Appendix A9.3

Anderson Acoustics Reports

BASELINE NOISE AND VIBRATION MONITORING

BANK STATION CAPACITY UPGRADE PROJECT

DRAGADOS SA

FEBRUARY 2014

BASELINE NOISE AND VIBRATION MONITORING
BANK STATION CAPACITY UPGRADE PROJECT

Our Ref: 2142_005r_2-0_ack

Anderson Acoustics

Client:	**Dragados SA** Bank Station Capacity Upgrade Project Office 84 Eccleston Square London SW1V 1PX
Report by:	**Anderson Acoustics Limited** 3 Trafalgar Mews 15-16 Trafalgar Street Brighton East Sussex BN1 4EZ www.andersonacoustics.co.uk T: 01273 696887
Date:	**7 February 2014**
Project No:	2142
Status:	**FINAL**

Author	**Andrew Knight** Assistant Consultant BSc (Hons) TechIOA	7 February 2014
Reviewed	**Richard Sullivan** Principal Consultant BSc (Hons) MIOA	7 February 2014
Approved	**Steve Summers** Technical Director BSc MSc CEng MIOA	7 February 2014

REVISION HISTORY

Version	Comments	Changes made by	Approved by
1-0	Draft report for comment	Richard West, Richard Sullivan	Steve Summers
2-0	Incorporating reviewer comments	Andrew Knight, Richard Sullivan	Steve Summers

PAGE LEFT INTENTIONALLY BLANK

CONTENTS

1 INTRODUCTION

This technical report provides the survey results for baseline noise and vibration monitoring undertaken between October and December 2013 at various locations in the vicinity of the proposed Bank Station Capacity Upgrade works in the City of London (CoL). This work was conducted on behalf of Dragados for the Bank Station Capacity Upgrade Project.

Baseline noise and vibration surveys are required in order to carry out the following tasks:

- Assessment of potential construction noise and vibration impacts;
- Identification of appropriate on-site and off-site mitigation;
- Applications for section 61 consent under the Control of Pollution Act 1974 (CoPA);
- Assessment of operational noise from the design of fixed installations;
- Determine suitability of site for over-site development; and
- Assessment of operational vibration from new southbound running tunnel.

Dragados document reference DRA-8798-MST-CIV-000156 provides the detailed method statement for the baseline surveys undertaken in this report.

This report describes the noise and vibration measurements conducted, the measurement locations, noise and vibration units and metrics derived from the survey data and the instrumentation used.

A plan showing the locations of the measurement positions is provided in Appendix A and a completed Survey Report Form is provided for each measurement location in Appendix B. The results of the measurements are presented in Appendix C and Appendix D.

2 MEASUREMENT UNITS AND INDICES

2.1 Noise

The noise survey instrumentation recorded a number of statistical indices, all of which are made available in the raw result data. Only those indices defined in the Method Statement are presented in this report. The following indices are reported, which were measured using "F" time response (fast) as defined in BS EN 61672: Part 1: 2003 [1].

- The $L_{Aeq,T}$ noise level – This is the "equivalent continuous A-weighted sound pressure level, in decibels" and is defined in British Standard BS 7445 [2] as the "*value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval, T, has the same mean square sound pressure as a sound under consideration whose level varies with time*".

  It is an index commonly used to describe construction noise and noise from industrial premises and is the most suitable index for the description of most other forms of environmental noise. In more straightforward terms, it is a measure of energy within the varying noise;

- The $L_{Amax,F}$ noise level – This is the maximum noise level recorded over the measurement period using the Fast time response;

- The $L_{A90,T}$ noise level – This is the noise level that is exceeded for 90% of the measurement period and gives an indication of the noise level during quieter periods. It is often referred to as the background noise level and is used in the assessment of disturbance from industrial noise.

2.2 Vibration

The vibration survey instrumentation recorded continuous raw acceleration data in the X, Y and Z axis which was then post-processed to derive the vibration dose value (VDV) and peak particle velocity (PPV).

- PPV – The peak particle velocity is the greatest instantaneous particle velocity during a given time interval;

- VDV - The vibration dose value is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. The VDV defines the relationship that yields a consistent assessment of continuous, intermittent, occasional and impulsive vibration and correlates well with subjective response.

3 MEASUREMENT LOCATIONS AND DURATIONS

The baseline noise and vibration monitoring has been carried out at a number of locations in the vicinity of the proposed Bank Station Capacity Upgrade works. The method statement for the baseline noise and vibration monitoring, which contains the measurement protocol, is referenced in Section 1. The locations include sensitive buildings that may be affected by the Bank Station Capacity Upgrade works.

The following survey durations have been adopted:

- 7 to 14 day long term unattended external noise monitoring;
- 2 hour short term attended vibration monitoring; or
- 24 hour short term unattended vibration monitoring

3.1 Noise

Long term unattended noise monitoring was carried out in locations representative of receptors, where equipment could be left in a safe and secure position for the duration of the survey. This was undertaken at several locations for a period of between seven and fourteen days, including a weekend. The surveys were all located on buildings at second floor window height or above. Many locations were situated on roofs or balconies of buildings. Measurements were taken 1 metre from the building facade.

Noise surveys were undertaken in accordance with BS 7445:1991 – Description and Measurement of Environmental Noise. The surveys required a period of acceptable weather conditions, i.e. no prolonged showers, periods of heavy rain or wind speeds in excess of 5 m/s. Surveys were extended beyond seven days when these conditions were not met. At location BSCU/N/1 a second survey was carried out due to insufficient battery power to extend the survey requiring a reinstall after recharge. Weather conditions during the survey periods have been obtained from internet sources in accordance with the method statement and are shown in the Survey report Forms in Appendix B.

The reported weather station data was sourced from IENGLAND274 (Angel/Farringdon, London) on www.wunderground.com. Notes were also taken of the general weather conditions when out on site and from the Anderson Acoustics London Bridge office during the surveys to confirm that the weather station data reported was representative (within acceptable limits).

To provide further assurances, weekly data from IENGLAND274 was compared to that from other weather stations surrounding the survey locations (ILONDONL28 Bermondsey and IENGLAND499 Upton Park) to see if they were generally the same. In most cases similar weather conditions were reported at all three stations.

All baseline noise monitoring locations are summarised below in Table 3.1 and in detail in the Survey Report Forms in Appendix B.

Table 3.1 – Summary of Noise Survey Locations

Location Reference	Address	Survey Duration	Installation Date	Collection Date
BSCU/N/1*	Nicholas Lane facade of 10 King William Street, London, EC4N 7DN	9 day	31/10/2013	09/11/2013
		11 day	15/11/2013	26/11/2013
BSCU/N/2	Daiwa Offices, 5 King William Street, London, EC4N 7AX	14 day	31/10/2013	14/11/2013
BSCU/N/4	Arthur Street facade of 10 Arthur Street, London, EC4R 9AY	14 day	04/11/2013	18/11/2013
BSCU/N/5	Martin Lane facade of 10 Arthur Street, London, EC4R 9AY	14 day	04/11/2013	18/11/2013
BSCU/N/6	Abchurch Yard facade of 131/133 Cannon Street, London, EC4N 5AX	8 day	26/11/2013	04/12/2013

* This survey was repeated due to bad weather and insufficient battery power to extend initial survey.

3.2 Vibration

Vibration monitoring was undertaken at several locations to measure the continuous raw acceleration data to enable the calculation of both the Vibration Dose Value (VDV) and Peak Particle Velocity (PPV). London Underground (LU) train movements were considered to be the main source of environmental vibration, and therefore the PPV and VDV has been determined from measurements of train pass-bys over a sample period of two hours.

Measurement locations were identified by consultation and liaison between URS, LU and Anderson Acoustics.

All baseline vibration monitoring locations are summarised below in Table 3.2 and in detail in the Survey Report Forms in Appendix B.

Table 3.2 – Summary of Vibration Survey Locations

Location Reference	Address	Survey Duration	Installation Date	Collection Date
BSCU/V/2	1-6 St Swithin's Lane, London, EC4N 8AL	2 hour	20/11/2013	21/11/2013
BSCU/V/4	St Mary Abchurch, Abchurch Lane, London, EC4N 7BA	24 hour	13/11/2013	14/11/2013
BSCU/V/5	St Clements Church, Clements Lane, London, EC4N 7AE	2 hour	12/11/2013	12/11/2013
BSCU/V/6	8-10 Mansion House Place, London, EC4N 8BJ	2 hour	19/11/2013	20/11/2013
BSCU/V/7	The Mansion House, Mansion House Place, London, EC4N 8LB	2 hour	21/11/2013	22/11/2013

4 MEASUREMENT INSTRUMENTATION

4.1 Noise

The following instrumentation has been used for the noise monitoring surveys:

- Rion NL-52 type 1 sound level meter with Rion NH-25 pre-amplifier and Rion UC-59A ½ inch pre-polarized condenser microphone with a Rion WS-15 windshield;

and calibrated with a:

- Rion NC-74 type 1 acoustic calibrator.

The equipment for long term surveys were set up with the sound level meters within water resistant environmental cases. The meters were powered by sealed lead acid batteries. The microphones were fitted with weatherproof windshields.

All noise measurement instrumentation was calibrated both prior to and immediately following each survey period. Calibration drifts are reported, but no significant calibration drifts occurred, with the maximum calibration drift of 0.3 dB observed.

All sound level meters were within one year of laboratory calibration traceable to UK National Standards. Calibration certificates for the instrumentation used for the noise surveys are provided in Appendix E.

4.2 Vibration

The following instrumentation system has been used for the vibration monitoring surveys:

- Rion DA-20 Data Recorder with Dytran 3233A triaxial accelerometer fixed using beeswax to a heavy mounting plate meeting DIN Standard 45669-2:2005.

The data recorder and accelerometer used for the vibration surveys were each within one year of laboratory calibration. Calibration certificates for this equipment are provided in Appendix E.

The calibration deviation for the complete system (which includes all cables used) was checked by recording calibration tones at 2.5 m/s^2 at both 80Hz and 160Hz using a laboratory shaker table at AV Calibration and the percentage error calculated in all three axes. The calibration deviation calculated from the measured tones ranged from 0.4% to 3.6%. In the absence of any international or British Standard specifically applicable to this instrument, a calibration deviation of less than or equal to 3.6% is deemed acceptable as it is within the range of +/-10% deviation adopted as an acceptable benchmark by a number of UK Calibration Laboratories.

5 MEASUREMENT RESULTS

5.1 Noise

The long term $L_{Aeq,T}$, $L_{max,F}$, L_{A90} noise monitoring results are presented as time history graphs in Figures C.1 to C.5 of Appendix C. The full results of the noise monitoring surveys are provided in raw data form and can be obtained from the following url: https://andersonacousticsltd.box.com/banknoisedata.

5.2 Vibration

The 2 hour vibration acceleration data is presented as time history graphs in Figures D.1 to D.5 of Appendix D.

The results of the vibration monitoring surveys have been processed using Prosig DATS-lite software version 7.0.23 to derive the Vibration Dose Value (VDV) and Peak Particle Velocity (PPV) for all train pass-by

events during a two hour period for each location. The exact times are presented in the Survey Report Forms in Appendix B. The full results of the vibration monitoring surveys are provided in raw data form along with a spreadsheet containing the calculated PPV and VDV values for each train event and can be obtained from the following url: https://andersonacousticsltd.box.com/bankvibrationdata.

6 REFERENCES

1. British Standards Institution. British Standard EN 61672: Electroacoustics – Sound Level Meters, Part 1. Specifications, 2003;
2. British Standards Institution. British Standard 7445: Description and Measurement of Environmental Noise, Part 1. Guide to Quantities and Procedures, 1991;
3. British Standards Institution. British Standard 6472: Guide to Evaluation of Human Exposure to Vibration in Buildings, Part 1. Vibration Sources other than Blasting, 2008;
4. British Standards Institution. British Standard ISO 4866: Mechanical Vibration and Shock – Vibration of Fixed Structures – Guidelines for the Measurement of Vibrations and Evaluation of their Effects on Structures, 2010.

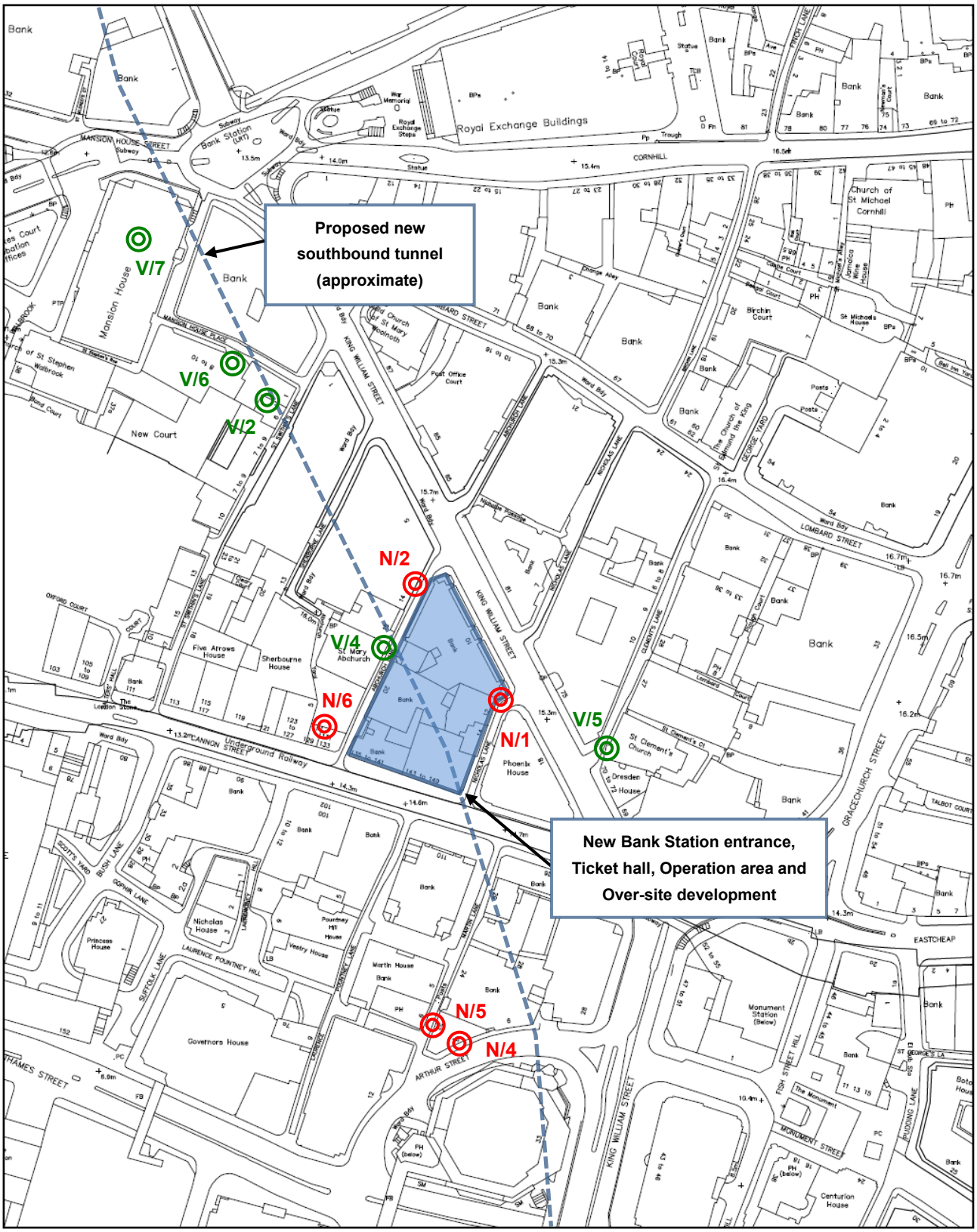
7 APPENDICES

Appendix A – Measurement Locations
Appendix B – Survey Report Forms
Appendix C – Baseline Noise Monitoring Results
Appendix D – Baseline Vibration Monitoring Results
Appendix E – Calibration Certificates

APPENDIX A

MEASUREMENT LOCATIONS

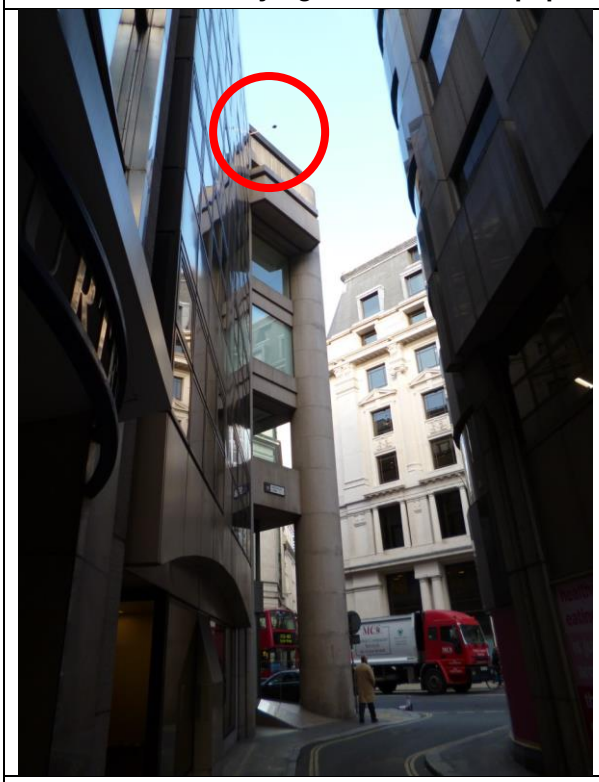
Figure A.1 Location Plan of Noise and Vibration Monitoring Positions



APPENDIX B

SURVEY REPORT FORMS

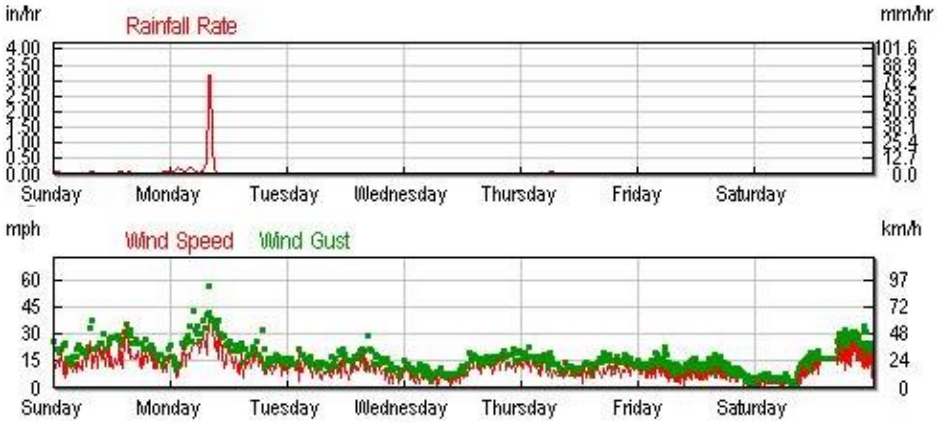
Location	BSCU/N/1 Nicholas Lane facade of 10 King William Street, London (Part 1)		
Personnel	Richard West / Andrew Knight (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00620960	**Pre-amplifier Type** **Serial No.**	NH-25 21001
Microphone Type **Serial No.**	UC-59 03878	**Calibrator Type** **Serial No.**	Rion NC-74 35125828
Start Date	31/10/2013	**End Date**	09/11/2013
Start Time	15:15	**End Time**	04:25
Start Calibration Level	94.0	**End Calibration Level**	93.9
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes



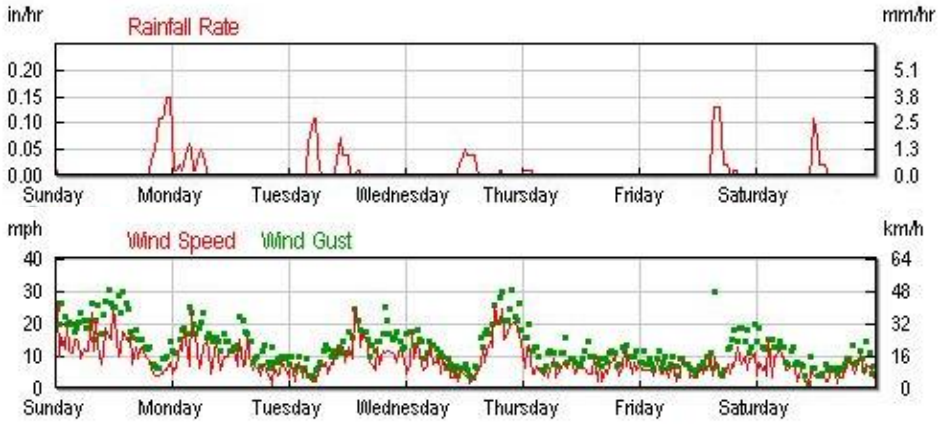
Description of site (Location of equipment, general surroundings etc.)	
Roof of building, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by road traffic throughout the daytime, evening and night time periods, with occasional construction noise during the daytime. There was also low level noise from plant on an adjacent roof.	

