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NOISE ASSESSMENT

Speke Hall Avenue, Liverpool
L24 1UY

Client: Barratt Homes.

Report by
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Report Date: 27th July 2011
Ref: 6214 Speke Hall Ave PPG24
Site Visited by: S Mellor MA, Dip. Acoustics, MIOA CMIOSH
Site Visit: 15th July 2011

CONTENTS

1.0 INTRODUCTION

Barratt Homes Ltd. instructed Martec Environmental Consultants Ltd. to undertake a noise assessment to consider the impact of environmental noise on a development at Speke Hall Avenue, Liverpool, L24 1UY as part of a planning application.

This preliminary report considers measurements taken on site, the requirements of PPG24 "*Planning and Noise*" and makes initial recommendations as necessary. Acoustic terminology is explained at Appendix 1; consultants' qualifications at Appendix 2; References at Appendix 3; Traces showing LAmax at Appendix 4; a site plan at Appendix 5; an extract from a Defra Paper appears at Appendix 6 and detailed frequency analysis results are presented at Appendix 7.

2.0 ASSESSMENT CRITERIA

2.1 Road Traffic

2.1.1 PPG 24

This is the main document to which local authorities are directed when deciding planning applications when noise is an issue.

PPG 24 [Ref.1] sets out guidance for local authorities to assist in planning decisions where the proposed site is exposed to noise from road, rail or air traffic or a combination possibly including industrial noise. Noise levels are measured at the site of the proposed dwelling nearest to the source of the noise. These measurements are compared to the levels set out in PPG 24 which places the site into one of four Noise Exposure Categories (NEC).

Annex 1 of PPG24 specifies Noise Exposure Categories (NEC) in terms of the daytime (and night time) $L_{Aeq, 16hr}$ (and $L_{Aeq, 8hr}$) readings. These readings are rounded to the nearest whole number and compared with the NEC bands. The NECs for road traffic are detailed in Table 1.

NEC		**Day ($L_{Aeq, 16hr}$)**	**Night ($L_{Aeq, 8hr}$)**
"A"	Road	< 55	< 45
"B"	Road	55 – 63	45 – 57
"C"	Road	63 – 72	57 – 66
"D"	Road	> 72	> 66

Table 1

PPG24 provides guidance on the suitability of sites depending on the NEC as below-

"A" For proposals in this category, noise would not normally be a controlling issue in granting planning consent.

"B" For proposals in this category, authorities should increasingly

take noise into account when determining planning applications, and require noise control measures.

"C" Whilst planning permission should not normally be granted, where it is given, conditions should be imposed to ensure an adequate level of insulation against external noise.

"D" Consent should normally be refused.

There is provision within PPG24 such that if night time events regularly exceed 82 dBA "slow" several times within any one night time hour then the site should be placed in NEC "C" unless it is already within NEC "D".

With regard to acceptable internal noise levels, in several circumstances, PPG24 refers to BS.8233 [2] (see below).

2.1.2 British Standard 8233

The latest version of BS.8233 "Sound Insulation and noise reduction for buildings - Code of practice", was published in 1999. *"Anonymous noise... is considered in Tables 5 and 6".* Figure 1 below shows an extract of the "Design Range" of BS.8233's Table 5 appears below and it should be noted that the assessment period is day (16 hours) or night (8 hours).

Criterion	Typical Situation	Design Range [LAeq,T dB]	
		Good	Reasonable
Reasonable resting/sleeping conditions	Living Rooms Bedrooms	30 30	40 35

Figure 1: Extract of BS8233 – Table 5

A footnote to this table states that "*For a reasonable standard in bedrooms at night, individual noise events (measured with F time-weighting) should not normally exceed 45 dB LAmax*".

2.1.3 Noise Insulation Proposals

When "Proposals for amending Part E (resistance to the passage of sound): consultation" [6] were published in 2000, this document contained building envelope construction recommendations for various external noise levels (see below).

Section C.1.1 of the Proposals stated
"The guidance in this section is intended to ensure that in all rooms, noise levels due to external sources of noise do not exceed certain target values. These are: 40 dB LAeq,16h in all rooms during the day-time (07:00 23:00); and 30 dB LAeq,8h in all bedrooms during the night-time (23:00 07:00)."

It can be seen therefore, that the noise insulation schemes were designed to meet the "Reasonable" standards from BS.8233 for Living

Rooms during the day and to meet the "Good" standards from BS.8233 for bedrooms at night.

2.2 Aircraft Noise

Although the development site is located approximately 1 mile to the north of John Lennon Airport, noise from aircraft movements should not be significant as the runway runs east-west; noise contour maps produced by Defra (available at http://www.liverpoolairport.com/assets/_files/documents/jul_09/peel__1246462584_Noise_Action_Plan_Consultation.pdf) show that the site is well outside the lowest publish contour (55dB L_{DEN}). Accordingly air traffic noise has not been considered further in this report.

3.0 SITE DESCRIPTION

The site of the proposed development is on the northern side of Speke Hall Avenue with industrial units located off Cartwright's Farm Road to the west of the site and dwellings off Dymchurch Road and School Way to the east of the site.

Road traffic noise from Speke Hall Avenue is the dominant noise source affecting the southern part of the development; similarly road traffic noise from Speke Boulevard is the dominant noise source

affecting the northern part of the development.

