6, 7	To determine maximum noise levels at proposed office buildings
Daytime evening	21:30 – 23:00	8, 9, 10	To establish minimum daytime noise levels at existing residential properties
Noisiest night time	23:00 – 00:30	1, 2, 3	To determine noisiest night time noise levels at proposed residential buildings
Quietest night time	02:00 – 04:00	8, 9, 10	To establish minimum night time noise levels at existing residential properties

Table 1: Baseline environmental noise measurements

Note: For the purpose of the measurements, daytime is taken as 07:00hrs – 23:00hrs and night time as 23:00hrs to 07:00hrs.

3.1 Survey Methodology

The noise measurements detailed in Table 1 were carried out between 13:30hrs on Thursday 17 November and 04:00hrs on Friday 18 November 2005 by Paul Adams of Arup Acoustics.

The equipment used for the measurements is detailed in Table 2.

At the measurement locations, statistical noise levels were recorded over 5 - 15 minute periods, storing L_{Aeq}, L_{A10}, L_{A90} and L_{Amax} indices. Octave band spectra were also recorded at all locations. All measurements were A-weighted and used a fast time constant (0.125s). L_{Amax} values were also recorded using a slow time constant (1s).

The microphone was located at a height of approximately 1.5m above the ground. The sound level meter and microphone are Type 1 conforming to BS EN 61672-1: 2003. The calibration of the sound level meter and microphone was checked before and after use, to confirm that there was no significant drift in meter response at the calibrator frequency and level. The meter is annually calibrated and this calibration is traceable to international stan

Manufacturer	Type Number	Full Name of Instrument
Brüel & Kjær	2260	Precision Modular Integrating Real Time Analyser 'Investigator'
Brüel & Kjær	4189	½" 'Falcon' Pre-polarised Condenser Microphone
Brüel & Kjær	4231	'Type 1' Sound Pressure Level Calibrator

Table 2: Measurement equipment

During the measurements the weather was clear and dry although cold. There was a gentle breeze between approximately 15:00hrs and 16:30hrs on 17 November but otherwise the conditions were still.

3.2 Baseline Information

Tables 3, 4 and 5 summarise the results for the baseline environmental noise survey. Full results are presented in Appendix B.

Location	Sound Pressure Level, dB re. 20µPa			
	L_{Aeq}		L_{A10}	
	Daytime	Night-time	Daytime	Night-time
1	**72** (71 – 72)	**67** (66 – 67)	**75** (73 – 75)	**71** (70 – 72)
2	**75** (71 – 78)	**68** (68 – 68)	**77** (75 – 78)	**72** (71 – 72)
3	**72** (70 – 74)	**69** (68 – 70)	**75** (73 – 78)	**72** (71 – 74)

Table 3: Summary of measured noise levels at the proposed residential buildings

Note: Noise levels are mean over the monitoring period (range of measurements in brackets)
Noise levels are given to the nearest dB (0.5 being rounded up)
All measurements are free field or corrected for free field
Averages of L_{Aeq} levels are logarithmic and L_{A10} levels are arithmetic

The dominant noise source at locations 1 – 3 was two-way road traffic on Manchester Road (A62). Some very distant construction and industrial noise was faintly audible during lulls in traffic flow. Distant road traffic from the ring road and northern end of Chapel Hill Road was also audible during quiet periods.

Location	Sound Pressure Level, dBL_{Aeq} re. 20µPa
4	**72** (72 – 73)
5	**71** (71 – 72)
6	**74** (73 – 75)
7	**74** (74 – 74)

Table 4: Summary of measured rush hour noise levels at proposed office buildings

Note: Noise levels are mean over the monitoring period (range of measurements in brackets)
Noise levels are given to the nearest dB (0.5 being rounded up)
All measurements are free field or corrected for free field
Averages are logarithmic

The main noise source at Locations 4 and 5 was road traffic on Manchester Road. At Location 5, road traffic noise from the ring road and at the northern end of Chapel Hill Road was also audible.

The main noise source at Locations 6 and 7 was road traffic on Chapel Hill Road. During quiet periods, road traffic from the ring road was audible at Location 6.

Location	Sound Pressure Level, dB re. 20µPa			
	L_{Aeq}		L_{A90}	
	Daytime	Night-time	Daytime	Night-time
8	**71** (71 – 72)	**63** (61 – 66)	**55** (51 – 58)	**38** (37 – 38)
9	**71** (70 – 72)	**63** (61 – 65)	**47** (45 – 49)	**40** (39 – 40)
10	**66** (65 – 66)	**59** (54 – 63)	**46** (46 – 47)	**40** (39 – 42)

Table 5: Summary of measured noise levels at existing residential properties

Note: Noise levels are mean over the monitoring period (range of measurements in brackets)
Noise levels are given to the nearest dB (0.5 being rounded up)
All measurements are free field or corrected for free field
Averages of L_{Aeq} levels are logarithmic and L_{A90} levels are arithmetic

The dominant noise source at Locations 8 – 10 was road traffic on Manchester Road. During quiet periods in traffic, distant road traffic and plant noise was faintly audible. Noise from houses along Bankfield Road was also audible during quiet periods at Locations 8 and 9.

4 Impact of Noise on Existing Sensitive Receivers

4.1 Aims

This section describes the assessment of potential noise and vibration effects of the proposed development on the surrounding area. Specifically it aims to:

- Establish evaluative criteria;
- Identify potential new noise sources;
- Identify local noise sensitive receivers;
- Assess the effects of the new sources on the noise sensitive receivers;
- Recommend appropriate mitigation, where required; and
- Assess the residual effect.

4.2 Terms of Reference and Evaluative Criteria

4.2.1 Operational Impacts

4.2.1.1 Plant Noise

It is common to assess and specify plant noise criteria with reference to the *Method for rating industrial noise in mixed residential and industrial areas* given in BS 4142: 1997. This standard provides a method for rating external noise levels from factories, industrial premises or fixed installations of an industrial nature, such as building services plant, to determine the likelihood of complaints from occupants of nearby residential properties.

The method is based on the difference between the background noise level without the industrial source and the rating noise level of the industrial source at the receiver location. The noise level from the industrial source (called the specific noise level) is weighted by 5dB where it displays an identifiable character (such as tonality, impulsiveness or intermittency) and by 0dB if there are no such features. This level then becomes the Rating Level. The background noise level is subtracted from the rating level and the difference used to assess the likelihood of complaints as shown in Table 6.

