

# **7 Rainforth Street Manchester**

Acoustic Planning Report  
0586/APR2

29 November 2022

For:

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# **Acoustic Planning Report**

## **0586/APR2**

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## **1.0 Introduction**

Lighthouse Acoustics has been appointed by Views Holdings Ltd to undertake an environmental sound survey at 7 Rainforth Street, Manchester and to undertake a detailed sound assessment for the proposed development.

The proposed development comprises the change of use of the existing 5 storey building (including basement) from commercial to form 6 residential flats at 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> floors with a retail unit at ground and basement floors.

The survey methodology, results and assessment for the proposed development are presented in this report.

## **2.0 Objectives**

To establish the Local Authority's acoustic requirements for the proposed development.

To visit site to undertake a detailed environmental sound survey in order to establish existing environmental sound levels at the proposed development.

To undertake a detailed environmental sound assessment of the proposed residential development to establish the acoustic specification for glazing/ventilation elements in order to achieve the acoustic requirements of the Local Authority.

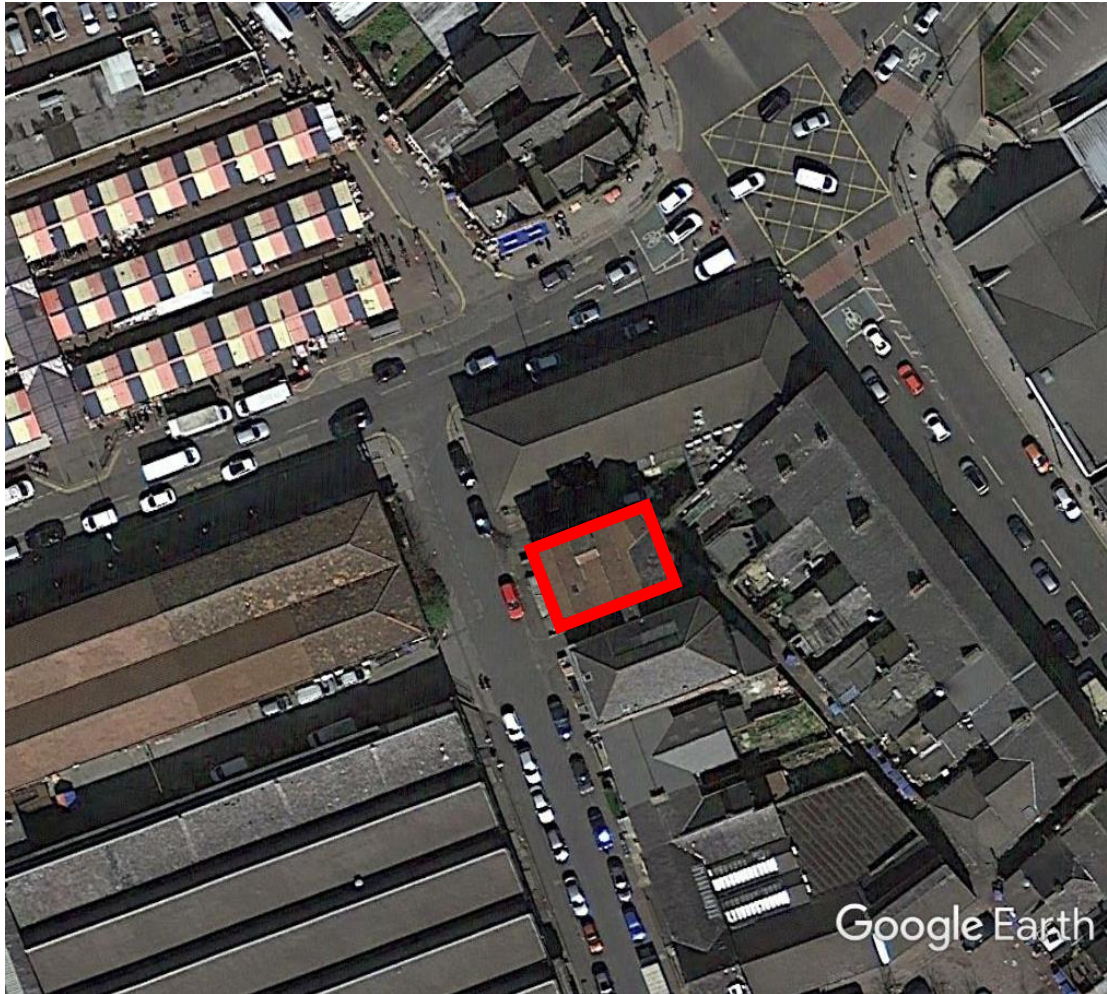
To propose atmospheric plant sound emission limits at the nearest noise sensitive receptors for subsequent use in designing building services proposals in order to comply with the requirements of the Local Authority.