The nearest facades (plots 69-71 in DK Architects' drawing Site Plan No 956-002F/20110713) of the southernmost proposed dwellings would be some 10m from the kerbside edge of Speke Hall Avenue. The nearest façades of the northernmost proposed dwellings (plots 187-192) are some 90m to the kerbside edge of Speke Boulevard.

4.0 NOISE MEASUREMENTS

The site was visited on 15th July 2011 and measurements were made at the following locations (see Appendix 5):

(1) at 10m from the kerbside edge of Speke Hall Avenue in free field (the approximate location of nearest façade).

(2) at 20m from the kerbside edge of Speke Boulevard.

(3) at 90m from the kerbside edge of Speke Boulevard (the approximate position of the nearest façade).

The weather conditions during the monitoring period were fine and dry with a temperature varying between 14-23 degrees Celsius during the monitoring period. Wind speeds were 3-4m/s with a north-north westerly direction. Cloud cover varied between 20-60%.

The sound level meters were a Cirrus type CR:821B (s/n C18361FE), microphone system MK:438 (s/n 46637) and a SVAN type 947 (s/n 4280); both were mounted on tripods at a height of 1.2m and fitted

with windmuffs. The Cirrus meter was used for general noise level measurements, the Svan meter was used to make a frequency analysis. The meters calibrated correctly before and after the measurements using a Cirrus calibrator type CR:551E (s/n 039816). Both meters and the calibrator had been laboratory calibrated within the preceding 2 years.

5.0 RESULTS

5.1 Measurement Results

The main results are shown below in Figure 2 and octave band results in Figure 3. The detailed third octave results are shown at Appendix 7.

Location	Start Time	Duration	LAeq	Lmax	L1	L10	L50	L90	L95	Lmin
1	04:00	01:00:01	61.5	74.0	69.9	66.3	55.5	44.9	43.1	36.9
1	05:00	01:00:01	63.1	74.5	70.9	67.5	58.5	49.0	47.0	40.8
1	06:00	01:00:02	61.6	75.4	70.3	66.4	56.0	47.2	45.7	39.8
1	10:00	01:00:04	62.8	76.8	69.9	66.8	59.6	50.7	48.6	41.0
1	11:00	00:59:59	62.9	74.5	70.0	66.9	60.1	51.4	48.7	40.4
1	12:00	01:00:02	63.9	75.7	70.4	67.3	62.0	54.4	52.3	41.9
2	13:26	00:56:50	67.0	93.7	76.4	68.0	64.0	59.4	56.6	48.1
3	14:30	01:00:01	58.0	76.5	64.5	60.5	56.6	50.3	48.8	44.5
3	15:30	01:00:03	64.9	89.8	77.4	65.9	57.3	49.6	48.0	42.9
3	16:30	00:28:59	55.0	70.6	62.9	58.3	51.7	48.4	47.9	46.0

Figure 2 – Main Results/dB

			Frequency/Hz							
Location	Start Time	Duration	63	125	250	500	1000	2000	4000	LAeq
1	05:00'08	01:00:00	59.3	53.3	51.4	51.8	55.5	46.5	38.6	62.3
1	06:00'42	01:00:00	61.3	53.7	50.9	51.3	53.7	45.0	36.8	60.7
1	11:00'02	01:00:00	62.3	56.3	53.8	52.7	55.5	46.7	39.1	62.5
2	13:30'32	00:52:45	69.4	60.0	56.0	56.3	57.4	55.9	52.0	66.9
3	14:30'12	01:00:00	65.9	56.1	51.3	47.9	48.7	42.4	35.0	57.2

Figure 3 – Octave Band Results/dBLin

5.2 Subjective Observations

From observations made at the time of the site visit, at location 1, 10m from the edge of Speke Hall Avenue, road traffic noise was the dominant source with occasional aircraft. Road vehicles produced maximum levels of 65-70LAmax, aircraft produced 62-65LAmax.

At location 2, 25m from Speke Boulevard, road traffic noise was the dominant source; some constructions noise was also audible from the development site itself, where preparatory works appeared to have commenced.

At location 3, 90m from Speke Boulevard, construction activities were audible together with road traffic noise and occasional emergency vehicles on Speke Boulevard. It is considered possible that construction noise could have influenced the measurements of L10 at this location.

6.0 ASSESSMENT OF RESULTS

6.1 PPG24 – Speke Hall Avenue - Daytime

The DoE and DTp have set out guidance in "Calculation of Road Traffic Noise" on how traffic noise levels can be either measured or calculated. The $L_{A10, 18Hr}$ can be found using a shortened measurement procedure, based on the average of any three consecutive hourly L_{A10} measurements, taken between 10am and 5pm, minus 1 dB. This shortened measurement procedure is accurate to +/- 1.5 dB (paragraph 44 of "*Calculation of Road Traffic Noise*").

Based on the above figures from Figure 2, the $L_{A10, 18Hr}$ at the monitoring position was 66dB.

However latest government advice (PPG24) is based on $L_{Aeq, 16Hr}$ (07.00 to 23.00 hr).