Description of weather conditions at start and end of survey
Start: 15ºC, wind 1.8 m/s, humidity 73%, dry, overcast. End: 11ºC, wind 2-4 m/s, humidity 58%, dry, light cloud. There were 3 days of weather acceptable for noise monitoring at this location during survey period Part 1: 1st, 2nd and 7th November.
Weather overview

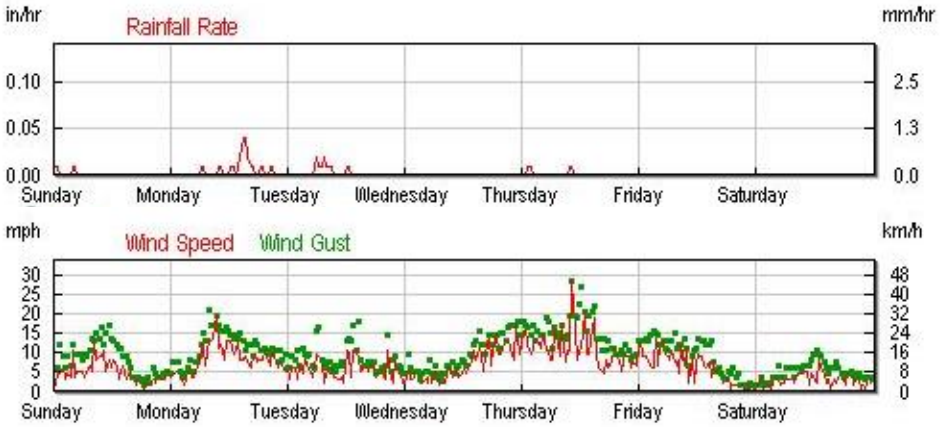
Week 45 (27/10/2013 to 02/11/2013)



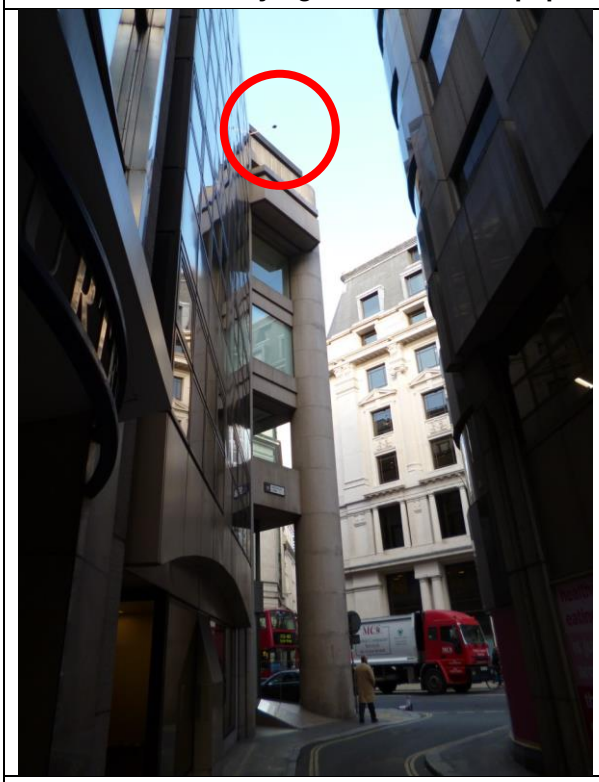
Week 46 (03/11/2013 to 09/11/2013)



Week 47 (10/11/2013 to 16/11/2013)



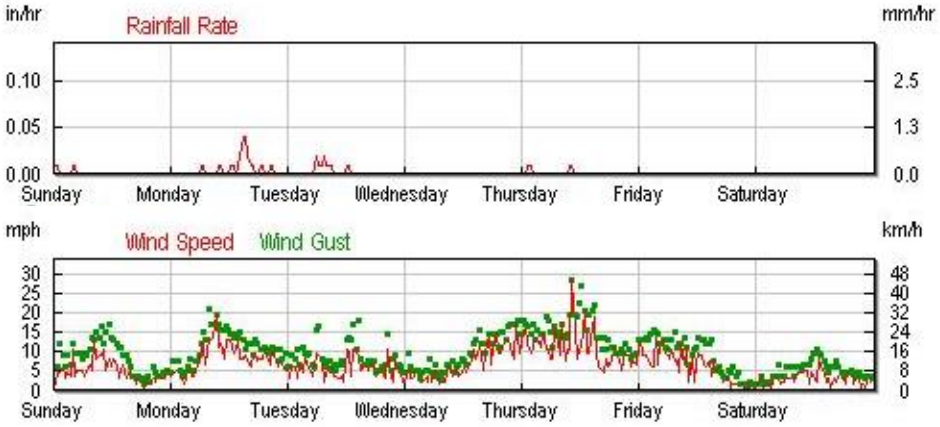
Location	BSCU/N/1 Nicholas Lane facade of 10 King William Street, London (Part 2)		
Personnel	Andrew Knight / Richard West (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00620960	**Pre-amplifier Type** **Serial No.**	NH-25 21001
Microphone Type **Serial No.**	UC-59 03878	**Calibrator Type** **Serial No.**	Rion NC-74 35125828 / 34625646
Start Date	15/11/2013	**End Date**	26/11/2013
Start Time	16:00	**End Time**	11:46
Start Calibration Level	94.0	**End Calibration Level**	93.8
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes



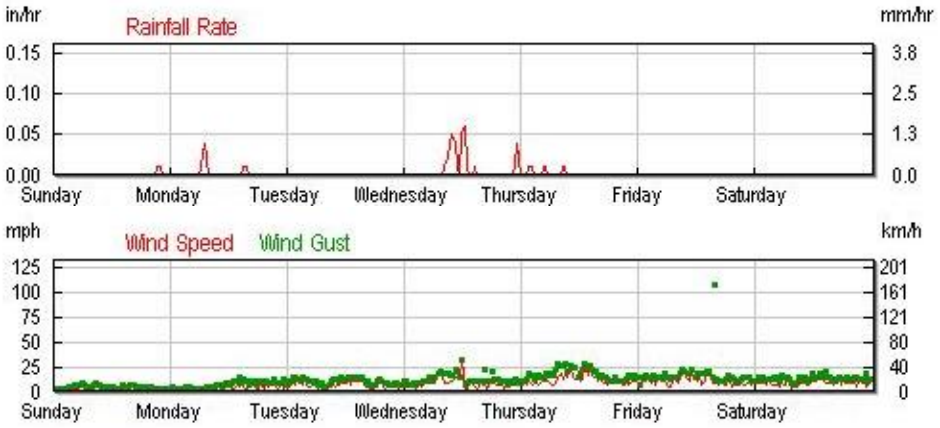
Description of site (Location of equipment, general surroundings etc.)	
Roof balcony on top of building, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by road traffic throughout the daytime, evening and night time periods, with occasional noise from manual work at road level during the daytime. There was also low level noise from plant on an adjacent roof.	

Description of weather conditions at start and end of survey
Start: 11ºC, wind 1.2 m/s, dry. End: 8ºC, wind 3.3 m/s dry. There were 9 days of good weather at this location during survey period Part 2: 16th to 19th and 21st to 25th November.
Weather overview

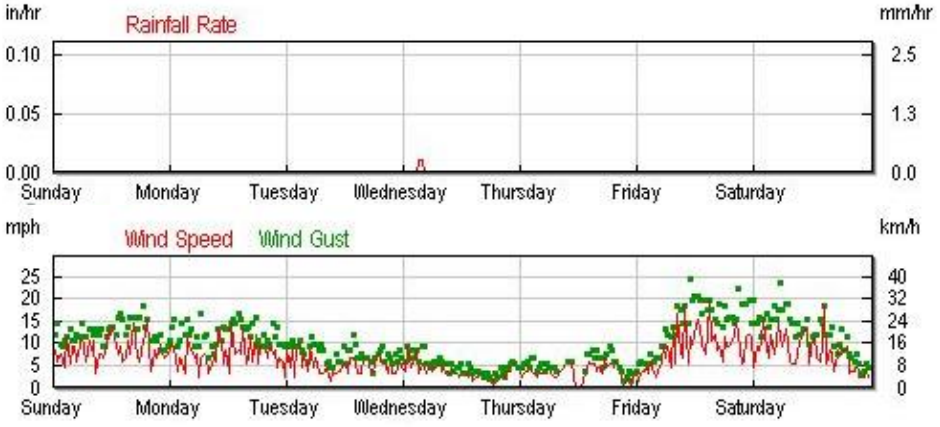
Week 47 (10/11/2013 to 16/11/2013)



Week 48 (17/11/2013 to 23/11/2013)



Week 49 (24/11/2013 to 30/11/2013)



Location	BSCU/N/2 Daiwa Offices, 5 King William Street, London		
Personnel	Richard West / Andrew Knight (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00732147	**Pre-amplifier Type** **Serial No.**	NH-25 32175
Microphone Type **Serial No.**	UC-59 05339	**Calibrator Type** **Serial No.**	Rion NC-74 35125828
Start Date	31/10/2013	**End Date**	14/11/2013
Start Time	13:10	**End Time**	14:17
Start Calibration Level	94.0	**End Calibration Level**	93.7
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)	
Balcony on 4th floor of building, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by road traffic throughout the daytime, evening and night time periods. There was also low level noise from plant on an adjacent roof.	

Furthermore, scaffolding was being removed from 5th to 13th November during the daytime periods. The time history graph shows this quite well, especially on 6th to 8th November and the morning of Saturday 9th November. After this the effect is less because the scaffolding removal work was occurring at a lower level and further away from the microphone.

Night-time L_{A90} levels were higher at the start of the survey than at the end. This appears to be due to plant on an adjacent roof which was observed as a source of low level noise while the survey personnel were on site installing the monitoring equipment. Listening to the audio recordings from 02:00 hours each night substantiates this conclusion. On 10th to 13th November there is occasional light traffic and it's very quiet in between vehicles, whereas on 1st to 3rd November there is more overall constant background noise between vehicles assumed to be due to the plant on an adjacent roof.

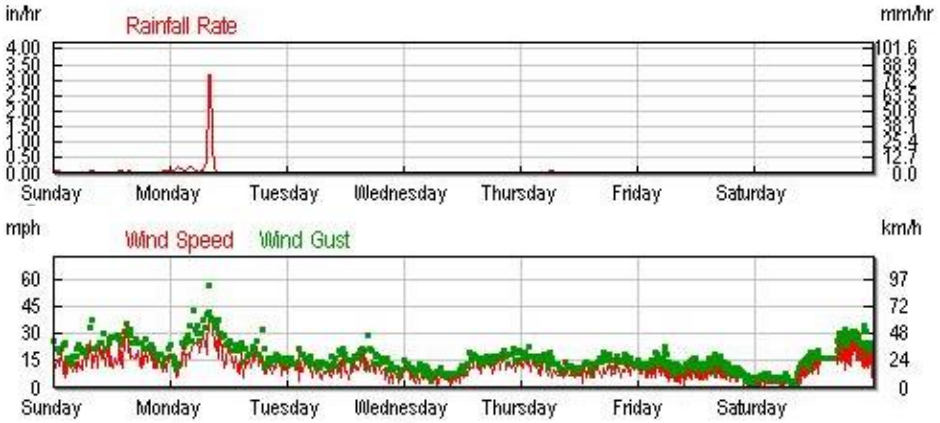
Overall the start of the survey from 31st October to 5th November appears to be the most suitable period for analysis, as the effect of adverse weather conditions during this period is considered a lot less significant than the effect of the scaffolding removal work. It should be noted however that scaffolding removal only affected daytime levels. The evening and night-time noise levels were not affected.

Description of weather conditions at start and end of survey

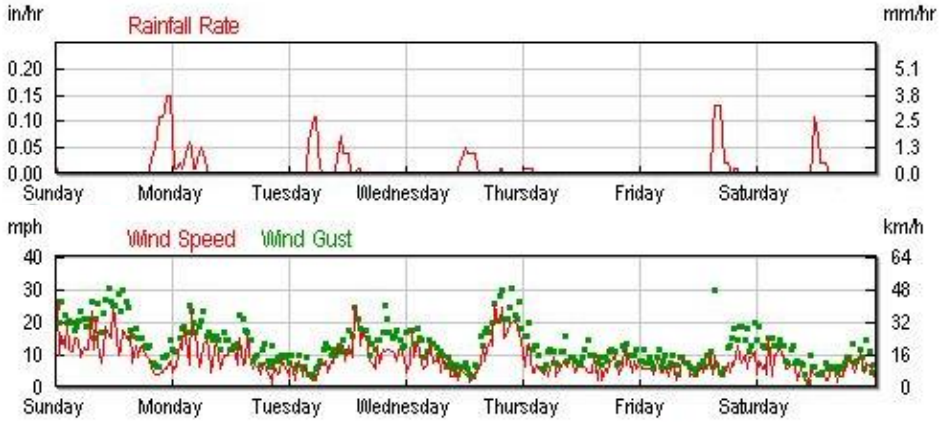
Start: 18ºC, negligible wind, humidity 58%, dry, overcast.
End: 11ºC, wind 2-4 m/s, humidity 58%, dry, light cloud.
There were 6 days of weather acceptable for noise monitoring at this location: 1st, 2nd 7th, 10th, 12th and 13th November.

Weather overview

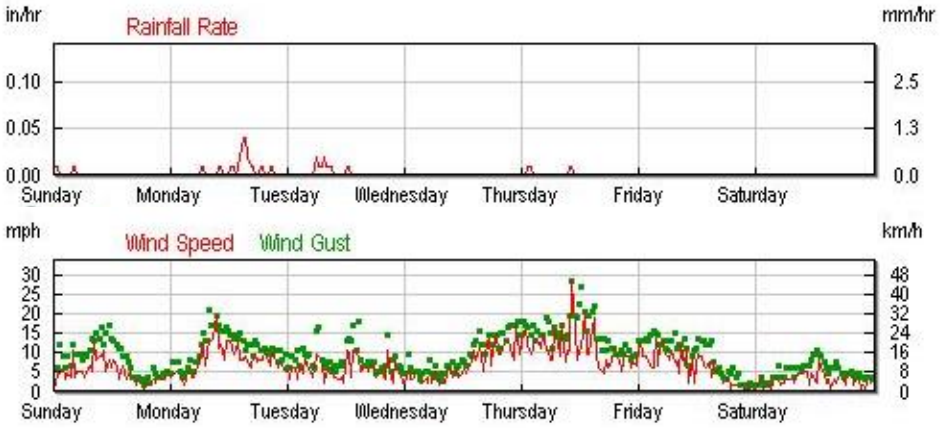
Week 45 (27/10/2013 to 02/11/2013)



Week 46 (03/11/2013 to 09/11/2013)

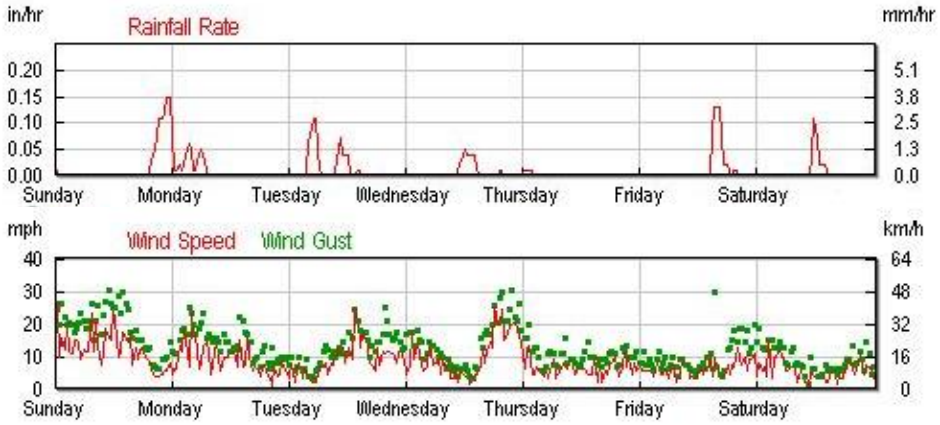
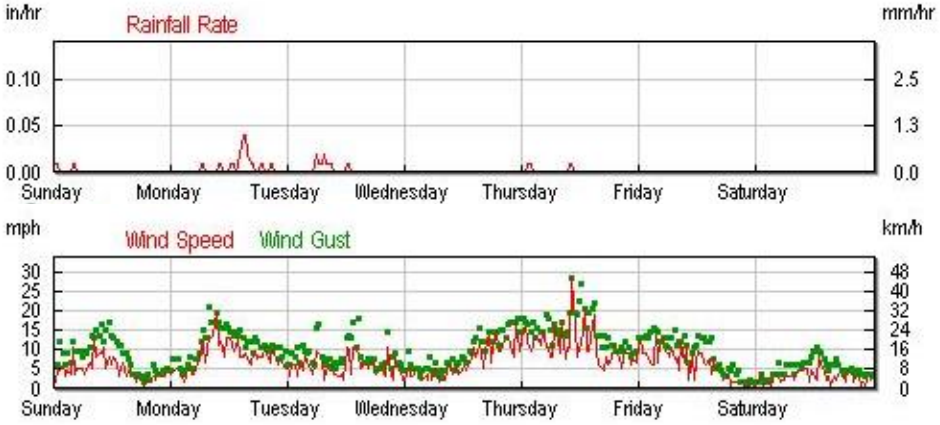
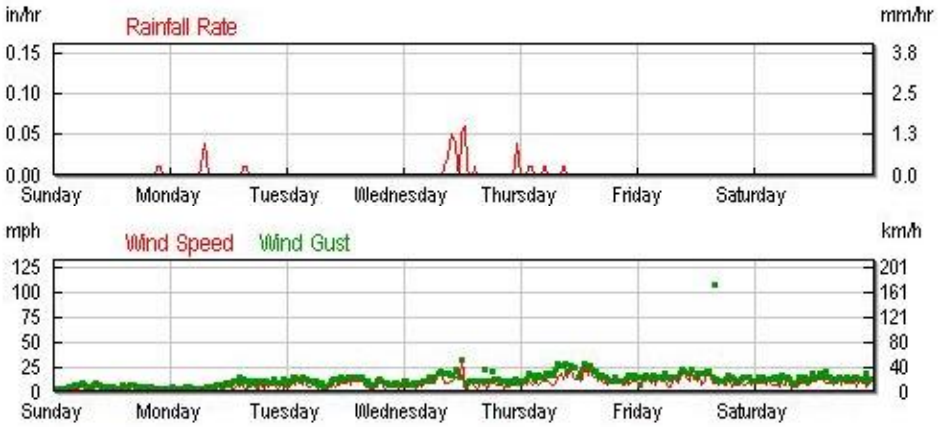


Week 47 (10/11/2013 to 16/11/2013)



Location	BSCU/N/4 Arthur Street facade of 10 Arthur Street, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00231666	**Pre-amplifier Type** **Serial No.**	NH-25 21610
Microphone Type **Serial No.**	UC-59 04711	**Calibrator Type** **Serial No.**	Rion NC-74 35125828
Start Date	04/11/2013	**End Date**	18/11/2013
Start Time	16:25	**End Time**	11:00
Start Calibration Level	94.0	**End Calibration Level**	93.8
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)	
Balcony on 3rd floor overlooking Arthur Street, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by road traffic throughout the daytime, evening and night time periods.	

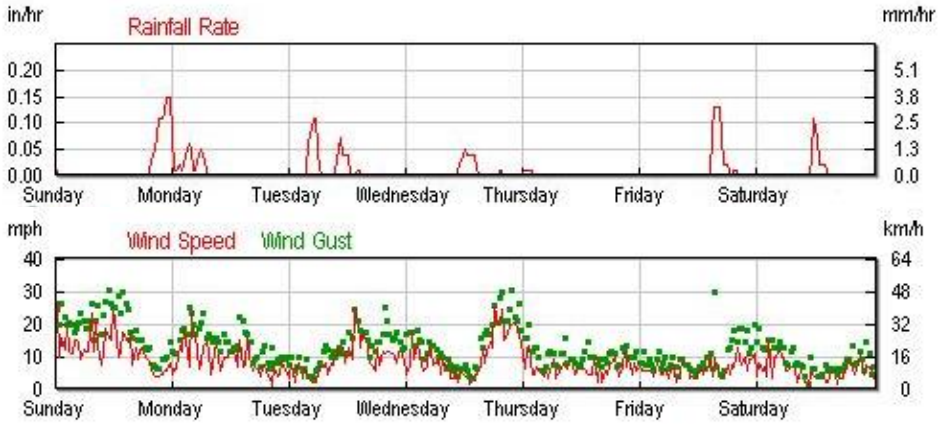
Description of weather conditions at start and end of survey
Start: 14ºC, negligible wind, humidity 51%, dry, no cloud. End: 15ºC, negligible wind, humidity 70%, dry, overcast. There were 8 days of weather acceptable for noise monitoring at this location: 7th, 10th, 12th to 17th November.
Weather overview
Week 46 (03/11/2013 to 09/11/2013)  Week 47 (10/11/2013 to 16/11/2013)  Week 48 (17/11/2013 to 23/11/2013)  © Weather Underground

Location	BSCU/N/5 Martin Lane facade of 10 Arthur Street, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00610203	**Pre-amplifier Type** **Serial No.**	NH-25 10197
Microphone Type **Serial No.**	UC-59 02545	**Calibrator Type** **Serial No.**	Rion NC-74 35125828
Start Date	04/11/2013	**End Date**	18/11/2013
Start Time	17:10	**End Time**	11:16
Start Calibration Level	94.0	**End Calibration Level**	93.9
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes

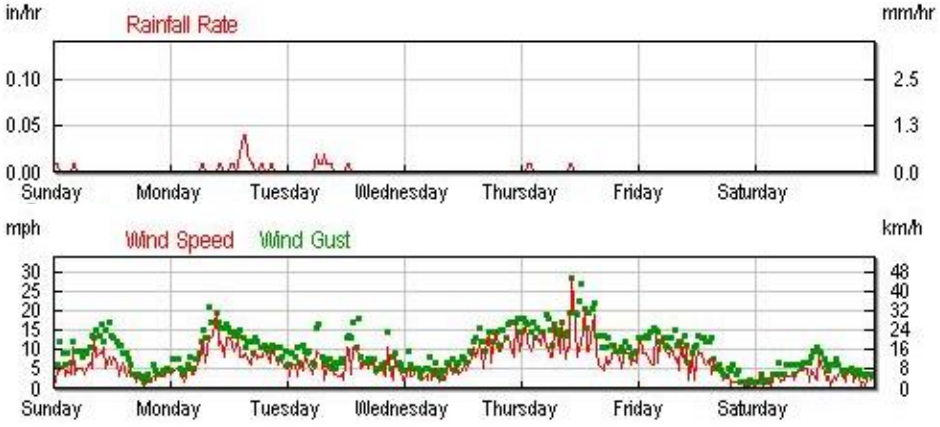
Description of site (Location of equipment, general surroundings etc.)	
Balcony on 3rd floor overlooking 6 Martin Lane, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by road traffic throughout the daytime, evening and night time periods with occasional noise from pedestrians. There was also occasional noise from manual work at road level during daytime and evenings.	