Difference between rating and background noise level	Assessment
10dB or higher	Complaints likely
5dB	Of marginal significance
-10dB	Positive indication that complaints are unlikely

Table 6: Summary of BS 4142 rating method

4.2.1.2 Road Traffic Noise

Design Manual for Roads and Bridges (DMRB), Volume 11, Environmental Assessment (Department of Transport 1994) requires that the change in noise exposure of a noise sensitive receiver be considered when a change of 1dB(A) is reached, this equates to a change in traffic volume of around 20 to 25%.

Differences in road traffic noise become clearly perceptible for increases or decreases in vehicle flow where the flow changes by around a factor of two or more, which can be equated to a change in level of around 3dB(A).

It is common to consider a change of 3dB(A) or greater to be an impact (beneficial or adverse).

4.2.1.3 Environmental Protection Act 1990: Part 3

The Environmental Protection Act provides local authorities and individuals with powers to serve, or request a magistrate to serve, abatement notices against noise (including

vibration) from premises that are considered to be a nuisance. The existence of Planning Permission for the use of a development is not a defence against action under the Act. Developers and local authorities alike will generally seek to ensure that a proposed development will not give rise to nuisance, or can be mitigated such hat it will not give rise to a nuisance, at the time of a planning application. It is a defence for commercial operators that best practicable means have been employed to minimise noise from the premises.

4.2.2 Construction Impacts

4.2.2.1 Control of Pollution 1974

The Control of Pollution Act provides local authorities with the power to control noise from construction sites. The powers include prosecution for failure to comply with the requirements of a notice served under the act, and a system of providing prior consents for works to be carried out in a specified manner so as to reduce the likelihood of causing disturbance ('s.61 consents'). Noise generators can use the defence that best practicable means have been to control noise emissions.

4.2.2.2 Environmental Protection Act 1990: Part 3

The Environmental Protection Act provides local authorities with powers to take action against noise (including vibration nuisance) arising from premises (including construction). Noise generators can use the defence that best practicable means have been used to control noise emissions or that the alleged nuisance arose from activities that were compliant with an extant consent under s.61 of the Control of Pollution Act (NB: this does not affect an individual's power to seek and abatement notice from a magistrate for an abatement notice).

4.2.2.3 BS 5228

BS 5228 *Noise and vibration control on construction and open sites: Part 1: Code of practice for basic information and procedures of noise and vibration control*, provides practical guidance on the control of construction site noise and vibration. The legislative background to noise and vibration controls is described and recommendations are given regarding procedures for creating effective liaison between developers, site operators and local authorities. Methods for predicting and measuring noise are presented and guidance is given concerning the measurement of vibration.

BS 5228 presents information on likely noise sources and on potential methods of noise control suitable to construction sites. These include selection of quiet machines, in particular those complying with the appropriate EU directives, machinery enclosure, work within acoustic sheds and acoustic screens. The effect of working hours on noise sensitive premises is discussed, and it is recommended that any work outside normal weekday working hours will require special consideration.

Part 4 of the standard considers vibration from piling.

4.3 Potential Sources of Impact

4.3.1 Operational impacts

4.3.1.1 Direct Impacts

The following potential sources of noise are anticipated to arise from the proposed development:

- Fixed plant on proposed buildings;
- Deliveries to and operation of A1 to A5 uses;

- Car parking; and
- Vehicle movements within and around the development.

4.3.1.2 Indirect impacts

Changes in traffic flows on roads around the proposed development could be a source of indirect impact.

4.3.2 Construction

4.3.2.1 Noise

Construction activity would occur across the full area of the site. At this stage it is not possible to be definitive about construction methods and therefore the following list of activities can only be used as a guide:

On site sources may include:

- Demolition;
- Piling, if required;
- Excavation;
- Construction of buildings;
- Construction of on-site roads and hard standings;
- Offloading and handling materials;
- Off site sources; and
- Heavy goods vehicles delivering materials.

4.3.2.2 Vibration

Vibration during construction work may arise from use of the following activities:

- Demolition;
- Piling (e.g. for building foundations);
- Ground improvement; and
- Vibratory compaction (for road construction).

It is not currently clear which, if any, of these processes may be required for these works. Selection of plant and methods will need to consider the possible effects of vibration on adjacent buildings and their occupants if these methods are used.

4.4 Potential Noise Sensitive Receivers

4.4.1 Direct

External and adjacent to the site there are the following potentially noise sensitive receivers.

- Properties on Manchester Road, opposite the proposed location of Building A (refer to Figure 1);
- Properties on Bankfield Road; and
- Properties on Manchester Road, close to the junction with Chapel Hill Road

There do not appear to be any residential premises in close proximity to the site along Chapel Hill Road.

4.4.2 Indirect

There are various other dwellings and commercial areas in the wider vicinity of the development.

4.5 Evaluation of Impacts and Effects

4.5.1 Operational

Potential impacts and effects from noise associated with the operation of the proposed buildings have been assessed.

4.5.1.1 Fixed Plant

Operation of fixed plant (such as air handling units) can give rise to impacts and effects during night-time operation. However, it is possible to avoid impacts by selection of appropriately quiet plant, locating it in a manner that reduces noise and/or provision of noise suppression measures.

Limiting noise levels have been derived from the baseline noise survey that would ensure that existing residential properties would not be adversely affected by the operational noise from fixed plant associated with the new buildings.

BS 4142 states that the difference between the rating noise level (the total specific noise level from fixed plant plus any weighting factors for distinguishable features) and the prevailing background noise level is of marginal significance when the rating noise level is 5dB above the background noise level.

For this project, it is proposed to limit the rating noise level to 5dB below the background noise level in accordance with the Noise Design Advice issued by Kirklees Environmental Services. This is 10dB quieter than that considered as marginally significant in BS 4142.

The measured background noise levels at the nearest noise sensitive premises were 45 – 58dBL_{A90} (arithmetic average 49dBL_{A90}) during the quietest period of the day (21:30hrs to 23:00hrs) and 37 – 42dBL_{A90} (arithmetic average 39dBL_{A90}) during the quietest night-time period (02:00hrs to 04:00hrs).