The DEFRA publication "*Method for Converting the UK Road Traffic Noise Index $L_{A10,18h}$ to the EU Noise Indices for Road Noise Mapping"*[4] includes formulae (*shown at Appendix 6)* to convert $L_{A10, 18Hr}$ into L_{Day} (07:00-19:00), LAeq,8hr (L_{Night}), LEvening (19:00-23:00) and LAeq,16hr which give results for 'non motorways' of:

The LAeq,16hr = **64dB** to the nearest whole number.
(The LAeq,8hr ***= 56dB*** *to the nearest whole number).*

6.2 PPG24 – Speke Hall Avenue – Night time

Given that Speke Hall Avenue serves John Lennon airport it was considered that it may have uncharacteristically high nighttime traffic flows, accordingly 'Method A' in *Shortened Measurement Procedure for Road Traffic Noise at night – revisited* [Ref.7] has been used in the following assessment which considers the logarithmic average of LAeq values measured between 04:00-07:00 to derive the LAeq,8hr value used by PPG24. Method A tends to slightly overestimate the nighttime traffic noise levels.

Based on the above figures from Figure 2, the LAeq,8hr **= 62dB** to the nearest whole number. *4dB higher than the derived figure based on daytime noise levels.*

Therefore the LAeq criterion places the nearest façade of the development site facing Speke Hall Avenue into NEC "**C**" for both daytime for night time and hence there is no requirement to consider the night time LAmax[S] criterion.

6.3 PPG24 – Speke Boulevard

Using the same method as above [Ref 3] and using the LA10 levels measured at 90m from Speke Boulevard shown in Figure 2, the $L_{A10,\ 18Hr}$ at the monitoring position was 60.6dB.

Again, using the Defra formulae for non motorways [Ref 4],
The LAeq,16hr = **58dB** to the nearest whole number.

The LAeq,8hr **= 51dB** to the nearest whole number.

It should be noted that the L10 figure was noticeably higher during the second hour of monitoring which coincided with heavy construction site activities therefore the derived results are possibly erring on the high side by 1-2dB.

6.4 Maximum Levels – Speke Boulevard

When considering maximum noise levels caused by road traffic, it is generally found that maximum noise levels are not governed by the volume of traffic, but by specific single events such as a car or motorbike passing by at high speed, an empty lorry passing over bumps or potholes in a section of road, a car horn, emergency siren or a vehicle skidding.

From the traces shown at Appendix 4; the typical dBAF maximum noise level was **66dBA** at the monitoring position. The higher transient levels were likely to have been caused by construction site traffic and occasional emergency vehicles and have therefore been disregarded.

It is likely that night time maximum noise levels would be similar and so the night time noise level criterion of 82dB[S] being exceeded several times within one hour is not met.

6.5 Summary of Results – PPG24 – Speke Boulevard

Therefore the Leq criterion places the nearest façade at the northern perimeter of the development in NEC "B" for both daytime and night time. The LAmax,S criterion does not alter the NEC.

It should be noted that construction site traffic is obviously a temporary noise source and so noise levels measured to the north of the site are likely to have been somewhat higher than would be the case once building works have been completed.

7.0 DISCUSSION OF INTERNAL NOISE LEVELS

The following section should be viewed as an indicative assessment using guideline data as the design of the site has not yet been finalized, e.g. room and window sizes etc.

The following is an extract from the proposed changes to Approved Document E discussed in Section 2.3:

"

Envelope constructions for external levels not exceeding 60dBLAeq,16h or 50dBLAeq,8h

7.7 Example envelope constructions are given in Table 7.1 below.

Element	***Example envelope construction***
Wall	*Solid brickwork, brick/block cavity, brick clad timber frame or timber frame with lightweight cladding.*
Window	*Any practical window specification, well sealed when closed.*
Roof	*Tiled/slated roof, 9 kg/m2 plasterboard ceiling.*

Ventilator	*Trickle ventilators.*

Table 7.1 Example envelope constructions for external levels not exceeding 60dBLAeq,16h or 50dBLAeq,8h"

"*Envelope constructions for external levels not exceeding 65dB$L_{Aeq,16h}$ or 60dB$L_{Aeq,8h}$*

7.8 Example envelope constructions are given in Table 7.2 below.

Element	***Example envelope construction***
Wall	*Solid brickwork, brick/block cavity, brick clad timber frame or timber frame with lightweight cladding.*
Window	*Double glazing, 10/12/6 mm, well sealed when closed.*
Roof	*Tiled/slated roof, 9 kg/m^2 plasterboard ceiling, 100 mm sound absorbing layer above the ceiling (for example, mineral wool loft insulation).*
Ventilator	*Mechanical ventilation in bedrooms.* *Acoustic trickle ventilators in other (living) rooms.*

Table 7.2 Example envelope constructions for external levels not exceeding 65dB$L_{Aeq,16h}$ or 60dB$L_{Aeq,8h}$

Envelope constructions for external levels not exceeding 75dB$L_{Aeq,16h}$ or 65dB$L_{Aeq,8h}$

7.9 Example envelope constructions are given in Table 7.3 below.

Element	*Example envelope construction*
Wall	*Solid brickwork, brick/block cavity, brick clad timber frame*
Window	*Double window 6/100/4 mm, limited to not more than 2.5m^2 in area in each habitable room, well sealed when closed.*
Roof	*Tiled/slated roof, 20 kg/m^2 plasterboard ceiling, 100 mm sound absorbing layer above the ceiling (e.g. mineral wool loft insulation) and timber boarding on top of ceiling joists.*
Ventilator	*Mechanical ventilation throughout.*

Table 7.3 Example envelope constructions for external levels not exceeding 75dBL$_{Aeq,16h}$ or 65dBL$_{Aeq,8h}$"

Habitable rooms are generally taken to include dining rooms, living rooms and bedrooms but exclude kitchens, bathrooms and en-suite bathrooms.

