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REPORT AS7911.140820.NIA

PROJECT OAK
33-34 ALFRED PLACE
LONDON

NOISE IMPACT ASSESSMENT

(DEFAULT SCHEME)

Prepared: 20 August 2014

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List of Attachments

1. INTRODUCTION

Planning approval is being sought for the installation of new building services plant at 33-34 Alfred Place, London as part of the refurbishment works.

Clarke Saunders Associates has been commissioned by Candy & Candy to undertake an environmental noise survey in order to measure the prevailing background noise climate at the site.

The background noise levels measured will be used to determine daytime and night-time noise emission limits for new building services plant in accordance with the planning requirements of Camden Council.

2. SURVEY PROCEDURE & EQUIPMENT

A survey of the existing background noise levels was undertaken at second floor level of the existing building at the location shown in site plan AS7911/SP1. Measurements of consecutive 5 minute L_{Aeq}, L_{Amax}, L_{A10} and L_{A90} sound pressure levels were taken between 15:15 hours on Wednesday 16th July and 02:45 hours on Monday 21st July 2014.

These measurements will allow suitable noise criteria to be set for the new building services plant, dependent on hours of operation.

The following equipment was used during the course of the survey:

- Norsonic data logging sound level meter type 118
- Norsonic sound level calibrator type 1251.

The calibration of the sound level meter was verified before and after use. No calibration drift was detected.

The weather during the survey was dry with light winds, which made the conditions suitable for the measurement of environmental noise.

Measurements were made generally in accordance with ISO 1996-2:2007 *Acoustics - Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels*.

Please refer to Appendix A for details of the acoustic terminology used throughout this report.

3. RESULTS

Figures AS7911/TH1-TH5 show the L_{Aeq}, L_{Amax}, L_{A10} and L_{A90} sound pressure levels as time histories at the measurement position.

4. DISCUSSION

The background noise climate at the property is determined by some existing roof-mounted plant and road traffic noise in the surrounding streets.

Measured minimum background and average noise levels are shown in **Error! Reference source not found.**.

Monitoring period	Minimum $L_{A90,15mins}$	Average $L_{Aeq, T}$
07:00 - 19:00 hours	49 dB 20/07/2014 08:30	57 dB
23:00 - 07:00 hours	49 dB 17/07/2014 05:30	52 dB

Table 4.1 - Minimum measured background and average noise levels [dB ref. 20µPa]

5. DESIGN CRITERIA

Camden Council currently requires new plant to be 5dB below the background level. In addition, the background level must not be exceeded by more than 1dB in any octave band between 63Hz and 8kHz. The typical planning condition is as follows:

Noise levels at a point 1 metre external to sensitive facades shall be at least 5dB(A) less than the existing background measurement (L_{A90}), expressed in dB(A) when all plant/equipment (or any part of it) is in operation unless the plant/equipment hereby permitted will have a noise that has a distinguishable, discrete continuous note (whine, hiss, screech, hum) and/or if there are distinct impulses (bangs, clicks, clatters, thumps), then the noise levels from that piece of plant/equipment at any sensitive façade shall be at least 10dB(A) below the L_{A90}, expressed in dB(A).

It is not expected that tonal noise will be generated by the proposed plant units and so the plant noise emissions criteria that should not be exceeded at the nearest noise sensitive receiver should be set to the proposed levels detailed in Table 5.1 and Table 5.2.

Daytime (07:00 – 23:00 hours)	Night-time (23:00 – 07:00 hours)	24 hours
L_{Aeq} 44 dB	L_{Aeq} 44dB	L_{Aeq} 44 dB

Table 5.1 - Proposed design noise criteria [dB ref. 20µPa]

Freq (Hz)	63	125	250	500	1k	2k	4k	8k
Criterion	52	49	48	45	44	40	35	26

Table 5.2 - Spectral design criterion (L_{A90} 49dB)

6. PREDICTED NOISE IMPACT

6.1 Proposed plant

The selected building services plant has been confirmed as:

- 2 no. Climaster ZCN 13/8;
- 1 no. Climaster ZCN 21/12;
- 2 no. Climaster ZCN 9/6;
- 2 no. Tetris 2A LN 34.4 Chillers.

The proposed location of the plant to be installed is shown on architect's drawing no. 54051/M/R/200, and approximately indicated on the attached site plan AS7911/SP1.

