ACOUSTICS CENTRAL

Birkbeck University - Cambridge House, 373-375 Euston Road

# Planning Noise & Vibration Report

2016032-0 R5

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# Planning Noise & Vibration Report

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## Document History and Version Control

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| V1.0 | Issued for comment | **Derek Nash** MSc BSc (Hons) CEng MIOA | 6th November 2017 |
| V1.1 | First Issue | **Derek Nash** MSc BSc (Hons) CEng MIOA | 15th December 2017 |
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## Executive Summary

Cambridge House, 373 – 375 Euston Road is an existing building which previously comprised a car show room at ground floor, and B1 Office use throughout the rest of the building. Birkbeck, University of London is to undertake works to convert the existing space to educational use, and construct a 2-storey extension on the roof.

As part of obtaining planning permission, it is required to demonstrate to the satisfaction of the local planning authority that both the impact of the existing noise and vibration climate on the development, and impact of the development on surrounding sensitivities has been properly considered.

To this end, Acoustics Central has been instructed to undertake acoustic assessments in order to identify any measures necessary and practicable to provide a suitable internal noise and vibration climate for future occupants of the building, and minimize the impact on existing sensitivities.

A series of noise measurements at the development site have been undertaken. Using these, existing façade incident and background noise levels have been quantified. Using the measured background noise levels, rating level limits for mechanical services plant installed as part of the development have been established in accordance with the Camden Local Plan.

Using these, along with the proposed mechanical services scheme for the building, noise calculations have been undertaken to the nearest effected residences. These have formed the basis of an assessment to identify whether the proposed plant is expected to comply with the plant noise criteria at nearby sensitivities.

The assessment concluded that as noise levels are calculated to be at least 1dB below the rating limits, the noise arising from the proposed plant is expected to comply with the plant noise criteria at all assessment positions. As such, mitigation beyond that already included in the scheme to reduce the levels is not expected to be warranted.

In order to demonstrate that the site provides a suitable noise climate for the proposed educational use, an assessment of the acoustic requirements of the building envelope was undertaken. The assessment used the noise survey data as a basis, along with relevant guidance from BB93.

Based in the assessment, acoustic performance requirements of the glazing were established. From a review of available manufacturer's test data, an example configuration was put forward for illustrative purposes. In this case, glazing specifications ranged from wide air space for windows exposed to the highest external levels, to standard double glazing away from major noise sources.

Using vibration data measured as part of the site survey as the basis, a vibration assessment was undertaken. Using the measured data, and guidance contained within BS 6472, it was concluded that the expected internal vibration levels would fall below the range corresponding to 'Low probability of adverse comment'. These are also below limiting level identified in the Camden Local Plan for offices, which is expected to be a suitable substitute in light of no specific criteria relating to educational use. As such, no specific measures are expected to be necessary to control vibration.

ACOUSTICS CENTRAL

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Plant Noise Schedule

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Example Plant Noise Calculation Sheets

**2016032-0 R5 Appendix A**
Glossary of Acoustics Terms

**2016032-0 R5 Appendix B**
Document Naming and Version Control Policy

# 1 Introduction

1.1 Cambridge House, 373 – 375 Euston road, is an existing building which previously comprised a car show room at ground floor, and B1 Office use throughout the rest of the building. Birkbeck, University of London is to undertake works to convert the existing space to educational use, and construct a 2-storey extension on the roof.

1.2 As part of obtaining planning permission, it is required to demonstrate to the satisfaction of the local planning authority that both the impact of the existing noise and vibration climate on the development, and impact of the development on surrounding sensitivities has been properly considered.

1.3 To this end, Acoustics Central has been instructed to undertake acoustic assessments in order to identify any measures necessary and practicable to provide a suitable internal noise and vibration climate for future occupants of the building, and minimize the impact on existing sensitivities.

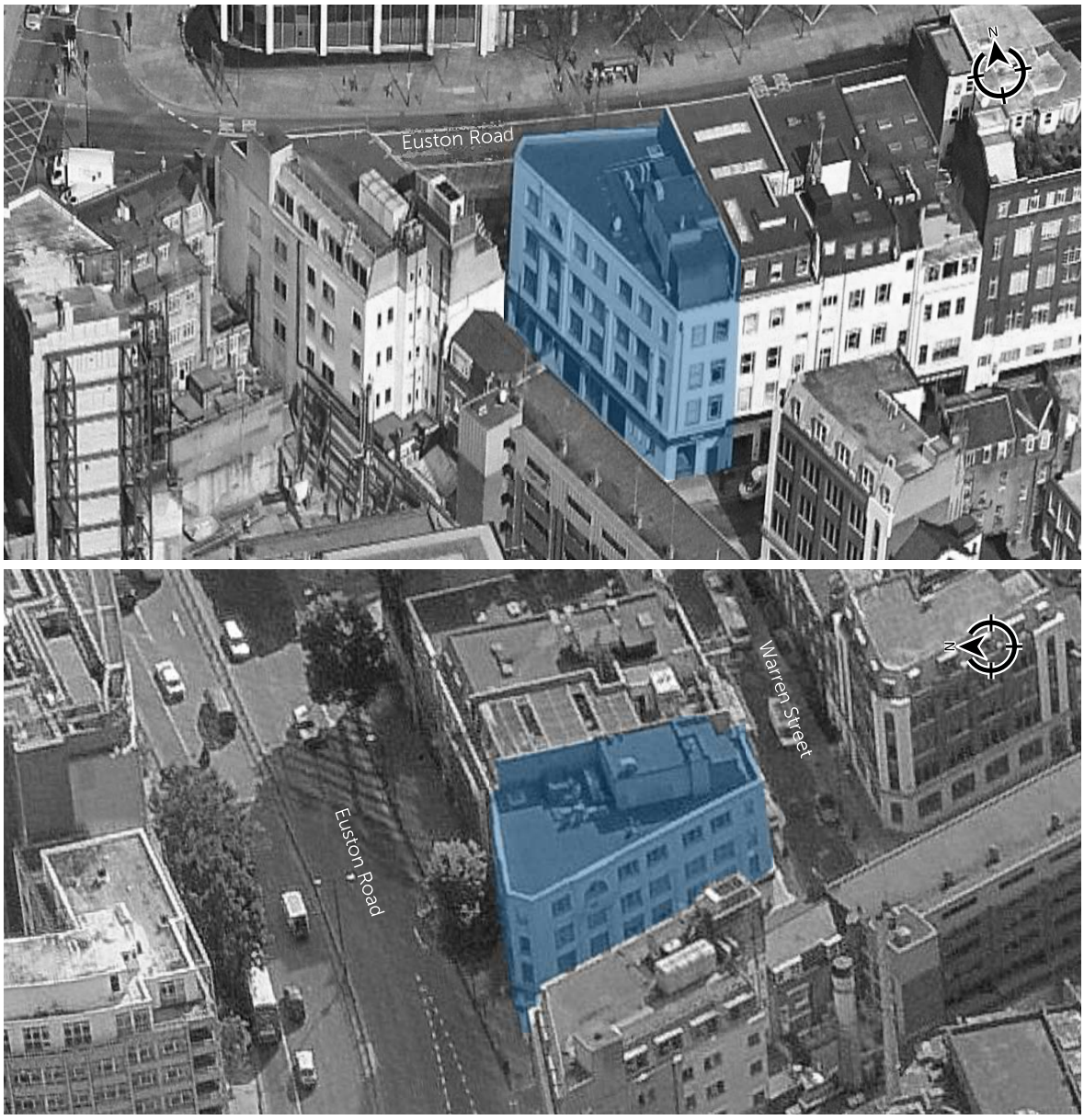
1.4 This report details an environmental noise and vibration survey carried out at the site, the subsequent assessment undertaken using the noise data collected which is considered in light of the architectural proposals, and conclusions drawn from the assessment.

1.5 The report is necessarily technical in nature, however every effort has been made to make it as clear as possible. In this regard, the Glossary of Acoustics Terms attached as Appendix A gives further explanation on relevant acoustics terminology used within the report.

# 2 Site Layout

## 2.1 General

2.1.1 Cambridge House is located at 373 - 375 Euston Road, London, NW1 3AR, and is illustrated in the following figures.




F1 Figure indicating the location of the site

2.1.2 As indicated on the above figures, the building is bounded by Euston Road to the north, Cleveland Street to the west, and Warren Street to the south.

## 2.2 Noise and Vibration Climate

2.2.1 Euston Road is a busy A-road (the A501) and consists of 3 lanes in each direction where it passes the site. Volumes of traffic remain high along the road during most of the day and night, and as such noise from traffic is the dominant contributor to the noise climate at the site.

2.2.2 Road vehicles along the smaller roads within the vicinity of the site also contribute to the noise climate.

2.2.3 A tube tunnel runs beneath Euston Road carrying Metropolitan Line, Hammersmith & City Line, and Circle Line trains. With these three lines operating in each direction in the tunnel, there are approximately 400 tube train pass-bys at the site across a typical working day (09h00 – 17h00).

2.2.4 With the building sitting in such close proximity to the tube tunnel, vibration levels from tube pass-bys are perceptible in the building.

2.2.5 In addition to this, re-radiated noise from tube pass-bys (vibration of the structure resulting in audible structure-borne noise) contributes to the noise climate in the Basement.

2.2.6 It is also worth noting that part of the pavement sits above the Basement Level space, and the noise generated by footfall, suitcases being dragged etc. is clearly noticeable depending on the type of footwear etc.

## 2.3 Existing Sensitivities

2.3.1 The closest sensitive receptors are those immediately adjacent to Cambridge House fronting on to Euston Road and Warren Street.