7.1 PPG24 – Southern Perimeter Dwellings

PPG24 is not clear on its requirements for sound insulation appropriate to new properties exposed to Noise Exposure Category "C". Annex 2 of PPG24 (which was written in 1994) states that for habitable rooms in existing properties exposed to these levels of noise, secondary glazing should be fitted with silenced mechanical ventilation.

Given that the daytime noise level was 64dB LAeq,16hr and the night time noise level was 62dB LAeq,8hr, the guidelines [ref 6] above

would suggest:

Element	
Wall	*Solid brickwork, brick/block cavity, brick clad timber frame*
Bedroom Window	*Double Window, 6/100/4, well sealed when closed, limited to not more than 2.5m2.*
Other Habitable Room Window	*Double glazing, 10/12/6 mm, well sealed when closed.*
Ventilator	*Mechanical ventilation in bedrooms.* *Acoustic trickle ventilators in other (living) rooms.*
Roof	*Tiled/slated roof, 20 kg/m^2 plasterboard ceiling, 100 mm sound absorbing layer above the ceiling (e.g. mineral wool loft insulation) and timber boarding on top of ceiling joists.*

7.2 PPG24 – Northern Perimeter Dwellings

PPG24 is not clear on its requirements for sound insulation appropriate to new properties exposed to Noise Exposure Category "B". Annex 2 of PPG24 states that for habitable rooms in existing properties exposed to these levels of noise, 'the minimum amelioration measure available to an occupant at night would be to close bedroom windows'.

Given that the derived daytime noise level was 58dB LAeq,16hr and the night time noise level was 51dB LAeq,8hr, the guidelines above would suggest.

Element	
Wall	*Solid brickwork, brick/block cavity, brick clad timber frame*
Bedroom Window	*Double glazing, 10/12/6 mm, well sealed when closed*
Other Habitable Room Window	*Double glazing, 10/12/6 mm, well sealed when closed.*
Ventilator	*Mechanical ventilation in bedrooms.* *Acoustic trickle ventilators in other (living) rooms.*
Roof	*Tiled/slated roof, 20 kg/m^2 plasterboard ceiling, 100 mm sound absorbing layer above the ceiling (e.g. mineral wool loft insulation) and timber boarding on top of ceiling joists.*

7.3 Discussion

As stated, the above recommendations should be viewed as indicative. Once the design is finalised, more detailed internal noise level calculations can be carried out to confirm the findings and 'fine tune' the recommendations.

8.0 CONCLUSIONS

8.1 The levels of road traffic noise affecting the development site place it into NEC "C" at the southernmost façade and NEC "B" at the northernmost facade. Aircraft noise is understood not to be an issue.

8.2 In summary it is recommended that:-

1. Walls - Solid brickwork, brick/block cavity, or brick clad timber frame.
2. For dwellings close to the southern boundary - Tiled/slated roof, 20kg/m^2 plasterboard ceiling, 100mm sound absorbing layer above the ceiling (e.g. mineral wool loft insulation) and timber boarding on top of ceiling joists **or equivalent**.
3. For other dwellings - Tiled/slated roof, 9 kg/m2 plasterboard ceiling.
4. Double Window, 6/100/4, well sealed when closed, limited to not more than 2.5m^2 to be installed in all Bedrooms facing or having a significant view of Speke Hall Avenue coupled with a mechanical ventilation system that complies with the performance specification given in Part 6 of Schedule 1 of the Noise Insulation Regulations 1975 ; this can either be "whole house" (e.g. www.nuaire.co.uk) or "room by room" (e.g. www.silavent.co.uk or www.titon.co.uk).
5. 10/12/6 upgraded thermal glazing, well sealed when closed, to be installed in all Living Rooms with windows facing or having a significant view of Speke Hall Avenue coupled with acoustic trickle vents.

6. 10/12/6 upgraded thermal glazing, well sealed when closed, to be installed in all Bedrooms with windows facing or having a significant view of Speke Boulevard coupled with a mechanical ventilation system that complies with the performance specification given in Part 6 of Schedule 1 of the Noise Insulation Regulations 1975 ; this can either be "whole house" (e.g. www.nuaire.co.uk) or "room by room" (e.g. www.silavent.co.uk or www.titon.co.uk).
7. 4/12/4 standard thermal glazing, well sealed when closed, to be installed in all other rooms with windows coupled with 'hit and miss' trickle vents.

8.3 Once designs are finalised, internal noise level calculations, which will employ Lmax and Frequency Analysis, should be carried out to confirm or modify the above recommendations.

APPENDIX 1
EXPLANATION OF ACOUSTIC TERMS

The dB or the decibel, is the unit of noise. The number of decibels or the level, is measured using a sound level meter. It is common for the sound level meter to filter or 'weight' the incoming sound so as to mimic the frequency response of the human ear. Such measurements are designated **dB(A)**.

A doubling of the sound is perceived, by most people, when the level has increased by 10 dB(A). The least discernible difference is 2 dB(A). Thus most people cannot distinguish between, say 30 and 31 dB(A).