Table 7 provides design target noise levels at the nearest residential properties to the proposed site. The noise should not have a character that will draw attention to it, i.e. there should be no tones, rattles or whistles and the noise should not be intermittent. If any of these conditions cannot be met, the plant noise limits set out below will be reduced by 5dB(A).

Location	Maximum daytime (07:00-23:00hrs) rating level[1]	Maximum night time (23:00-07:00hrs) rating level[1]
Nearest residential dwelling	44	34
Site boundary or nearest adjacent retail/office building[2]	50	50

Table 7: Noise design criteria for fixed plant, dBL_{Aeq}

Notes: 1. Refer to BS 4142 for definition
2. To protect local amenity

4.5.1.2 Car Parking and Deliveries

The main car parks associated with this development are underground and/or enclosed within the building facade, so external noise impacts associated with vehicle movements are

not expected. Building F will include surface car parking for 12 vehicles. Due to the low number of spaces, and that there are no noise sensitive receivers in close proximity to the proposed location of the car park, noise effects would not be considered significant.

Generated traffic on the development site will not give rise to significant noise levels at the nearest existing noise sensitive receivers as a consequence of the small volume of traffic, the distance between the traffic and the receivers, screening by buildings within the development and the high noise levels at the receivers arising from existing noise sources.

Any ventilation plant associated with the underground car parks will need to achieve the noise criteria set out in Table 7.

Deliveries are likely to be associated with some of the commercial areas. However, detailed information on the use of these areas is not available at this stage. Based on the typical uses of these areas (i.e. offices, café etc.), deliveries are only likely to be intermittent, but as is generally the case may occur outside normal working hours. These matters need to be considered further during detailed design to ensure that design and location of delivery areas avoids noise impact.

4.5.1.3 Road Traffic Noise

The main potential indirect effect of the development is from increased traffic on roads around the development giving rise to increased noise levels at existing noise sensitive receivers.

Assessments of traffic noise impacts have been based on the 18 hour traffic flows, as required by CRTN. Table 8 presents the traffic flows on which the traffic noise predictions have been based.

The 18 hour traffic flows are calculated from the 24 hour flow using a conversion factor of 0.982 as supplied by Sanderson Associates, the traffic consultants for this project.

The base flows of 2005 have been used as a worst case.

Location	Base (2005)	Base + Development	% Change	Noise Change, dB
A62 Ring Road Castlegate	42609	44906	5.4%	0.2
A62 Ring Road Queensgate	32881	34777	5.8%	0.2
Chapel Hill	29619	31444	6.2%	0.3
Manchester Road (one way)	10835	12272	13.3%	0.5
Outcote Bank	8833	9987	13.1%	0.5
Manchester Road (two way)	19090	20586	7.8%	0.3

Table 8: 18 hour base and development traffic flows

The highest percentage increase in flow would be along the one way section of Manchester Road and Outcote Bank; along which the flow would increase by around 13%. The flows around the remaining roads would be between 5% and 8%. Such percentage increases in road traffic flow would result in an increase in road traffic noise of less than 1dB. It can therefore be concluded that the proposed development will not cause any significant indirect effect in this regard.

4.5.2 Construction

Potential impacts from noise and vibration arising from construction activities have been assessed at a level appropriate for this stage of the project.

4.5.2.1 Noise

Noise from construction sites is calculated using the methodology given in BS 5228 and is dependant on a good understanding of the construction methods, sequence and equipment used.

At this stage in any project these variables are not yet known and it is therefore not possible to undertake an accurate prediction of noise levels from construction activities at the nearest residential premises.

However, by law noise from construction will be mitigated using Best Practicable Means (BPM) measures.

Successful experience has shown that the success of construction noise control at a site can be increase by forward planning and engagement between the developer, its contractor and the local authority. Strategic approaches and outline mitigation measures are therefore provided in the following sections to assist in the forward planning process.

4.5.2.2 Vibration

Ground borne vibration from construction work has broadly two potential impacts. At very high levels, damage to local structures is possible. However, damage by vibration from construction works is very rare and generally only occurs when receiving buildings are very close to very intensive vibration generating activities. It is considered highly unlikely that this will be the case for this development.

Conversely, humans are sensitive to vibration (more than 100 times more sensitive than buildings) and therefore perceptible vibration may give rise to complaints of disturbance over a wider area from the works.

The risk of excessive ground borne vibration from the construction of the proposed scheme has been assessed to be low. Nonetheless the strategic approach to vibration control is the same as that described in section 4.5.2.1 for noise (the Control of Pollution Act explicitly applies to vibration as well as noise).

4.6 Mitigation

4.6.1 Operation

The adjacent residential buildings may dictate a degree of mitigation is required for any new fixed plant. This can be readily incorporated in the design of mechanical services and should therefore not cause any residual effects.

The lower floor of Building M is proposed for A1 – A5 use. Noise from fixed plant for these facilities would be controlled by appropriate design. Break out noise from these facilities will need to be controlled through appropriate acoustic design to preserve the amenity of residential buildings and possible conditioning of their use.

These matters require further consideration during detailed design.

4.6.2 Construction

The following points should be considered in preparing a scheme of work for the construction, in order to minimise the chance of adverse comment due to construction works.

The developer and contractor should consider and comply with any code of construction practice established by the local authority. In the absence of a code of practice or in addition to any code the following good practice should be employed.

Details of construction activities, prediction levels and assessments should be discussed with the Local Authority, both prior to construction and during construction. Detailed construction programmes should be available in advance of work starting onsite. Prediction, evaluation and assessment of noise and vibration as well as discussion between the management team and Local Authority, should be a continuous activity throughout the construction period.

Control of working hours is, where reasonably practicable, a fundamental means of minimising the likelihood of complaint arising from noise and vibration. By law works must be carried out in such a way as to minimise, as far as reasonably practicable, the adverse noise and vibration impact of the construction activities and as such activities outside normal working hours must be minimised in so far as is reasonably practicable.

Normal working hours should be defined: typical hours are 08:00 to 18:00hrs on weekdays (excluding public and/or bank holidays), from 08:00 to 13:00hrs on Saturdays with no working on Sundays, public and bank holidays. The contractors should adhere to these normal working hours as far as reasonably practicable and, where possible, operations anticipated to cause disturbance would be limited to these hours.