Description of weather conditions at start and end of survey
Start: 14ºC, negligible wind, humidity 51%, dry, no cloud. End: 15ºC, negligible wind, humidity 70%, dry, overcast. There were 8 days of weather acceptable for noise monitoring at this location: 7th, 10th, 12th to 17th November.
Weather overview

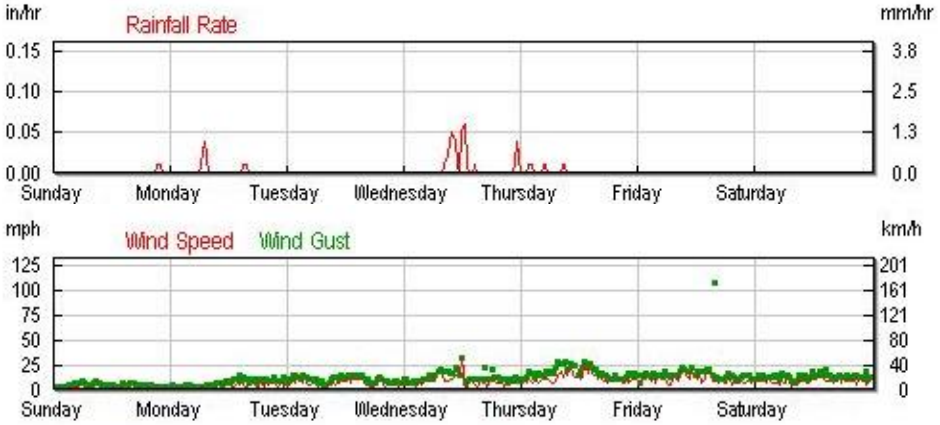
Week 46 (03/11/2013 to 09/11/2013)



Week 47 (10/11/2013 to 16/11/2013)



Week 48 (17/11/2013 to 23/11/2013)

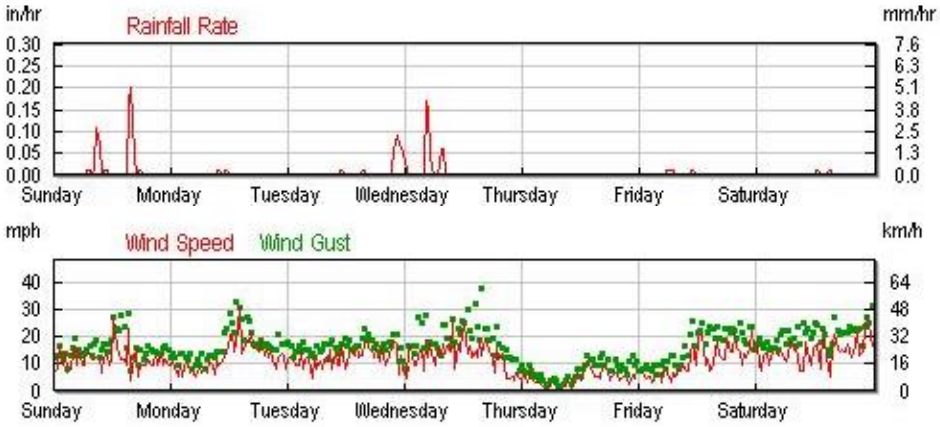


Location	BSCU/N/6 Abchurch Yard facade of 131-133 Cannon Street, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
SLM Type **Serial No.**	Rion NL-52 00620960	**Pre-amplifier Type** **Serial No.**	NH-25 21001
Microphone Type **Serial No.**	UC-59 03878	**Calibrator Type** **Serial No.**	Rion NC-74 34625646/34304643
Start Date	26/11/2013	**End Date**	04/12/2013
Start Time	12:40	**End Time**	10:42
Start Calibration Level	94.0	**End Calibration Level**	94.1
Frequency Weighting	A	**Time Response**	F
Store Intervals	5 minutes and L_p 100ms	**Store Parameters**	L_{eq}, L_E, L_{max}, L_{min}, L_1, L_{10}, L_{50}, L_{90}, L_{99} (A-weighted and 1/3 octave bands)
Photo taken identifying location with equipment installed			Yes

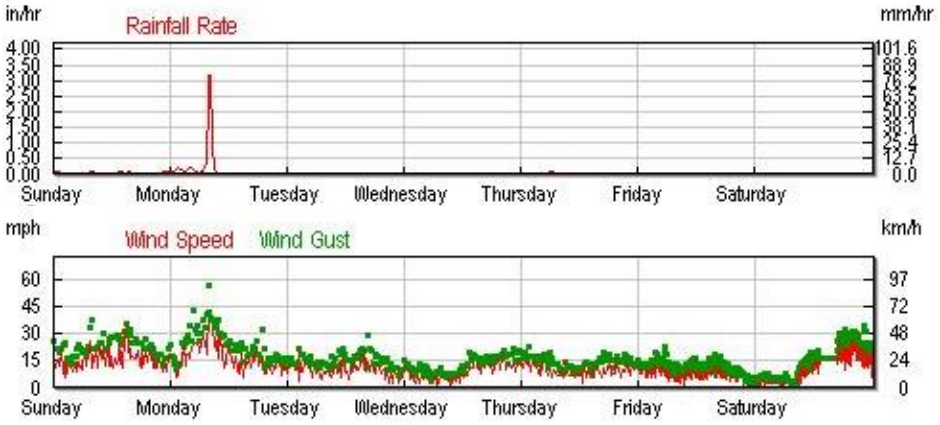
Description of site (Location of equipment, general surroundings etc.)	
Rear facade on 2nd floor overlooking Abchurch Yard, 1m from façade.	
Facade or Free-field position	Façade
Description of noise environment at start and end of survey	
The noise environment was dominated by pedestrians and road traffic throughout the daytime, evening and night time periods. There was also occasional low level noise from local plant.	

Description of weather conditions at start and end of survey
Start: 9ºC, negligible wind, dry, overcast. End: 9ºC, negligible wind, dry, overcast. There were 7 days of weather acceptable for noise monitoring at this location: 27th November to 3rd December.
Weather overview

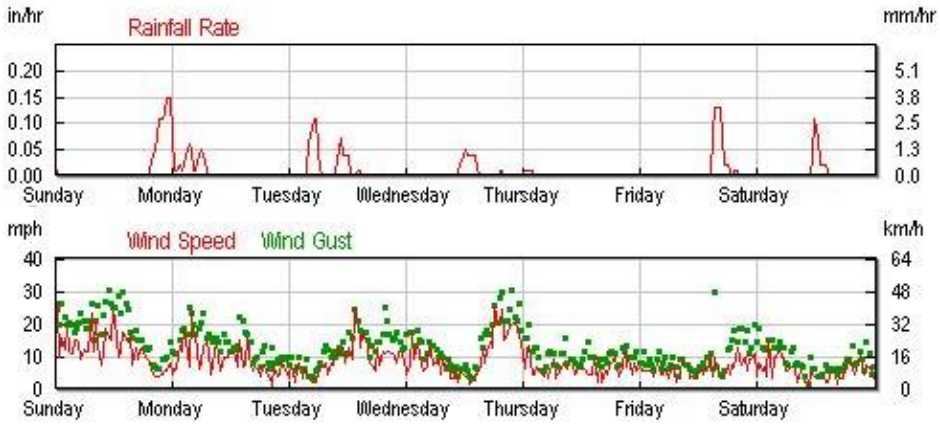
Week 44 (20/10/2013 to 26/10/2013)



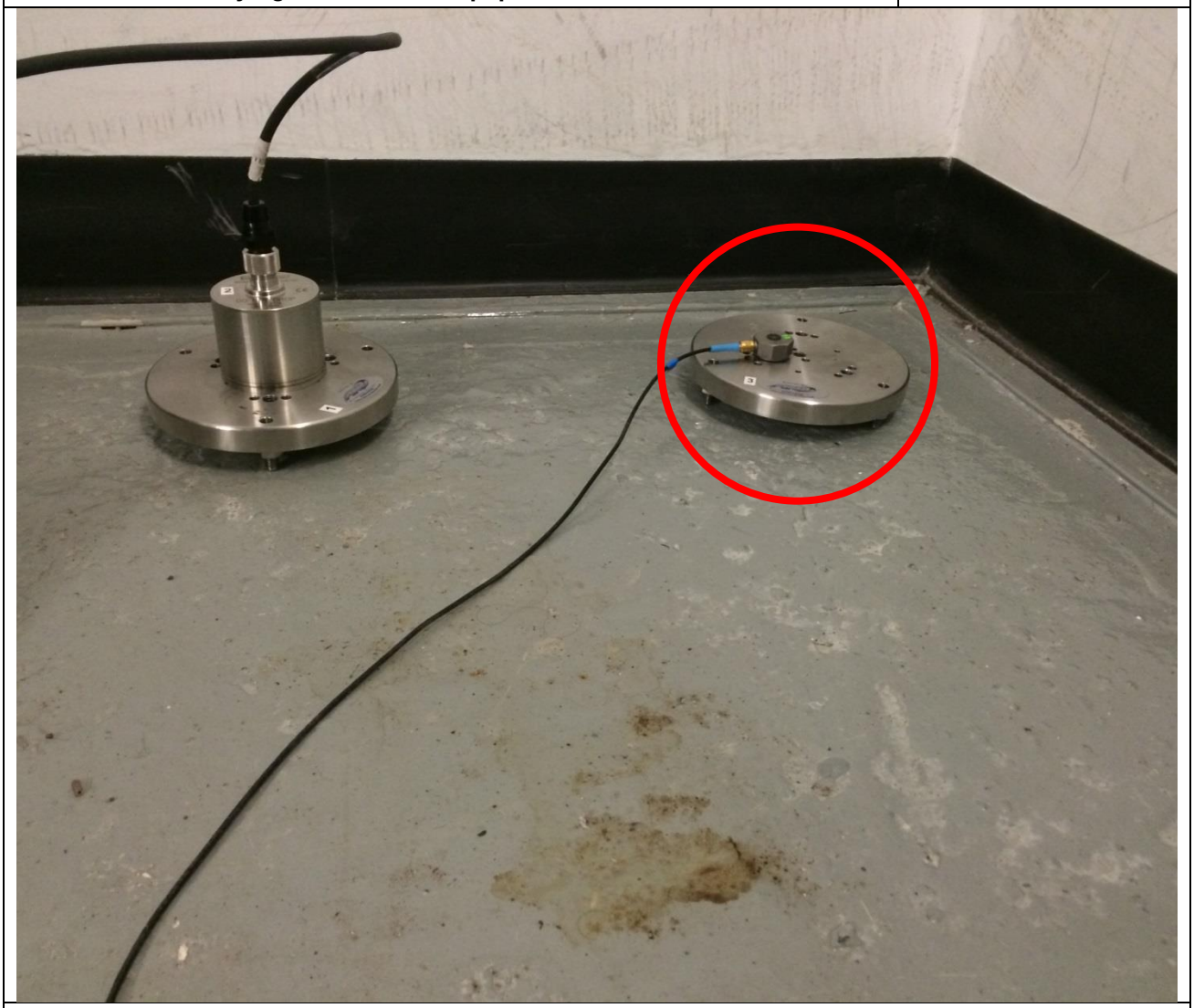
Week 45 (27/10/2013 to 02/11/2013)



Week 46 (03/11/2013 to 09/11/2013)

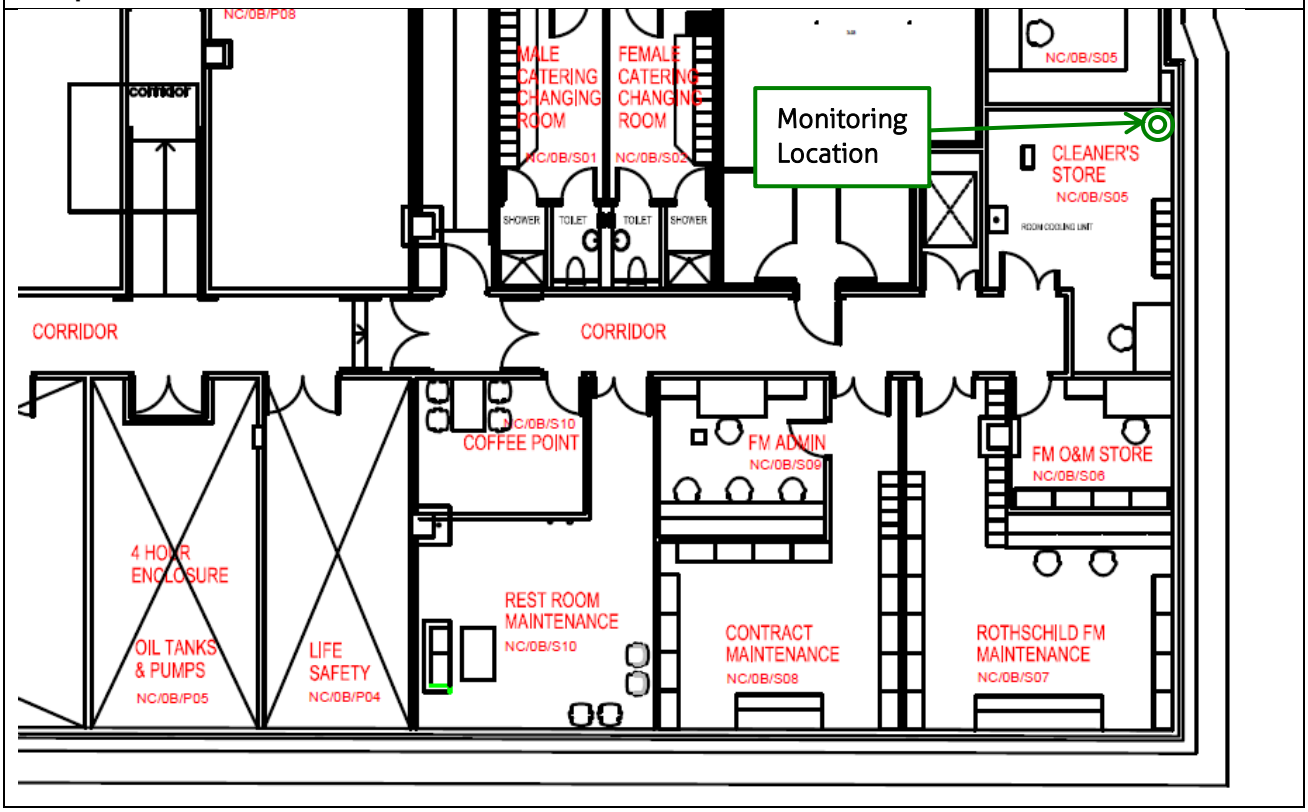


Location	BSCU/V/2 1-6 St Swithin's Lane, London		
Personnel	Andrew Knight (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	Rion DA-20 00260254	**Accelerometer Type** **Serial No.**	Dytran 3233A 879
Start Date	20/11/2013	**End Date**	21/11/2013
Start Time	22:18	**End Time**	00:18
Photo taken identifying location with equipment installed			Yes



Description of site (Location of equipment, general surroundings etc.)
Located on concrete floor in north east corner of the Cleaner's Store by external wall.
Description of environment
Extractor fan in corridor joining room just audible (possible source of vibration but not perceived).

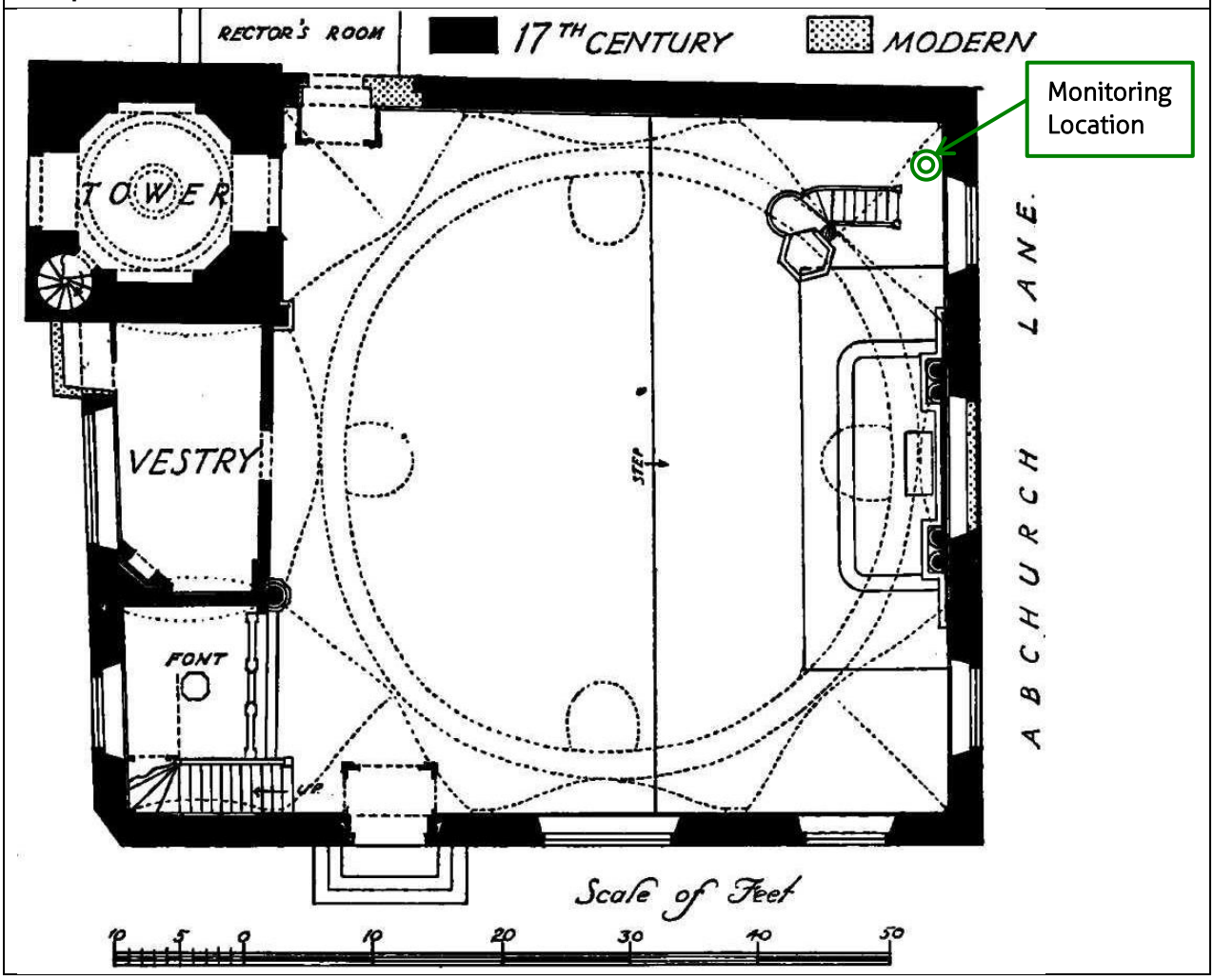
Site plan


NC/0B/P08
corridor
MALE CATERING CHANGING ROOM
NC/0B/S01
FEMALE CATERING CHANGING ROOM
NC/0B/S02
SHOWER
TOILET
TOILET
SHOWER
Monitoring Location
NC/0B/S05
CLEANER'S STORE
NC/0B/S05
CORRIDOR
CORRIDOR
NC/0B/S10
COFFEE POINT
FM ADMIN
NC/0B/S09
FM O&M STORE
NC/0B/S06
4 HOUR ENCLOSURE
OIL TANKS & PUMPS
NC/0B/P05
LIFE SAFETY
NC/0B/P04
REST ROOM MAINTENANCE
NC/0B/S10
CONTRACT MAINTENANCE
NC/0B/S08
ROTHSCHILD FM MAINTENANCE
NC/0B/S07

Location	BSCU/V/4 1-6 St Mary Abchurch, Abchurch Lane, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	Rion DA-20 00260254	**Accelerometer Type** **Serial No.**	Dytran 3233A 879
Start Date	13/11/2013	**End Date**	14/11/2013
Start Time	15:44	**End Time**	13:44
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)
Located on stone floor in north east corner of church by external wall.
Description of environment at start and end of survey
Road traffic and church visitors audible (possible source of vibration but not perceived).

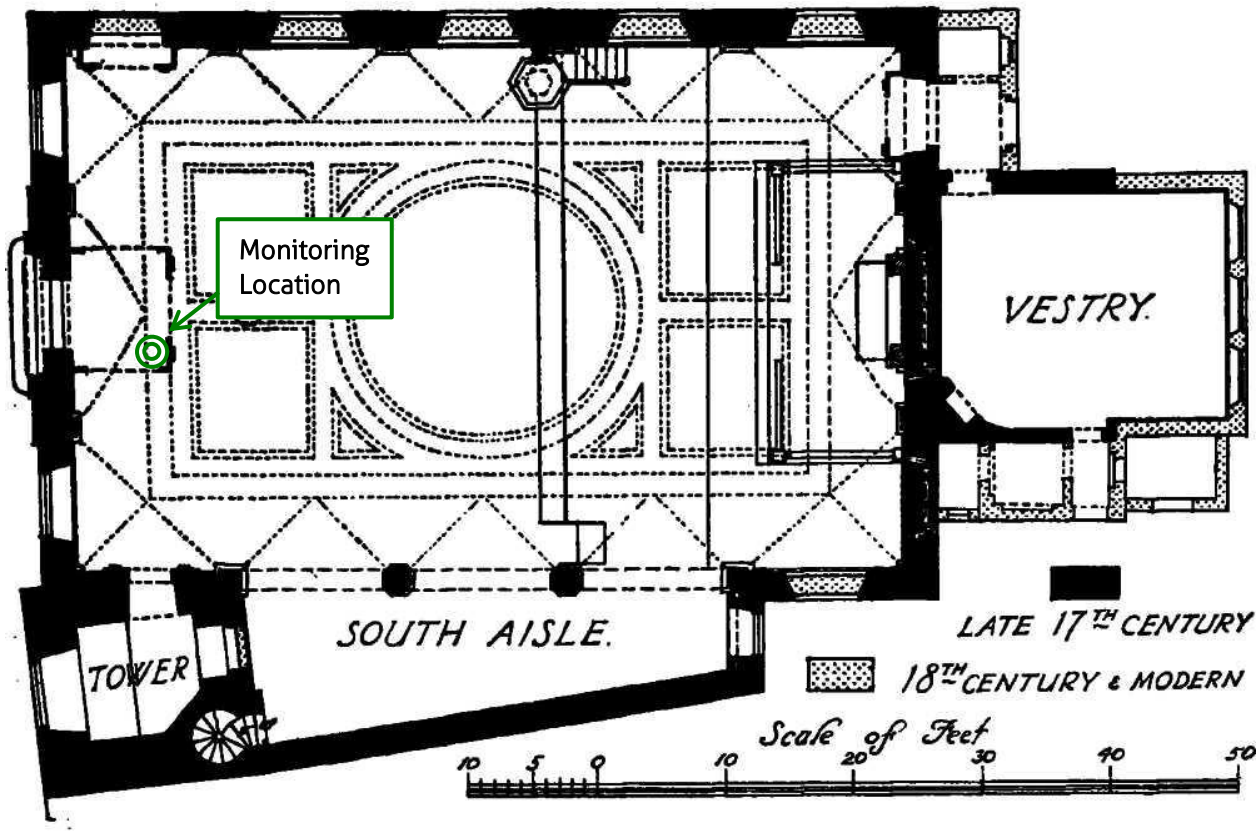
Site plan


RECTOR'S ROOM
17 TH CENTURY
MODERN
Monitoring Location
TOWER
VESTRY
FONT
STEP
UP
ABCHURCH LANE.
Scale of Feet
10 5 0 10 20 30 40 50

Location	BSCU/V/5 1-6 St Clements Church, Clements Lane, London		
Personnel	John Smethurst / Richard West (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	Rion DA-20 00260254	**Accelerometer Type** **Serial No.**	Dytran 3233A 879
Start Date	12/11/2013	**End Date**	13/11/2013
Start Time	22:00	**End Time**	00:00
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)
Located on stone floor in entrance foyer of church.
Description of environment
Road traffic and tube trains audible (possible source of vibration but not perceived).