Maximum noise levels generated by the building services plant to be installed have been confirmed by the manufacturer as follows:

AHU/01 Climaster ZCN 13/8

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Supply Inlet Lw	69	70	80	68	64	51	34	27
Extract Outlet Lw	76	79	92	89	87	80	75	69
Breakout Lw	65	69	76	59	54	43	41	37

Table 6.1 – Source noise data for AHU/01 Climaster ZCN 13/8 dB ref. 10^{-12}W

AHU/02 Climaster ZCN 21/12

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Supply Inlet Lw	70	70	74	63	61	52	35	30
Extract Outlet Lw	77	79	86	84	85	81	76	73
Breakout Lw	66	69	70	54	53	47	42	40

Table 6.2 – Source noise data for AHU/02 Climaster ZCN 21/12 **dB ref. 10^{-12}W**

AHU/03 Climaster ZCN 13/8 (extract only)

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Extract Outlet Lw	70	77	76	71	72	66	66	62
Breakout Lw	59	66	60	41	38	32	32	29

Table 6.3 – Source noise data for AHU/03 Climaster ZCN 13/8 **dB ref. 10^{-12}W**

AHU/04 Climaster ZCN 9/6 (extract only)

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Extract Outlet Lw	70	74	79	79	76	72	68	63
Breakout Lw	65	69	76	59	54	43	41	37

Table 6.4 – Source noise data for AHU/04 Climaster ZCN 9/6 **dB ref. 10^{-12}W**

AHU/05 Climaster ZCN 9/6 (extract only)

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Extract Outlet Lw	73	77	82	83	80	76	71	67
Breakout Lw	60	64	64	51	44	40	35	32

Table 6.5 – Source noise data for AHU/05 Climaster ZCN 9/6 **dB ref. 10^{-12}W**

Chiller Tetris 2A LN 34.4

Freq (Hz)	63	125	250	500	1000	2000	4000	8000
Lp @ 10m	24	23	41	49	52	49	44	38

Table 6.6 – Source noise data for Chiller Tetris 2A LN 34.4 **dB ref. 20µPa**

6.2 Predicted Noise Levels

Following an inspection of the site, the nearest noise sensitive receiver is situated on Ridgmount Place at 4th floor level, as shown on the indicative site plan AS7911/SP1. This window is approximately 30 metres away from the nearest proposed plant items.

The cumulative noise level at the nearest noise sensitive receiver, based on the plant being installed as per the architect's drawing, has been calculated using the noise data above. Screening losses afforded by the building edge forming a barrier have been included in the prediction of the cumulative plant noise level at the nearest receiver. An acoustic attenuator has been used for the AHU/02 unit, and a 1.2m high screen has been used in the calculation for the chillers.

The predicted sound pressure level 1m from the receiver is given in the table below

Predicted level at 1m from receiver	Design Criterion
42 dB(A)	44dB(A)

Table 6.7 – Predicted sound pressure level at receiver dB ref. 20µPa

The spectral prediction is given in the table below, alongside the design criterion for comparison.

Freq (Hz)	63	125	250	500	1k	2k	4k	8k
Design criterion	52	49	48	45	44	40	35	26
Predicted level at 1m from receiver	30	35	40	39	39	33	28	23

Table 6.8 – Predicted L90 spectral sound pressure level at receiver dB ref. 20µPa

A summary of the calculations are shown in Appendix B.

Table 6.8 shows that the predicted spectral levels do not exceed the existing L_{90} background noise level by more than 1dB in any octave band, in accordance with Camden Council's requirements.

Any other air handling and extract plant will be fitted with acoustically specified splitter silencers in order that the cumulative noise level does not exceed the 24-hour design noise criterion.

7. CONCLUSION

An environmental noise survey has been undertaken at 33-34 Alfred Place, London by Clarke Saunders Associates between Wednesday 16th July and Monday 21st July 2013.

Measurements have been made to establish the current background noise climate. This has enabled a 24-hour design criterion to be set for the control of plant noise emissions to noise sensitive properties, in accordance with Camden Council's requirements.

Manufacturer's data for the new proposed air handling and chiller units have been used to predict the noise impact of the new plant on neighbouring residential properties.

Compliance with the noise emission design criterion has been demonstrated. No further mitigation measures are, therefore, required for external noise emissions.