The contractor should discuss and agree work outside normal working hours with the local authority in advance. The contractor should carefully consider the benefits to all parties of seeking advanced consent to the works and associate noise control measures under s.61 of the Control of Pollution Act.

In order to maintain the above working hours, the contractor(s) may require a period of up to half an hour before and up to one hour after normal working hours for start up and close down of activities (not including operation of plant or machinery giving rise to noise likely to disturb nearby residents nor the arrival of any HGV at site before 07:30hrs).

The list below sets out the foreseeable specific activities expected to be carried out in the start up and close down periods:

- arrival and departure of workforce and site staff;
- maintenance and checking of plant and machinery;
- general refuelling;
- site inspections and safety checks prior to commencing work;
- site meetings; and
- site clean up.

Start up and close down periods are not an extension of normal working hours, and particular care should be taken to limit and control disturbance to local residents during such periods.

All repairs and maintenance should be undertaken during normal working hours wherever reasonably practicable. Activities outside normal working hours that could give rise to disturbance should be kept to a practicable minimum.

Best practicable means shall be employed to minimise noise at all times and at all locations to achieve compliance with the relevant applicable legislation and standards.

Measures to be considered in implementing best practicable means will be consistent with the recommendations of BS 5228 and should, where reasonably practicable, include as

appropriate careful selection of working hours, plant, construction methods programming and screening. Only plant conforming to relevant national or international standards, directives and recommendations on noise and vibration emissions should be used. Specific measures to be employed may, where reasonably practicable, include (but not limited to):

- provision of lined and sealed acoustic covers for equipment, which must be in place during use of equipment;
- regular maintenance of all equipment;
- operation of equipment in the mode of operation that minimises noise;
- shutting down equipment when not in use;
- avoiding waiting or queuing on the public highway with engines running;
- construction of temporary infrastructure to minimise noise and vibration;
- selection of piling and other construction methods which minimise noise and vibration;
- breaking out concrete by means other than percussion;
- noise reduction measures for temporary ventilation equipment;
- handling all materials in a manner which minimises noise;
- where audible warnings are necessary for reversing vehicles, operations will be planned to minimise reversing;
- fitting of silencers to all plant, machinery and vehicles;
- design and use of site hoardings and screens, where practicable and necessary, to provide acoustic screening at the earliest opportunity. Where practicable, doors and gates should not be located opposite occupied noise-sensitive buildings;
- choice of routes and programming for the transport of construction materials, spoil and personnel.

Unless otherwise agreed with the Local Authority, any prediction of noise and vibration levels will be in accordance with the methods set out in BS 5228. However, source levels for items of plant or activities should, where practicable, be based upon measured levels or other authoritative sources agreed with the Local Authority rather than those estimated from the generic tables in BS 5228. Also where noise and vibration measurements during the works give rise to more accurate information on levels and propagation characteristics, this information should be used in addition to or instead of the generic assumptions in BS 5228.

The contractors should comply with the guidance and procedures given in BS 5228 Parts 1, 2 and 4 and in the case of vibration, reference should also be made to BS 7385 and BS 6472 as necessary. Where alternative authoritative guidance and procedures are thought to be more reasonable and have been agreed in advance with the Local Authority, these could be adopted instead.

4.7 Residual Effects

There are a number of noise producing activities associated with operation of the development, which fall into three main categories: fixed plant, vehicle movements and occupational noise from buildings. Noise from these and from construction of the development will be controlled to avoid disturbance to local residents within and outside the development:

- Noise from fixed plant will be mitigated through local control;

- Noise from vehicle movements has been assessed and will not provide a significant increase on existing noise levels from traffic at existing noise sensitive receivers;
- Operation of A1 to A5 uses may require control through Conditions to the Planning Approval;
- Construction noise will be mitigated through best practice.

Overall it is expected that any noise impact from the site can be controlled to reasonable levels through good design and mitigation. As a result, no residual effects of noise or vibration are anticipated.

4.8 Summary of Impacts and Effects

The following table summarises the impacts, proposed mitigation and residual effects of the proposed development.

	Description of Potential Impact	Nature of Impact	Duration of Impact	Significance	Mitigation	Residual Impact
Construction	Noise from demolition and construction on local noise sensitive receivers.	Negative	Short Term	Moderate Local	Use of Best Practicable Means. Public liaison. Enforcement of noise control measures on contractor. Use of silenced, well maintained plant and noise enclosures and barriers, where necessary. Limiting hours of site working.	Minor Local
	Vibration from demolition and construction on local residents and listed structures.	Negative	Short Term	Minor Local	Use of Best Practicable Means.	Negligible
Operation	Increase traffic noise on local residents and other noise sensitive receptors	Negative	Long Term	Negligible	Not required	Negligible
	Traffic vibration on local residents and buildings	Negative	Long Term	Negligible	Not required	Negligible
	Patron and commercial noise from A1 – A5 use.	Negative	Long Term	Moderate Local	Enforcement of noise control measures through Condition to the Planning Approval or licensing control.	Negligible
	Vehicle noise from car parking and deliveries.	Negative	Long Term	Negligible	Not required	Negligible
	Noise emissions from fixed plant on local residents and other noise sensitive receptors	Negative	Long Term	Minor Local	Compliance with criteria by incorporating noise control measures into design of fixed plant	Negligible

Table 9: Summary table of impacts

5 Impact of Noise from Existing Noise Sources

5.1 Aims

The planning process, especially for residential development, requires consideration of the noise climate on the development site and its implications for the proposed development. This issue is discussed in this section of the report.

5.2 Terms of Reference and Assessment Criteria

5.2.1 Planning Policy Guidance note 24

Planning Policy Guidance note 24 (PPG24), published by the Department of the Environment, sets out the Government's policies relating to noise as it affects development control. PPG24 outlines the considerations to be taken into account in determining planning applications for noise sensitive uses, and activities that generate noise. PPG24 uses noise exposure categories (NECs) for proposed residential development affected by transportation noise or mixed source (those where no one source is considered dominant), and recommends appropriate levels for exposure to different sources of noise. Generic guidance is also provided for other land uses and for vibration. The guidance also advises on the use of planning conditions to minimise the impact of noise.