2.3.2 There are also sensitive receptors on the opposite side of Warren Street to the south, and Cleveland Street to the west.

# 3 Guidance and Standards

## 3.1 General

3.1.1 As part of obtaining planning permission, it is required to demonstrate to the satisfaction of the local planning authority that both the impact of the existing noise and vibration climate on the development, and impact of the development on surrounding sensitivities has been properly considered. In this case, the following need to be addressed:

- the impact of noise and vibration from surrounding transportation sources on future occupants of the building,
- the impact of noise generated by any fixed mechanical services plant on existing residences within the vicinity of the site.

3.1.2 When addressing the issue of suitable internal and external noise climate for educational use, Building Bulletin 93[1] provides relevant guidance.

3.1.3 When addressing the issues of the impact of vibration on the development, and noise generated by the development, Camden Council's Local Plan[2] sets out the relevant acoustic criteria.

## 3.2 Internal Noise

3.2.1 The following table presents the internal noise criteria relevant to this project as taken from BB93. The reverberation time requirements are also presented as these are relevant when calculating the subsequent noise break-in from external sources. For the purposes of the noise break-in calculations, it is assumed the reverberation times set out in the table are achieved.

| Place and time | $L_{Aeq,30\ min}$ | $L_{A1,30\ min}$ | $T_{mf}$ |
|---|---|---|---|
| General Teaching Space | 40 dB | 60 dB | ≤ 1.0 seconds |
| Lecture Theatre | 40 dB | 60 dB | ≤ 1.0 seconds |

T1 BB93 criteria for teaching spaces

3.2.2 BB93 allows for a relaxation on internal noise levels where ventilation is provided by natural means. Where natural ventilation is used, internal levels may exceed the normal value by 5dB.

3.2.3 In addition, where the ventilation strategy is by natural means, internal noise levels may increase to 55dB under summertime (hottest 200 hrs of the year) or intermittent boost (venting of fumes) conditions.

## 3.3 Impact of Vibration on Development

3.3.1 Appendix 3 of the Camden Local Plan sets out limiting Vibration Dose Values (VDVs) from various sources, the limits for which are dependent on the nature of the development.

[1] Building Bulletin 93 - Acoustic design of schools: performance standards, DfE and EFA, December 2014
[2] Camden Local Plan, Camden Council, 2017

Educational use developments are not specifically identified, however it is expected that the limits corresponding to office use developments serve as an appropriate substitute as these fall under the same category in BS 6472[3]. The VDV limits set out in the Camden Local Plan for offices are 0.4 $m/s^{1.75}$, which correspond to the threshold for 'Low Probability of Adverse Comment' in BS 6472 as shown in the following table.

| Place and time | Vibration Does Value, VDV ($m/s^{1.75}$) | | |
|---|---|---|---|
| | Low probability of adverse comment | Adverse comment possible | Adverse comment probable |
| Educational Spaces | 0.4 to 0.8 | 0.8 to 1.6 | 1.6 to 3.2 |

T2 Vibration thresholds for the likelihood of adverse comment given in BS 6472

### 3.4 Impact of Noise Generated by Development

3.4.1 With regards to the impact of noise generated by the development, the Camden Local Plan states the following in relation to industrial and commercial noise sources:

*A relevant standard or guidance document should be referenced when determining values for LOAEL and SOAEL for non-anonymous noise. Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' (BS 4142) will be used. For such cases a 'Rating Level' of 10 dB below background (15dB if tonal components are present) should be considered as the design criterion).*

Noise Policy Statement for England

3.4.2 The Noise Policy Statement for England (NPSE) provides the context of the LOAEL and SOAEL terminology used in the Camden Local Plan. The document seeks to clarify the underlying principles and aims in existing policy documents, legislation and guidance that relate to noise. The statement applies to all forms of noise, including environmental noise, neighbour noise and neighbourhood noise.

3.4.3 The statement sets out the long term vision of the government's noise policy, which is to "promote good health and a good quality of life through the effective management of noise within the context of policy on sustainable development".

3.4.4 The NPSE adopts established concepts from toxicology that are currently being applied to noise effects. The concept details noise level thresholds, at which the effects of an exposure may be classified into a specific category. The classification categories as detailed within NPSE are as follows:

- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;

[3] BS 6472-1:2008 - Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting

- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and

- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.

3.4.5 The first aim of the NPSE is to avoid significant adverse effects on health and quality of life, taking into account the guiding principles of sustainable development. The second aim considers situations where effects are established between the LOAEL and SOAEL. In such circumstances, all reasonable steps should be taken to mitigate and minimise the effects. However this does not mean that such adverse effects cannot occur. The third aim seeks to improve health and quality of life, where possible, through the pro-active management of noise, whilst also taking account of the guiding principles of sustainable development.

3.4.6 It is recognised that SOAEL does not have a single objective noise-based level that is applicable to all sources of noise in all situations; therefore the SOAEL is likely to be different for different sources, receptors and at different times of the day.

### Planning Practice Guidance

3.4.7 Planning practice guidance on noise attempts to clarify the thresholds set out above. To this end, the table below taken from the guidance summarises the noise exposure hierarchy, based on the likely average response.

| Perception | Examples of Outcomes | Increasing Effect Level | Action |
|---|---|---|---|
| Not noticeable | No Effect | No Observed Effect | No specific measures required |
| Noticeable and not intrusive | Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life. | No Observed Adverse Effect | No specific measures required |
| | | Lowest Observed Adverse Effect Level | |
| Noticeable and intrusive | Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life. | Observed Adverse Effect | Mitigate and reduce to a minimum |
| | | Significant Observed Adverse Effect Level | |
| Noticeable and disruptive | The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area. | Significant Observed Adverse Effect | Avoid |
| Noticeable and very disruptive | Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory | Unacceptable Adverse Effect | Prevent |

T3 Summary of the noise exposure hierarchy, based on the likely average response

BS 4142

3.4.8 BS 4142:2014 – "Methods for rating and assessing industrial and commercial sound" describes a method for assessing whether noise from factories, industrial premises, fixed installations, sources of industrial nature and commercial premises is likely to give rise to complaints.

3.4.9 Under the BS 4142 procedure, a noise rating level is calculated for the source at a receiver location (normally an existing residence or other sensitive premises). This rating level takes the predicted noise level at that location and adds various penalties for acoustic features expected to increase the significance of the source, such as tonality, impulsivity and intermittency.

3.4.10 The significance of the sound is then calculated by comparing the measured background noise level with the rating level, and observing the following principles:

- Typically, the greater this difference, the greater the magnitude of the impact.
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

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

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

3.4.12 BS 4142 contains particular terminology which it's helpful to summarise here.

- **Specific sound:** sound from the source being assessed – in this case the extract plant. The specific sound level is measured and reported using the $L_{Aeq}$ index.
- **Residual sound:** ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound. The residual sound level is also measured and reported using the $L_{Aeq}$ index.
- **Ambient sound:** totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far. This includes the specific sound. The ambient sound level is also measured and reported using the $L_{Aeq}$ index.
- **Background sound:** this is the sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval. It's used to indicate the underlying noise levels in the absence of more transient sources, and is measured and reported using the $L_{A90}$ index.
- **Rating level:** The rating level is the specific sound once any adjustments for the characteristic features of the sound that result in an increased likelihood of disturbance (such as tonality, impulsivity, intermittency etc.) have been taken into account. It should be noted that these adjustments are as heard at the receiver, and not simply a consequence of the plant operating sound levels and conditions. As the adjustments increase the rating level, these can be thought of as penalties. As such, the rating level is the specific sound level with penalties applied.

### Limiting Noise Levels

3.4.13 Taking the above into consideration, numerical values for LOAEL and SOAEL need to be determined in the context of a BS 4142 assessment. To this end, the Camden Local Plan puts forward the following table and footnotes:

| Existing Noise sensitive receptor | Assessment Location | Design Period | LOAEL (Green) | LOAEL to SOAEL (Amber) | SOAL (Red) |
|---|---|---|---|---|---|
| Dwellings** | Garden used for main amenity (free field) and Outside living or dining or bedroom window (façade) | Day | 'Rating level' 10dB* below background | 'Rating level' between 9dB below and 5dB above background | 'Rating level' greater than 5dB above background |
| Dwellings** | Outside bedroom window (façade) | Night | 'Rating level' 10dB* below background and no events exceeding 57dB$L_{Amax}$ | 'Rating level' between 9dB below and 5dB above background or noise events between 57dB and 88dB $L_{Amax}$ | 'Rating level' greater than 5dB above background and/or events exceeding 88dB$L_{Amax}$ |

T4 Table C from the Camden Local Plan: Noise levels applicable to proposed industrial and commercial developments (including plant and machinery)

**10dB should be increased to 15dB if the noise contains audible tonal elements. (day and night). However, if it can be demonstrated that there is no significant difference in the character of the residual background noise and the specific noise from the proposed development then this reduction may not be required. In addition, a frequency analysis (to include, the use of Noise Rating (NR) curves or other criteria curves) for the assessment of tonal or low frequency noise may be required.*

***levels given are for dwellings, however, levels are use specific and different levels will apply dependent on the use of the premises.*

*The periods in Table C correspond to 0700 hours to 2300 hours for the day and 2300 hours to 0700 hours for the night. The Council will take into account the likely times of occupation for types of development and will be amended according to the times of operation of the establishment under consideration.*

# 4 Noise Survey

## 4.1 General

4.1.1 In order to quantify the existing noise climate at the site, a noise survey was undertaken.

4.1.2 The objective of this was to determine the levels of noise incident on the building from external sources, such as the roads, and to establish the noise climate present at sensitivities within the vicinity of the site.