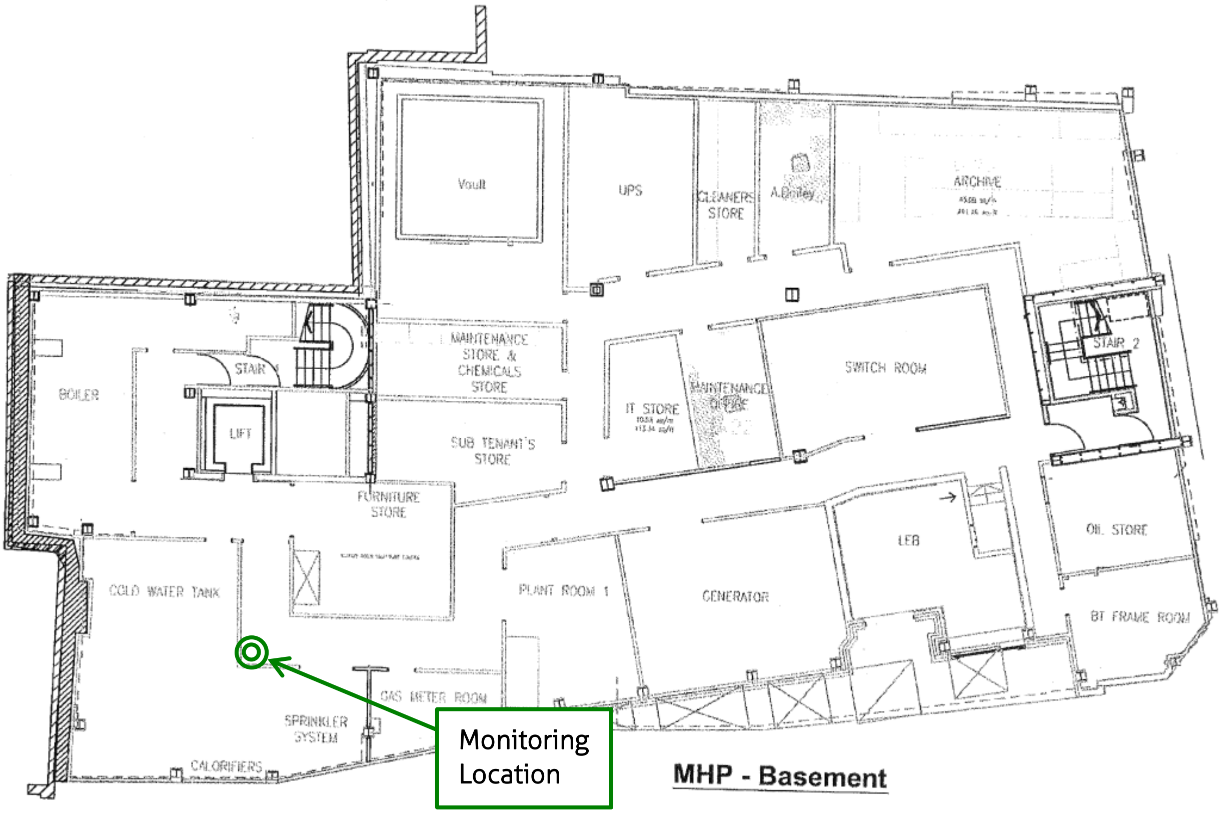
Site plan


Monitoring Location
VESTRY.
SOUTH AISLE.
TOWER
LATE 17TH CENTURY
18TH CENTURY & MODERN
Scale of Feet
10 5 0 10 20 30 40 50

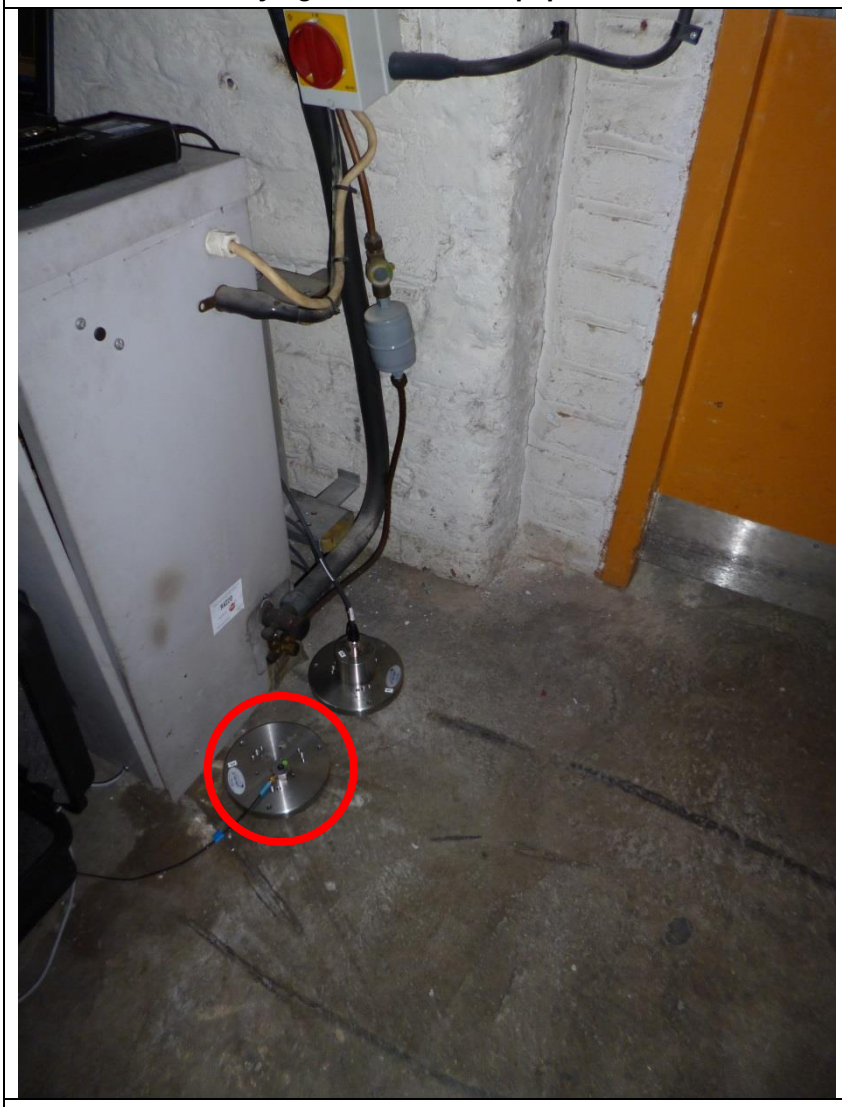
Location	BSCU/V/6 8-10 Mansion House Place, London		
Personnel	John Smethurst / Andrew Knight (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	Rion DA-20 00260254	**Accelerometer Type** **Serial No.**	Dytran 3233A 879
Start Date	19/11/2013	**End Date**	20/11/2013
Start Time	22:04	**End Time**	00:04
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)
Located on concrete floor in corridor adjacent to Cold Water Tank room.
Description of environment
Water booster pump just audible (possible source of vibration but not perceived).

Site plan

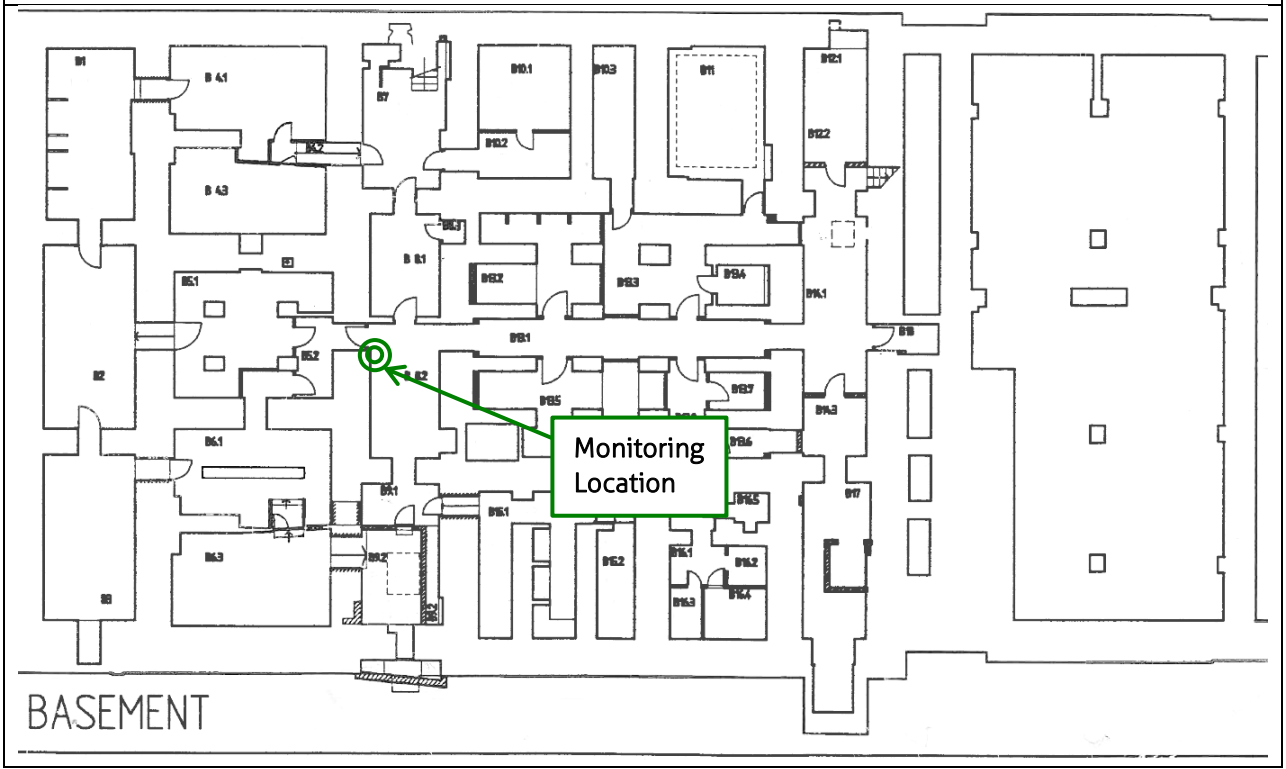

Vault
UPS
CLEANERS STORE
ARCHIVE
BOILER
STAIR 1
LIFT
MAINTENANCE STORE & CHEMICALS STORE
SUB TENANT'S STORE
IT STORE
MAINTENANCE OFFICE
SWITCH ROOM
STAIR 2
FURNITURE STORE
OIL STORE
COLD WATER TANK
PLANT ROOM 1
GENERATOR
LEB
BT FRAME ROOM
GAS METER ROOM
SPRINKLER SYSTEM
CALORIFIERS
Monitoring Location
MHP - Basement

Location	BSCU/V/7 The Mansion House, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	Rion DA-20 00260254	**Accelerometer Type** **Serial No.**	Dytran 3233A 879
Start Date	21/11/2013	**End Date**	22/11/2013
Start Time	22:00	**End Time**	00:00
Photo taken identifying location with equipment installed			Yes



Description of site (Location of equipment, general surroundings etc.)
Located on concrete floor in the basement in the southern half of the building.
Description of environment
Underground trains and some road traffic audible (possible source of vibration but not perceived).

Site plan



APPENDIX C

BASELINE NOISE MONITORING RESULTS

Figure C.1a Noise Level Time History for Location BSCU/N/1 (1st Survey)

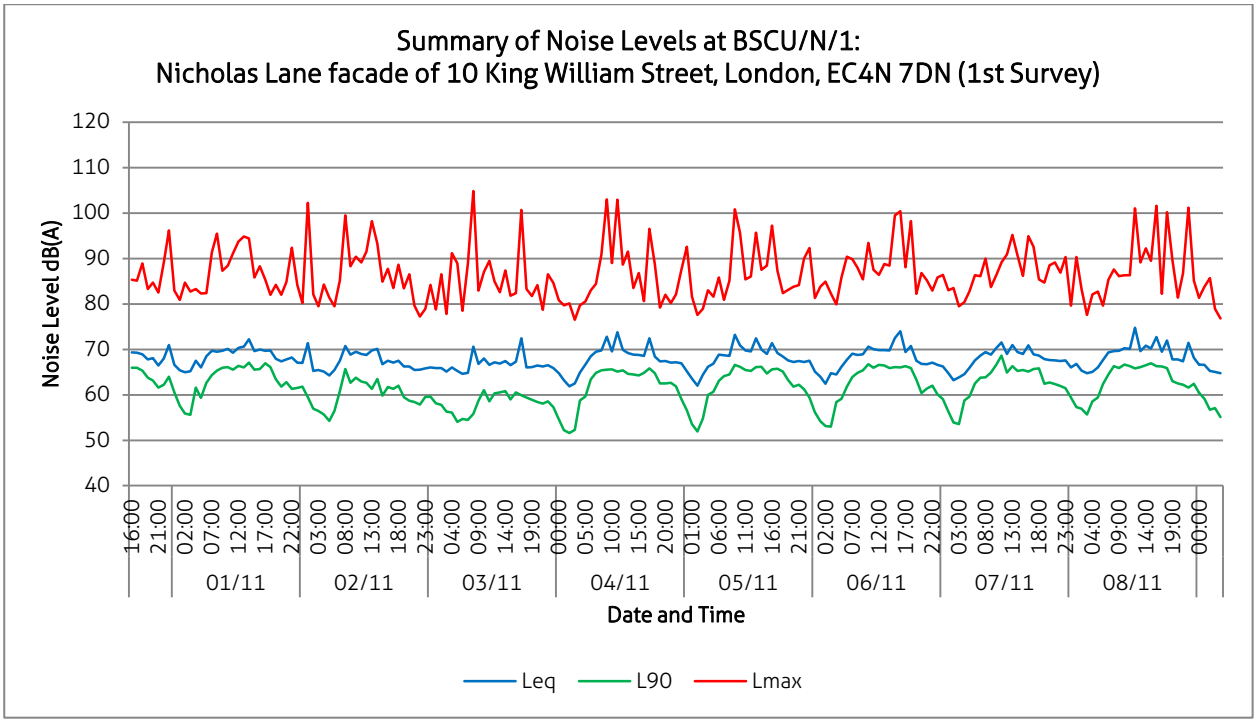


Figure C.1b Noise Level Time History for Location BSCU/N/1 (2nd Survey)