One of the general principles of PPG24 is that, where practicable, noise sensitive developments should be separated from major sources of noise, and new developments involving noisy activities should, if possible, be sited away from noise sensitive land uses. However, it does recognise that there will be circumstances where it is acceptable or even desirable in order to meet other planning objectives to permit noise generating activities on land near noise sensitive uses. This has been a more significant issue since the mid 1990s and the strategic planning guidance and emphasis on brown field mixed use developments as part of urban regeneration. Nevertheless, the local planning authorities must ensure that any development does not cause an unacceptable degree of disturbance to occupiers. In such cases it is suggested that local authorities consider the use of planning conditions or obligations to safeguard amenity. For noisy sites it is recommended that the most noise sensitive land uses are kept away from the boundaries, and/or that measures are provided to reduce the impact of the noise either on the site or within the buildings.

The noise exposure categories and the levels of road traffic noise and mixed sources that apply to new residential property are given in Table 10 and Table 11.

NEC	
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 a desirable level.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there is no alternative quieter site available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

Table 10: Noise exposure categories from PPG24

Noise levels corresponding to the Noise Exposure Categories for new dwellings $L_{Aeq,T}$ dB				
Noise source and time of day	**Noise Exposure Category**			
	A	**B**	**C**	**D**
Road traffic				
07:00 – 23:00	<55	55 – 63	63 – 72	>72
23:00 – 07:00	<45	45 – 57	57 – 66	>66
Mixed sources				
07:00 – 23:00	<55	55 – 63	63 – 72	>72
23:00 – 07:00	<45	45 – 57	57 – 66	>66

Table 11: Recommended noise exposure categories for new dwellings near existing noise sources from PPG24

5.2.2 Internal Noise Criteria

Suitable target internal noise criteria are given in PPG and Table 12 below. These criteria are based on World Health Organisation recommendations as documented in *Guidelines for Community Noise* (1999) and BS 8233:1999: *Sound insulation and noise reduction for buildings – Code of practice*.

There is currently no guidance on acceptable noise levels in college buildings. Therefore the design criterion below is based on Building Bulletin 93 (BB93): *Acoustic Design of Schools. A Design Guide*. It should be noted that the internal noise levels given in BB93 are for any 30 minute period during the school day.

Space	Criteria
Bedrooms (night-time: 2300hrs to 0700 hrs)	$30dBL_{Aeq}$
Bedrooms* (night-time: 2300hrs to 0700 hrs)	$45dBL_{Amax}$
Living rooms (daytime: 0700hrs to 2300 hrs)	$35dBL_{Aeq}$
Offices	$40 - 45dBL_{Aeq}$
Classrooms	$35dBL_{Aeq}$

Table 12: Internal noise criteria

Note: *Noise events should not exceed the given level more than 10-15 times per night.

5.2.3 Kirklees Noise Design Advice

A copy of the Noise Design Advice document has been received from Kirklees Environmental Services. Whilst this is not currently a planning requirement, the design and calculations reference this document for information.

5.3 Potential Sources of Impact

The ambient noise climate in the vicinity of the proposed residential buildings is dominated by road traffic on Manchester Road, with noise from road traffic on the Ring Road and northern end of Chapel Hill Road also audible during quiet periods.

5.4 Potential Noise Sensitive Receivers

In the proposed development, Buildings A, B and C (see Figure 1) are currently to be residential and therefore represent the potential noise sensitive receivers for this section of the assessment. Noise control inside office space and college teaching areas is also required to ensure appropriate working environments.

5.5 Evaluation of Impact and Effects

5.5.1 Residential

The impact of noise from existing sources on the proposed residential development has been assessed. Given that road traffic is the dominant noise source at the location of the proposed residential buildings, the method described in PPG24 has been used to determine the daytime noise level.

The shortened measurement procedure calculation given in the Calculation of Road Traffic Noise document (Department of Transport and Welsh Office, 1988) has been used to calculate the $L_{A10,18\ hr}$ noise levels, and the $L_{Aeq,16hr}$ noise levels have been calculated using the correction given in PPG24. The resultant noise levels are given in Table 13.

It is important to note that the information in Table 13 represents very much a worst case. This for a number of reasons.

Firstly, access constraints to the development site at the time of the survey have meant that noise measurements have only been possible at the boundaries of the site closest to the main noise sources. These are the noisiest areas of the site.

Secondly, the night-time levels have been derived from measurements conducted between 23:00 and 00:30 hours (considered the noisiest time of the night).

Measurement Location	Daytime $L_{Aeq,16hr}$ (07:00 – 23:00 hrs)	Night-time $L_{Aeq,8hr}$ (23:00 – 07:00 hrs)	NEC
1	73	67	D
2	75	68	D
3	72	69	D

Table 13: Calculated free field noise levels, dB re 20µPa

Comparing these levels with the criteria in Table 11 indicate that sections of the outer edge of the site on the northern and eastern boundaries fall just within Noise Exposure Category D. The night-time noise levels are worst case.

Road traffic noise levels will be at their lowest around the mid point of the southern boundary, adjacent to the River Colne. Noise calculations show that at this location the noise levels will fall within noise exposure category ‘B’. The remainder of the site is likely to be NEC ‘C’.

Buildings A, B and C (the nearest to the road) are some 5 – 6m back from the kerbside. Calculations indicate that noise levels at the façade of the residential buildings are likely to be 3 – 4dB lower than those given in Table 13. The result is that noise levels at the northern most façade (the noisiest point) of Buildings A – C can be considered to fall within NEC ‘C’.

Overall, as an average consistent with the requirements of PPG24, the site as a whole should be classified as NEC ‘C’.

It is important to note that once the buildings are complete those buildings closest to the north and eastern boundaries will act as noise screens meaning that the remainder of the site will be exposed to substantially lower levels of noise from the existing main roads to the benefit of the other buildings proposed and the overall environment and amenity on the site.

The remaining issue is therefore consideration of the noise sensitive uses on the building elevations facing the Manchester Road and Chapel Hill.

The mitigation measures could take a number of forms including:

- Increased sound insulation from well specified glazing and provision of additional ventilation (e.g. sound attenuated mechanical ventilation or cross ventilation to the quieter south façade);
- Revised space planning of the site;
- Revised internal space planning of individual buildings;
- Roadside noise barrier; and
- Other solutions including 'twin skin' facades (e.g. glazed second façade skin integrated with the façade) possibly combined with 'stack' natural ventilation.