4.1.3 The survey took place between Wednesday 6th and Friday 8th April 2016. It comprised a combination of attended and unattended measurements. The attended measurements were made at both internal and external locations.

## 4.2 Guidance and Standards

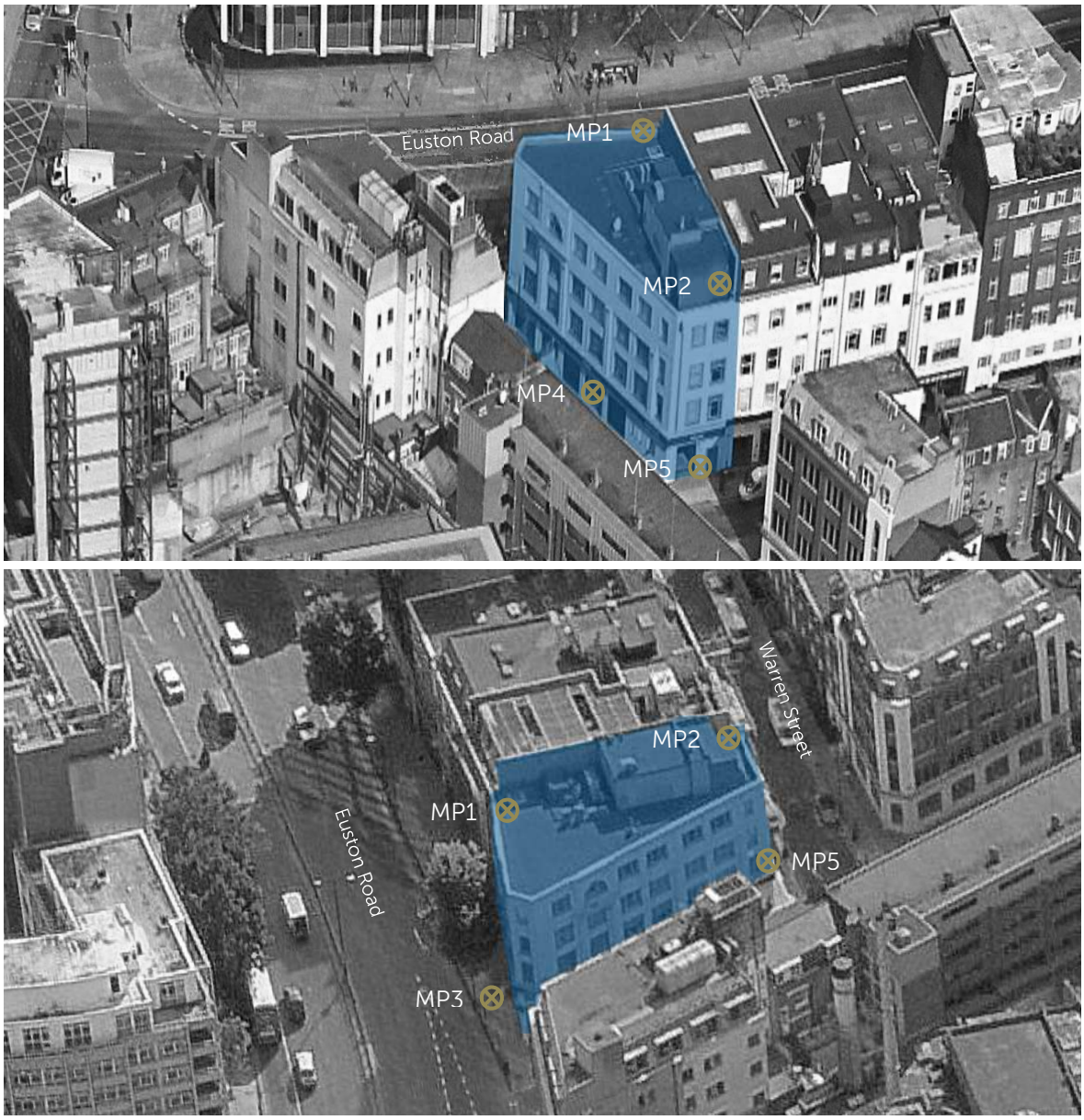
4.2.1 The survey instrumentation, methodology and reporting of results was carried out following guidance contained within British Standard 7445-1:2003 - *'Description and measurement of environmental noise - Part 1: Guide to quantities and procedures'*.

## 4.3 Measurement Positions

4.3.1 Unattended noise measurements were made for 24 hours at two positions both located on the roof. One was located at the northern end of the roof facing Euston Road (MP1), and one at the southern end of the roof, facing Warren Street (MP2).

4.3.2 As mentioned above, in addition to the unattended noise monitors, a series of attended measurements were made at a further three external positions (MP3 – MP5) close to the north, west and south facades at street level.

4.3.3 The following figures illustrate the measurement locations.




F2 Figures illustrating locations of noise measurement positions

## Unattended Positions

MP1 The sound level meter microphone was fixed to the top of a tripod approximately 1.5m above roof level at the northern corner of the roof. Measurements were therefore made under free-field conditions. The purpose of this position was to measure general noise levels from the principle noise source – Euston Road – as well as quantifying background noise levels at adjacent sensitivities fronting onto Euston Road.

MP2 The sound level meter microphone was fixed to the top of a tripod approximately 1.5m above roof level at the south-eastern corner of the roof. Measurements were therefore

made under free-field conditions. The purpose of this position was to measure general noise levels at the rear of the site, as well as quantifying background noise levels at adjacent sensitivities fronting onto Warren Street.

Attended Positions

MP3 The sound level meter microphone was fixed to the top of a tripod approximately 1.5m above ground level, and 1m from the façade facing Euston Road. Measurements were therefore made under façade-incident conditions. The purpose of this position was to measure general noise levels from the principle noise source i.e. Euston Road.

MP4 The sound level meter microphone was fixed to the top of a tripod approximately 1.5m above ground level, and 1m from the façade facing Cleveland Street. Measurements were therefore made under façade-incident conditions. The purpose of this position was to measure any contribution from traffic on Cleveland Street, as well as determine the reduction in levels from Euston Road at this part of the building.

MP5 The sound level meter microphone was fixed to the top of a tripod approximately 1.5m above ground level, and 1m from the façade facing Warren Street. Measurements were therefore made under façade-incident conditions. The purpose of this position was to measure any contribution from traffic on Warren Street, as well as determine the reduction in levels from Euston Road at this part of the building.

## 4.4 Noise Monitoring Equipment

4.4.1 All noise measurements were made with the equipment detailed in the following table.

| Item | Manufacturer | Type |
|---|---|---|
| Sound Level Analyser | NTi | XL2-TA |
| Acoustic Calibrator | NTi | CAL200 |

T5 Equipment used during internal noise measurements

4.4.2 The sound level analyser presented in the above table conforms to the Type 1 specification as given in BS EN 61672-1:2003 - *'Electroacoustics - Sound level meters - Part 1: Specifications'*. The calibrator presented in the above table conforms to the Class 1 specification as specified in IEC 60942:2003 – *'Electroacoustics - Sound calibrators'*.

Traceable Calibration

4.4.3 The measurement instrumentation, including sound level analyser, preamplifier and microphone have undergone traceable calibration by a competent laboratory within the last two years.

4.4.4 The associated acoustic calibrator has undergone traceable calibration by a competent laboratory within the last year. The calibration certificates for the above equipment can be provided on request.

4.4.5 The noise measurement equipment was calibrated before and after the survey to ensure a consistent and acceptable level of accuracy is maintained. No significant drift (greater than 0.2dB) was noted to have occurred.

### 4.5 Data Recorded

4.5.1 Noise data was recorded in all relevant indices, including $L_{Aeq}$, $L_{A90}$, $L_{AMax,F}$ and $L_{AMax,S}$[4]. See attached Appendix A for an explanation of noise units used.

4.5.2 Octave band data for each of the above indices was also recorded, the filters for which met the requirements of BS EN 61260:1996, Class 1.

4.5.3 Noise data was recorded over consecutive 15-minute periods during the unattended measurements, and for a single 15-minute period during the attended measurements. All indices and octave band spectra were recorded.

4.5.4 Audio recordings were also made throughout the duration of the survey.

### 4.6 Meteorological Conditions

4.6.1 During the survey, temperatures were generally cold to mild, ranging between 14°C during the day to 5°C during the night. Wind speeds on average between 3m/s and 6 m/s. Some rain was noted on the morning of the 6th April 2016 prior to commencement of the survey which took place between 6th and 8th April 2016, however this is not expected to have significantly affected the measurements.

### 4.7 Internal Measurements

4.7.1 In addition to those set out above, internal noise measurements were also made in the Basement over a 15-minutee period, and of a number of individual tube pass-by events. The purpose of these measurements was to quantify re-radiated noise from tube pass-bys in the basement.

4.7.2 Measurements were also made at Ground Floor level, in order to quantify the level of sound insulation being provided by the existing glazing. Due to the presence of large gaps around the existing glazed door however, the measurements were unable to provide an accurate reflection of the sound insulation from the glazing.

### 4.8 Results

4.8.1 The attached time-history figures TH1 & TH2 present the noise levels measured at MP1 and MP2 respectively.

4.8.2 The attached schedule SCH1 presents the noise levels recorded at attended positions MP3 to MP5, as well as the internal noise measurements.