Alex Foster
CLARKE SAUNDERS ASSOCIATES

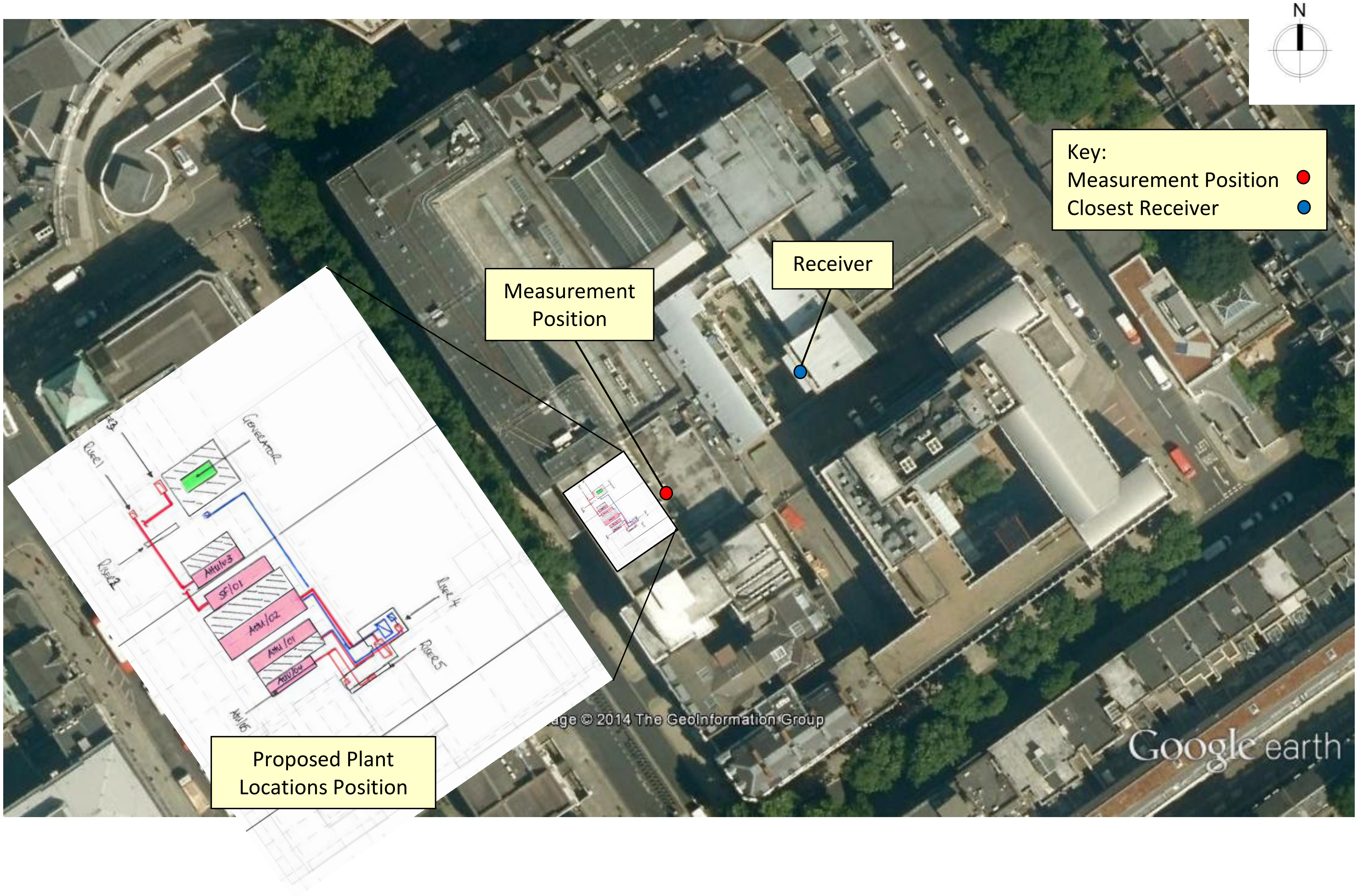
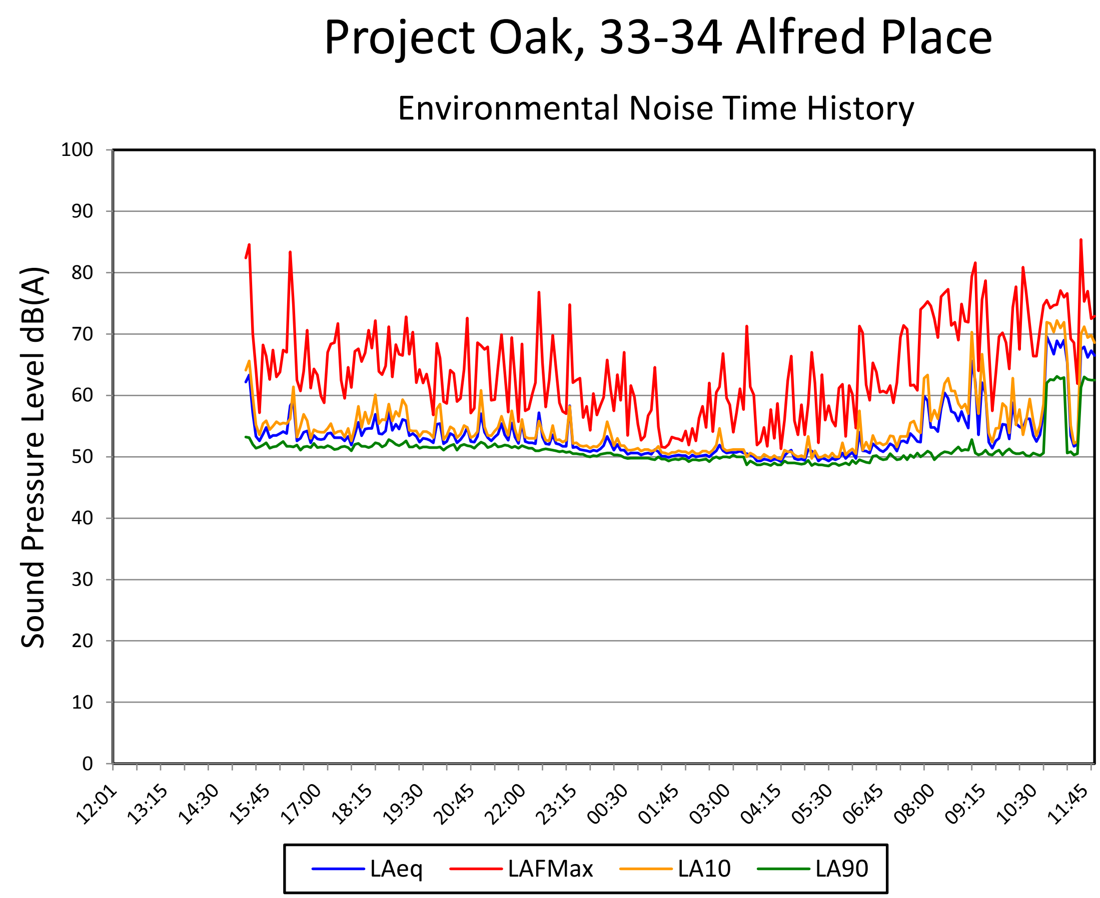