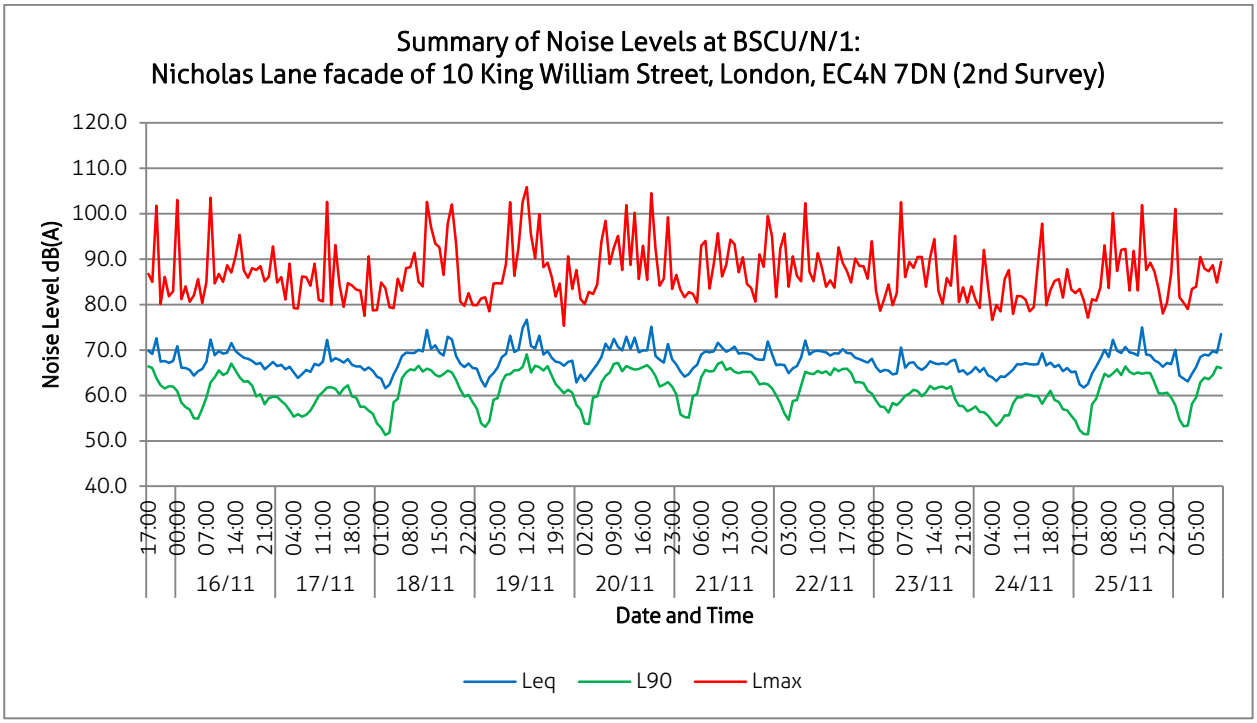


Figure C.2 Noise Level Time History for Location BSCU/N/2

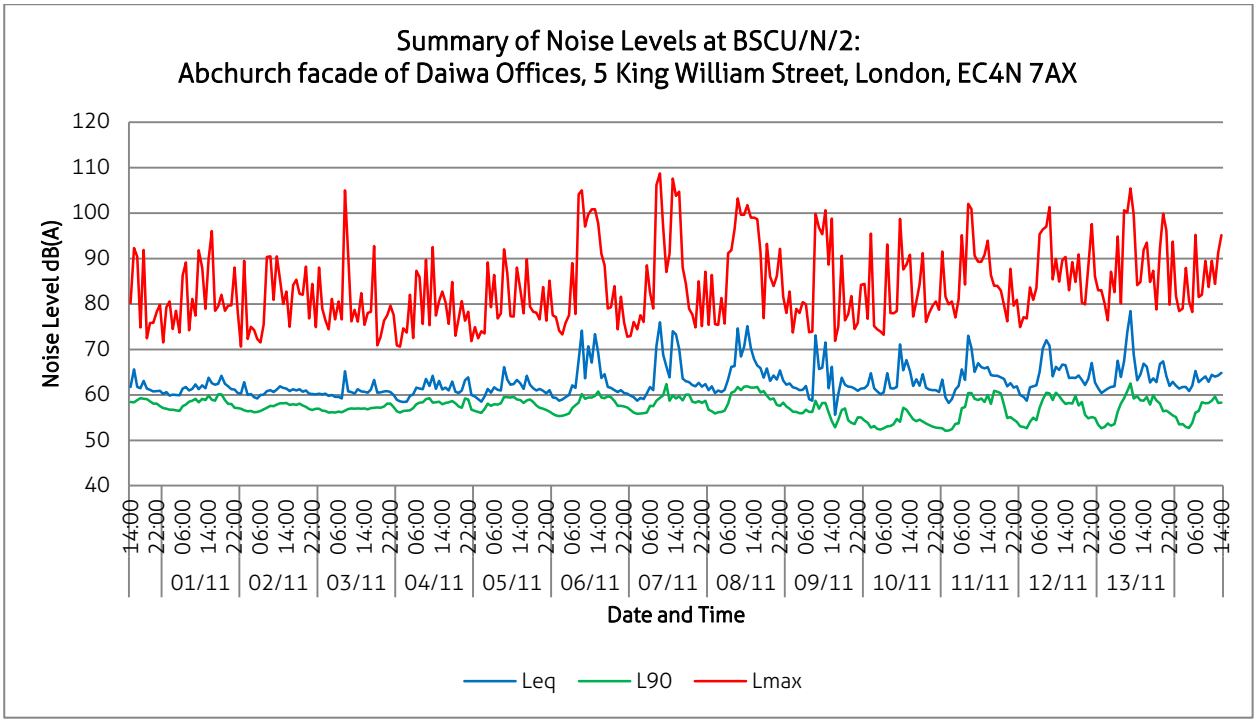


Figure C.3 Noise Level Time History for Location BSCU/N/4

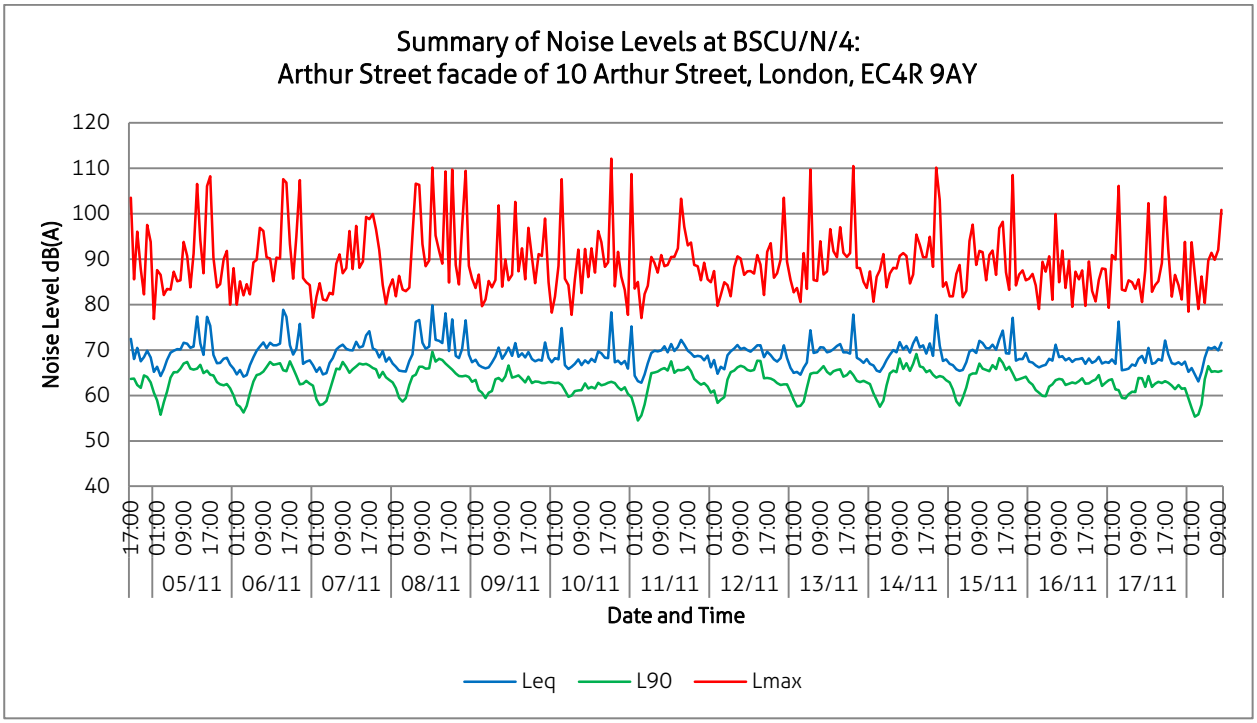


Figure C.4 Noise Level Time History for Location BSCU/N/5

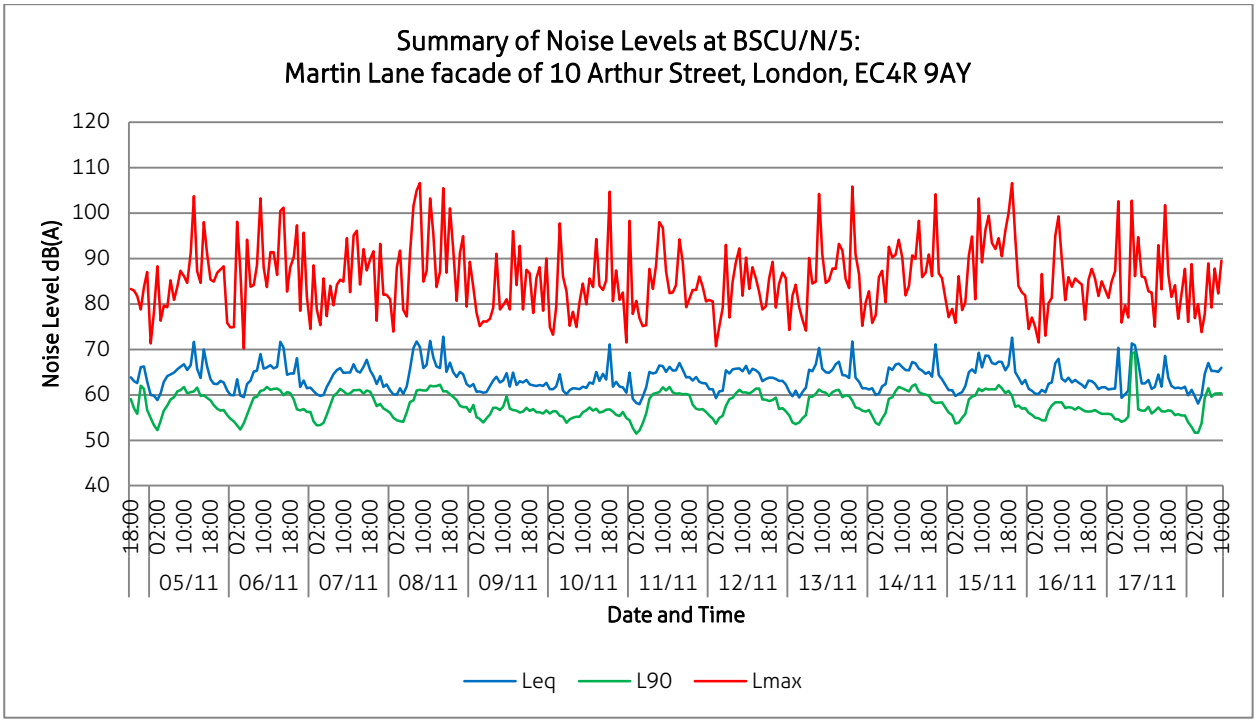
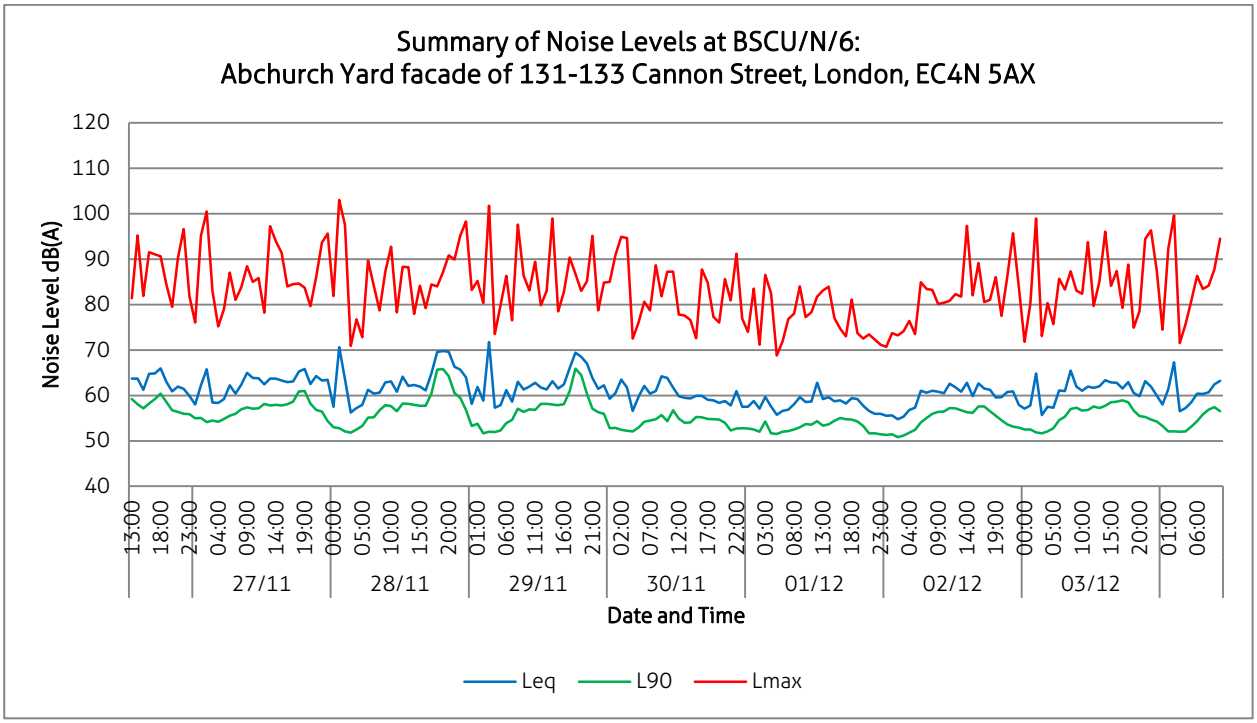


Figure C.5 Noise Level Time History for Location BSCU/N/6



APPENDIX D

BASELINE VIBRATION MONITORING RESULTS

Figure D.1 Raw Acceleration Time History for Location BSCU/V/2

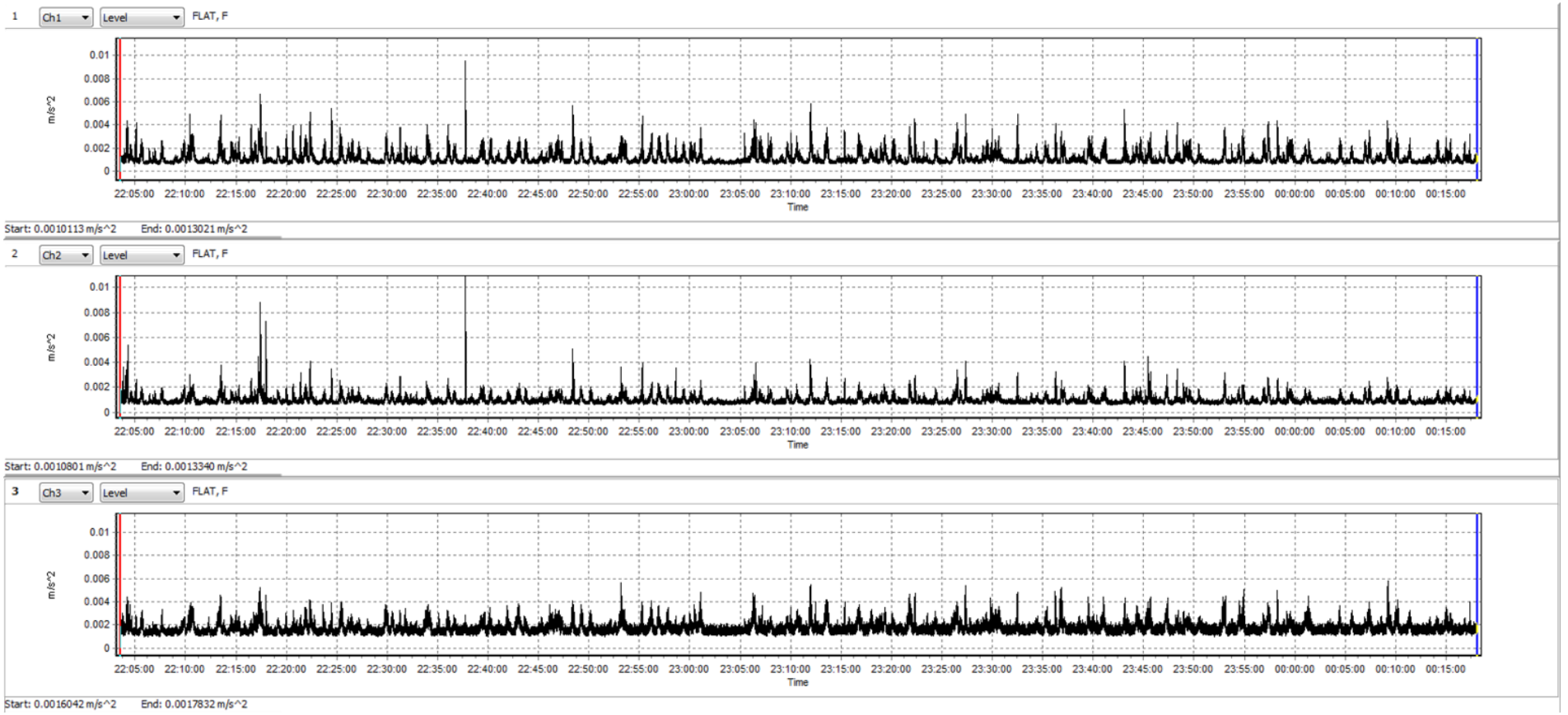


Figure D.2 Raw Acceleration Time History for Location BSCU/V/4

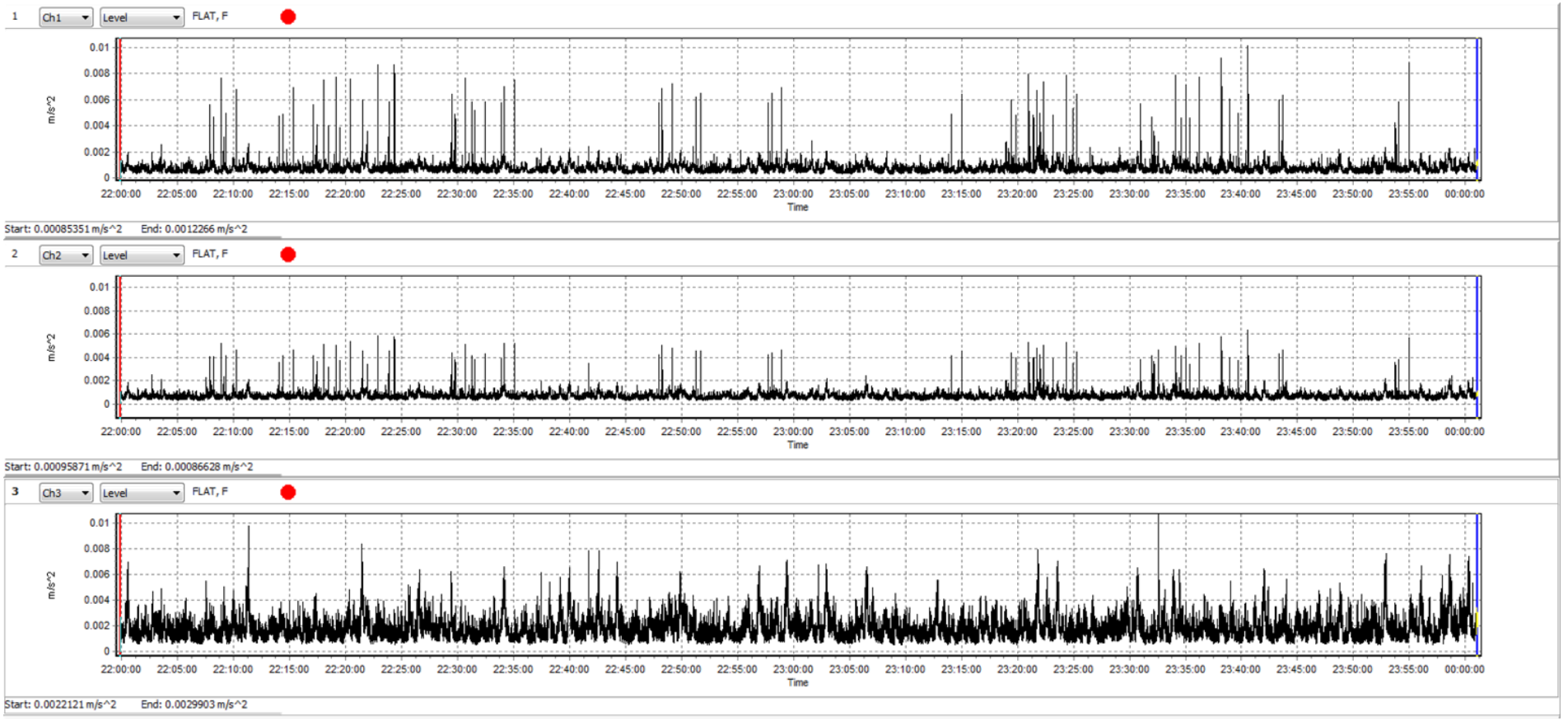


Figure D.3 Raw Acceleration Time History for Location BSCU/V/5

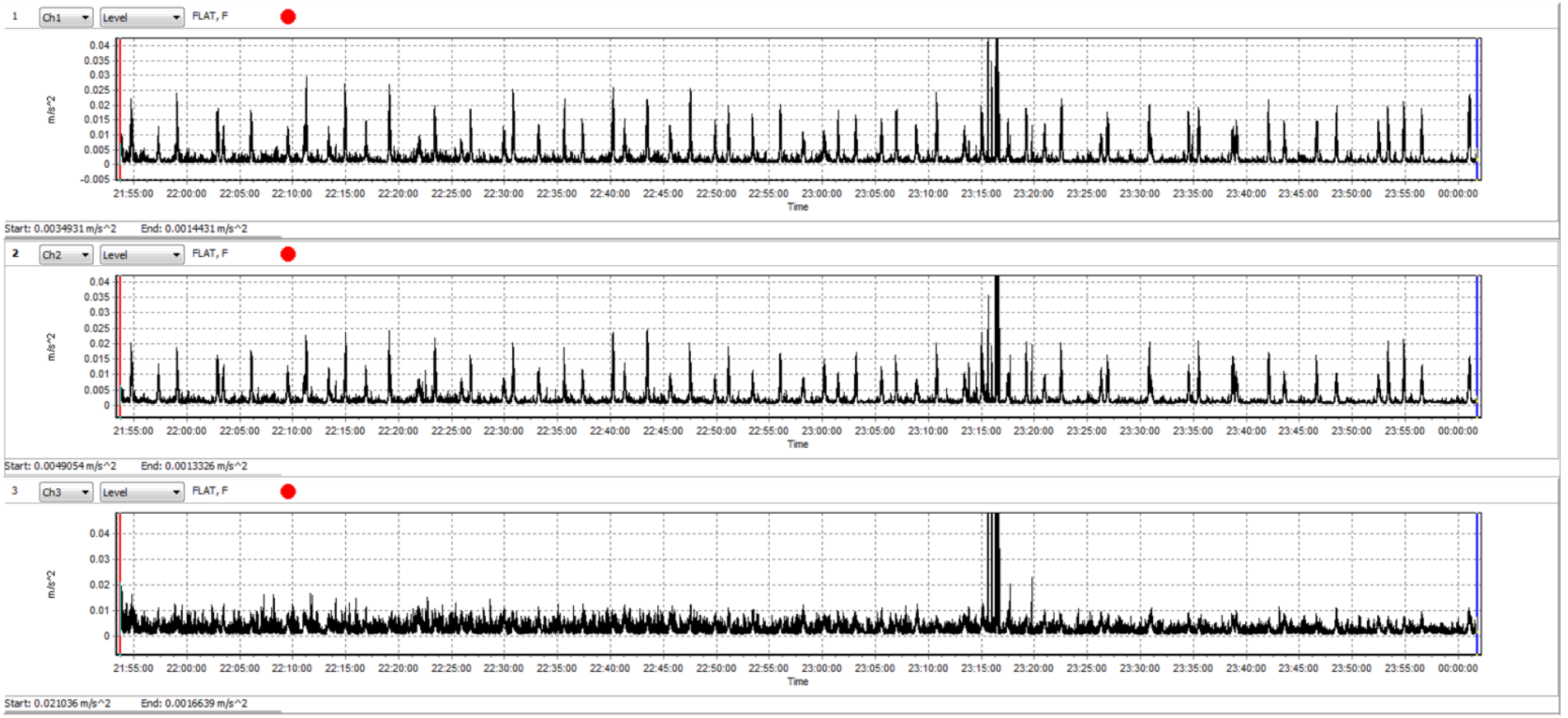


Figure D.4 Raw Acceleration Time History for Location BSCU/V/6

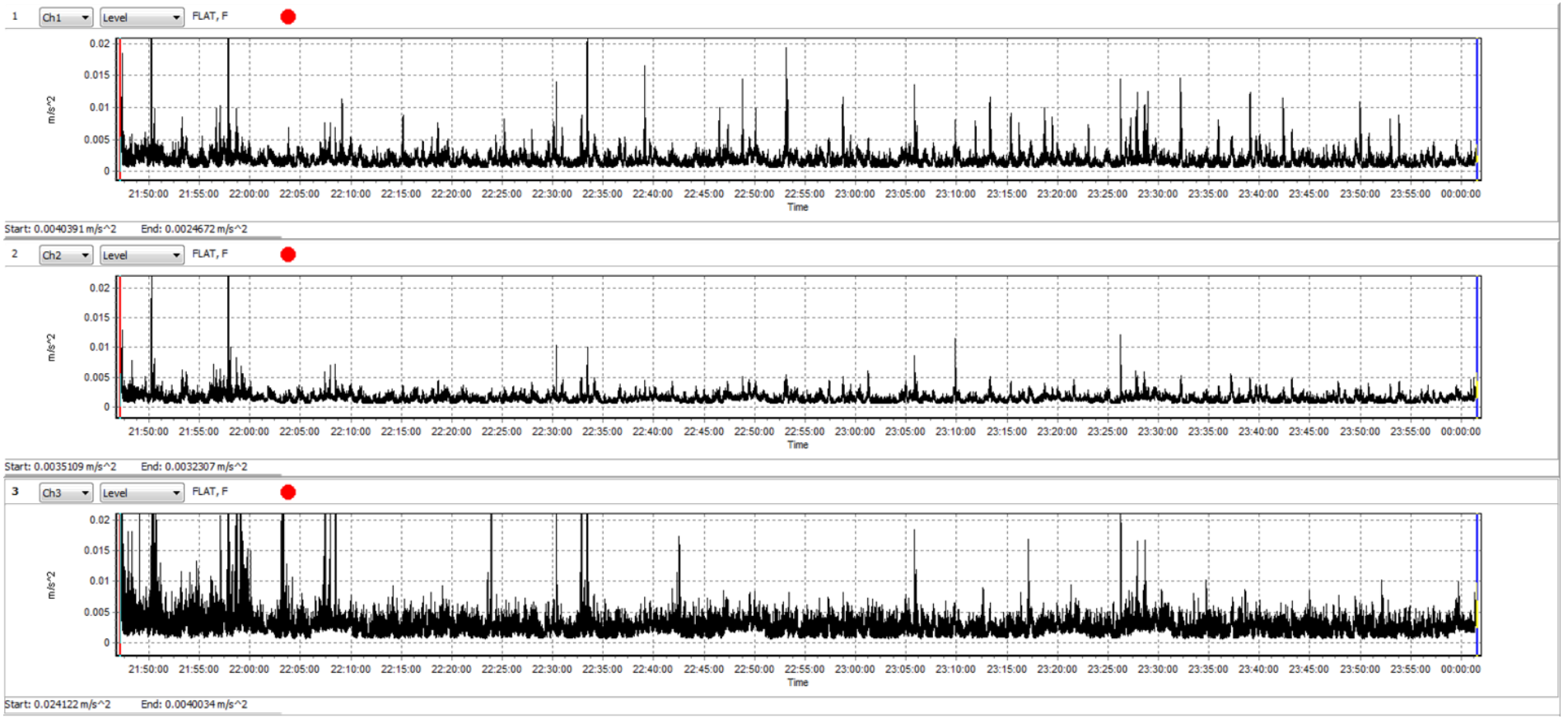
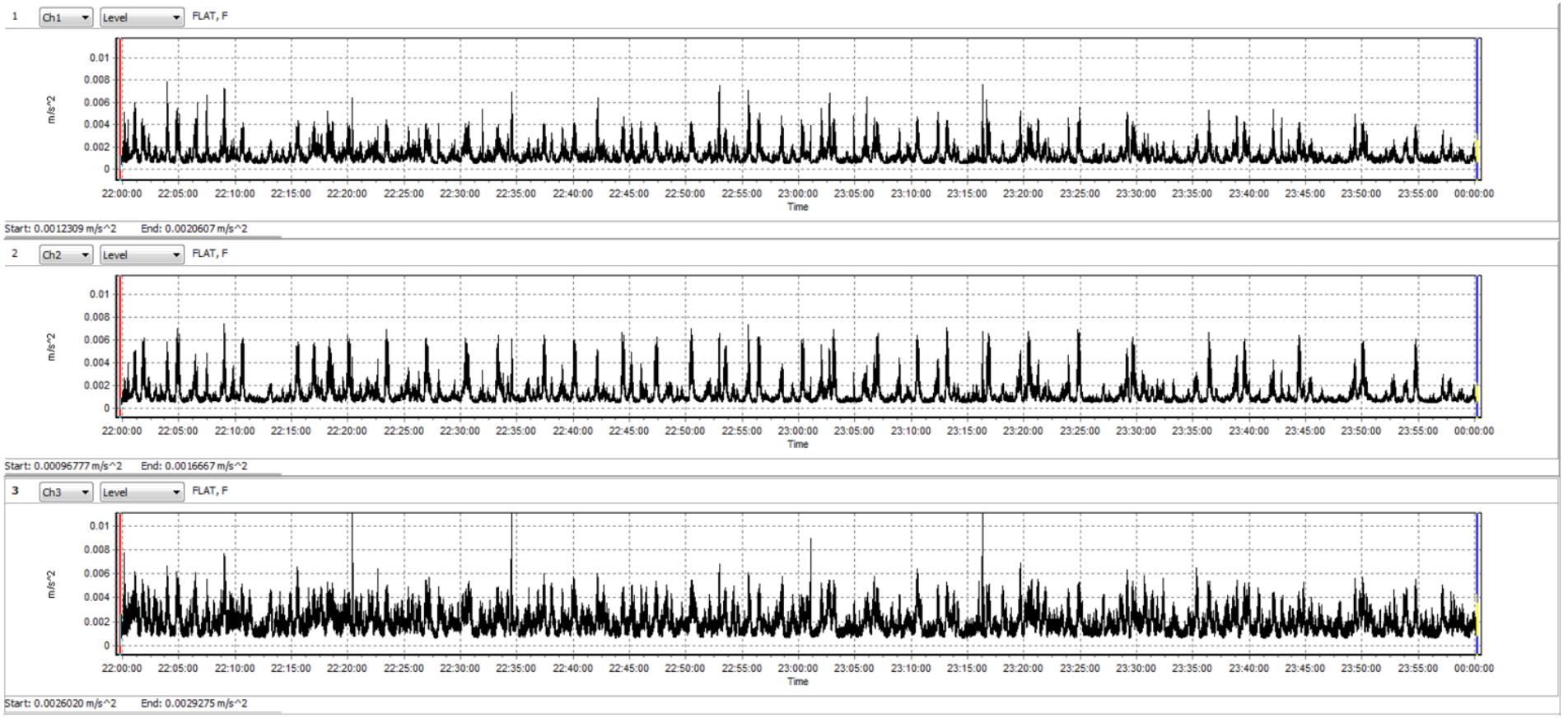