### 4.9 Plant Noise Limits

4.9.1 As detailed in section 3.4.13, the mechanical services systems will need to be designed such that noise is 10dB below the lowest recorded $L_{A90}$ in the relevant time period, and 15dB below if there is an expectation of tonality or intermittency.

[4] Maximum A-weighted sound pressure level using time-weighting "F" and "S". As stated in BS EN 61672–1:2003 Design-goal time constants are 0,125 s for time-weighting F (Fast) and 1 s for time weighting S (Slow).

4.9.2 On this basis, the noise limits for non-tonal/intermittent plant to apply at 1m from the windows of the nearest affected noise sensitive premises within the vicinity of the plant locations are as shown in the following table.

| Location | Noise Emission Limits, dB | | |
|---|---|---|---|
| | Day<br>*07h00 – 19h00* | Evening<br>*19h00 – 23h00* | Night<br>*23h00 – 07h00* |
| Noise sensitivities on Cleveland Street – Low Level | 50 | 50 | 48 |
| Noise sensitivities on Cleveland Street – High Level | 47 | 47 | 44 |
| Noise sensitivities on Warren Street – High Level | 42 | 40 | 37 |

T6 Noise Limits for Mechanical Services Plant

4.9.3 In addition, plant that is tonal or is intermittent in nature as heard at the receptor location would need to be designed to a level 5dB lower than the values shown in the above table.

# 5 Vibration Survey

## 5.1 General

5.1.1 In order to quantify the existing vibration climate at the site, a vibration survey was undertaken. The objective of this was to determine the levels of vibration within the building arising from tube pass-bys.

5.1.2 The survey was undertaken on Wednesday 17th May, and involved making measurements at three positions across each of the five floors of the building.

## 5.2 Guidance and Standards

5.2.1 Information contained within BS 6472-1:2008[5] was taken into account during the vibration measurements in relation to instrumentation, methodology and reporting.

## 5.3 Methodology

5.3.1 Measurements of vibration were made using the equipment detailed in the following table.

| Item | Manufacturer | Type |
|---|---|---|
| Vibration Analyser | Rion | XV-2P |
| Tri-Axial Accelerometer | Rion | PV-83C |

T7 Equipment used to carry out vibration measurements

5.3.2 The accelerometer was placed directly on the existing floor surfaces and oriented such that the X-direction measured the horizontal axis parallel to the tube line, the y-direction the horizontal axis perpendicular to it, and the Z-direction the vertical axis.

5.3.3 Measurements were made close to the front wall of the building(relative to Euston road), around 1/3rd of the floor length back, and around 2/3rds back on each of the five floors of the building.

5.3.4 Measurements were made in terms of Vibration Dose Value (VDV) with the appropriate weighting curve ($W_b$ for vertical and $W_d$ for horizontal axes as given in BS 6841).

5.3.5 Measurements were made for at least 10 minutes at each of these positions, this being of sufficient duration given the volume of tube pass-bys, and the fact that VDVs are more influenced by the magnitude of individual events, rather than the number of events.

5.3.6 The measured VDVs were then multiplied to cover a 16-hour time period for comparison with the criteria set out in BS 6472 by following the procedure set out in Annex B of BS 6472-1 to give an overall VDV value in each axis for the day at each location on each floor.

[5] BS 6472-1:2008 - *'Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration source other than blasting'*

## 5.4 Results

5.4.1 The following tables present the resultant values for a typical day for X, Y and Z axis respectively.

| Location | X-axis Vibration Does Value, $VDV_{d,day}$ ($m/s^{1.75}$) | | |
|---|---|---|---|
| | Front | Middle | Rear |
| Basement | 0.004 | 0.002 | 0.002 |
| Ground Floor | 0.012 | 0.011 | 0.007 |
| 1st Floor | 0.006 | 0.005 | 0.005 |
| 2nd Floor | 0.013 | 0.007 | 0.008 |
| 3rd Floor | 0.008 | 0.009 | 0.006 |

T8 Vibration Does Value measured for X axis

| Location | Y-axis Vibration Does Value, $VDV_{d,day}$ ($m/s^{1.75}$) | | |
|---|---|---|---|
| | Front | Middle | Rear |
| Basement | 0.003 | 0.003 | 0.002 |
| Ground Floor | 0.004 | 0.005 | 0.006 |
| 1st Floor | 0.006 | 0.005 | 0.006 |
| 2nd Floor | 0.013 | 0.007 | 0.010 |
| 3rd Floor | 0.009 | 0.007 | 0.005 |

T9 Vibration Does Value measured for Y axis

| Location | Z-axis Vibration Does Value, $VDV_{b,day}$ ($m/s^{1.75}$) | | |
|---|---|---|---|
| | Front | Middle | Rear |
| Basement | 0.058 | 0.051 | 0.044 |
| Ground Floor | 0.080 | 0.153 | 0.068 |
| 1st Floor | 0.147 | 0.092 | 0.081 |
| 2nd Floor | 0.089 | 0.106 | 0.056 |
| 3rd Floor | 0.090 | 0.138 | 0.114 |

T10 Vibration Does Value measured for Z axis

# 6 Noise from Mechanical Services

## 6.1 General

6.1.1 In order to address the issue of noise generated by mechanical services installed as part of the development, an atmospheric plant noise assessment has been carried out.

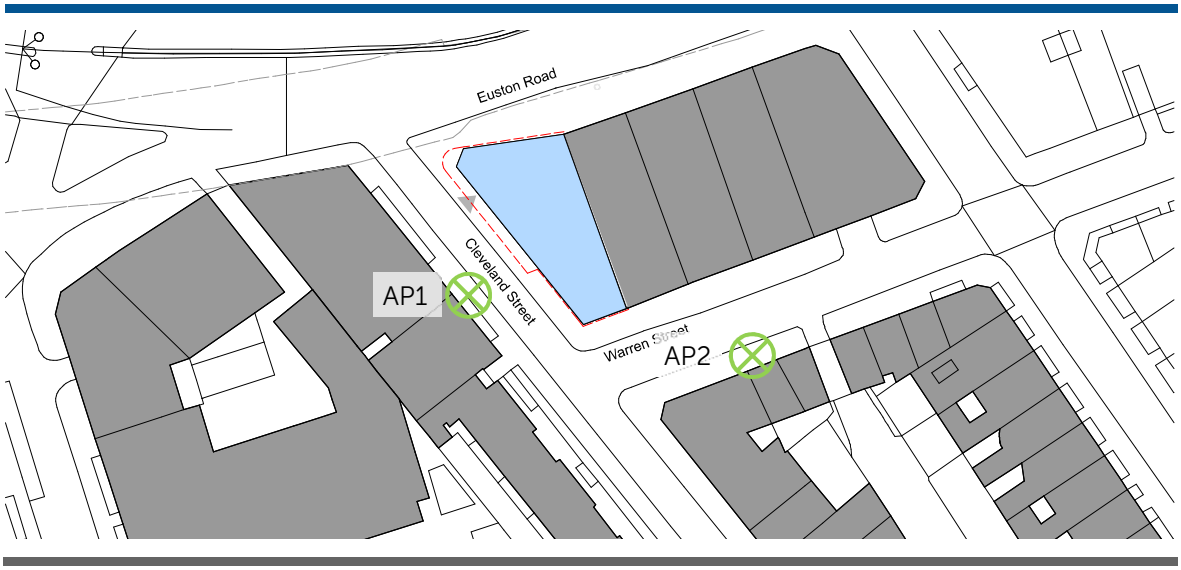
6.1.2 The assessment starts with plant noise levels as provided by the manufacturer. Account is then taken of any system or propagation losses, and the resultant levels are compared with the previously established plant noise limits.

## 6.2 Assessment Locations

6.2.1 Atmospheric-side plant noise assessments have been carried out to the following locations:

- AP1 - L Existing residences on opposite side of Cleveland street at first floor level
- AP1 - H Existing residences on opposite side of Cleveland street at top floor level
- AP2 Existing residences on Warren Street at top floor level

6.2.2 Each of the above assessment positions is illustrated on the following figure.




T11 Site plan indicating noise assessment positions

## 6.3 Scheme

6.3.1 In general, the mechanical services scheme involves the installation of 5 air-handling units to serve the various spaces, 2 internal water cooled chillers and 2 external dry air coolers. Plant will located in a basement plant room, a 5th floor mezzanine plant room, and an external roof plant area.

6.3.2 To realise the above scheme, the following plant items will be installed:

Basement Plant Room

- 1no. Flakt Woods eQ TOP 008 Active Learning Air Handling Unit (AHU-01)

Roof External Plant Area

- 2 no. Guntner GFHC FD 06 Dry Air Coolers (DAC-01)
- 1no. Flakt Woods eQ PRIME 032 1F & 2F Classroom Air Handling Unit (AHU-02)
- 1no. Nuaire BPS Size 1.75 3F & 4F Classroom Air Handling Unit (AHU-03)

Fifth Floor Mezzanine Plant Room

- 2 no. water cooled chillers (CH-01)
- 1no. Nuaire BPS Size 2.25 Lecture Theatre Air Handling Unit (AHU-04)
- 1no. Nuaire XBC 65 WC Air Handling Unit (AHU-05)

### 6.4 Data Used

6.4.1 Octave band sound power levels provided by the manufacturers of the above equipment are presented on the attached Plant Noise Schedule SCH2.

### 6.5 Mitigation

6.5.1 In order to control atmospheric noise from the proposed plant, a series of mitigation measures have been selected. These include screening around the external plant, and silencers on the exhaust-side of air handing units AHU-02 and AHU-03.

6.5.2 The insertion losses to be achieved by the mitigation measures are set out in the attached Mitigation Schedule SCH3.