Figure AS7911/SP1

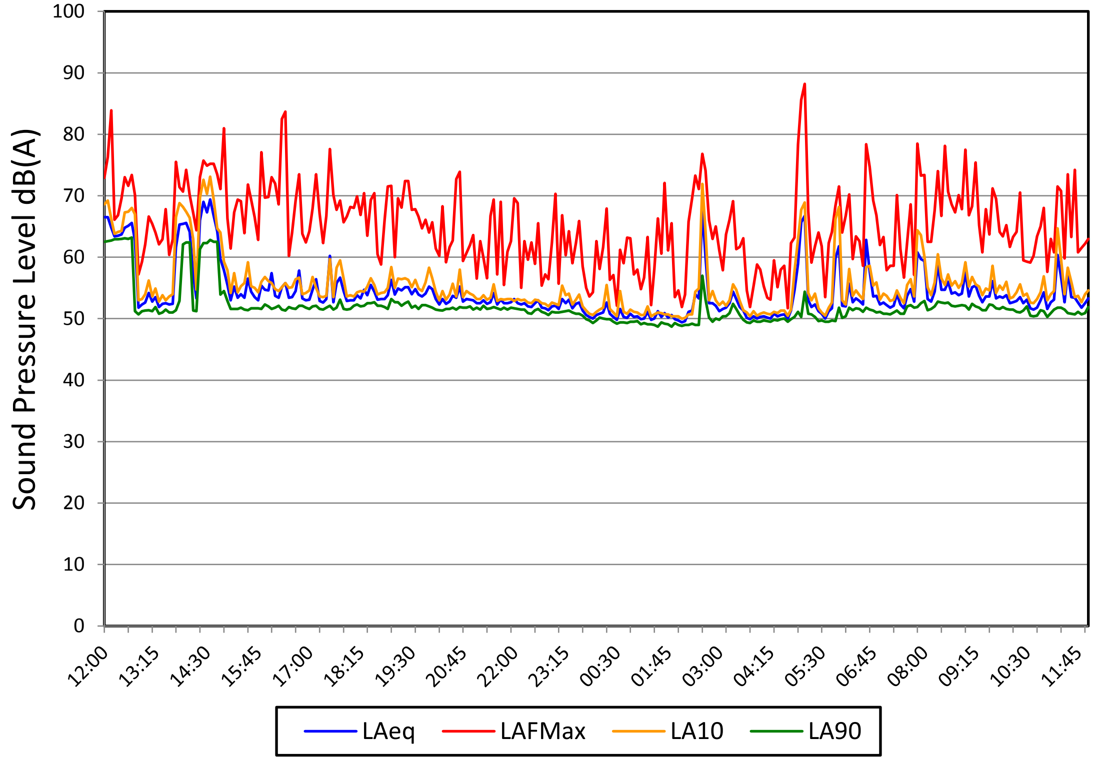


Wednesday 16 July to Thursday 17 July 2014

Figure AS7911/TH1

Project Oak, 33-34 Alfred Place

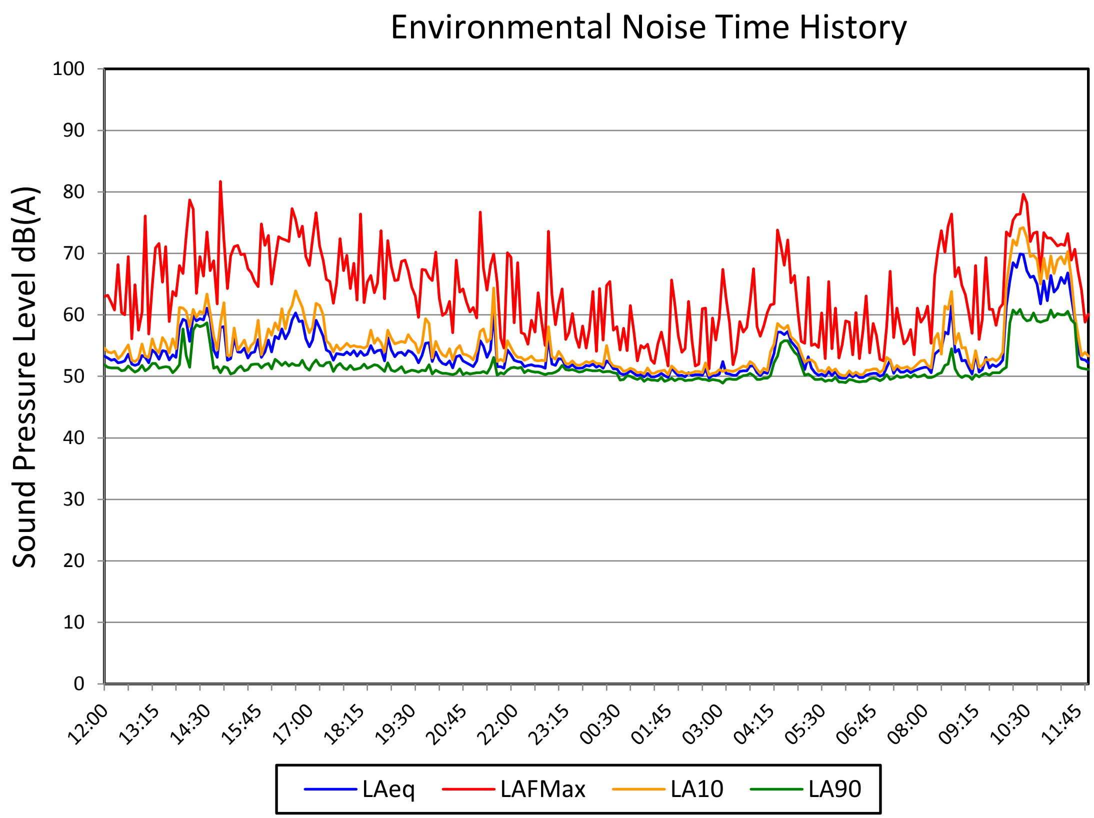
Environmental Noise Time History



Thursday 17 July to Friday 18 July 2014

Figure AS7911/TH2

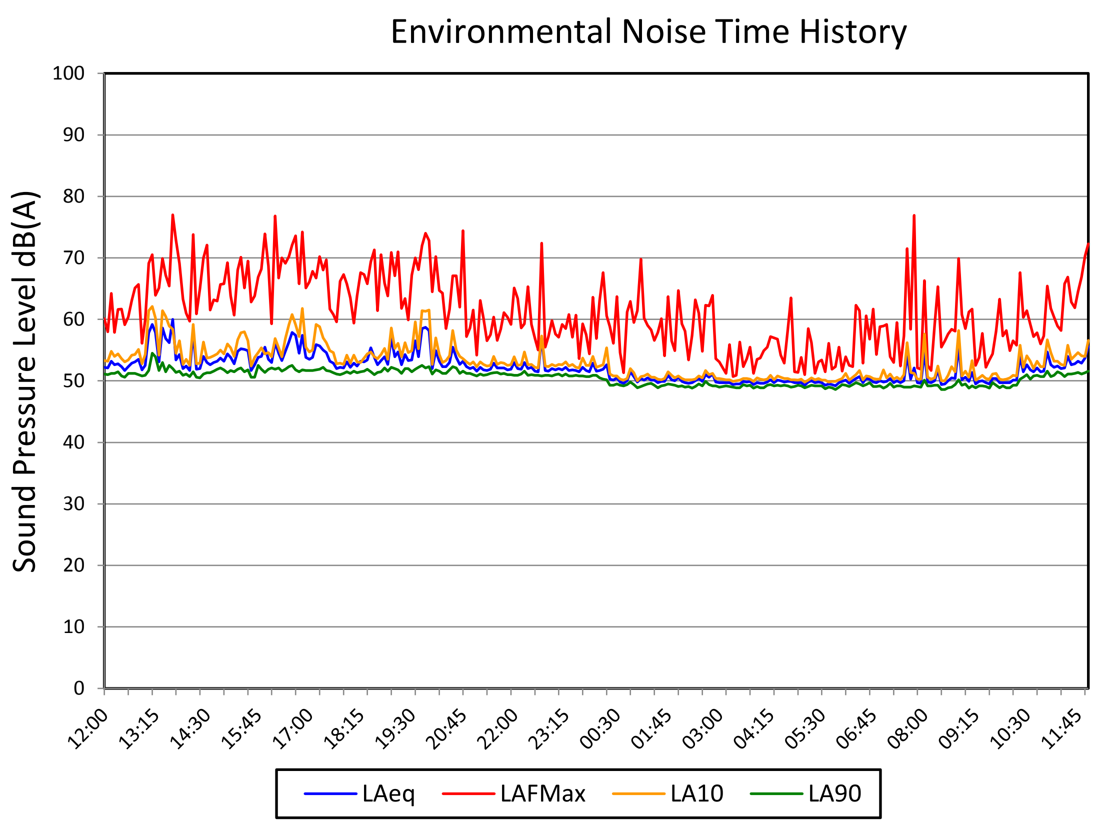
Project Oak, 33-34 Alfred Place



Friday 18 July to Saturday 19 July 2014

Figure AS7911/TH3

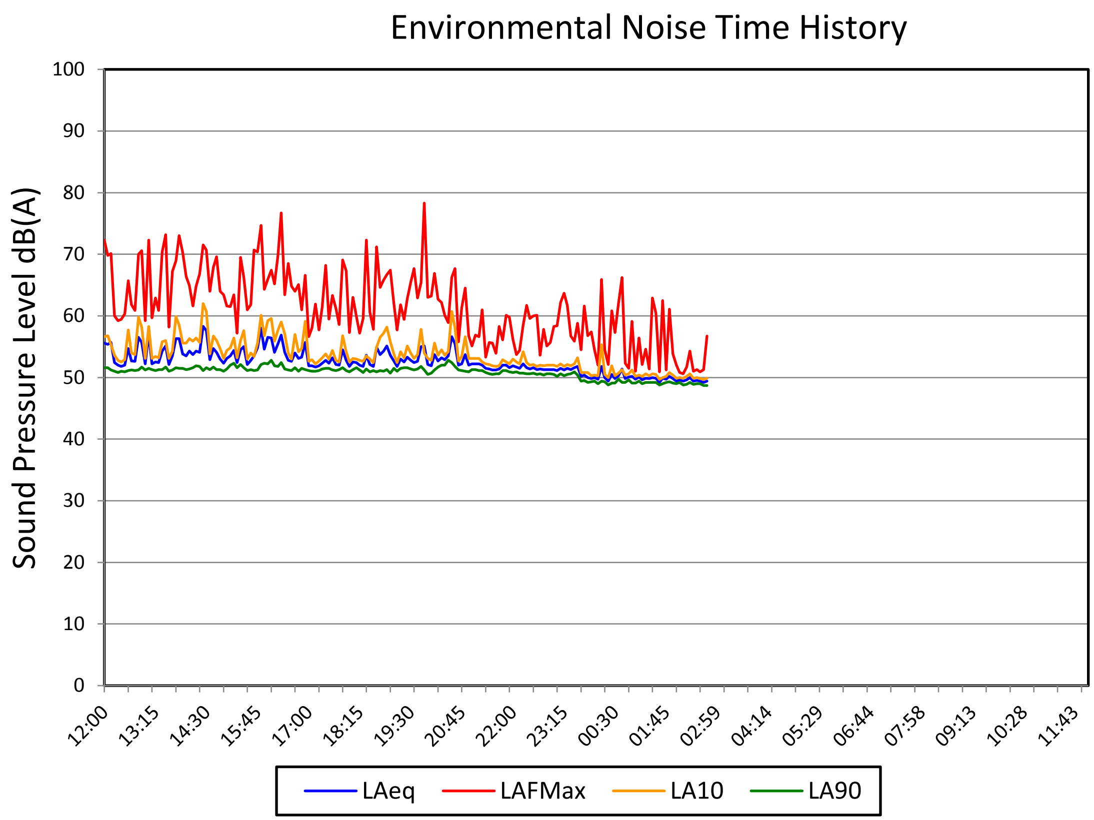
Project Oak, 33-34 Alfred Place



Saturday 19 July to Sunday 20 July 2014

Figure AS7911/TH4

Project Oak, 33-34 Alfred Place



Sunday 20 July to Monday 21 July 2014

Figure AS7911/TH5

APPENDIX A

ACOUSTIC TERMINOLOGY & HUMAN RESPONSE TO BROADBAND NOISE

1.0 ACOUSTIC TERMINOLOGY

The annoyance produced by noise is dependent upon many complex interrelated factors such as 'loudness', its frequency (or pitch) and any variations in its level. In order to have some objective measure of the annoyance, scales have been derived to allow for these subjective factors.