## **3.0 Site Description**

The proposed residential development is at 7 Rainforth Street, Manchester. The site comprises an existing 5 storey building (including basement).

The site is bound by an access road to the north, commercial premises to the east, an access road to the south and Rainforth Street to the west.

The site plan below indicates the extent of the site and the surrounding environment.



Site plan indicating the extent of the site and the surrounding environment

## 4.0 Local Authority Requirements

### 4.1 Residential Developments

With regard to residential developments, Section 3.7.1.1 of the Planning & Noise Technical Guidance document (dated October 2022) produced by Manchester City Council states the following:

*"The Council has adopted the following internal noise limits for residential properties:*

- **Bedrooms (night time - 23.00 - 07.00) 30dB  $L_{Aeq}$  (individual noise events should not normally exceed 45dB  $L_{Amax,F}$  by more than 10 times)**
- **Living Rooms (daytime - 07.00 - 23.00) 35dB  $L_{Aeq}$**
- **Gardens and terraces (daytime) 55dB  $L_{Aeq}$ "**

## 4.2 Building Services

With regard to noise and vibration from fixed plant/equipment, Section 3.7.1.5 of the Planning & Noise Technical Guidance document (dated October 2022) produced by Manchester City Council states the following:

*“The noise assessment should be based on BS 4142: 2014 and any application for fixed plant, equipment or machinery must demonstrate that:*

***‘Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5dB ( $L_{Aeq}$ ) below the typical background ( $L_{A90}$ ) level at the nearest noise sensitive location.’***

## 5.0 Environmental Sound Survey

### 5.1 Measurements

Automated environmental sound measurements were undertaken from 14:00 hours on Wednesday 23 November 2022 to 14:00 hours on Thursday 24 November 2022. During this period the  $L_{Amax}$ ,  $L_{Aeq}$  and  $L_{A90}$  sound pressure levels were measured continuously over 15 minute periods along with the corresponding octave band sound pressure levels.

### 5.2 Weather Conditions

At the start of the survey period there was a light southerly breeze (<3m/s) and the sky was overcast. There was no rainfall and road surfaces were dry. The temperature was approximately 10°C.

At the end of the survey period there was a light southerly breeze (<3m/s) and the sky was overcast. There was no rainfall and road surfaces were dry. The temperature was approximately 9°C.