Given that space is very constrained on the western side of the site and given the need to meet a commercially sustainable property density, there is likely to be little scope for spatial re-planning beyond that already undertaken to move the residential buildings further away from the road. Furthermore, the multiple occupancy high-rise nature of the buildings means that noise barriers are impracticable. However, the internal acoustic environment of the internal spaces can nonetheless be successfully protected by increased sound insulation from external façade (especially windows) and provision of sound attenuated ventilation to ensure that acceptable conditions can be maintained with windows closed.

PPG24 refers to BS 8233 for acceptable internal noise levels, which gives a level of 30 – 40dBL_{Aeq} in living rooms during the day and 30 to 35dBL_{Aeq} in bedrooms at night.

Calculations have been carried out to determine the likely glazing requirements in order to achieve the noise levels referenced in BS8233 and with reference to Kirklees Noise Design Advice (for information). These requirements are shown in Table 14.

Building	Sound insulation requirements		Typical Configuration
	Façade Performance	Glazing Performance	
A, B and C	D_w 40 dB	R'_w 42 dB	10mm glass/100mm cavity/6mm glass + sound attenuated mechanically assisted ventilation (probably air conditioning)

Table 14: Typical glazing configurations for residential buildings (refer to ISO 140 Part 5)

The octave band calculation methodology is shown in Appendix C.

It must be noted that the residential buildings have moved further from Manchester Road since the original planning application. Therefore noise levels at the façade of buildings A – C are likely to be 3 – 4dB lower than was the case when the calculations were originally

undertaken. As a result, it is likely the glazing requirements given in Table 14 could be reduced. This will be investigated further during detailed design.

5.5.2 Office Buildings

Noise break-in to the office buildings from road traffic on Manchester Road and Chapel Hill Road has been considered and assessed.

Calculations have been undertaken based on noise levels measured along Manchester Road and Chapel Hill Road during rush hour. The results of these calculations suggest that the glazing configurations given in Table 15 will be required on the facades facing the road in order to achieve the internal noise levels given in Table 12.

Building	Sound insulation requirements		Typical Configuration
	Façade Performance	Glazing Performance	
E	D_w 27 dB	R'_w 29 dB	6mm glass/12mm cavity/6mm glass + sound attenuated mechanically assisted ventilation (probably air conditioning)
F & L	D_w 40 dB	R'_w 42 dB	10mm glass/100mm cavity/6mm glass + sound attenuated mechanically assisted ventilation (probably air conditioning)

Table 15: Typical glazing configurations for office buildings

5.5.3 College Building

Noise break-in to the college buildings from road traffic on Manchester Road has also been assessed.

Calculations have been undertaken based on noise levels measured along Manchester Road during rush hour and are based on achieving noise levels within a general teaching classroom. Specialist rooms (such as music and drama room spaces) may require lower internal noise levels and conversely, in less sensitive spaces (such as science labs) higher internal noise levels may be acceptable.

The results of these calculations indicate that the glazing configurations given in Table 16 will be required on the facades facing the road in order to achieve the internal noise levels given in Table 12.

Building	Sound insulation requirements		Typical Configuration
	Façade Performance	Glazing Performance	
HTC	D_w 40 dB	R'_w 42 dB	10mm glass/100mm cavity/6mm glass + sound attenuated mechanically assisted ventilation (probably air conditioning)

Table 16: Typical glazing configurations for college buildings

It should be recognised that large areas of the college façade are located away from the main roads and therefore consideration to space planning would be likely to significantly reduce the sound insulation requirements of the façades.

6 Intra-Development Noise

6.1 Aims

This section reviews the sources of noise and the new noise sensitive receivers that will be within the proposed development. Outline comments on mitigation requirements are noted. Intra development noise and vibration issues will need careful consideration during the detailed design stage.

6.2 Potential Noise Sources

There are a number of potential noise sources from within the development including:

- Fixed plant on adjacent buildings;
- Cars and delivery vehicles using the access road; and
- Noise from A1 – A5 uses.

6.3 Potential Noise Sensitive Receivers

The proposed development incorporates three residential buildings. These buildings are noise sensitive.

The development also contains a public square. A commensurate environment and amenity will need to be provided in this location.

6.4 Evaluation of Impacts and Effects

Within external areas normally accessible to the general public and within residential areas, noise from fixed plant shall be restricted to the target criteria specified in Table 7, in order to protect amenity.

There are two roads proposed at each end of the development. However, these are likely to be used only by the users/occupants of the development (e.g. residents of the dwellings, deliveries, access to car parks etc). The noise produced by the intermittent traffic on these roads is not anticipated to have a significant effect on the residential buildings within the development.

Car parking and deliveries were considered in Section 4.5.1.2.

The noise impact from A1 – A5 activities within the proposed development is difficult to assess accurately as the full details of the type of uses that may exist has not been finalised. However, assuming bars and restaurants are likely to exist on the site, there is the potential for some noise breakout to occur and a moderate local impact is anticipated. This impact will be mitigated by careful space planning and the introduction of appropriately designed sound insulating constructions as well as the possibility of conditioning use of bars (opening hours etc.).

6.5 Mitigation

Impacts of noise from sources within the development on noise sensitive receivers within the development will be controlled through the following means.

- Appropriate design and location of fixed plant;
- Screening of noise sources, where appropriate;
- Internal space planning of residential buildings to locate less sensitive spaces in locations closer to external noise sources; and
- Conditioning the use of A3/A4 uses.

7 Conclusions

This report presents an assessment of noise and vibration issues and their mitigation in support of the planning application. Separate sections set out the assessment and mitigation of: potential environmental noise impact of the development on the surrounding area; existing noise on the development site (and how this might effect the proposed residential and office buildings); and potential noise issues within the development.

An environmental noise survey has been undertaken to establish the existing noise climate on the site and at existing noise sensitive receptors around the site. The methodology was discussed in advance with the Environmental Health team of the local council.

Effect of noise from the development on existing receptors

The principal potential environmental noise sources associated with the development are generated road traffic and fixed mechanical plant as part of the office development. Road traffic is potentially a direct effect (from new traffic on the development site) and an indirect effect (intensification of existing roads).

The traffic impact assessment has shown that whilst the development will give rise to additional traffic, the volume will be small compared the flows on existing roads. Additionally, the volume of traffic on the site, combined with the distances to the nearest receptor, mean that it is considered highly unlikely that changes in road traffic will give rise to noise impacts or effects.