If a noise varies over time then the **equivalent continuous level, or LAeq**, is the notional constant level of noise which would contain the same amount of acoustic energy as the time varying noise.
The following table gives an indication of the comparative loudness of various noises expressed in terms of the A weighted scale:

Source of noise	**dB(A)**	**Nature of Noise**
Inside Quiet bedroom at night	30	Very Quiet
Quiet office	40	
Rural background noise	45	
Normal conversational level	60	
Busy restaurant	65	
Typewriter @ 1m	73	
Inside suburban electric train	76	
Alarm clock ringing @ .5m	80	
Hand clap @ 1m	80	
HGV accelerating @ 6m	92	Very Loud

APPENDIX 2

QUALIFICATIONS AND EXPERIENCE OF M.A. KENYON

My full name is Melville Alexander Kenyon. I am the principal of the firm of Martec Environmental Consultants Ltd, a consultancy company that specialises in environmental noise assessment and control. I hold a Bachelor's degree in Engineering and a Master's degree in Environmental Acoustics. I am a member of the professional body for noise and vibration specialists, the Institute of Acoustics and have sat on the British Standards Committee dealing with noise in buildings [BS.8233].

My company is on the panel of noise advisers the Clay Pigeon Shooting Association and I have lectured at Liverpool John Moores University on the Diploma of Acoustics course and at Manchester Metropolitan University on their Environmental Health degree course.

I have some 28 years experience of dealing with problems caused by noise and vibration, both regarding noise and vibration in the environment, the workplace and the home. The firm of Martec Environmental Engineering was formed 35 years ago. During that time we have advised many groups of both residents and developers about the problems of noise and vibration in the environment.

QUALIFICATIONS OF P. M. DYSON

Peter Dyson holds the Institute of Acoustics Diploma in Acoustics and Noise Control, a Bachelor’s degree in Mechanical Engineering, The Institute of Acoustics Certificates of Competence in Environmental Noise Assessment and in Workplace Noise Measurement. He is a Member of the Institute of Acoustics.

APPENDIX 3

REFERENCES

1 Planning Policy Guidance 24: Planning and Noise. - http://www.communities.gov.uk/publications/planningandbuilding/ppg24

2 BS.8233:1999 "Sound Insulation and noise reduction for buildings – Code of practice."

3 Calculation of Road Traffic Noise (CRTN) – Department of Transport and the Welsh Office, HMSO,1988, ISBN 0-11-550847-3

4 Method for Converting the UK Road Traffic Noise Index $L_{A10,18h}$ to the EU Noise Indices for Road Noise Mapping – TRL/Casella Stanger http://www.defra.gov.uk/environment/quality/noise/research/crtn/documents/noise-crtn-update2006.pdf

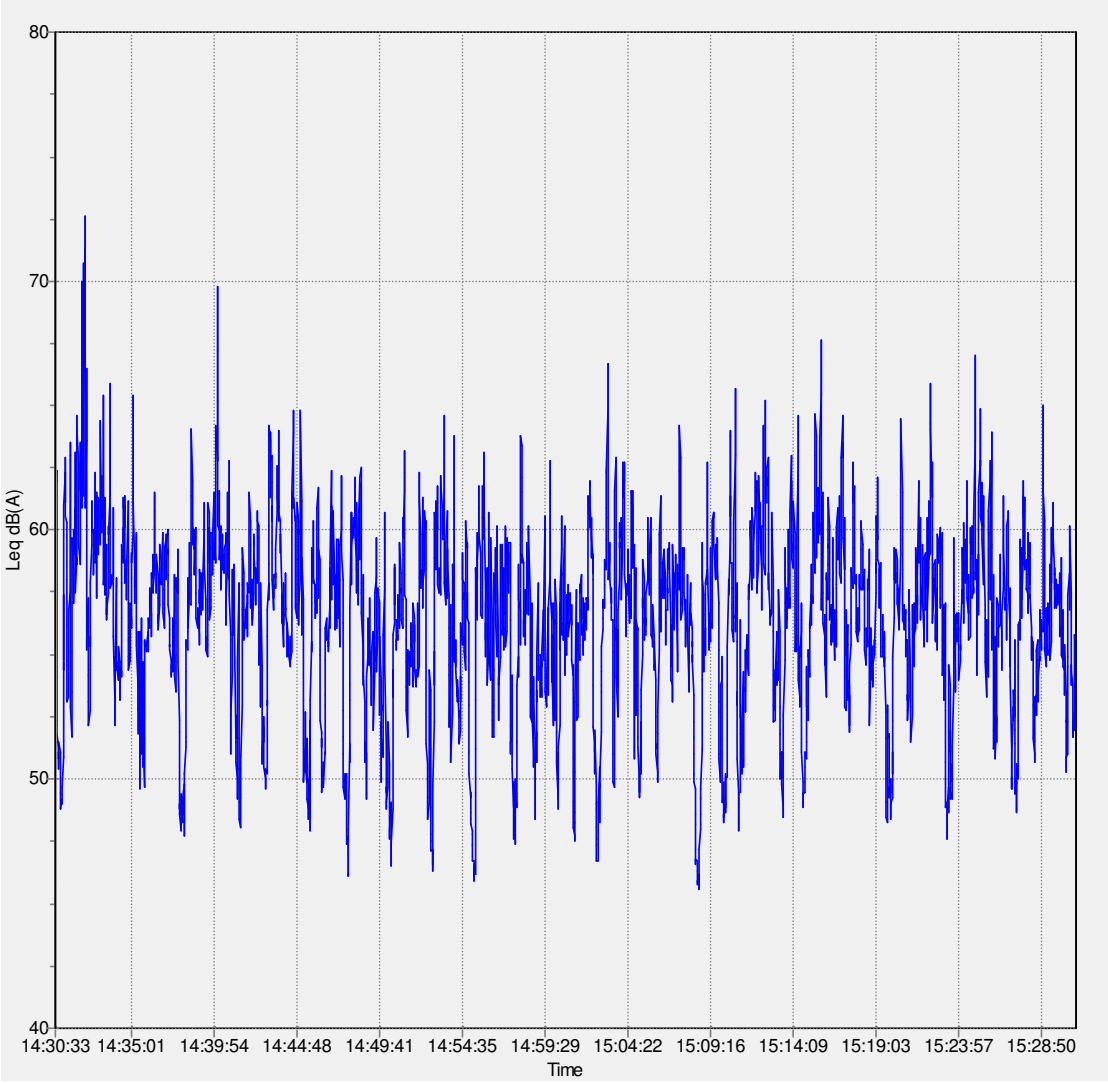
5 BS EN 12354-3:2000 *Building Acoustics-Estimation of Acoustic Performance in buildings from the performance of elements. Part 3 Airborne Sound Insulation against Outdoor Sound.*