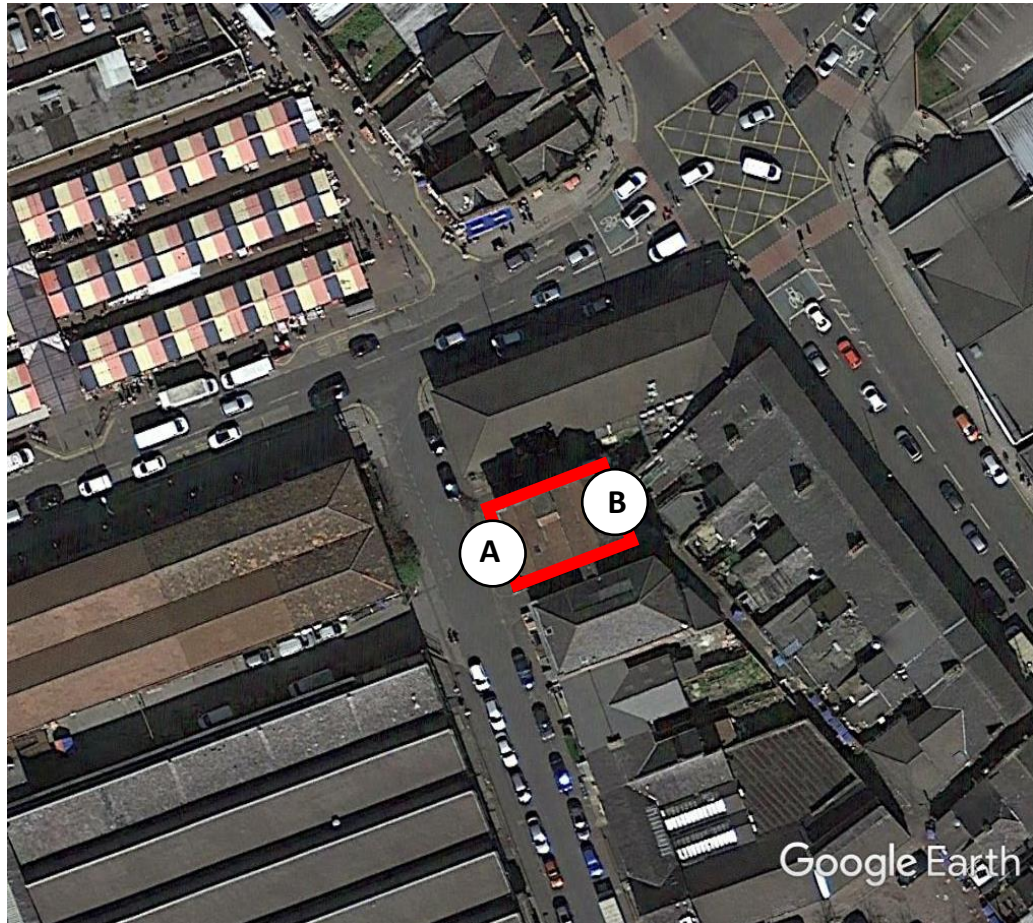
Based on publicly available weather data for the survey period we understand that weather conditions remained similar for the duration of the survey with no significant periods of rainfall or strong breezes. The weather conditions during the survey period are therefore considered to be suitable for undertaking measurements of sound levels.

### 5.3 Measurement Positions

Environmental sound levels were measured at 2No. positions on-site as described in the table below.

| Position | Description                                                                                                                         |
|----------|-------------------------------------------------------------------------------------------------------------------------------------|
| A        | Microphone at 1 <sup>st</sup> floor level at 1m from the west façade of the existing building overlooking Rainforth Street.         |
| B        | Microphone at 2 <sup>nd</sup> floor level at 1m from the east façade of the existing building overlooking the rear of the building. |

The measurement positions are shown on the site plan below.



Site plan showing measurement positions

The measurement positions were selected in order to assess typical environmental sound levels incident upon the front and rear facades of the proposed residential development.

#### 5.4 Equipment

The following equipment was used to undertake the environmental sound survey.

| Equipment                  | Manufacturer | Model   | Serial No. | Calibration Date |
|----------------------------|--------------|---------|------------|------------------|
| Class 1 Sound Level Meter  | Casella      | 633C    | 0721320    | 28/09/2021       |
| Preamplifier               | Casella      | 495     | 001414     | 28/09/2021       |
| Microphone                 | Casella      | 251     | 1025       | 28/09/2021       |
| Class 1 Sound Level Meter  | Casella      | 633C    | 0721319    | 28/09/2021       |
| Preamplifier               | Casella      | 495     | 001446     | 28/09/2021       |
| Microphone                 | Casella      | 251     | 1996       | 28/09/2021       |
| Class 1 Sound Calibrator   | Casella      | 120/1   | 3864878    | 27/10/2022       |
| Environmental Noise Kit    | Casella      | 6847    | -          | -                |
| Microphone Extension Cable | Casella      | C6717/5 | -          | -                |
| Weather Protection System  | Casella      | 6737    | -          | -                |

Field calibration checks were performed on the sound level meters prior to and on completion of the survey and were found to be within acceptable tolerance limits.