With appropriate selection, location and, where necessary, suppression of fixed plant it is possible to mitigate noise impacts from these sources completely. The results of the survey have been used to define proposed limits for fixed plant noise at receptors around the site that will ensure that the development will not give rise to noise impact.

Effect of existing noise sources on the development

The noise survey has been used to assess the site according to Planning Policy Guidance note (PPG24). Noise on the site is dominated by the two main roads that border the northern and eastern boundaries. Whilst the noise levels along the northern and eastern edges of the development site were found to fall, just, within Noise Exposure Category D, for which the PPG24 advises that planning permission should normally be refused, noise levels on the remainder of the site are lower, especially furthest from the roads along the bank of the River Colne. On average the site falls into exposure category C where the advice in PPG 24 is that permission should not normally be given although there is extensive precedence in urban redevelopment for planning permission being granted on urban 'brown field' sites categorised in exposure categorises C and D where there is a demonstrable need, as there is in this case. From successful experience, appropriate noise control can be developed during detailed design through a mix of detailed spatial planning and design of high sound insulation facades (and ventilation) for the aspect of buildings facing the two main roads to achieve acceptable internal noise levels.

Intra-development noise

No substantive intra-development noise or vibration issues have been identified. Detailed matters, such as the appropriate mitigation of noise sources to protect new noise sensitive

receivers (especially residential property) will need to be considered as part of detailed design.

FIGURES

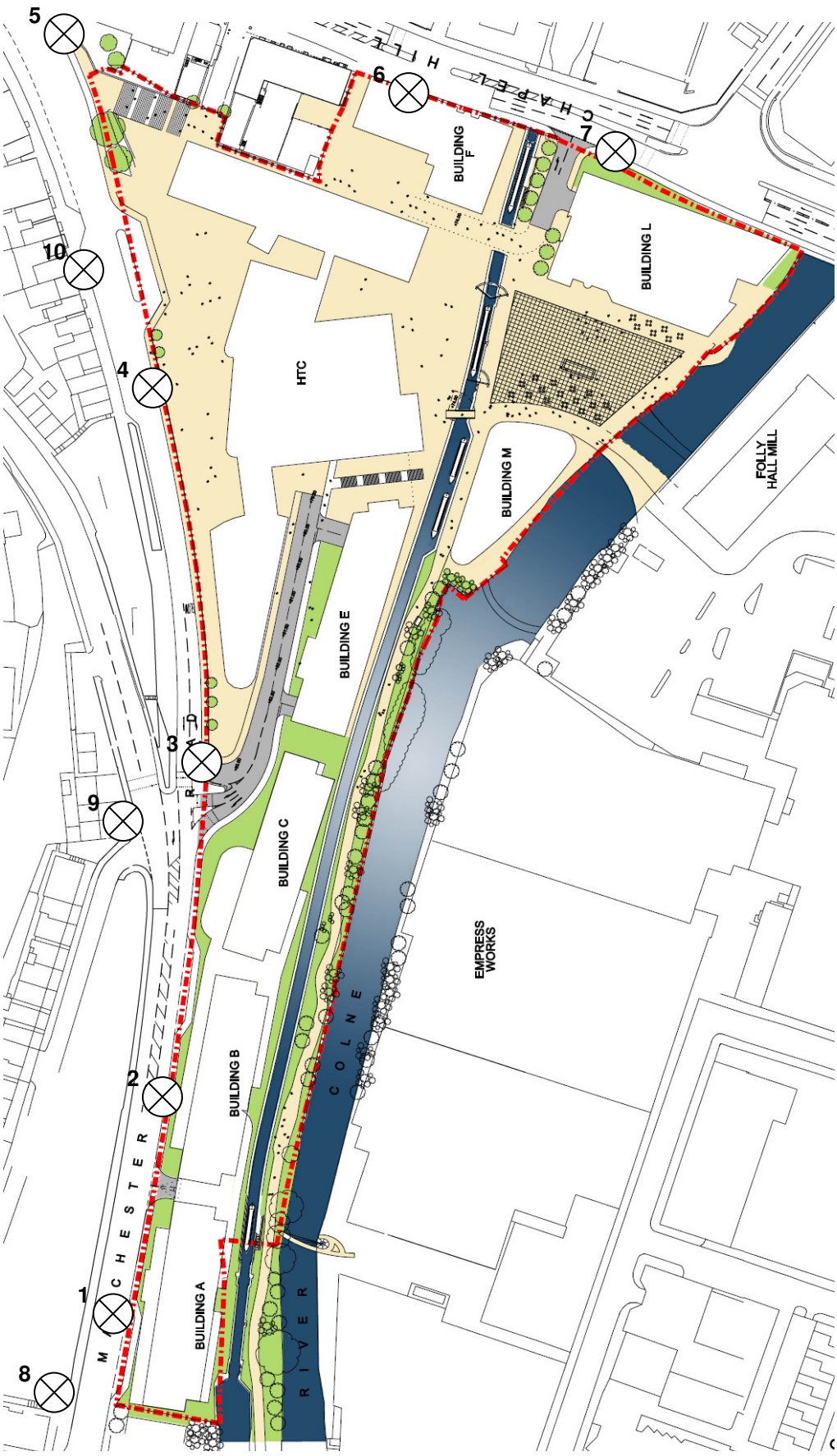

Figure 1: Site plan and measurement locations

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Appendix A

Glossary of Acoustic Terminology

A1 Glossary of Acoustic Terminology

Decibel

The ratio of sound pressures which we can hear is a ratio of $1:10^6$ (one:one million). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. It is worth noting that an increase or decrease of approximately 10dB corresponds to a subjective doubling or halving of the loudness of a noise, and a change of 2 to 3dB is subjectively barely perceptible.

Equivalent Continuous Sound Level

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

Frequency

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kHz, eg 2kHz = 2000Hz. Human hearing ranges approximately from 20Hz to 20kHz. For design purposes, the octave bands between 63Hz to 8kHz are generally used. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For more detailed analysis, each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.

Statistical Noise Levels

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index which allows for this variation. The L_{10}, the level exceeded for ten per cent of the time period under consideration, has been adopted in this country for the assessment of road traffic noise. The L_{90}, the level exceeded for ninety per cent of the time, has been adopted to represent the background noise level. The L_1, the level exceeded for one per cent of the time, is representative of the maximum levels recorded during the sample period. A weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg $dBL_{A10, 5min}$ or $dBL_{A90, 8hr}$.