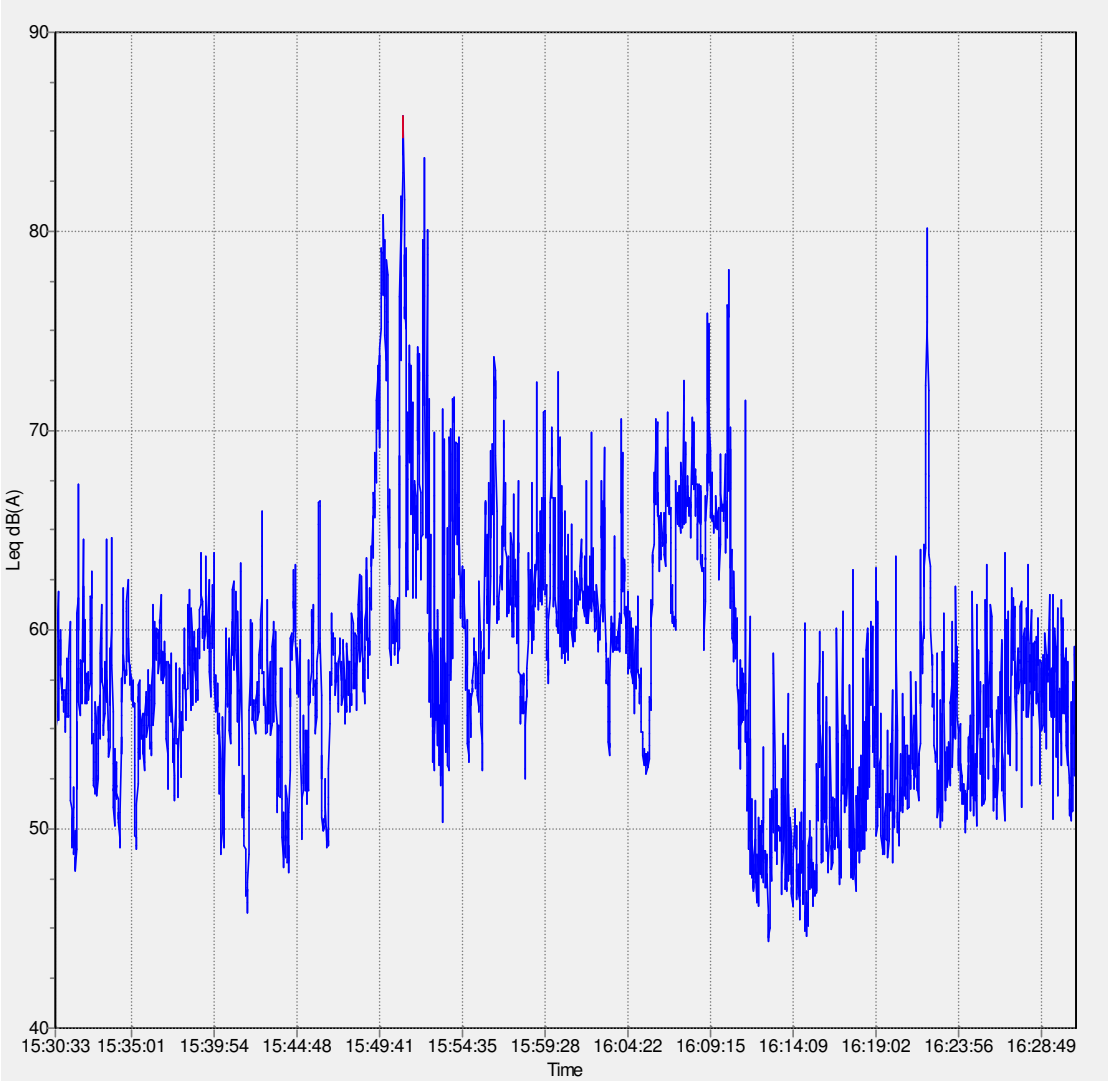
6 Proposals for Amending Part E (Resistance to the Passage of Sound): Consultation. - http://www.communities.gov.uk/documents/planningandbuilding/pdf/proposals-partE.pdf

7 Shortened measurement procedure for road traffic noise at night – revisited. (Euronoise 2009) - http://www.hepworth-acoustics.co.uk/content/EN09_039.pdf