## 5.5 Results

### 5.5.1 Time History Graphs

The results of the environmental sound survey are presented on Time History Graphs 0586/THG1 and 0576/THG2 enclosed at the rear of the report. The presented results for Positions A and B have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

### 5.5.2 $L_{Aeq,T}$ Ambient Sound Levels

In order to compare the results of the environmental sound survey with the internal BS 8233: 2014 levels it is necessary to convert the  $L_{Aeq,15min}$  sound levels into single figure daytime  $L_{Aeq,16hour}$  and night-time  $L_{Aeq,8hour}$  sound levels. This has been calculated using the following formula:

$$L_{Aeq,T} = 10 \log_{10} \left( \frac{1}{N} \sum_i^N 10^{L_{Aeq,15min}^i/10} \right)$$

The calculated daytime  $L_{Aeq,16hour}$  and night-time  $L_{Aeq,8hour}$  sound levels at each measurement position are presented in the table below.

| Position | Daytime $L_{Aeq,16hour}$ (dB) | Night-time $L_{Aeq,8hour}$ (dB) |
|----------|-------------------------------|---------------------------------|
| A        | 60                            | 55                              |
| B        | 56                            | 52                              |

The presented results for Positions A and B have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

The highest daytime  $L_{Aeq,16hour}$  and night-time  $L_{Aeq,8hour}$  sound levels at each measurement position are presented in the table below along with the corresponding octave band sound pressure levels.

| Position | Period                 | Leq Sound Pressure Level (dB)<br>at Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | dBA |
|----------|------------------------|-----------------------------------------------------------------------|-----|-----|-----|----|----|----|----|-----|
|          |                        | 63                                                                    | 125 | 250 | 500 | 1k | 2k | 4k | 8k |     |
| A        | Daytime<br>(16 hour)   | 67                                                                    | 63  | 60  | 55  | 56 | 52 | 47 | 39 | 60  |
|          | Night-time<br>(8 hour) | 58                                                                    | 55  | 53  | 49  | 50 | 48 | 39 | 30 | 55  |
| B        | Daytime<br>(16 hour)   | 61                                                                    | 61  | 58  | 55  | 52 | 46 | 39 | 33 | 56  |
|          | Night-time<br>(8 hour) | 54                                                                    | 55  | 53  | 50  | 48 | 41 | 36 | 35 | 52  |

The presented results for Positions A and B have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

### 5.5.3 L<sub>Amax,F</sub> Sound Level Events

The highest 10No. individual L<sub>Amax,F</sub> sound level events measured during the night-time period (23:00 to 07:00 hours) over the survey period at each measurement position are detailed in the table below along with the corresponding octave band sound pressure levels.

| Position | L <sub>max,F</sub> Sound Pressure Level (dB)<br>at Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | dBA |
|----------|--------------------------------------------------------------------------------------|-----|-----|-----|----|----|----|----|-----|
|          | 63                                                                                   | 125 | 250 | 500 | 1k | 2k | 4k | 8k |     |
| A        | 84                                                                                   | 82  | 83  | 80  | 80 | 83 | 70 | 56 | 83  |
|          | 83                                                                                   | 85  | 84  | 79  | 73 | 75 | 75 | 69 | 77  |
|          | 86                                                                                   | 83  | 81  | 74  | 74 | 73 | 67 | 59 | 73  |
|          | 84                                                                                   | 80  | 72  | 72  | 72 | 70 | 63 | 59 | 72  |
|          | 76                                                                                   | 75  | 80  | 73  | 67 | 60 | 50 | 48 | 72  |
|          | 77                                                                                   | 72  | 75  | 78  | 68 | 59 | 59 | 55 | 71  |
|          | 80                                                                                   | 83  | 74  | 68  | 72 | 67 | 55 | 47 | 70  |
|          | 78                                                                                   | 67  | 66  | 63  | 67 | 67 | 68 | 49 | 69  |
|          | 79                                                                                   | 68  | 67  | 64  | 70 | 65 | 53 | 42 | 69  |
|          | 76                                                                                   | 68  | 67  | 66  | 70 | 65 | 56 | 51 | 69  |