### 6.6 Operating Hours

6.6.1 Mechanical services plant installed as part of the development will run during the day and evening time only (i.e. 07h00 – 23h00), and this has therefore been reflected in our assessment.

### 6.7 Assessment

6.7.1 Our calculations take into account the effects of distance and, where relevant, screening from roof and wall edges where these obscure the plant from direct view.

6.7.2 In addition, when calculating the rating level, corrections for tonality, impulsivity, intermittency or any other characteristic feature that would allow the source to be readily distinguished against the residual acoustic environment as heard at the assessment positions have been considered.

6.7.3 In this regard, the Local Camden Plan states *"10dB should be increased to 15dB if the noise contains audible tonal elements. (day and night). However, if it can be demonstrated that there is no significant difference in the character of the residual background noise and the specific noise from the proposed development then this reduction may not be required."*

6.7.4 In this instance, the noise levels from the highest generating items are calculated to be 15dBA, 25dBA, and 19dBA below the existing ambient noise levels at AP1–L, AP1-H and AP2 respectively. As such, these are not expected to be distinguishable from the existing noise climate.

6.7.5 A large number of plant noise calculations have been undertaken as part of the assessment, an example of which are attached as Plant Noise calculation sheets CS1 – CS3. Full calculations can be provided on request.

6.7.6 By utilising the methodology set out above we calculate rating levels at the aforementioned assessment positions as presented in the following table. The existing background sound levels are also reproduced for ease of comparison.

| Location | Rating Limit, dB *(07h00 – 23h00)* | Rating Level, dB | Comparison, dB | Impact |
|---|---|---|---|---|
| AP1-L | 50 | 47 | -3 | Complies with criteria |
| AP1-H | 47 | 46 | -1 | Complies with criteria |
| AP2 | 40 | 38 | -2 | Complies with criteria |

T12 Background and rating levels calculated for the plant

6.7.7 As the above table T12 shows, the noise arising as a result of the plant is expected to comply with the local authority criteria at all assessment positions. As such, mitigation beyond that already included in the scheme to reduce the levels is not expected to be warranted.

# 7 Internal Noise

## 7.1 Basement

7.1.1 Internal noise levels within the basement were measured to be 40 dB – 43 dB $L_{Aeq}$, with maximum levels from tube pass-bys of 51 dB – 53 dB $L_{AMax,Fast}$.

7.1.2 At the current levels, the internal noise climate in the basement is marginally too high for educational uses, the limit for these spaces being 40 dB $L_{Aeq}$.

7.1.3 As the current noise climate in the basement is currently controlled by re-radiated noise from tube pas-bys, it is expected that lining the basement wall that connects to the tube tunnel would provide the required reduction.

7.1.4 The lining itself should comprise at least 12.5 mm SoundBloc, and there should be a cavity of at least 85mm between the basement wall and the lining, with 50mm mineral wool in the cavity. The lining should be supported from either an independent frame, or fixed to the wall using resilient mounts[6].

## 7.2 Ground Floor and Above

7.2.1 The internal noise climate within teaching spaces at ground floor level and above will be controlled by the sound reduction performance of the glazing and ventilation strategies.

### Glazing

7.2.2 We understand that the existing primary and secondary glazing will be replaced as part of the works. With external noise levels in the order of 73 dB $L_{Aeq}$, a reduction of at least 33 dBA will be required to meet the internal target of 40 dBA.

7.2.3 In order to determine the acoustic specification for the glazing, a noise break-in assessment has been undertaken. In principle, this starts with measured external noise levels, takes an allowance for the various elements forming the façade, and compares the resultant levels with the internal noise criteria.

7.2.4 The procedure used to carry out the break-in assessment is presented in Paragraph 2.1 of Annex G of BS 8233. Full calculations undertaken as part of this process can be provided on request.

7.2.5 Based on the above, sound insulation requirements for three types of glazing have been established, one for the Active Learning space on the Ground Floor, one for teaching spaces on First Floor and above with a view of Euston Road, and one for those on First Floor and above without a view of Euston Road. The acoustic requirements of the glazing specification are set out in the following table.

[6] http://www.mason-uk.co.uk/basket.asp?pid=412#.WbKjRtFumUk

| | Sound Reduction Index (dB) at Octave band with Centre Frequency (Hz) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 125 | 250 | 500 | 1k | 2k | 4k | $R'_w$ |
| **Glazing Type A** Glazing to GF Active Learning Space | 26 | 34 | 44 | 56 | 53 | 52 | 45 |
| **Glazing Type B** Glazing to Teaching Spaces with a view of Euston Road at FF and above | 24 | 24 | 32 | 37 | 37 | 44 | 35 |
| **Glazing Type C** Glazing to Teaching Spaces without a view of Euston Road at FF and above | 20 | 18 | 28 | 38 | 34 | 38 | 31 |

T13 Sound reduction performance required for windows to teaching spaces

7.2.6 The sound reduction performance figures quoted above are valid for the building glazing elements taken as a whole and in their installed condition. The specification therefore applies to the glass, the frames or mullions, all seals on any openable part of the system and any openings in the frames required for ventilation purposes. This list is not exhaustive: no part of the glazed element shall cause the above figures not to be achieved.

7.2.7 It's worth clarifying that Glazing Type B applies to all windows to rooms which face onto Euston Road, as opposed to only the glazed elements in the façade that faces Euston Road directly.

7.2.8 Based on general data provided in BS EN 12758:2011[7] and BS 6262-2:2005[8] the following glazing and airspace configurations are expected to be capable of providing the required sound reduction indices for the indicated glazing types:

- Glazing Type A - 6/100/6: 6 mm pane, 100 mm air space with absorption in reveals, 6 mm pane. (either wide airspace or secondary glazed)
- Glazing Type B - 10/6-16/6: 10 mm pane, 6 mm - 16 mm air space, 6 mm pane.
- Glazing Type C – 6/6-16/6: 6 mm pane, 6 mm - 16 mm airspace, 6 mm pane.

7.2.9 It should be noted that it may be preferable to reduce the number of glazing specifications for coordination purposes. In this case, any glazed element may use either the type identified, or a type with higher specification. For example, Type B glazing could be substituted for Type A glazing.

### Ventilation

7.2.10 As the external levels show, noise levels reduce considerably away from Euston Road, in particular at the façade facing Warren Street which is totally screened from Euston Road.

[7] BS EN 12758:2011 - Glass in building — Glazing and airborne sound insulation — Product descriptions and determination of properties
[8] BS 6262-2:2005 - Glazing for buildings. Code of practice for energy, light and sound

7.2.11 With external levels incident on the Warren Street façade in the order of 55 dB – 59 dB $L_{Aeq}$, a reduction of 10 – 15 dB would be required to meet the naturally ventilated target of 45 dBA. As this order of reduction is expected through a partially open window, a natural ventilation strategy that includes ventilation elements in the Warren Street façade is feasible.

7.2.12 With external levels on Cleveland Street measured to be 67 dB $L_{Aeq}$, it is not expected to be feasible to provide natural ventilation through this façade.

# 8 Vibration

## 8.1 General

8.1.1 In order to determine whether vibration mitigation measures would be required to prevent levels of vibration from tube trains giving rise to disturbance within the building, a vibration assessment has been carried out.

8.1.2 This uses the levels of vibration measured in the building as described in section 5, and compares the resultant levels within the values given in Section 3.3.

## 8.2 Internal Levels

8.2.1 The following table gives the highest daytime vibration dose values using the data measured in the existing building. The relevant criteria from BS 6472 are also presented for ease of comparison.

| | Vibration Does Value, $VDV_{day}$ ($m/s^{1.75}$), with $W_b$ weighting for vertical and $W_d$ weighting for horizontal axes. | | |
|---|---|---|---|
| | X | Y | Z |
| BS 6472 Office Low Probability of Adverse Comment | 0.4 – 0.8 | 0.4 – 0.8 | 0.4 – 0.8 |
| BS 6472 Office Adverse Comment Possible | 0.8 – 1.6 | 0.8 – 1.6 | 0.8 – 1.6 |
| BS 6472 Office Adverse Comment Probable | 1.6 – 3.2 | 1.6 – 3.2 | 1.6 – 3.2 |
| Highest Measured on Slab | 0.012 | 0.013 | 0.147 |

T14 Comparison of measured vibration dose values with BS 6472 Thresholds

8.2.2 As the above table shows, levels of vibration are significantly below the range corresponding to 'Low probability of adverse comment' as set out in BS 6472. The levels are also below the limiting level of 0.4 $m/s^{1.75}$ identified in the Camden Local Plan for offices, which is expected to be a suitable substitute in light of no specific criteria relating to educational use. As such, no specific measures to the building foundations are expected to be necessary to control vibration.

# 9 Conclusions

9.1 A series of noise measurements at the development site have been undertaken. Using these, existing façade incident and background noise levels have been quantified.

9.2 Using the measured background noise levels, rating level limits for mechanical services plant installed as part of the development have been established in accordance with the Camden Local Plan.

9.3 Using these, along with the proposed mechanical services scheme for the building, noise calculations have been undertaken to the nearest effected residences. These have formed the basis of an assessment to identify whether the proposed plant is expected to comply with the plant noise criteria at nearby sensitivities.

9.4 The assessment concluded that as noise levels are calculated to be at least 1dB below the rating limits, the noise arising from the proposed plant is expected to comply with the plant noise criteria at all assessment positions. As such, mitigation beyond that already included in the scheme to reduce the levels is not expected to be warranted.