APPENDIX 4

Maximum Noise Levels, Location 3, 90m from Speke Boulevard




90
80
70
60
50
40
Leq dB(A)
15:30:33 15:35:01 15:39:54 15:44:48 15:49:41 15:54:35 15:59:28 16:04:22 16:09:15 16:14:09 16:19:02 16:23:56 16:28:49
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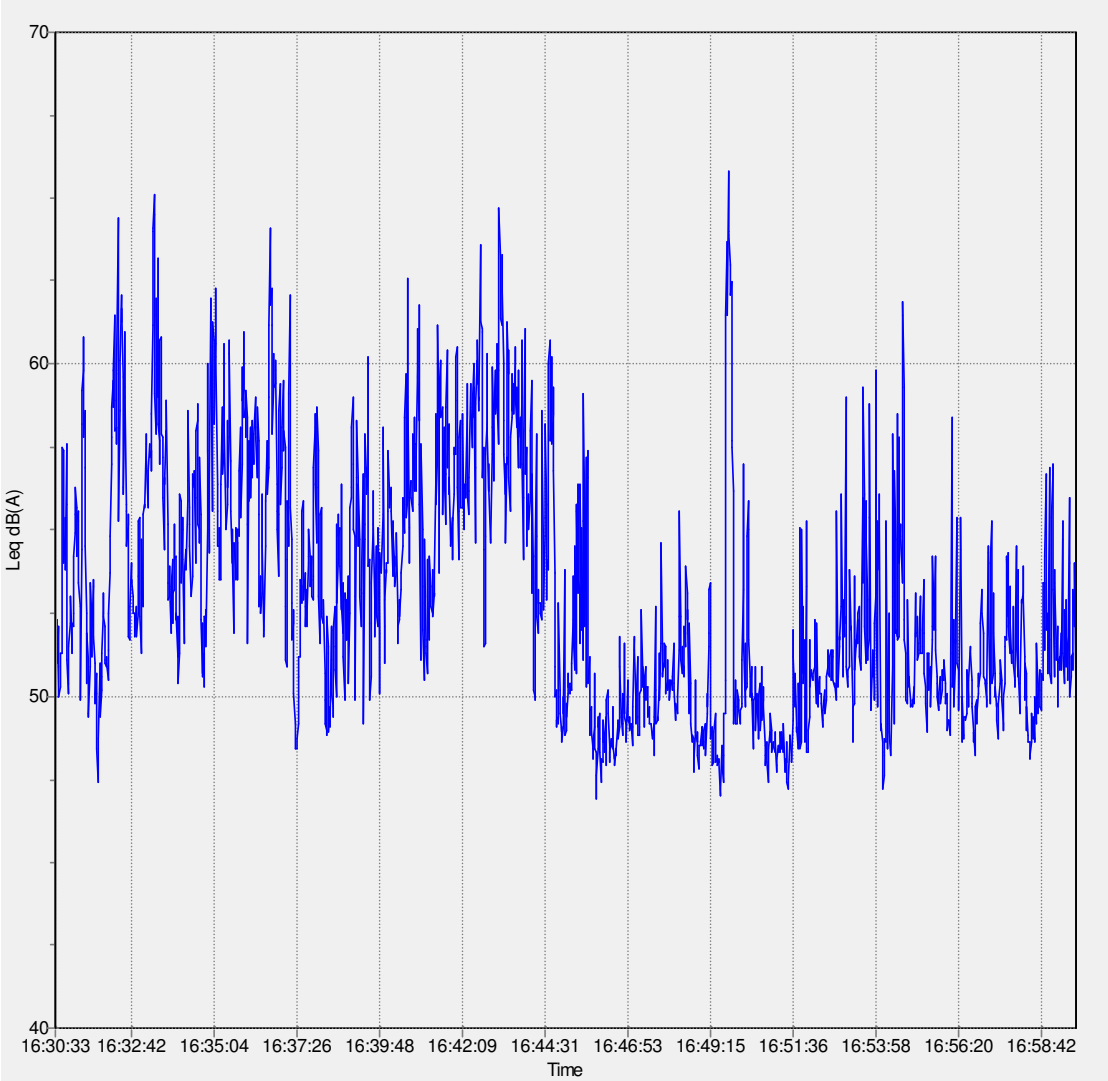
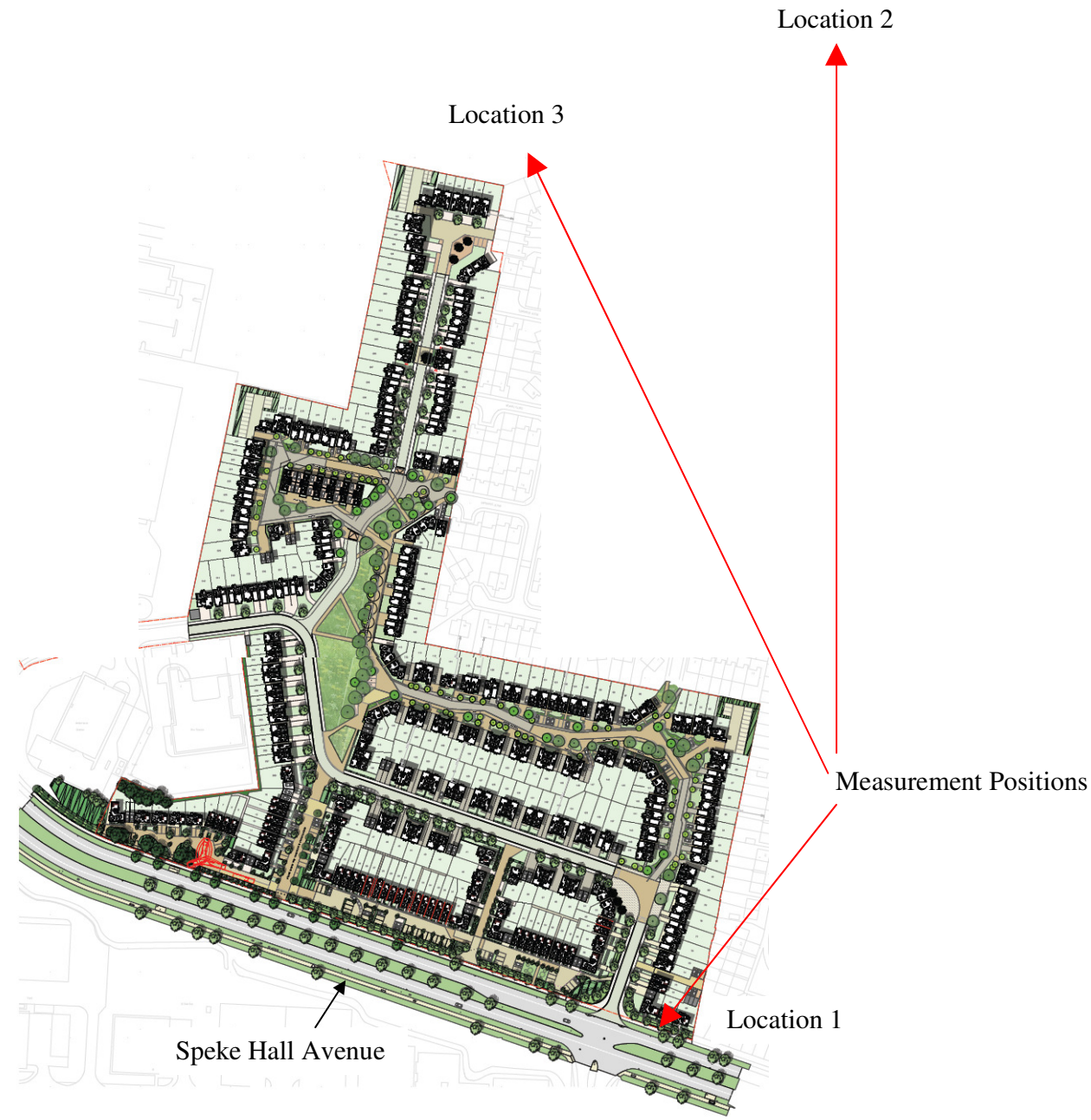