The presented results for Position A have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

| Position | L <sub>max,F</sub> Sound Pressure Level (dB)<br>at Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | dBA |
|----------|--------------------------------------------------------------------------------------|-----|-----|-----|----|----|----|----|-----|
|          | 63                                                                                   | 125 | 250 | 500 | 1k | 2k | 4k | 8k |     |
| B        | 77                                                                                   | 80  | 83  | 84  | 82 | 83 | 84 | 85 | 90  |
|          | 69                                                                                   | 70  | 67  | 73  | 76 | 68 | 56 | 48 | 76  |
|          | 69                                                                                   | 67  | 78  | 77  | 72 | 64 | 59 | 51 | 76  |
|          | 72                                                                                   | 72  | 71  | 73  | 68 | 63 | 57 | 56 | 73  |
|          | 74                                                                                   | 73  | 69  | 73  | 67 | 58 | 57 | 52 | 70  |
|          | 75                                                                                   | 75  | 68  | 73  | 67 | 58 | 53 | 50 | 70  |
|          | 70                                                                                   | 67  | 67  | 62  | 65 | 60 | 55 | 53 | 67  |
|          | 71                                                                                   | 77  | 67  | 64  | 61 | 58 | 50 | 45 | 63  |
|          | 74                                                                                   | 76  | 71  | 61  | 52 | 53 | 45 | 41 | 62  |
|          | 71                                                                                   | 65  | 64  | 65  | 58 | 54 | 46 | 41 | 62  |

The presented results for Position B have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

### 5.5.4 $L_{A90,T}$ Background Sound Levels

The lowest representative daytime and night-time  $L_{A90,15min}$  background sound levels measured at each position during the survey period are detailed in the table below.

| Position | Lowest Representative $L_{A90,15min}$ Background Sound Levels (dB) |            |
|----------|--------------------------------------------------------------------|------------|
|          | Daytime                                                            | Night-time |
| A        | 57                                                                 | 41         |
| B        | 55                                                                 | 40         |

The presented results for Positions A and B have been corrected for reflections from the façade by subtracting 3dB from the measured sound levels in order to obtain free field sound levels.

## 5.6 Discussion of Sound Climate

At the start and end of the survey period the dominant sound sources at Position A were noted to be frequent road traffic along Rainforth Street and the surrounding road network and low level building services noise from the surrounding commercial premises.

At the start and end of the survey period the dominant sound sources at Position B were noted to be road traffic from the surrounding road network and low level building services noise from the surrounding commercial premises.

Whilst we are unable to comment on dominant sound sources or individual sound events during the survey period, based on the surrounding environment it is likely that road traffic and low level building services remained the dominant sound sources.

## 6.0 Detailed Sound Assessment

### 6.1 Assessment Method

In order to establish the acoustic specification for glazing/ventilation elements required to achieve the internal daytime  $L_{Aeq,16hour}$ , night-time  $L_{Aeq,8hour}$  and night-time  $L_{Amax,F}$  requirements an assessment has been undertaken in accordance with the more rigorous calculation method detailed in BS 8233:2014, "Guidance on sound insulation and noise reduction for buildings".

This calculation method takes into account the external sound pressure level, the sound reduction indices of the façade elements, the area of the facade and the absorption within the room at octave band centre frequencies.

Detailed calculation sheets for living rooms, dining rooms and bedrooms are enclosed at the rear of the report.

## 6.2 Proposed Development

The assessment has been based on the following drawings.

| Author                        | Drawing No.    | Revision | Date     |
|-------------------------------|----------------|----------|----------|
| Create It Studios<br>(NW) Ltd | A1265(02)AP002 | P1       | 18/10/22 |
|                               | A1265(02)AP003 | P1       | 18/10/22 |

The proposals include the change of use of the existing 5 storey building (including basement) from commercial to form 6 residential flats at 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> floors with a retail unit at ground and basement floors.

## 6.3 Acoustic Requirements

The proposed residential apartments comprise living room/kitchen and bedroom spaces. Based on the requirements of the Local Authority detailed in Section 4.0, the following internal sound limits have been assessed to.

| Room Type           | 07:00 to 23:00   | 23:00 to 07:00                 |
|---------------------|------------------|--------------------------------|
| Living Room/Kitchen | 35dB LAeq,16hour | -                              |
| Bedroom             | 35dB LAeq,16hour | 30dB LAeq,8hour<br>45dB LAmax* |

\* should not be exceeded more than 10 times per night.