9.5 In order to demonstrate that the site provides a suitable noise climate for the proposed educational use, an assessment of the acoustic requirements of the building envelope was undertaken. The assessment used the noise survey data as a basis, along with relevant guidance from BB93.

9.6 Based in the assessment, acoustic performance requirements of the glazing were established. From a review of available manufacturer's test data, an example configuration was put forward for illustrative purposes. In this case, glazing specifications ranged from wide air space for windows exposed to the highest external levels, to standard double glazing away from major noise sources.

9.7 Using vibration data measured as part of the site survey as the basis, a vibration assessment was undertaken. Using the measured data, and guidance contained within BS 6472, it was concluded that the expected internal vibration levels would fall below the range corresponding to 'Low probability of adverse comment'. These are also below limiting level identified in the Camden Local Plan for offices, which is expected to be a suitable substitute in light of no specific criteria relating to educational use. As such, no specific measures are expected to be necessary to control vibration.

# SCH1

## Attended Noise Measurement Results

External

| Position | Time | $L_{Aeq}$ | $L_{AMax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| MP3 | 10h00 | 73 | 88.5 | 75.8 | 67 |
| MP4 | 10h00 | 66.5 | 81.6 | 68.7 | 61.3 |
| MP5 | 10h00 | 58.8 | 73.5 | 61 | 55.1 |
| MP3 | 11h00 | 73.3 | 87.2 | 76.3 | 67.4 |

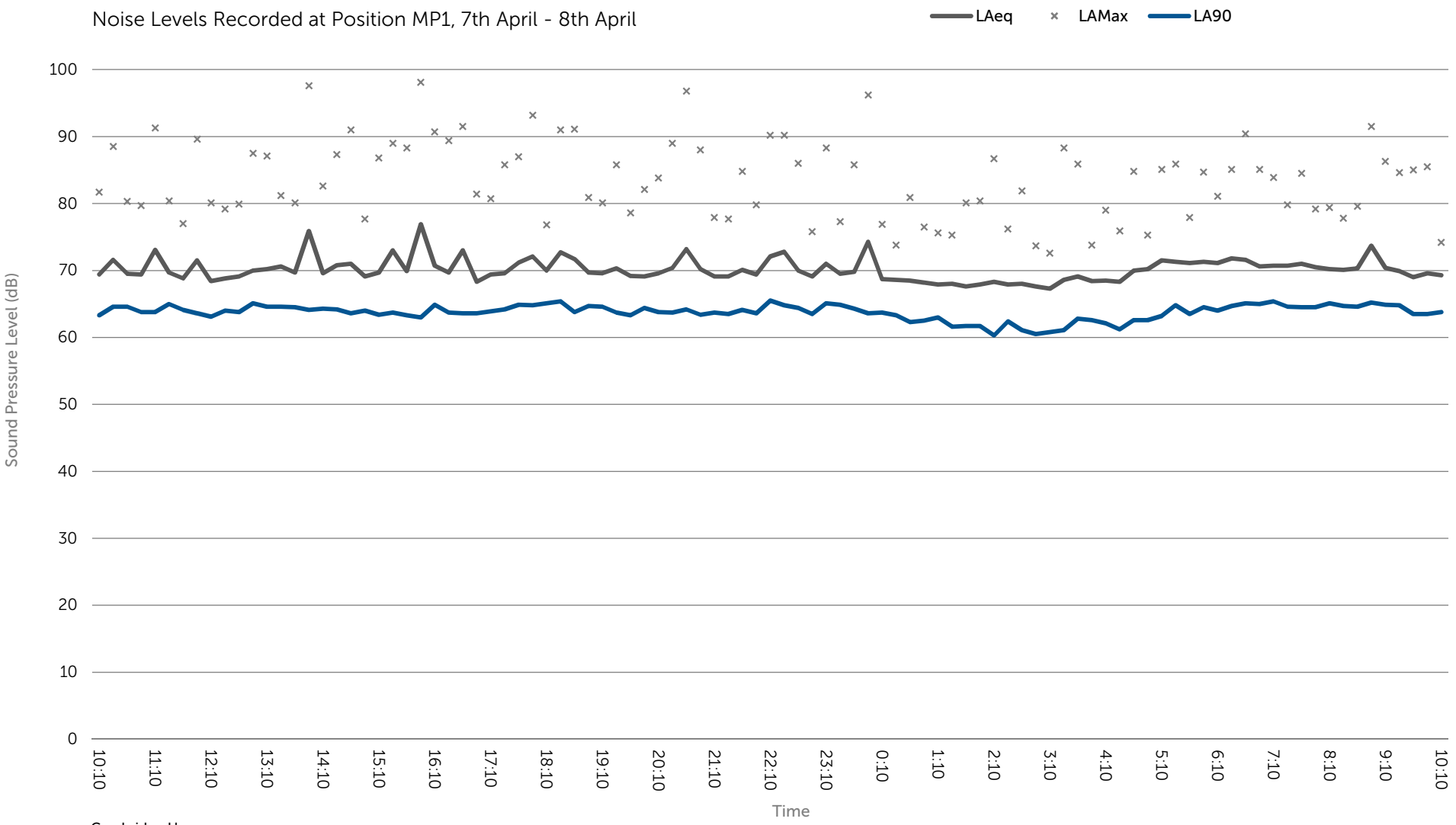
Internal

| Position | | $L_{Aeq}$ | $L_{AMax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| Basement | 10h00 - 5 min | 41.3 | 52.8 | 46 | 32.5 |
| Basement | 10h00 - 5 min | 42.2 | 55.8 | 45.4 | 33.2 |
| Basement | 11h00 - 5 min | 40.5 | 53.2 | 44.5 | 31.4 |
| Basement | 11h00 - 5 min | 42.7 | 61.2 | 46.6 | 33 |
| Ground Floor | 12h00 - 5 min | 45.9 | 57.8 | 48.9 | 41.2 |
| Ground Floor | 12h00 - 5 min | 47 | 63.7 | 49.3 | 41.3 |

Event Levels

| Position | $L_{Aeq}$ | Duration (s) | $L_{AE}$ | $L_{AMax,Fast}$ |
|---|---|---|---|---|
| Basement Tube Pass-by | 46.1 | 18 | 58.6 | 51.2 |
| Basement Tube Pass-by | 46.8 | 27 | 61.1 | 52.7 |
| Basement Tube Pass-by | 46.5 | 32 | 61.6 | 52.8 |
| Basement Tube Pass-by | 44.7 | 14 | 56.2 | 50.8 |