Figure D.5 Raw Acceleration Time History for Location BSCU/V/7



APPENDIX E

CALIBRATION CERTIFICATES

Figure E.1 Calibration Certificate for Rion NL-52 (Location BSCU/N/1, 6)

CERTIFICATE OF CALIBRATION

ISSUED BY AV CALIBRATION

Date of issue 11 October 2013 Certificate N° 07364

UKAS CALIBRATION 0653

AV Calibration
2 Warren Court
Chicksands, Shefford
Bedfordshire SG17 5QB
U.K.
Tel: +44 (0)1462 638600
Fax: +44 (0)1462 638601
Email: lab@avcalib.co.uk
www.avcalibration.co.uk

Page 1 of 7 pages

Approved Signatory
G.Parry

CLIENT	Anderson Acoustics Ltd 3 Trafalgar Mews 15 - 16 Trafalgar Street Brighton East Sussex BN1 4EZ
F.A.O.	Andrew Knight
REF.	- Job N° UKAS13/10213/02
DATE OF RECEIPT	8 October 2013
PROCEDURE	AV Calibration Engineer's Handbook, Section 25: periodic testing of sound level meters to IEC 61672-3:2006 (BS EN 61672-3:2006) as modified by UKAS TPS 49 Edition 2:June 2009
IDENTIFICATION	Sound level meter Rion type NL-52 [serial no. 00620960] connected via a preamplifier type NH-25 [serial no. 21001] to a half-inch microphone type UC-59 [serial no. 03878] fitted with a foam windshield type WS-10. Associated calibrator Rion type NC-74 [serial no. 34625646] with one-inch housing and adapter type NC-74-002 for half-inch microphone.
CALIBRATED ON	11 October 2013

Figure E.2 Calibration Certificate for Rion NL-52 (Location BSCU/N/2)

MEASUREMENT SYSTEMS

CERTIFICATE OF CONFORMANCE

Date of Issue	**25 October 2013**
Customer	**Anderson Acoustics**
Certificate Number	**CONF101303**

	Manufacturer	**Type**	**Serial Number**
Sound Level Meter	Rion	NL-52	00732147
Preamplifier	Rion	NH-25	32175
Microphone	Rion	UC-59	05339

This is to certify that the instrument was tested and calibrated at the Manufacturer's factory according to their specification and that the product satisfied all the relevant requirements of the following Standards:

IEC 61672-1:2002 Class 1.

The instrument also received a functional check by ANV Measurement Systems prior to despatch in the UK, in accordance with our standard procedures.

Signed. Amrat C Patel. Position.Laboratory Manager. Date.25/10/2013.

Amrat C Patel

BEAUFORT COURT, 17 ROEBUCK WAY, MILTON KEYNES, MK5 8HL
☎ 01908 642846 🖷 01908 642814
✉ info@noise-and-vibration.co.uk 💻 www.noise-and-vibration.co.uk

Figure E.3 Calibration Certificate for Rion NL-52 (Location BSCU/N/4)

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

UKAS CALIBRATION 7623

Date of Issue: 11 May 2013 **Certificate Number: UCRT13/1060**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Page 1 of 2 Pages
Approved Signatory
M. Breslin

Customer	ANV Measurement Systems Beaufort Court 17 Roebuck Way Milton Keynes MK5 8HL			
Order No.	ANV MS Hire			
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator			
Identification	*Manufacturer*	*Instrument*	*Type*	*Serial No. / Version*
	Rion	Sound Level Meter	NL-52	00231666
	Rion	Firmware		1.3 (01060011)
	Rion	Pre Amplifier	NH-25	21610
	Rion	Microphone	UC-59	04711
	Rion	Calibrator	NC-74	35015343
		Calibrator adaptor type if applicable		NC-74-002
Performance Class	1			
Test Procedure	TP 2.SLM 61672-3 TPS-49 *Procedures from IEC 61672-3:2006 were used to perform the periodic tests.*			
Type Approved to IEC 61672-1:2002	YES	Approval Number	21.21 / 13.02	
	If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003			
Date Received	10 May 2013	ANV Job No.	UKAS13/04040	
Date Calibrated	11 May 2013			

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	Initial Calibration		

Figure E.3 (continued)

CERTIFICATE OF CALIBRATION

UKAS Accredited Calibration Laboratory No. 7623

Certificate Number
UCRT13/1060

Page 2 of 2 Pages

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter NL-42 / NL-52		
SLM instruction manual ref / issue	11-03		
SLM instruction manual source	Manufacturer		
Internet download date if applicable	N/A		
Case corrections available	Yes		
Uncertainties of case corrections	Yes		
Source of case data	Manufacturer		
Wind screen corrections available	Yes		
Uncertainties of wind screen corrections	Yes		
Source of wind screen data	Manufacturer		
Mic pressure to free field corrections	Yes		
Uncertainties of Mic to F.F. corrections	Yes		
Source of Mic to F.F. corrections	Manufacturer		
Total expanded uncertainties within the requirements of IEC 61672-1:2002	Yes		
Specified or equivalent Calibrator	Specified		
Customer or Lab Calibrator	Lab Calibrator		
Calibrator adaptor type if applicable	NC-74-002		
Calibrator cal. date	19 April 2013		
Calibrator cert. number	UCRT13/1038		
Calibrator cal cert issued by	7623		
Calibrator SPL @ STP	94.05	dB	Calibration reference sound pressure level
Calibrator frequency	1001.30	Hz	Calibration check frequency
Reference level range	25 - 130	dB	

Accessories used or corrected for during calibration - Extension Cable & Wind Shield WS-15
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests	Start	End	
Temperature	22.06	22.16	± 0.20 °C
Humidity	37.6	40.7	± 3.00 %RH
Ambient Pressure	99.82	99.78	± 0.03 kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	94.0 dB		Adjusted indicated level	94.1	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±				0.10	dB

Self Generated Noise — This test is currently not performed by this Lab.

Microphone installed (if requested by customer) = Less Than	N/A	dB	A Weighting
Uncertainty of the microphone installed self generated noise ±	N/A	dB	

Microphone replaced with electrical input device - UR = Under Range indicated

Weighting	A			C			Z		
	11.4	dB	UR	15.8	dB	UR	21.8	dB	UR
Uncertainty of the electrical self generated noise ±							0.12	dB	

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the Actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

..... END .....

Calibrated by: A Patel

Additional Comments

None

Figure E.4 Calibration Certificate for Rion NL-52 (Location BSCU/N/5)

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

UKAS CALIBRATION 7623

Date of Issue: 31 July 2013 **Certificate Number: UCRT13/1119**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Page 1 of 2 Pages
Approved Signatory
M. Breslin [ ]

Customer	ANV Measurement Systems Beaufort Court 17 Roebuck Way Milton Keynes MK5 8HL			
Order No.	ANV MS Hire			
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator			
Identification	*Manufacturer*	*Instrument*	*Type*	*Serial No. / Version*
	Rion	Sound Level Meter	NL-52	00610203
	Rion	Firmware		1.3 (01060011)
	Rion	Pre Amplifier	NH-25	10197
	Rion	Microphone	UC-59	02545
	Rion	Calibrator	NC-74	35015343
		Calibrator adaptor type if applicable		NC-74-002
Performance Class	1			
Test Procedure	TP 2.SLM 61672-3 TPS-49 *Procedures from IEC 61672-3:2006 were used to perform the periodic tests.*			
Type Approved to IEC 61672-1:2002	YES	Approval Number	21.21 / 13.02	
	If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003			
Date Received	30 July 2013	ANV Job No.	UKAS13/07074	
Date Calibrated	31 July 2013			

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	21 August 2012	TCRT12/1168	ANV Measurement Systems

Figure E.4 (continued)

CERTIFICATE OF CALIBRATION	Certificate Number UCRT13/1119
UKAS Accredited Calibration Laboratory No. 7623	Page 2 of 2 Pages

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter	NL-42 / NL-52	
SLM instruction manual ref / issue		11-03	
SLM instruction manual source		Manufacturer	
Internet download date if applicable		N/A	
Case corrections available		Yes	
Uncertainties of case corrections		Yes	
Source of case data		Manufacturer	
Wind screen corrections available		Yes	
Uncertainties of wind screen corrections		Yes	
Source of wind screen data		Manufacturer	
Mic pressure to free field corrections		Yes	
Uncertainties of Mic to F.F. corrections		Yes	
Source of Mic to F.F. corrections		Manufacturer	
Total expanded uncertainties within the requirements of IEC 61672-1:2002		Yes	
Specified or equivalent Calibrator		Specified	
Customer or Lab Calibrator		Lab Calibrator	
Calibrator adaptor type if applicable		NC-74-002	
Calibrator cal. date		10 July 2013	
Calibrator cert. number		UCRT13/1110	
Calibrator cal cert issued by		ANV Measurement Systems	
Calibrator SPL @ STP		94.09 dB	Calibration reference sound pressure level
Calibrator frequency		1001.20 Hz	Calibration check frequency
Reference level range		25 - 130 dB	

Accessories used or corrected for during calibration - Extension Cable & Wind Shield WS-15
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests	Start	End	
Temperature	22.96	23.09	± 0.20 °C
Humidity	54.9	55.7	± 3.00 %RH
Ambient Pressure	100.45	100.43	± 0.03 kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	94.3 dB		Adjusted indicated level	94.1	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±				0.10	dB

Self Generated Noise	This test is currently not performed by this Lab.		
Microphone installed (if requested by customer) = Less Than		N/A dB	A Weighting
Uncertainty of the microphone installed self generated noise ±		N/A dB	

Microphone replaced with electrical input device - UR = Under Range indicated

Weighting	A			C			Z		
	12.2	dB	UR	16.2	dB	UR	22.2	dB	UR
Uncertainty of the electrical self generated noise ±							0.12	dB	

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the Actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

..... END .....

Calibrated by: A Patel

Additional Comments

None

Figure E.5 Calibration Certificate for Rion NL-74 (Location BSCU/N/1, 2, 4, 5)

ANV MEASUREMENT SYSTEMS

CERTIFICATE OF CONFORMANCE

Date of Issue	**01 February 2013**
Customer	**Anderson Acoustics**
Certificate Number	**CONF021301**

	Manufacturer	**Type**	**Serial Number**
Acoustic Calibrator	Rion	NC-74	35125828

This is to certify that the instrument was tested and calibrated at the Manufacturer's factory according to their specification and that the product satisfied all the relevant requirements of the following Standards:

IEC 60942:2003 Class 1 (Electroacoustics - Sound Calibrators)

The instrument also received a functional check by ANV Measurement Systems prior to despatch in the UK, in accordance with our standard procedures.

Signed. Amrat C Patel Position. Laboratory Manager Date. 01-02-2013

BEAUFORT COURT, 17 ROEBUCK WAY, MILTON KEYNES, MK5 8HL
☎ 01908 642846 🖷 01908 642814
✉ info@noise-and-vibration.co.uk 💻 www.noise-and-vibration.co.uk

Figure E.6 Calibration Certificate for Rion NL-74 (Location BSCU/N/1, 6)

CERTIFICATE OF CALIBRATION

ISSUED BY AV CALIBRATION

Date of issue 08 October 2013 Certificate N° 07352

UKAS CALIBRATION 0653

AV Calibration
2 Warren Court
Chicksands, Shefford
Bedfordshire SG17 5QB
U.K.
Tel: +44 (0)1462 638600
Fax: +44 (0)1462 638601
Email: lab@avcalib.co.uk
www.avcalibration.co.uk
Acoustics Noise and Vibration Ltd trading as AV Calibration

Page 1 of 2 Pages

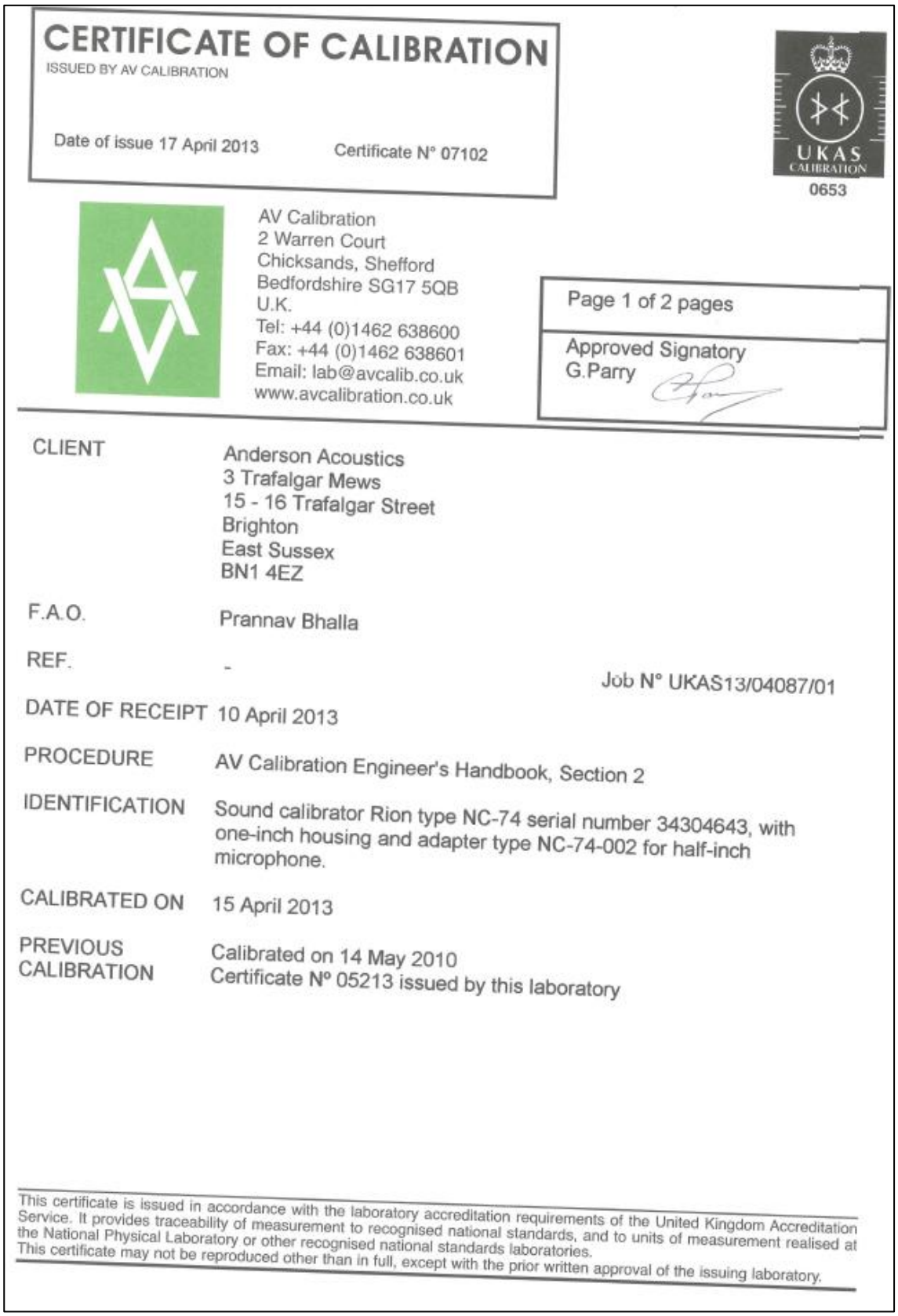
Approved Signatory

G. Parry [ ] B. Baker [ ]

CLIENT	Anderson Acoustics Ltd 3 Trafalgar Mews 15 - 16 Trafalgar Street Brighton East Sussex BN1 4EZ
F.A.O.	Andrew Knight
ORDER No	- Job No UKAS13/10213/01
DATE OF RECEIPT	08 October 2013
PROCEDURE	AV Calibration Engineer's Handbook section 2
IDENTIFICATION	Sound Calibrator Rion type NC-74 serial number 34625646 with one-inch housing and adapter type NC-74-002 for half-inch microphone
CALIBRATED ON	08 October 2013

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Figure E.7 Calibration Certificate for Rion NL-74 (Location BSCU/N/6)



CERTIFICATE OF CALIBRATION

ISSUED BY AV CALIBRATION

Date of issue 17 April 2013 Certificate N° 07102

UKAS CALIBRATION 0653

AV Calibration
2 Warren Court
Chicksands, Shefford
Bedfordshire SG17 5QB
U.K.
Tel: +44 (0)1462 638600
Fax: +44 (0)1462 638601
Email: lab@avcalib.co.uk
www.avcalibration.co.uk

Page 1 of 2 pages

Approved Signatory
G.Parry

CLIENT	Anderson Acoustics 3 Trafalgar Mews 15 - 16 Trafalgar Street Brighton East Sussex BN1 4EZ
F.A.O.	Prannav Bhalla
REF.	-
	Job N° UKAS13/04087/01
DATE OF RECEIPT	10 April 2013
PROCEDURE	AV Calibration Engineer's Handbook, Section 2
IDENTIFICATION	Sound calibrator Rion type NC-74 serial number 34304643, with one-inch housing and adapter type NC-74-002 for half-inch microphone.
CALIBRATED ON	15 April 2013
PREVIOUS CALIBRATION	Calibrated on 14 May 2010 Certificate N° 05213 issued by this laboratory

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories.
This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Figure E.8 Calibration Certificate for Rion DA-20 (Location BSCU/V/2, 4, 5, 6, 7)

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

Date of Issue: 29 April 2013 **Certificate Number: TCRT13/1158**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone +(44) 1908 642846 Fax +(44) 1908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Page 1 of 4 Pages
Approved Signatory
M. Breslin [ ] L.P. Jephson [ ]

Customer	ANV Measurement Systems Beaufort Court 17 Roebuck Way Milton Keynes MK5 8HL			
Order No.	ANV MS Hire			
Description	Data Recorder			
Identification	*Manufacturer*	*Instrument*	*Type*	*Serial No. / Version*
	Rion	Data Recorder	DA-20	00260254
	Rion	Firmware		1.6

Equipment Used to Carry Out Calibration

Equipment ID.	Serial Number	Date Of Calibration
Stanford DS360 Function Generator	123151	17 April 2013
FLUKE 8845A	2230021	14 December 2012

The measurements reported in this certificate were carried out using equipment whose values are traceable to national standards.

Date Received 15 April 2013 ANV Job No. TRAC13/04078
Date Calibrated 29 April 2013
Comments:-
This calibration certificate contains reported values only.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	Initial Calibration		

This certificate provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Figure E.9 Calibration Certificate for Dytran 3233A (Location BSCU/V/2, 4, 5, 6, 7)

SVANTEK Calibration Certificate

Manufacturer	Instrument	Serial #	Level	Frequency	Sensitivity	Unit	Date Calibrated
Dytran	3233A	879	10 ms^{-2}	79.58 Hz	102	mV/ms^{-2}	
			10 ms^{-2}	79.58 Hz	105	mV/ms^{-2}	
			10 ms^{-2}	79.58 Hz	110	mV/ms^{-2}	
							11th November 2013

Manufacturer	Instrument	Serial #	Last calibrated	By
Svantek	SV958	20844		
Svantek	SV111	30521	13/09/2012	Svantek

Signed: Daniel O'Meara Date: 11/11/2013

Svantek UK Ltd
8B Wingbury Courtyard, Wingrave, Aylesbury, HP22 4LW
T: 01296 682040 F: 01296 682860 W: www.acsoft.co.uk E: sales@svantek.co.uk

GROUNDBORNE NOISE AND VIBRATION

BANK STATION CAPACITY UPGRADE PROJECT

DRAGADOS SA

JUNE 2014

GROUNDBORNE NOISE AND VIBRATION
BANK STATION CAPACITY UPGRADE PROJECT

Our Ref: 2142_006r_2-0_rps_e

Client: **Dragados SA**
Bank Station Capacity Upgrade Project Office
84 Eccleston Square
London
SW1V 1PX

Report by: **Anderson Acoustics Limited**
3 Trafalgar Mews
15-16 Trafalgar Street
Brighton
East Sussex BN1 4EZ

www.andersonacoustics.co.uk
T: 01273 696887

Date: **6 June 2014**

Project No: **2142**
Status: **FINAL**

Author	**Richard West** **Consultant** **BEng (Hons) MIOA**	**6 June 2014**
Reviewed	**Richard Sullivan** **Principal Consultant** **BSc (Hons) MIOA**	**6 June 2014**
Approved	**Steve Summers** **Technical Director** **BSc MSc CEng MIOA**	**6 June 2014**

REVISION HISTORY

Version	Comments	Changes made by	Approved by
2-0	Final	Richard Sullivan	Steve Summers

PAGE LEFT INTENTIONALLY BLANK

CONTENTS

1 INTRODUCTION

This technical report provides the survey results for groundborne noise and vibration monitoring undertaken between November and December 2013 at two locations in the vicinity of the proposed Bank Station Capacity Upgrade works in the City of London (CoL). This work was conducted on behalf of Dragados for the Bank Station Capacity Upgrade Project.