dB (A): The human ear is more susceptible to mid-frequency noise than the high and low frequencies. To take account of this when measuring noise, the 'A' weighting scale is used so that the measured noise corresponds roughly to the overall level of noise that is discerned by the average human. It is also possible to calculate the 'A' weighted noise level by applying certain corrections to an un-weighted spectrum. The measured or calculated 'A' weighted noise level is known as the dB(A) level.

L_{10} & L_{90} : If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time, hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the `average maximum level'. Similarly, L_{90} is the average minimum level and is often used to describe the background noise.

It is common practice to use the L_{10} index to describe traffic noise, as being a high average, it takes into account the increased annoyance that results from the non-steady nature of traffic noise.

L_{eq} : The concept of L_{eq} (equivalent continuous sound level) has up to recently been primarily used in assessing noise in industry but seems now to be finding use in defining many other types of noise, such as aircraft noise, environmental noise and construction noise.

L_{eq} is defined as a notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (e.g. 8 hour, 1 hour, etc).

The use of digital technology in sound level meters now makes the measurement of L_{eq} very straightforward.

Because L_{eq} is effectively a summation of a number of noise events, it does not in itself limit the magnitude of any individual event, and this is frequently used in conjunction with an absolute noise limit.

L_{max} : L_{max} is the maximum sound pressure level recorded over the period stated. L_{max} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the L_{eq} noise level.

D The sound insulation performance of a construction is a function of the difference in noise level either side of the construction in the presence of a loud noise source in one of the pair of rooms under test. *D*, is therefore simply the *level difference* in decibels between the two rooms in different frequency bands.