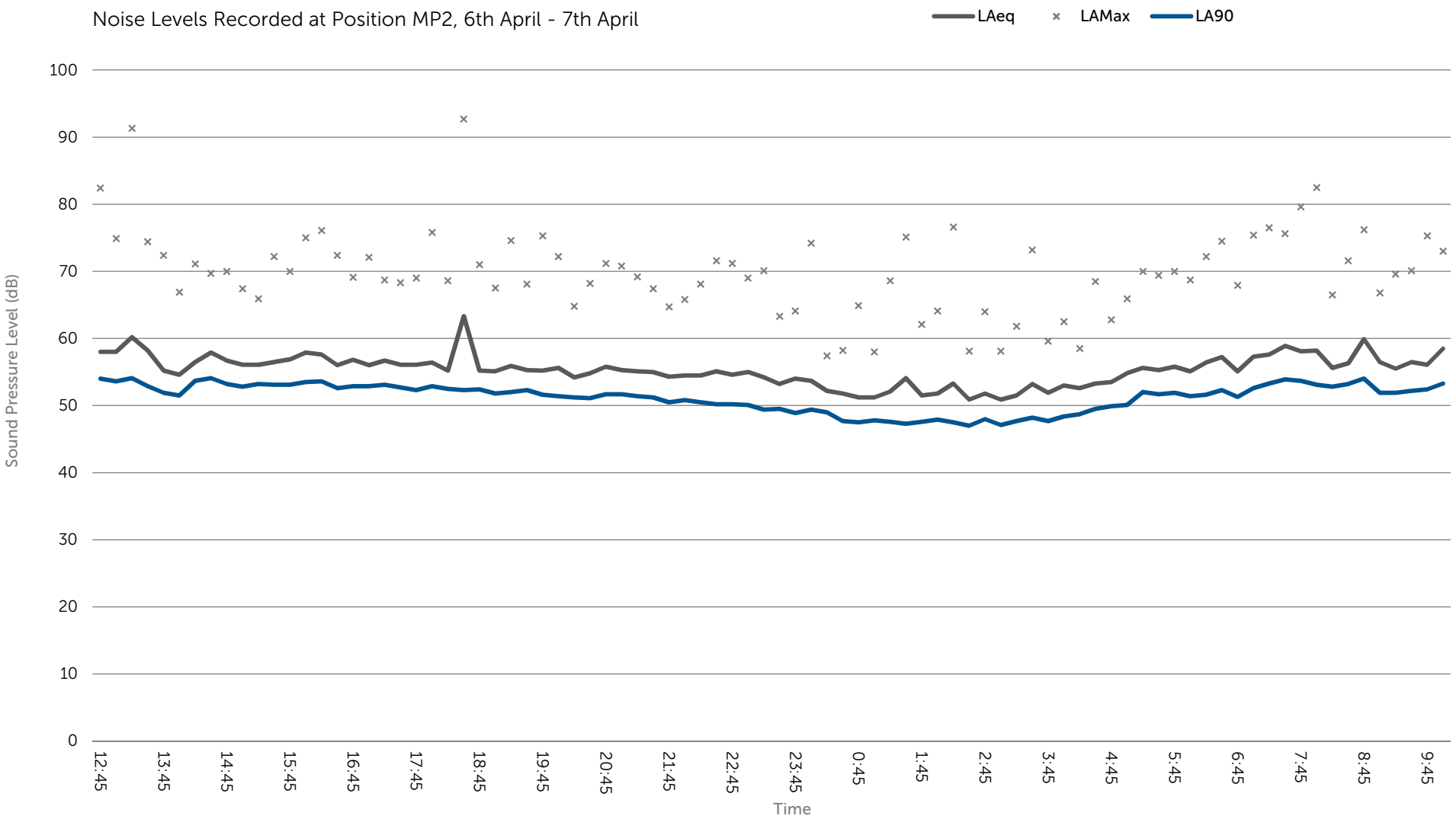
Figure 2016032-0 R1 TH1



ACOUSTICS CENTRAL

Figure 2016032-0 R1 TH2

Noise Levels Recorded at Position MP2, 6th April - 7th April



# Plant Noise Schedule

| Reference | Description | Unit Details | Data Source | Noise Level Type | dB(A) | Noise Levels (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| CH-01 | Chiller | Carrier 30WG-120A | Man | Sound Power, Lw | 95.0 | | | | | | | | |
| DAC-01 | Dry Air Cooler | Guntner GFHC FD 06 | Man | Sound Power, Lw | | 77.0 | 83.0 | 82.0 | 81.0 | 81.0 | 70.0 | 75.0 | 66.0 |
| AHU-01 FAI | Active Learning AHU Fresh Air | Flakt Woods eQ TOP 008 | Man | Sound Power, Lw | | 60.0 | 60.0 | 62.0 | 72.0 | 67.0 | 64.0 | 61.0 | 59.0 |
| AHU-01 RSS | Active Learning AHU Supply | Flakt Woods eQ TOP 008 | Man | Sound Power, Lw | | 68.0 | 67.0 | 69.0 | 78.0 | 78.0 | 78.0 | 76.0 | 67.0 |
| AHU-01 RSE | Active Learning AHU Extract | Flakt Woods eQ TOP 008 | Man | Sound Power, Lw | | 60.0 | 60.0 | 62.0 | 72.0 | 67.0 | 64.0 | 61.0 | 59.0 |
| AHU-01 EXH | Active Learning AHU Exhaust | Flakt Woods eQ TOP 008 | Man | Sound Power, Lw | | 70.0 | 69.0 | 71.0 | 80.0 | 80.0 | 79.0 | 76.0 | 72.0 |
| AHU-01 BRK | Active Learning AHU Break-Out | Flakt Woods eQ TOP 008 | Man | Sound Power, Lw | | 54.0 | 55.0 | 51.0 | 51.0 | 44.0 | 47.0 | 43.0 | 33.0 |
| AHU-02 FAI | Classrooms 1F & 2F AHU Fresh Air | Flakt Woods eQ PRIME 032 | Man | Sound Power, Lw | | 65.0 | 70.0 | 74.0 | 66.0 | 57.0 | 58.0 | 56.0 | 53.0 |
| AHU-02 RSS | Classrooms 1F & 2F AHU Supply | Flakt Woods eQ PRIME 032 | Man | Sound Power, Lw | | 68.0 | 72.0 | 75.0 | 72.0 | 73.0 | 69.0 | 63.0 | 59.0 |
| AHU-02 RSE | Classrooms 1F & 2F AHU Extract | Flakt Woods eQ PRIME 032 | Man | Sound Power, Lw | | 69.0 | 74.0 | 74.0 | 66.0 | 57.0 | 60.0 | 59.0 | 57.0 |
| AHU-02 EXH | Classrooms 1F & 2F AHU Exhaust | Flakt Woods eQ PRIME 032 | Man | Sound Power, Lw | | 70.0 | 77.0 | 77.0 | 77.0 | 77.0 | 75.0 | 72.0 | 68.0 |
| AHU-02 BRK | Classrooms 1F & 2F AHU Break-Out | Flakt Woods eQ PRIME 032 | Man | Sound Power, Lw | | 64.0 | 66.0 | 65.0 | 51.0 | 44.0 | 47.0 | 46.0 | 36.0 |
| AHU-03 FAI | Classrooms 3F & 4F AHU Fresh Air | Nuaire BPS Size 1.75 | Man | Sound Power, Lw | | 68.0 | 69.0 | 80.0 | 78.0 | 74.0 | 72.0 | 71.0 | 72.0 |
| AHU-03 RSS | Classrooms 3F & 4F AHU Supply | Nuaire BPS Size 1.75 | Man | Sound Power, Lw | | 72.0 | 71.0 | 81.0 | 84.0 | 83.0 | 79.0 | 75.0 | 73.0 |
| AHU-03 RSE | Classrooms 3F & 4F AHU Extract | Nuaire BPS Size 1.75 | Man | Sound Power, Lw | | 68.0 | 69.0 | 80.0 | 78.0 | 74.0 | 72.0 | 71.0 | 72.0 |
| AHU-03 EXH | Classrooms 3F & 4F AHU Exhaust | Nuaire BPS Size 1.75 | Man | Sound Power, Lw | | 72.0 | 71.0 | 81.0 | 84.0 | 83.0 | 79.0 | 75.0 | 73.0 |
| AHU-03 BRK | Classrooms 3F & 4F AHU Break-Out | Nuaire BPS Size 1.75 | Man | Sound Power, Lw | | 71.0 | 61.0 | 70.0 | 64.0 | 55.0 | 44.0 | 38.0 | 28.0 |



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| Reference | Description | Unit Details | Data Source | Noise Level Type | dB(A) | Noise Levels (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| AHU-04 FAI | Lecture Theatre AHU Fresh Air | Nuaire BPS Size 2.25 | Man | Sound Power, Lw | | 68.0 | 71.0 | 81.0 | 75.0 | 73.0 | 73.0 | 70.0 | 68.0 |
| AHU-04 RSS | Lecture Theatre AHU Supply | Nuaire BPS Size 2.25 | Man | Sound Power, Lw | | 72.0 | 75.0 | 80.0 | 81.0 | 82.0 | 79.0 | 75.0 | 72.0 |
| AHU-04 RSE | Lecture Theatre AHU Extract | Nuaire BPS Size 2.25 | Man | Sound Power, Lw | | 68.0 | 71.0 | 81.0 | 75.0 | 73.0 | 73.0 | 70.0 | 68.0 |
| AHU-04 EXH | Lecture Theatre AHU Exhaust | Nuaire BPS Size 2.25 | Man | Sound Power, Lw | | 72.0 | 75.0 | 80.0 | 81.0 | 82.0 | 79.0 | 75.0 | 72.0 |
| AHU-04 BRK | Lecture Theatre AHU Break-Out | Nuaire BPS Size 2.25 | Man | Sound Power, Lw | | 72.0 | 65.0 | 71.0 | 61.0 | 55.0 | 46.0 | 38.0 | 27.0 |
| AHU-05 FAI | WC AHU Fresh Air | Nuaire XBC 65 | Man | Sound Power, Lw | | 79.0 | 79.0 | 72.0 | 66.0 | 64.0 | 59.0 | 48.0 | 34.0 |
| AHU-05 RSS | WC AHU Supply | Nuaire XBC 65 | Man | Sound Power, Lw | | 83.0 | 85.0 | 79.0 | 74.0 | 72.0 | 68.0 | 61.0 | 54.0 |
| AHU-05 RSE | WC AHU Extract | Nuaire XBC 65 | Man | Sound Power, Lw | | 81.0 | 79.0 | 70.0 | 67.0 | 64.0 | 60.0 | 48.0 | 35.0 |
| AHU-05 EXH | WC AHU Exhaust | Nuaire XBC 65 | Man | Sound Power, Lw | | 85.0 | 85.0 | 79.0 | 75.0 | 72.0 | 69.0 | 61.0 | 55.0 |
| AHU-05 BRK | WC AHU Break-Out | Nuaire XBC 65 | Man | Sound Power, Lw | | 71.0 | 69.0 | 56.0 | 51.0 | 45.0 | 41.0 | 35.0 | 20.0 |



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# Mitigation Schedule

| Reference | Description | Location | Pressure Drop (Pa) | Face Velocity (m/s) | Insertion Losses (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| AS-01 | 47% 1200mm | AHU-02 EXH | | | 3 | 6 | 13 | 22 | 28 | 28 | 16 | 7 |
| AS-02 | 47% 1200mm | AHU-03 EXH | | | 3 | 6 | 13 | 22 | 28 | 28 | 16 | 7 |



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## Calculation Sheet

# DAC-01 to AP1 HL - Day

| | | Octave Band Centre Frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| *Noise Source* | | | | | | | | | | |
| Noise Source - DAC-01 | | | | | | | | | | |
| Sound Power Levels | | 77.0 | 83.0 | 82.0 | 81.0 | 81.0 | 70.0 | 75.0 | 66.0 | 84.3 dBA |
| *+10 log (N)* | | | | | | | | | | |
| N | 2.0 | | | | | | | | | |
| | | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | |
| *Point Source Radiation Loss* | | | | | | | | | | |
| Radiation - Hemispherical | | | | | | | | | | |
| | | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | |
| *Point Source Distance Loss* | | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | | |
| End Distance (m) | 17.0 | | | | | | | | | |
| | | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | |
| *Maekawa Screening Loss* | | | | | | | | | | |
| Path Difference (m) | 0.3 | | | | | | | | | |
| | | *-7.2* | *-8.7* | *-10.7* | *-13.1* | *-15.8* | *-18.6* | *-21.6* | *-24.5* | |
| *External Receiver* | | | | | | | | | | |
| External Receiver - AP1 HL - Day | | | | | | | | | | |
| Sound Pressure, Lp | | 40.3 | 44.7 | 41.7 | 38.3 | 35.6 | 21.8 | 23.9 | 11.9 | 40.1 dBA |