Our document "Bank Station Capacity Upgrade Project – Scope Variation" reference 2412_004S_1-0_RPS dated 11 November 2013 provides the scope of works for the groundborne noise and vibration monitoring, analysis and reporting undertaken in this report.

This report describes the groundborne noise and vibration measurements conducted, the measurement locations, noise and vibration units and metrics derived from the survey data and the instrumentation used.

A plan showing the locations of the measurement positions is provided in Appendix A and a completed Survey Report Form is provided for each measurement location in Appendix B. The results of the measurements are presented in Appendix C and Appendix D.

2 MEASUREMENT UNITS AND INDICES

Vibration and sound pressure measurements were carried out in 100ms measurement intervals in $L_{max,F}$ (dB). Vibration was measured in acceleration in the vertical direction (Z-axis). Vibration acceleration levels (dB) presented in this report were calculated to a reference level of 10^{-6} m/s^2.

3 MEASUREMENT LOCATIONS AND DURATIONS

The groundborne noise and vibration monitoring has been carried out at two locations in the vicinity of the proposed Bank Station Capacity Upgrade works. The locations include sensitive buildings that may be affected by the Bank Station Capacity Upgrade works.

The locations are summarised below in Table 3.1 and in detail in the Survey Report Forms in Appendix B.

Table 3.1 – Summary of Survey Locations

Location Reference	Address	Survey Duration	Installation Date	Collection Date
BSCU/V/5	St Clements Church, Clements Lane, London, EC4N 7AE	16 hour	11/12/2013	12/12/2013
BSCU/V/7	The Mansion House, Mansion House Place, London, EC4N 8LB	2 hour	21/11/2013	22/11/2013

It was understood that London Underground (LU) train movements were likely to be the main source of groundborne noise and vibration and therefore analysis has been made of train pass-bys over a sample period of two hours between 22:00 and 00:00 for each location.

Measurement locations were identified by consultation and liaison between URS, LU and Anderson Acoustics.

4 MEASUREMENT INSTRUMENTATION

The following equipment was used for the groundborne noise and vibration measurements:

- **1 No. Laptop Running – 01dB Metravib Trig32 Data Acquisition software;**
- **1 No. 01dB Metravib Data Acquisition Box – Symphonie 2 Channel Noise and Vibration Analyser, with the following transducers:**
- **1 No. Wilcoxon Research 731A Ultra-quiet, ultra-low frequency, seismic accelerometer;**
- **1 No. 01dB Metravib ½ in. Pre-polarized Microphone with 01dB Metravib Preamplifier Type 21A.**

The accelerometer was mounted on a heavy metal plate (conforming to DIN Standard 45669-2:2005 'Measurement of vibration immission - Part 2: Measuring method'). The microphone was fixed to a tripod approximately 1.2 m above ground/floor level.

All noise measurement instrumentation was calibrated both prior to and immediately following each survey period. No calibration drifts occurred. Laboratory calibration certificates are shown in Appendix E.

5 MEASUREMENT RESULTS

Groundborne noise and vibration levels for each monitoring location are presented in Appendix C and D.

Time history graphs are presented in Figures C.1, C.2, D.1 and D.2 showing $L_{max,F}$ levels. Annotations show known extraneous noise and vibration events. Other peaks in the time histories generally represent LU trains.

1/3 octave band graphs showing groundborne noise from individual train events are presented in Figures C.3 and D.3. Train events containing extraneous noise have not been included.

All noise and vibration data recorded between 22:00 and 00:00 for each location can be obtained from the following url: https://andersonacousticsltd.box.com/bankgbnvdata. Tables showing details of individual train events are also available at this location in Excel format. Where possible the train, line and direction have been identified using dwell time data for the Northern and Central lines. In cases where the source was unclear the information has been left blank.

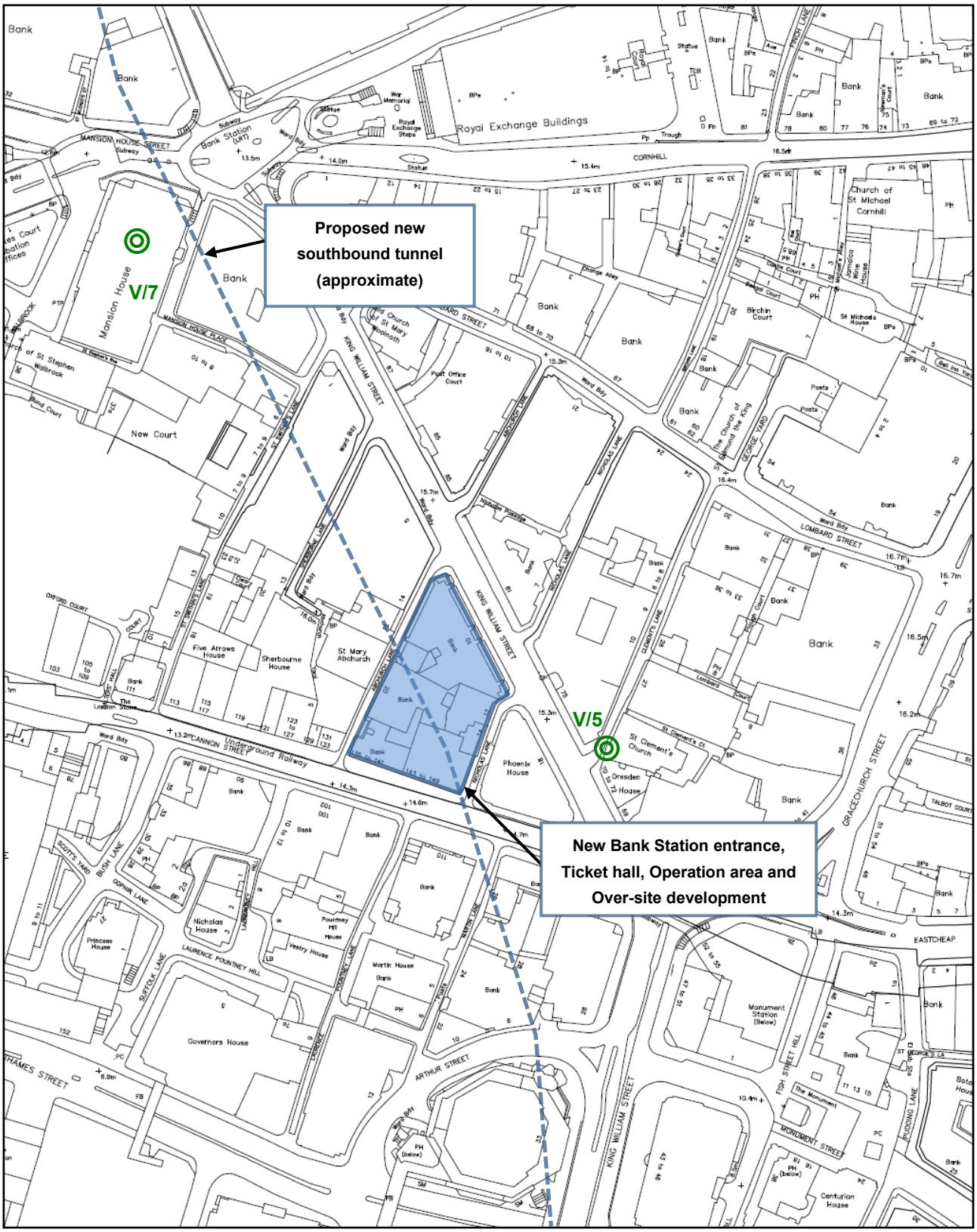
6 APPENDICES

Appendix A – Measurement Locations
Appendix B – Survey Report Forms
Appendix C – Results for Location BSCU/V/5
Appendix D – Results for Location BSCU/V/7
Appendix E – Calibration Certificates

APPENDIX A

MEASUREMENT LOCATIONS

Figure A.1 Location Plan of Groundborne Noise and Vibration Monitoring Positions



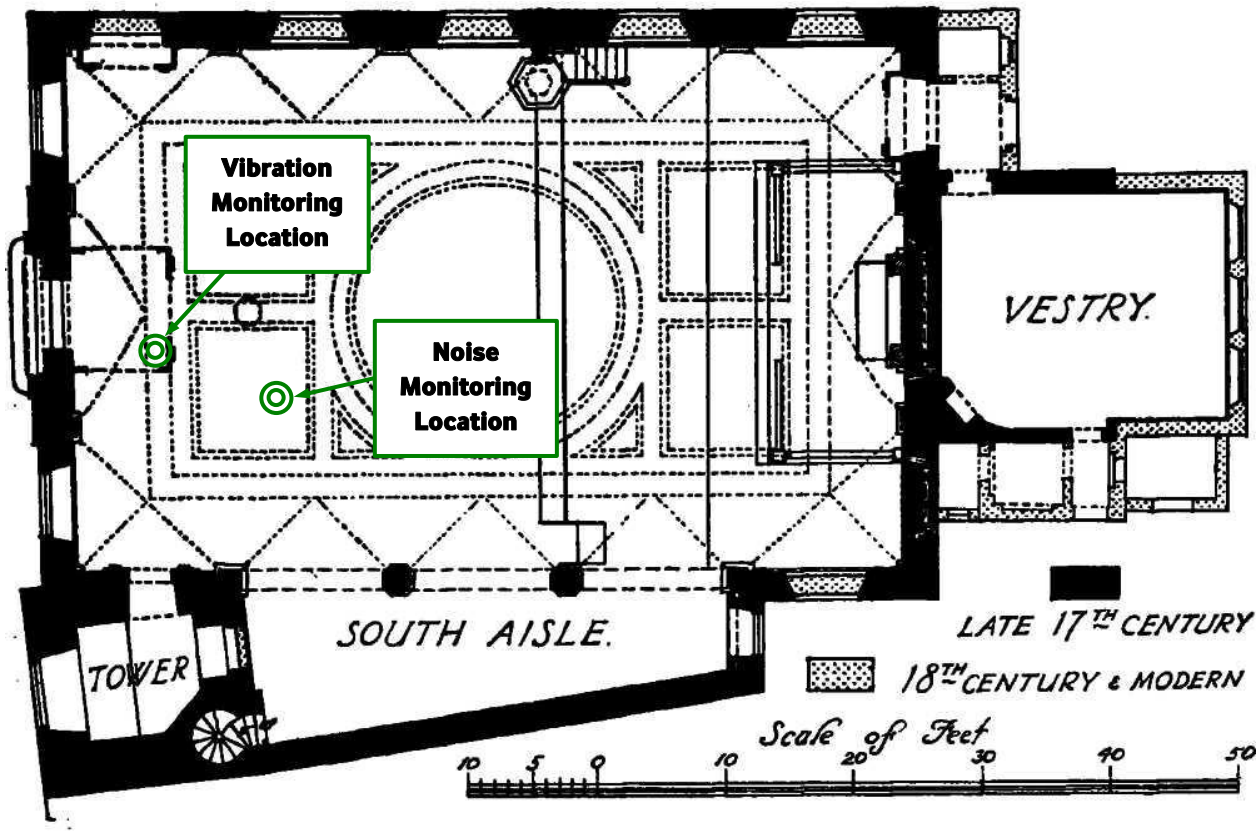
APPENDIX B

SURVEY REPORT FORMS

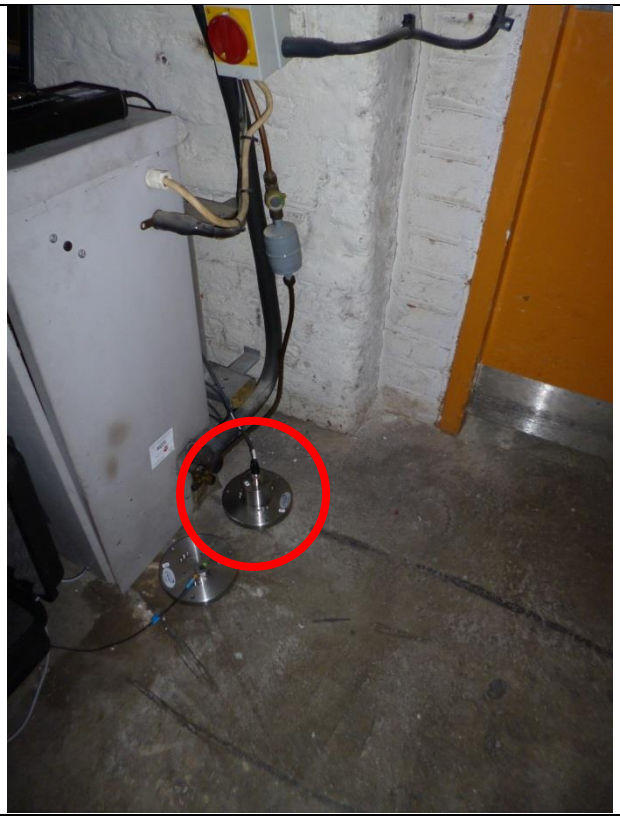
Location	BSCU/V/5 St Clements Church, Clements Lane, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	01dB Symphonie 01704	**Pre-amplifier Type** **Serial No.**	01dB 21A 20503
Microphone Type **Serial No.**	01dB MCE 212 39855	**Calibrator Type** **Serial No.**	Rion NC-74 34304643
Accelerometer Type **Serial No.**	Wilcoxon 731A 4453		
Start Date	11/12/2013	**End Date**	12/12/2013
Start Time	17:45	**End Time**	10:00
Start Calibration Level	94.0	**End Calibration Level**	94.0
Store Intervals	100ms.	**Store Parameters**	Ch1 & Ch2: L_{eq}, Peak, Slow, Slow Max, Fast, Fast Max, 1/3 Oct Fast.
Photo taken identifying location with equipment installed			Yes

Description of site (Location of equipment, general surroundings etc.)
Located on stone floor in entrance foyer of church.
Description of environment at start and end of survey
Road traffic, pedestrians on main road (possible source of vibration but not perceived).

Site plan

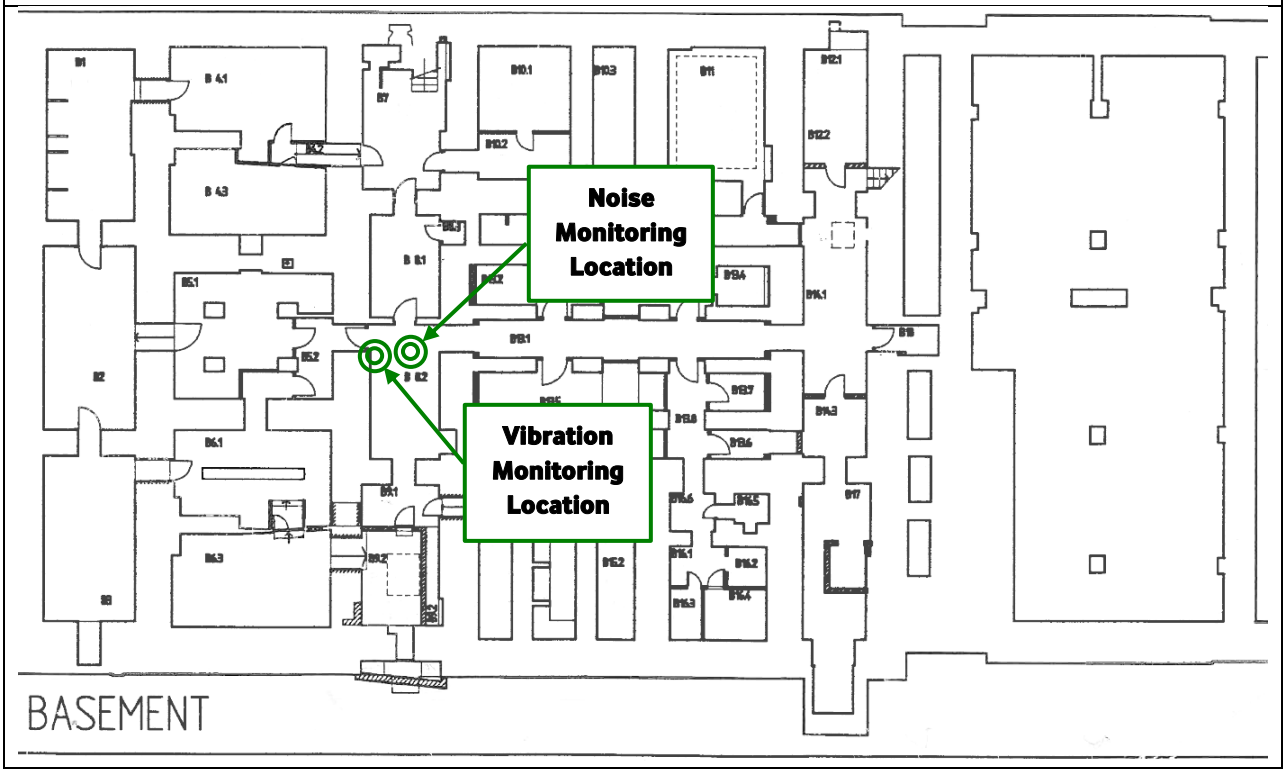

Vibration Monitoring Location
Noise Monitoring Location
VESTRY.
SOUTH AISLE.
TOWER
LATE 17TH CENTURY
18TH CENTURY & MODERN
Scale of Feet
10 5 0 10 20 30 40 50

Location	BSCU/V/7 The Mansion House, London		
Personnel	Richard West (Anderson Acoustics Ltd)		
Recorder Type **Serial No.**	01dB Symphonie 01704	**Pre-amplifier Type** **Serial No.**	01dB 21A 20503
Microphone Type **Serial No.**	01dB MCE 212 39855	**Calibrator Type** **Serial No.**	Rion NC-74 34304643
Accelerometer Type **Serial No.**	Wilcoxon 731A 4453		
Start Date	21/11/2013	**End Date**	22/11/2013
Start Time	22:00	**End Time**	00:00
Start Calibration Level	94.0	**End Calibration Level**	94.0
Store Intervals	100ms.	**Store Parameters**	Ch1 & Ch2: L_{eq}, Peak, Slow, Slow Max, Fast, Fast Max, 1/3 Oct Fast.
Photo taken identifying location with equipment installed			Yes



Description of site (Location of equipment, general surroundings etc.)
Located on concrete floor in the basement in the southern half of the building.
Description of environment
Underground trains and some road traffic audible (possible source of vibration but not perceived).