D_w D_w is the *Weighted Level Difference* The level difference is determined as above, but weighted in accordance with the procedures laid down in BS EN ISO 717-1.

$D_{nT,w}$ $D_{nT,w}$ is the *Weighted Standardised Level Difference* as defined in BS EN ISO 717-1 and represents the *weighted level difference*, as described above, corrected for room reverberant characteristics.

C_{tr} C_{tr} is a spectrum adaptation term to be added to a single number quantity such as $D_{nT,w}$, to take account of characteristics of a particular sound.

$L'_{nT,w}$ $L'_{nT,w}$ is the *Weighted Standardised Impact Sound Pressure Level* as defined in BS EN ISO 717-2 and represents the level of sound pressure when measured within room where the floor above is under excitation from a calibrated tapping machine, corrected for the receive room reverberant characteristics.

APPENDIX A

ACOUSTIC TERMINOLOGY & HUMAN RESPONSE TO BROADBAND NOISE

2.0 OCTAVE BAND FREQUENCIES

In order to determine the way in which the energy of sound is distributed across the frequency range, the International Standards Organisation have agreed on "preferred" bands of frequency for sound measurement and analysis. The widest and most commonly used band for frequency measurement and analysis is the Octave Band. In these bands, the upper frequency limit is twice the lower frequency limit, with the band being described by its "centre frequency" which is the average (geometric mean) of the upper and lower limits, eg. 250 Hz octave band runs from 176 Hz to 353 Hz. The most commonly used bands are:

Octave Band Centre Frequency Hz	63	125	250	500	1000	2000	4000	8000

3.0 HUMAN PERCEPTION OF BROADBAND NOISE

Because of the logarithmic nature of the decibel scale, it should be borne in mind that noise levels in dB(A) do not have a simple linear relationship. For example, 100dB(A) is not twice as loud as 50 dB(A) sound level. It has been found experimentally that changes in the average level of fluctuating sound, such as traffic noise, need to be of the order of 3 dB(A) before becoming definitely perceptible to the human ear. Data from other experiments have indicated that a change in sound level of 10 dB(A) is perceived by the average listener as a doubling or halving of loudness. Using this information, a guide to the subjective interpretation of changes in traffic noise level can be given.

INTERPRETATION

Change in Sound Level dB(A)	Subjective Impression	Human Response
0 to 2	Imperceptible change in loudness	Marginal
3 to 5	Perceptible change in loudness	Noticeable
6 to 10	Up to a doubling or halving of loudness	Significant
11 to 15	More than a doubling or halving of loudness	Substantial
16 to 20	Up to a quadrupling or quartering of loudness	Substantial
21 or more	More than a quadrupling or quartering of loudness	Very Substantial

4.0 EARTH BUNDS AND BARRIERS - EFFECTIVE SCREEN HEIGHT

When considering the reduction in noise level of a source provided by a barrier, it is necessary to establish the "effective screen height". For example if a 3 metre high barrier exists between a noise source and a listener, with the barrier close to the listener, the listener will perceive the noise source is louder, if he climbs up a ladder (and is closer to the top of the barrier) than if he were standing at ground level. Equally if he sat on the ground the noise source would seem quieter than it was if he were standing. This may be explained by the fact that the "effective screen height" is changing with the three cases above, the greater the effective screen height, in general, the greater the reduction in noise level.

Where the noise sources are various roads, the attenuation provided by a fixed barrier at a specific property will be greater for roads close to the barrier than for roads further away.

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

AHU1

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Supply Inlet		Lw	69	70	80	68	64	54	34	27	
End Reflection			-8	-4	-1	0	0	0	0	0	
Propagation Correction			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			1	2	2	3	4	5	5	5	
Distance loss	37 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-13	-15	-18	-18	-18	-18	-18	-18	
SPL at receiver			10	13	24	14	10	1	0	0	18

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Extract Outlet		Lw	76	79	92	89	87	80	75	69	
End Reflection			-8	-4	-1	0	0	0	0	0	
Propagation Correction			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			1	2	2	3	4	5	5	5	
Distance loss	37 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-13	-15	-18	-18	-18	-18	-18	-18	
SPL at receiver			17	22	36	35	33	27	22	16	37

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Breakout		Lw	65	68	76	59	53	46	41	36	
Propagation Correction			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			3	4	5	6	6	6	6	6	
Distance loss	37 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-13	-15	-18	-18	-18	-18	-18	-18	
SPL at receiver			16	17	24	7	1	0	0	0	16

Combined SPL at receiver	20	24	36	35	33	27	22	16	37

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

AHU2

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Supply Inlet		Lw	70	70	74	63	61	52	35	30	
Attenuator			-2	-6	-11	-20	-23	-19	-12	-9	
End Reflection			-8	-4	-1	0	0	0	0	0	
Propagation Correction			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			1	2	2	3	4	5	5	5	
Distance loss	36 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-5	-5	-5	-5	-6	-7	-8	-10	
SPL at receiver			17	17	20	2	0	0	0	0	13