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## Calculation Sheet

# AHU-01 FAI to AP1 HL - Day

| | | Octave Band Centre Frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| *Noise Source* | | | | | | | | | | |
| Noise Source - AHU-01 FAI | | | | | | | | | | |
| Sound Power Levels | | 60.0 | 60.0 | 62.0 | 72.0 | 67.0 | 64.0 | 61.0 | 59.0 | 72.6 dBA |
| *Rect Unlined Duct Losses* | | | | | | | | | | |
| Width (m) | 0.8 | | | | | | | | | |
| Height (m) | 0.4 | | | | | | | | | |
| Length (m) | 20.0 | | | | | | | | | |
| | | *-12.0* | *-8.0* | *-6.0* | *-2.0* | *-2.0* | *-2.0* | *-2.0* | *-2.0* | |
| *Bend Loss* | | | | | | | | | | |
| Dimension (mm) | 450.0 | | | | | | | | | |
| No. of Bends (no.) | 4.0 | | | | | | | | | |
| Type - Unlined Square Bend - No Vanes | | | | | | | | | | |
| | | *0.0* | *-4.0* | *-20.0* | *-32.0* | *-16.0* | *-12.0* | *-12.0* | *-12.0* | |
| *Point Source Radiation Loss* | | | | | | | | | | |
| Radiation - Hemispherical | | | | | | | | | | |
| | | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | |
| *End Reflection - Rect Free Space* | | | | | | | | | | |
| Width (m) | 0.8 | | | | | | | | | |
| Height (m) | 0.4 | | | | | | | | | |
| | | *-8.6* | *-4.1* | *-1.4* | *-0.4* | *-0.1* | *0.0* | *0.0* | *0.0* | |
| *External Grille Directivity* | | | | | | | | | | |
| Width (m) | 0.8 | | | | | | | | | |
| Height (m) | 0.4 | | | | | | | | | |
| Angle (°) | 90.0 | | | | | | | | | |
| | | *-1.3* | *-2.9* | *-5.6* | *-8.8* | *-12.1* | *-15.0* | *-15.0* | *-15.0* | |
| *Point Source Distance Loss* | | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | | |
| End Distance (m) | 17.0 | | | | | | | | | |
| | | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | *-24.6* | |



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| | Octave Band Centre Frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| *External Receiver* | | | | | | | | | |
| External Receiver - AP1 HL - Day | | | | | | | | | |
| Sound Pressure, Lp | 5.6 | 8.4 | -3.6 | -3.8 | 4.2 | 2.4 | -0.6 | -2.6 | 8.4 dBA |



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## Calculation Sheet

# AHU-02 FAI to AP1 HL - Day

| | | Octave Band Centre Frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| *Noise Source* | | | | | | | | | | |
| Noise Source - AHU-02 FAI | | | | | | | | | | |
| Sound Power Levels | | 65.0 | 70.0 | 74.0 | 66.0 | 57.0 | 58.0 | 56.0 | 53.0 | 68.8 dBA |
| *Rect Unlined Duct Losses* | | | | | | | | | | |
| Width (m) | 1.4 | | | | | | | | | |
| Height (m) | 0.8 | | | | | | | | | |
| Length (m) | 0.5 | | | | | | | | | |
| | | *-0.2* | *-0.2* | *-0.1* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | |
| *Bend Loss* | | | | | | | | | | |
| Dimension (mm) | 800.0 | | | | | | | | | |
| No. of Bends (no.) | 1.0 | | | | | | | | | |
| Type - Unlined Square Bend - No Vanes | | | | | | | | | | |
| | | *-1.0* | *-5.0* | *-8.0* | *-4.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | |
| *Point Source Radiation Loss* | | | | | | | | | | |
| Radiation - Hemispherical | | | | | | | | | | |
| | | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | *-8.0* | |
| *End Reflection - Rect Free Space* | | | | | | | | | | |
| Width (m) | 1.4 | | | | | | | | | |
| Height (m) | 0.8 | | | | | | | | | |
| | | *-4.9* | *-1.9* | *-0.5* | *-0.1* | *0.0* | *0.0* | *0.0* | *0.0* | |
| *External Grille Directivity* | | | | | | | | | | |
| Width (m) | 1.4 | | | | | | | | | |
| Height (m) | 0.8 | | | | | | | | | |
| Angle (°) | 90.0 | | | | | | | | | |
| | | *-2.5* | *-4.9* | *-8.0* | *-11.4* | *-14.8* | *-15.0* | *-15.0* | *-15.0* | |
| *Point Source Distance Loss* | | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | | |
| End Distance (m) | 12.0 | | | | | | | | | |
| | | *-21.6* | *-21.6* | *-21.6* | *-21.6* | *-21.6* | *-21.6* | *-21.6* | *-21.6* | |



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| | Octave Band Centre Frequency (Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| *External Receiver* | | | | | | | | | |
| External Receiver - AP1 HL - Day | | | | | | | | | |
| Sound Pressure, Lp | 26.8 | 28.5 | 27.8 | 20.9 | 9.6 | 10.4 | 8.4 | 5.4 | 22.9 dBA |



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# Appendix A

## Glossary of Acoustics Terms – Noise Levels

### Single Figures and Spectra

Generally speaking, the human ear is capable of hearing noise within the frequency range 20Hz to 20kHz. To make handling of data more meaningful and manageable, the range is often divided into 'bands', each of which covers a specific part.

For most acoustics applications, either octave or third-octave bands are used. Each band has a specific centre frequency which is used to identify it. When reported, the band centre frequency is given, along with the associated noise level, e.g. 63dB $L_{eq}$ at 500Hz.

Noise levels can also be reported as single figure values where all energy contained within the measured frequency range is summed to provide a single figure. However, as the human ear does not hear noise at different frequencies with equal loudness, a weighting curve is often applied to levels before summing to account for this fact.

The most common curve is the A-weighting curve, and its use is denoted by including the letter 'A' with either the index e.g. 63dB $L_{Aeq}$, or with the decibel suffix (if the index is described elsewhere), e.g. 63dBA. 'B' and 'C' weighting curves may also be applied, depending on the application. A 'Z' is used to indicate a single figure where no weighting has been applied, e.g. 63dB $L_{Zeq}$.

### Noise Level Indices

Noise level measurements can be made and reported in a variety of indices. The index is reported using the letter *L* to indicate Level, followed by, for example, abbreviations to represent the specifics of the index, and time intervals where applicable. The most commonly used are given below.

#### $L_{eq,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{eq,T}$ value is the sound pressure level in decibels of a continuous steady sound that within a specified time interval, T, has the same mean-squared sound pressure as a sound that varies with time. It is often used as a descriptor of the **ambient noise climate**, and commonly seen as a single A-weighted figure $L_{Aeq,T}$.

#### $L_{max}$, (dB) - Maximum Sound Pressure Level

The $L_{max}$ value is the highest recorded sound pressure level in decibels averaged across a specified time constant during a noise measurement of certain duration. Two time constants are used, Fast and Slow, where the time constants are 0.125s and 1s respectively. The time constant is denoted in the index, $L_{max,F}$ for Fast and $L_{max,S}$ for Slow. It is often used to identify transient events that have a high-level relative to the ambient noise climate, and commonly seen as a single A-weighted figure $L_{Amax}$.

$L_{10,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{10,T}$, value is the sound pressure level in decibels that is exceeded for 10% of a given time interval, T. It is often used as a measurement of noise from transportation sources such as road and rail. It is commonly seen as a single A-weighted figure $L_{A10,T}$.

$L_{90,T}$, (dB) - Equivalent Continuous Sound Pressure Level

The $L_{90,T}$, value is the sound pressure level in decibels that is exceeded for 90% of a given time interval, T. It is often used as a descriptor of the **background noise climate**, and commonly seen as a single A-weighted figure $L_{A90,T}$.

# Appendix B

## Document Naming and Version Control Policy

All documents are issued with a unique number which comprises the principle 7-digit project and 1-digit subsection numbers, for example 2015123-0, and a reference indicting iteration of document type, for example R1 for Report 1, M2 for Memorandum 2 etc.

All documents employ version control through the use of a unique version number. The version numbers employ two levels of hierarchy, and use the format illustrated below:

V 1 . 2

Major Minor

### Major

A major revision occurs when the report is revised to reflect significant changes in design strategy. For example, wide scale changes to building footprint or general arrangements, changes to principle construction type (e.g. masonry to lightweight), reselection of mechanical services plant etc. A change in strategy that takes place within the same RIBA work stage for example will prompt a major revision to a document.

### Minor

A minor revision occurs when the report is revised to reflect minor changes to the design implementation. For example a change in the type of natural vent, extract fan, surface finish etc. to be used, on the project. Minor revisions will also occur when there is a change in wording of the report text.

### Reporting

The Document History and Version Control table on the second page of each report identifies the versions through which the document has moved, along with the date, author that produced the version, and a description of its purpose or change. Prior to issue, the document will be signed (physically or electronically) by the most recent author and reviewer.

### Electronic File Naming

Reports issued electronically use the following format:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2015xxx | - | x | Rx | Noise Assessment Report | v1.0 | 15.02.12 | .pdf |
| Project Number | | Subsection Report Number | | Report Name | Version | Date | File Extension |

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