Site plan


Noise Monitoring Location
Vibration Monitoring Location
BASEMENT

APPENDIX C

RESULTS FOR LOCATION BSCU/V/5

Figure C.1 Groundborne Noise Level Time History for Location BSCU/V/5

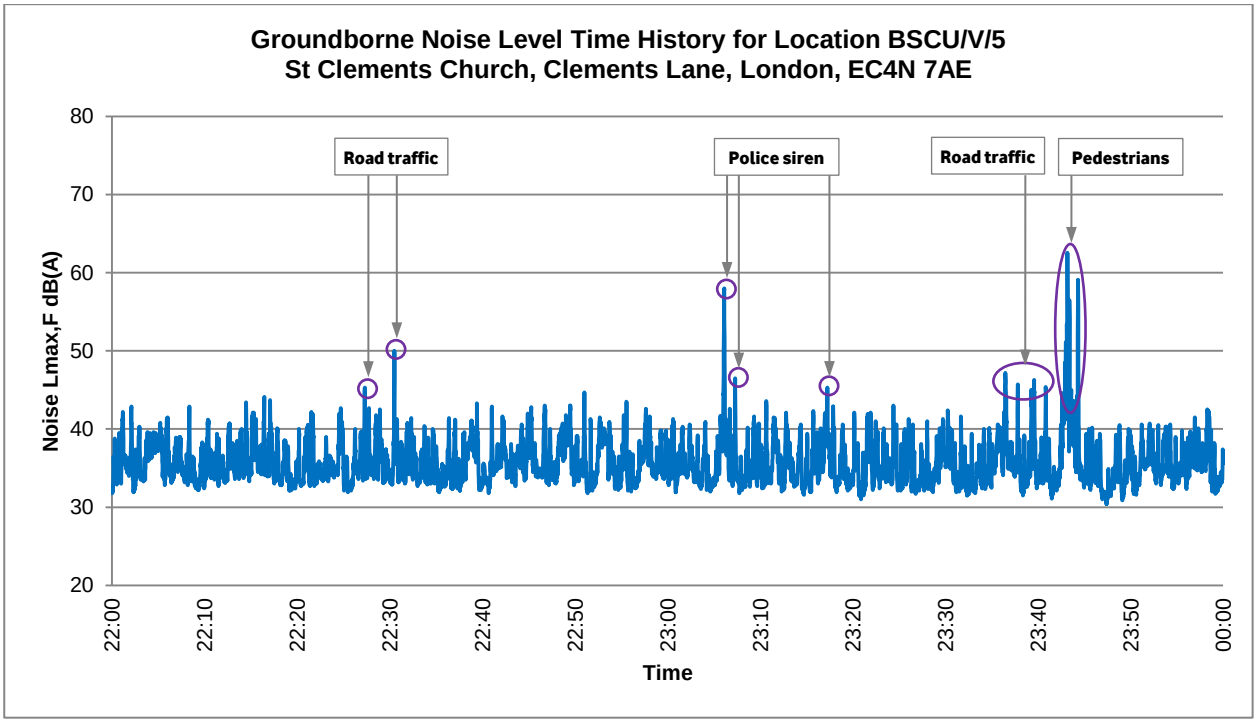


Figure C.2 Groundborne Vibration Level Time History for Location BSCU/V/5

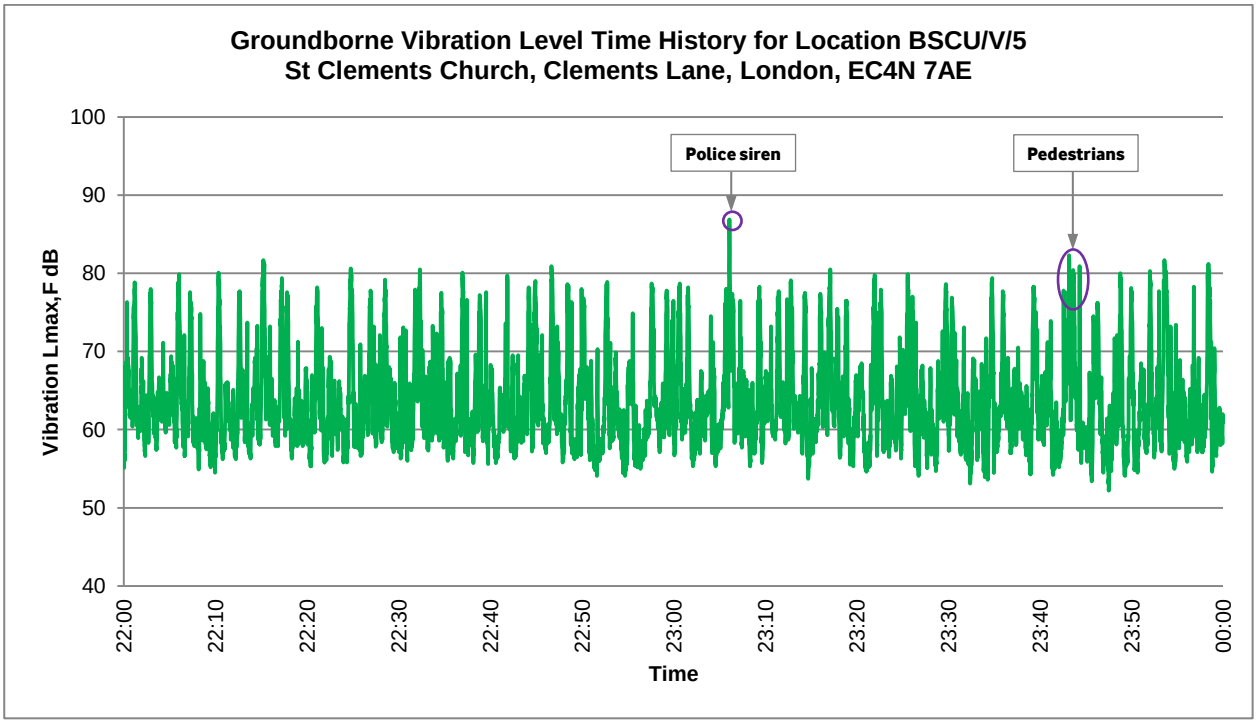
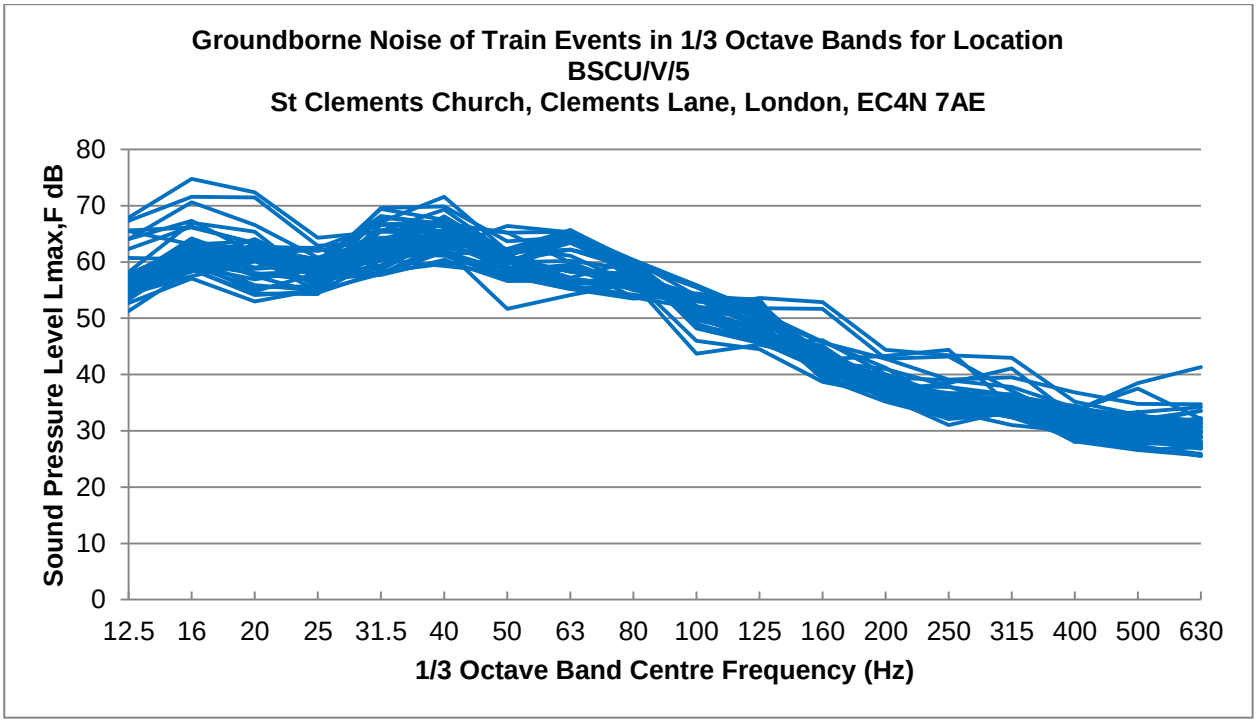


Figure C.3 Groundborne Noise of Train Events in 1/3 Octave Bands for Location BSCU/V/5



APPENDIX D

RESULTS FOR LOCATION BSCU/V/7

Figure D.1 Groundborne Noise Level Time History for Location BSCU/V/7

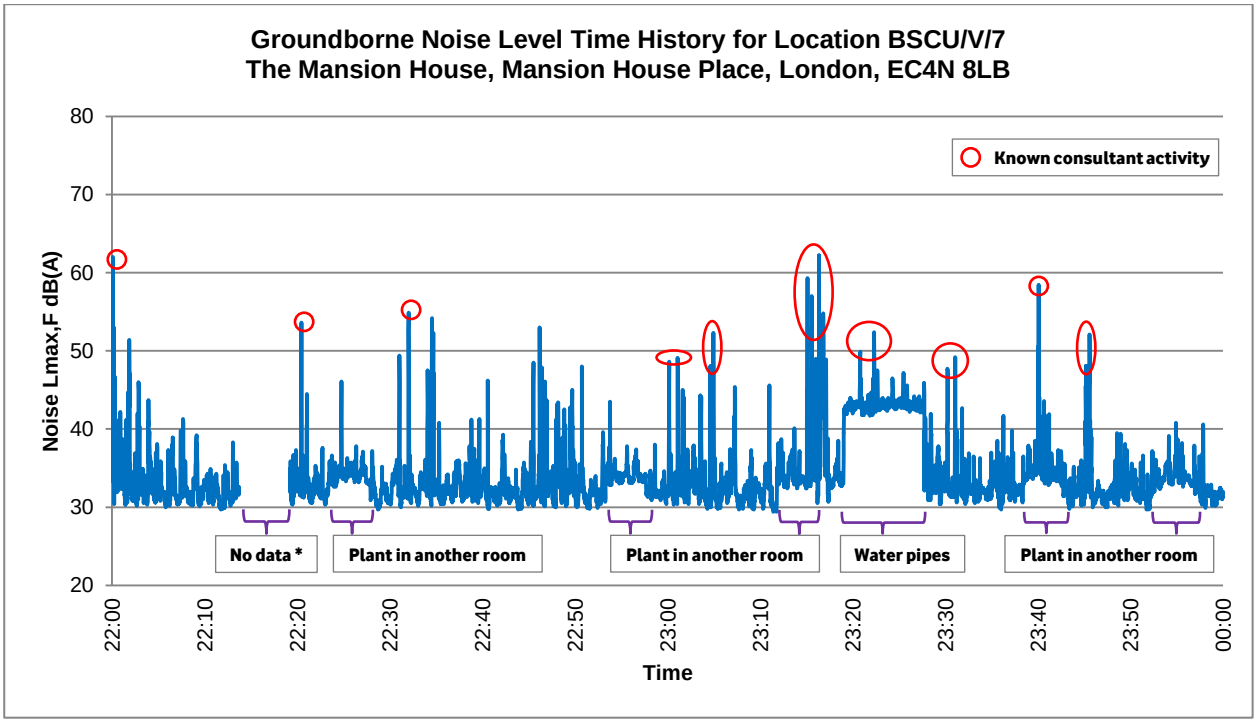
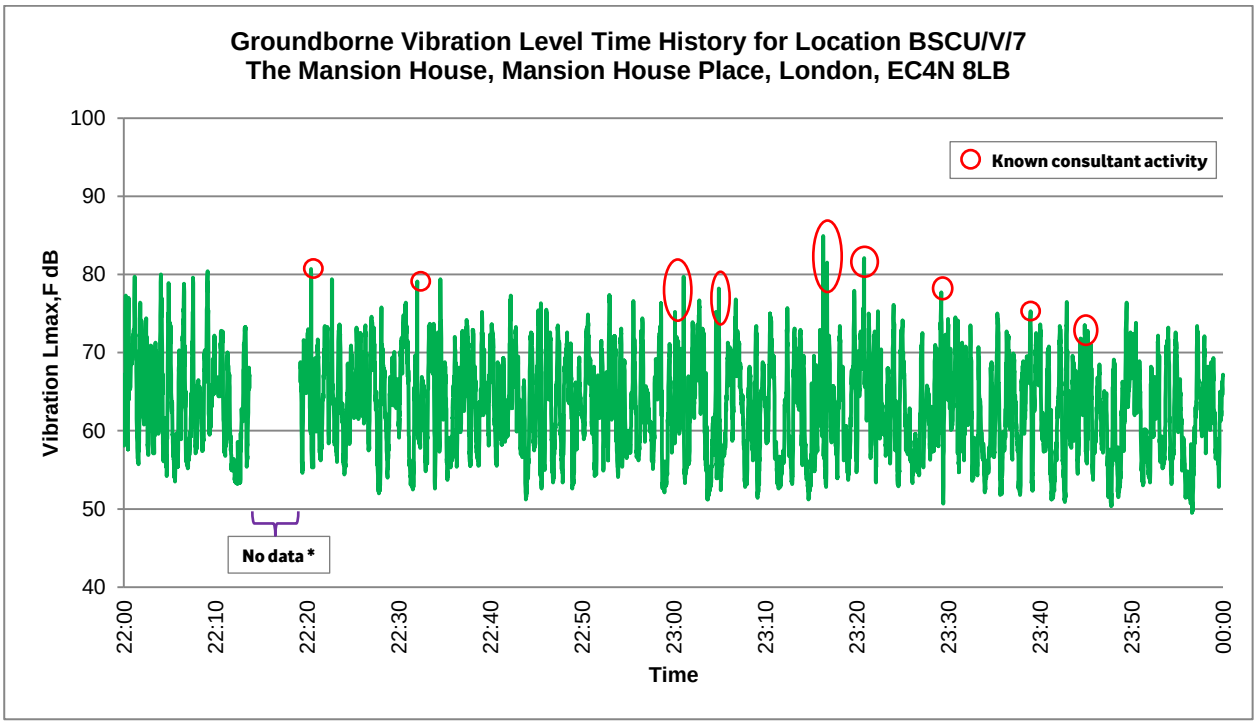
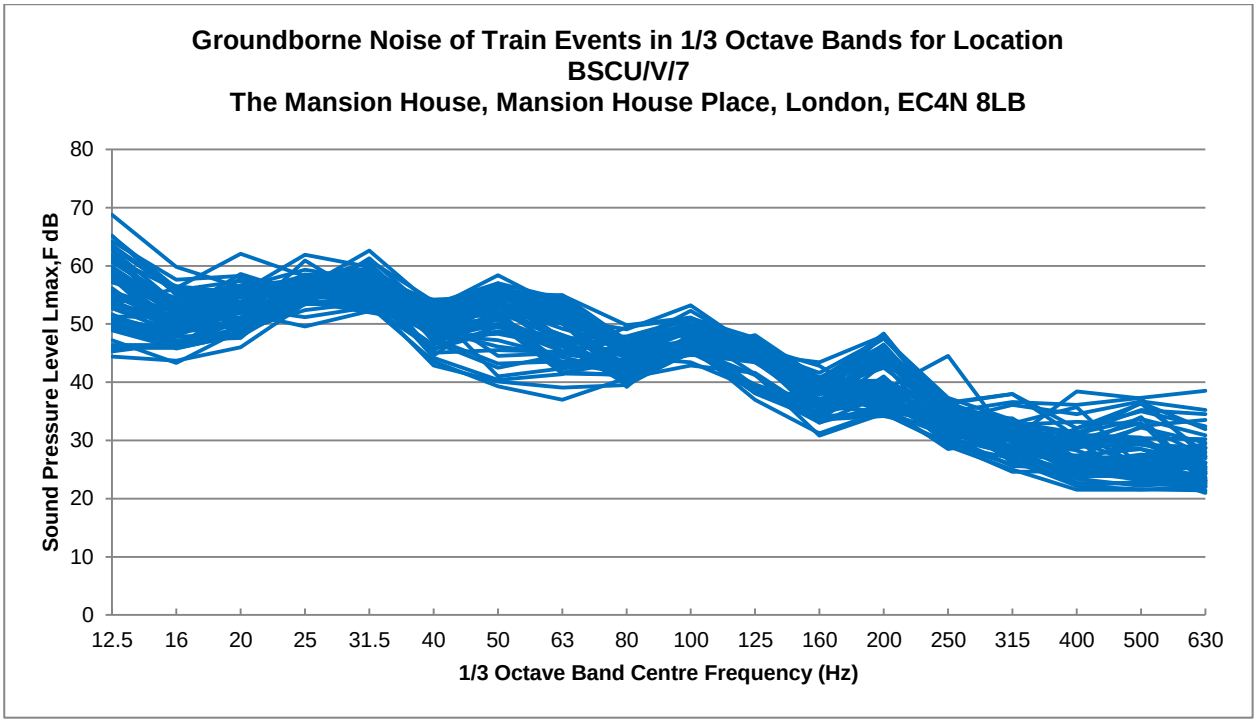


Figure D.2 Groundborne Vibration Level Time History for Location BSCU/V/7



No data between 22:14 and 22:19 while system sensitivity was changed.

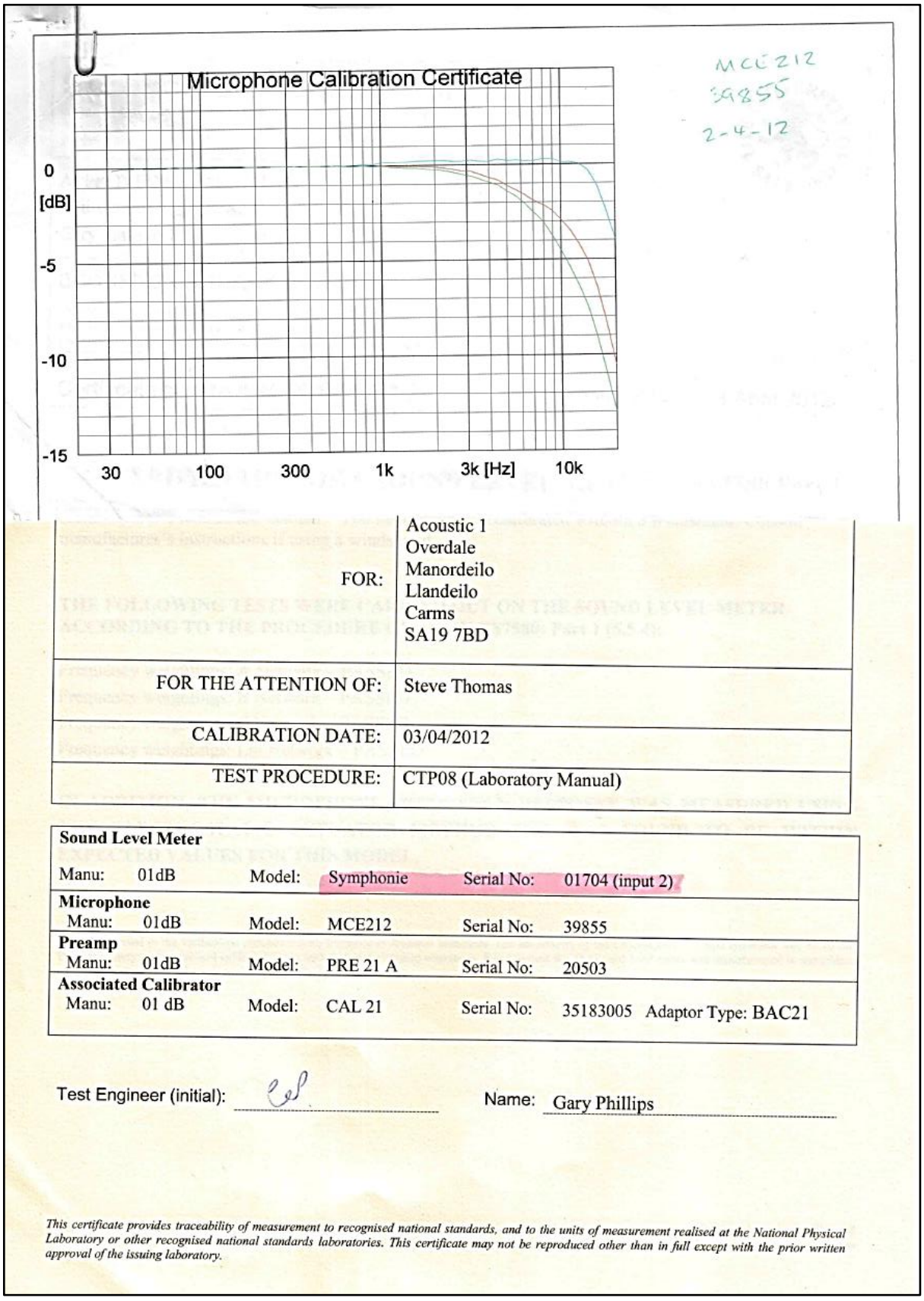
Figure D.3 Groundborne Noise of Train Events in 1/3 Octave Bands for Location BSCU/V/7



APPENDIX E

CALIBRATION CERTIFICATES

Figure E.1 Calibration Certificate for 01dB Symphonie (Location BSCU/V/5, BSCU/V/7)



Microphone Calibration Certificate

MCE212
39855
2-4-12

FOR:	Acoustic 1 Overdale Manordeilo Llandeilo Carms SA19 7BD
FOR THE ATTENTION OF:	Steve Thomas
CALIBRATION DATE:	03/04/2012
TEST PROCEDURE:	CTP08 (Laboratory Manual)

Sound Level Meter					
Manu:	01dB	Model:	Symphonie	Serial No:	01704 (input 2)
Microphone					
Manu:	01dB	Model:	MCE212	Serial No:	39855
Preamp					
Manu:	01dB	Model:	PRE 21 A	Serial No:	20503
Associated Calibrator					
Manu:	01 dB	Model:	CAL 21	Serial No:	35183005 Adaptor Type: BAC21

Test Engineer (initial): GP Name: Gary Phillips

This certificate provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full except with the prior written approval of the issuing laboratory.

Figure E.2 Calibration Certificate for Wilcoxon 731A (Location BSCU/V/5, BSCU/V/7)

MEGGiTT

Calibration Data

Low Frequency Accelerometer

Model **731A**

Serial Number **4453**

Sensitivity **10.4 V/g**

Bias Voltage **9.7 Vdc**

Resonance **850 Hz**

Maximum Amplitude Range **0.5 g peak**

Frequency Response			
±1dB	**0.10 Hz**	to	**330 Hz**
±3dB	**0.05 Hz**	to	**500 Hz**

Calibrated by: **T.PHOUBANDITH** Date: **04/01/2013**

This calibration is traceable to the National Institute of Standards and Technology, Gaithersburg, MD 20899.
Frequency Response is traceable 5 Hz to 10 kHz.
Low end frequency response and amplitude range are nominal values.
Sensitivity measured at 10 Hz, 0.5g, 25°C.

Meggitt (Maryland), Inc. is an ISO 9001:2008 and EN/JISQ/AS9100:2004 Registered Company.

Meggitt Sensing Systems
20511 Seneca Meadows Parkway, Germantown MD 20876, USA

Meggitt (Maryland), Inc d/b/a Meggitt Sensing Systems

Tel: +1 (301) 330 8811
Tel: 1 800 WILCOXON
Fax: +1 (301) 330 8873
www.meggittsensingsystems.com
www.meggitt.com

Figure E.3 Calibration Certificate for Rion NC-74 (Location BSCU/V/5, BSCU/V/7)

CERTIFICATE OF CALIBRATION

ISSUED BY AV CALIBRATION

Date of issue 17 April 2013 Certificate N° 07102

UKAS CALIBRATION 0653

AV Calibration
2 Warren Court
Chicksands, Shefford
Bedfordshire SG17 5QB
U.K.
Tel: +44 (0)1462 638600
Fax: +44 (0)1462 638601
Email: lab@avcalib.co.uk
www.avcalibration.co.uk

Page 1 of 2 pages

Approved Signatory
G.Parry

CLIENT	Anderson Acoustics 3 Trafalgar Mews 15 - 16 Trafalgar Street Brighton East Sussex BN1 4EZ
F.A.O.	Prannav Bhalla
REF.	-
	Job N° UKAS13/04087/01
DATE OF RECEIPT	10 April 2013
PROCEDURE	AV Calibration Engineer's Handbook, Section 2
IDENTIFICATION	Sound calibrator Rion type NC-74 serial number 34304643, with one-inch housing and adapter type NC-74-002 for half-inch microphone.
CALIBRATED ON	15 April 2013
PREVIOUS CALIBRATION	Calibrated on 14 May 2010 Certificate Nº 05213 issued by this laboratory