Graph 1 – LAmax,10s

APPENDIX 5

Sketch Plan of Site Showing Monitoring Positions (not to scale)



APPENDIX 6

Formulae to Convert LA10,18h to Lday, Lnight and Levening

For non-motorway roads:

$$L_{day} = 0.95 \times L_{A10,18h} + 1.44 \text{ dB} \quad \textit{(Equation 1)}$$

$$L_{evening} = 0.97 \times L_{A10,18h} - 2.87 \text{ dB} \quad \textit{(Equation 2)}$$

$$L_{night} = 0.90 \times L_{A10,18h} - 3.77 \text{ dB} \quad \textit{(Equation 3)}$$

For motorways:

$$L_{day} = 0.98 \times L_{A10,18h} + 0.09 \text{ dB} \quad \textit{(Equation 4)}$$

$$L_{evening} = 0.89 \times L_{A10,18h} + 5.08 \text{ dB} \quad \textit{(Equation 5)}$$

$$L_{night} = 0.87 \times L_{A10,18h} + 4.24 \text{ dB} \quad \textit{(Equation 6)}$$

Formula to convert Lday and Levening into LAeq,16hr

$$L_{Aeq,16h} = 10 \log_{10} \left[\frac{1}{16} \right] \left[12 \times 10^{L_{day}/10} + 4 \times 10^{L_{evening}/10} \right] dB$$

APPENDIX 7

Detailed Frequency Analysis Results

		Frequency/Hz																						
	Start Time	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	LAeq
S H Avenue	05:00'08	61	61	57	55	55	51	51	52	50.7	50	52.1	53.7	56	57.1	53.8	50.2	47.1	44.2	41.6	38.8	36.7	33.8	30.6	62.3
S H Avenue	06:00'42	63	61	60	56	54	52	51	51	50.4	50	51.3	52.4	54	55.2	52.2	48.7	45.6	42.7	39.9	37.3	34.7	32.7	30.1	60.7
S H Avenue	11:00'02	63	63	61	58	57	55	54	55	52.6	52	52.8	54	56	57.1	53.9	50.1	47.1	44.6	42.2	39.6	36.9	34.3	31	62.5
Boulevard @20m	13:30'32	75	70	67	64	61	58	56	56	56.2	57	55.4	57	57	58	57.1	57.3	55.9	54.8	54.3	52.5	50.1	49.5	48	66.9
Boulevard @90m	14:30'12	69	68	63	60	57	54	53	52	49.4	48	47.9	48	49	49.8	47.7	45.5	42.9	40.2	38.1	35.5	32.8	29.9	26.7	57.2