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Extract Outlet		Lw	77	79	86	84	85	81	76	73	
Attenuator			-2	-6	-11	-20	-23	-19	-12	-9	
End Reflection			-8	-4	-1	0	0	0	0	0	
Propagation Correction			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			1	2	2	3	4	5	5	5	
Distance loss	36 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-5	-5	-5	-5	-6	-7	-8	-10	
SPL at receiver			24	26	32	23	21	21	21	19	29

			63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Breakout		Lw	66	68	70	54	51	47	42	40	
Propagation			-8	-8	-8	-8	-8	-8	-8	-8	
Directivity			3	4	5	6	6	6	6	6	
Distance loss	36 m		-31	-31	-31	-31	-31	-31	-31	-31	
Barrier			-5	-5	-5	-5	-6	-7	-8	-10	
SPL at receiver			25	28	31	15	12	7	0	0	23

Combined SPL at receiver	28	31	35	24	21	21	21	20	30

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

AHU3

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Extract Outlet	Lw	70	77	76	71	72	66	66	62	
End Reflection		-8	-4	-1	0	0	0	0	0	
Propagation Correction		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		1	2	2	3	4	5	5	5	
Distance loss	35 m	-31	-31	-31	-31	-31	-31	-31	-31	
Barrier		-5	-5	-5	-6	-6	-7	-9	-11	
SPL at receiver		19	31	33	30	30	24	23	16	34

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Breakout	Lw	59	66	60	41	38	32	32	29	
Propagation		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		3	4	4	5	6	6	6	6	
Distance loss	35 m	-31	-31	-31	-31	-31	-31	-31	-31	
Barrier		-5	-5	-5	-6	-6	-7	-9	-11	
SPL at receiver		18	26	20	2	0	0	0	0	14

Combined SPL at receiver	22	32	33	30	31	24	23	17	34

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

AHU4

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Extract Outlet	Lw	70	74	79	79	76	72	68	63	
End Reflection		-8	-4	-1	0	0	0	0	0	
Propagation Correction		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		1	2	2	3	4	5	5	5	
Distance loss	38 m	-32	-32	-32	-32	-32	-32	-32	-32	
Barrier		-11	-13	-16	-19	-22	-25	-28	-31	
SPL at receiver		12	19	25	24	18	12	5	0	24

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Breakout	Lw	57	61	61	47	40	36	32	28	
Propagation		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		2	3	4	4	5	6	6	6	
Distance loss	38 m	-32	-32	-32	-32	-32	-32	-32	-32	
Barrier		-11	-13	-16	-19	-22	-25	-28	-31	
SPL at receiver		8	11	9	0	0	0	0	0	8

Combined SPL at receiver	14	19	25	24	19	13	7	3	24

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

AHU5

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Extract Outlet	Lw	73	77	82	83	80	76	71	67	
End Reflection		-8	-4	-1	0	0	0	0	0	
Propagation Correction		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		1	2	2	3	4	5	5	5	
Distance loss	39 m	-32	-32	-32	-32	-32	-32	-32	-32	
Barrier		-11	-13	-16	-19	-22	-25	-28	-31	
SPL at receiver		15	22	27	28	22	16	8	1	28

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
Breakout	Lw	60	64	64	51	44	40	35	32	
Propagation		-8	-8	-8	-8	-8	-8	-8	-8	
Directivity		2	3	4	4	5	6	6	6	
Distance loss	39 m	-32	-32	-32	-32	-32	-32	-32	-32	
Barrier		-11	-13	-16	-19	-22	-25	-28	-31	
SPL at receiver		11	14	12	0	0	0	0	0	9

Combined SPL at receiver	17	22	28	28	22	16	9	4	28

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

Chillers

		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dB(A)
SPL	10 m	24	23	41	49	52	49	44	38	55
No. of Units	2	3	3	3	3	3	3	3	3	
Propagation Correction		3	3	3	3	3	3	3	3	
Distance loss	28 m	-9	-9	-9	-9	-9	-9	-9	-9	
Barrier (1.2m high)		-6	-7	-9	-11	-14	-16	-19	-22	
SPL at receiver		15	13	29	35	36	30	22	13	38

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

Summary

	SPL @ Receiver	
AHU/01	37	
AHU/02*	30	*with silencer
AHU/03	34	
AHU/04	24	
AHU/05	28	
Chillers**	38	**1.2m Screen
TOTAL SPL	**42**	**dB(A)**

APPENDIX B

AS7911: 33-34 Alfred Place
Plant Noise Calculations (Default Scheme)

Summary

Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	dB(A)
AHU/01	20	24	36	35	33	27	22	16	37
AHU/02*	28	31	35	24	21	21	21	20	30
AHU/03	22	32	33	30	31	24	23	17	34
AHU/04	14	19	25	24	19	13	7	3	24
AHU/05	17	22	28	28	22	16	9	4	28
Chillers**	15	13	29	35	36	30	22	13	38
Cumulative SPL	**30**	**35**	**40**	**39**	**39**	**33**	**28**	**23**	**42**
Design Criterion	**52**	**49**	**48**	**45**	**44**	**40**	**35**	**26**	**44**

*with silencer   ** 1.2m screen