Typical Noise Levels

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside disco
90	Heavy lorries at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

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Appendix B

Noise Survey Results

B1 Full Results of Environmental Noise Survey

The following tables contain the full results of the environmental noise survey.

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	13:37	15:00	72	56	75	81	85
17/11/05	14:32	15:00	72	59	75	83	86
17/11/05	15:30	15:00	71	61	73	93	98
17/11/05	23:06	10:00	67	44	72	79	81
17/11/05	23:42	10:00	66	44	70	81	88

Table B1: Free-field noise levels measured at location 1, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	13:56	15:00	74	62	77	83	86
17/11/05	14:49	15:00	78	63	78	102	107
17/11/05	15:46	15:00	71	61	75	84	88
17/11/05	23:17	10:00	68	43	72	81	85
17/11/05	23:53	10:00	68	40	71	84	87

Table B2: Free-field noise levels measured at location 2, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	14:14	15:00	74	60	78	84	88
17/11/05	15:06	15:00	71	62	74	80	82
17/11/05	16:03	15:00	70	62	73	83	85
17/11/05	23:29	10:00	68	43	71	81	83
18/11/05	00:05	10:00	70	46	74	82	84

Table B3: Free-field noise levels measured at location 3, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	16:54	10:00	73	54	77	88	93
17/11/05	17:49	10:00	72	51	76	84	90

Table B4: Free-field noise levels measured at location 4, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	17:06	10:00	72	59	75	84	92
17/11/05	18:02	10:00	71	58	75	80	82

Table B5: Free-field noise levels measured at location 5, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	17:20	10:00	75	68	78	89	91
17/11/05	18:14	10:00	73	66	76	82	89

Table B6: Free-field noise levels measured at location 6, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	17:33	10:00	74	63	78	82	84
17/11/05	18:26	10:00	74	63	78	86	89

Table B7: Free-field noise levels measured at location 7, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	21:30	10:00	72	58	76	85	88
17/11/05	22:26	10:00	71	51	75	81	83
18/11/05	02:20	05:00	66	37	67	82	85
18/11/05	02:25	05:00	65	38	66	80	83
18/11/05	03:00	05:00	61	38	66	75	76
18/11/05	03:05	05:00	63	37	64	79	81

Table B8: Free-field noise levels measured at location 8, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	21:59	10:00	72	49	77	83	85
17/11/05	22:39	10:00	70	45	73	83	85
18/11/05	02:32	05:00	61	40	64	76	78
18/11/05	02:37	05:00	65	40	67	80	82
18/11/05	03:12	05:00	64	39	63	82	84
18/11/05	03:17	05:00	63	39	61	79	80

Table B9: Free-field noise levels measured at location 9, dB

Date	Start time (hh:mm)	Elapsed time (mm:ss)	L_{Aeq}	L_{A90}	L_{A10}	$L_{Amax,s}$	$L_{Amax,f}$
17/11/05	22:12	10:00	66	47	71	80	82
17/11/05	22:51	10:00	65	46	71	76	78
18/11/05	02:45	05:00	63	41	67	75	77
18/11/05	02:50	05:00	61	39	60	76	79
18/11/05	03:25	05:00	61	42	63	73	75
18/11/05	03:30	05:00	54	40	47	72	74

Table B10: Free-field noise levels measured at location 10, dB

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Appendix C

Calculations

C1 Calculations of Noise Break-in

		Octave Band Centre Frequency, Hz						dB(A)
		125	**250**	**500**	**1k**	**2k**	**4k**	
1	Measured traffic noise, $dBL_{eq,10mins}$, day	69	65	65	68	66	57	72
2	Measured traffic noise, $dBL_{eq,10mins}$, night	60	58	59	63	61	51	67
3	Measured traffic noise, $dBL_{1,10mins}$, night	72	67	70	75	73	64	78
4	Measured traffic noise, $dBL_{max,10mins}$, night	81	71	77	81	81	71	85
5								
6	R of 10/100/6 float glazing	28	36	42	46	50	50	
7	R' of façade inc. flanking (*6*-3dB)	25	33	39	43	47	47	
8	Estimated area of window, $2m^2$							
9	Estimated volume of living room/bedroom, $60m^3$							
10	Estimated reverberation time in room, s	0.7	0.6	0.5	0.5	0.5	0.4	
11	Calculated absorption area in room, m^2	14	16	19	19	19	24	
12								
13	Direct L_p in room, $dBL_{eq,10mins}$, day [1]	44	32	26	25	19	10	
14	Reverberant L_p in room, $dBL_{eq,10mins}$, day [2]	41	29	23	22	15	5	
15	**Total L_p in room, $dBL_{eq,10mins}$, day (*13+14*)**	**46**	**33**	**28**	**27**	**20**	**11**	**33**
16								
17	Direct L_p in room, $dBL_{eq,10mins}$, night [1]	35	25	20	20	14	4	
18	Reverberant L_p in room, $dBL_{eq,10mins}$, night [2]	33	22	16	16	11	0	
19	**Total L_p in room, $dBL_{eq,10mins}$, night (*17+18*)**	**37**	**26**	**21**	**22**	**16**	**6**	**27**
20								
21	Direct L_p in room, $dBL_{1,10mins}$, night [1]	47	34	31	32	16	17	
22	Reverberant L_p in room, $dBL_{1,10mins}$, night [2]	44	31	27	28	22	12	
23	**Total L_p in room, $dBL_{1,10mins}$, night (*21+22*)**	**49**	**36**	**32**	**33**	**27**	**18**	**38**
24								
25	Direct L_p in room, $dBL_{max,10mins}$, night [1]	56	44	38	38	34	24	
26	Reverberant L_p in room, $dBL_{max,10mins}$, night [2]	54	40	34	34	30	19	
27	**Total L_p in room, $dBL_{max,10mins}$, night (*25+26*)**	**58**	**45**	**40**	**40**	**35**	**25**	**46**

Table C1: Example calculation of noise break-in to residential units

Note: [1] $LpDir_{in} = Lp_{ext} - R'$

[2] $LpRev_{in} = Lp_{ext} - R' + 10Log(8) - 10Log(11) + 6$

All italicised numbers refer to calculation line