## 6.4 Room Assumptions

The following typical dimensions and finishes/furnishings have been assumed for the purpose of the assessment.

| Room Type            | Typical Room Dimensions | Typical Window Area | Typical Room Finishes / Furnishings             |
|----------------------|-------------------------|---------------------|-------------------------------------------------|
| Living Room/ Kitchen | 5m x 3m x 2.4m          | 3m <sup>2</sup>     | Wood/vinyl floor, curtains, sofa, table, chairs |
| Bedroom              | 3m x 2.5m x 2.4m        | 1.5m <sup>2</sup>   | Carpet & underlay, curtains, bed                |

Should the proposed dimensions/finishes/furnishings differ from those detailed above a re-assessment may be required.

## 6.5 Construction Proposals

It is understood that the external walls and roof of the dwellings will comprise the following typical constructions.

| Element        | Typical Construction                                               |
|----------------|--------------------------------------------------------------------|
| External Walls | Brickwork with cavity, insulation and internal plasterboard lining |
| Roof           | Tiles with insulation in void and plasterboard ceiling             |

The following typical Sound Reduction Indices have been assumed for the various elements.

| Element        | Sound Reduction Index (dB)<br>at Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    |
|----------------|--------------------------------------------------------------------|-----|-----|-----|----|----|----|----|
|                | 63                                                                 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| External Walls | 32                                                                 | 40  | 44  | 45  | 51 | 56 | 56 | 56 |
| Roof           | 20                                                                 | 28  | 34  | 40  | 45 | 49 | 49 | 49 |

## 6.6 Glazing Specifications

In order to achieve the internal daytime and night-time requirements the glazing system as a whole including glass, frame, seals and openings shall provide the following minimum sound insulation performance when tested in accordance with BS EN ISO 10140-2: 2010.

| Facade                                       | Room Type               | Sound Reduction Index (dB)<br>at Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    |
|----------------------------------------------|-------------------------|--------------------------------------------------------------------|-----|-----|-----|----|----|----|----|
|                                              |                         | 63                                                                 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| Front & Sides to Front<br>(Rainforth Street) | Living Room/<br>Kitchen | 21                                                                 | 25  | 22  | 33  | 40 | 43 | 44 | 48 |
|                                              | Bedroom                 | 23                                                                 | 27  | 29  | 36  | 41 | 42 | 52 | 56 |
| Rear & Sides to Rear                         | Living Room/<br>Kitchen | 21                                                                 | 25  | 22  | 33  | 40 | 43 | 44 | 48 |
|                                              | Bedroom                 | 21                                                                 | 25  | 22  | 33  | 40 | 43 | 44 | 48 |

The table below presents typical configurations and  $R_w$  sound insulation values which may be expected to achieve the sound insulation performance specified above.

| Facade                                       | Room Type               | Typical $R_w$ Sound<br>Insulation Value<br>(dB) | Typical Configuration |
|----------------------------------------------|-------------------------|-------------------------------------------------|-----------------------|
| Front & Sides to Front<br>(Rainforth Street) | Living Room/<br>Kitchen | 35                                              | 10mm/16mm/4mm         |
|                                              | Bedroom                 | 40                                              | 10mm/16mm/6.4mm       |
| Rear & Sides to Rear                         | Living Room/<br>Kitchen | 35                                              | 10mm/16mm/4mm         |
|                                              | Bedroom                 | 35                                              | 10mm/16mm/4mm         |

Acoustic test data for the proposed glazing systems should be forwarded for review.

## 6.7 Ventilation Provision

### 6.7.1 Background Ventilation

In order to achieve the internal daytime and night-time requirements openable windows must remain closed. Background ventilation shall therefore be provided by ventilators in the building façade and shall provide the following minimum element normalised level differences in the open position when tested in accordance with BS EN ISO 10140-2: 2010.

| Façade                                       | Room Type               | Element Normalised Level Difference, $D_{n,e}$ (dB)<br>in Open Position at Octave Band Centre<br>Frequency (Hz) |     |     |     |    |    |    |    |
|----------------------------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------|-----|-----|-----|----|----|----|----|
|                                              |                         | 63                                                                                                              | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| Front & Sides to Front<br>(Rainforth Street) | Living Room/<br>Kitchen | 27                                                                                                              | 33  | 39  | 39  | 43 | 50 | 50 | 50 |
|                                              | Bedroom                 | 42                                                                                                              | 48  | 46  | 49  | 54 | 65 | 65 | 65 |
| Rear & Sides to Rear                         | Living Room/<br>Kitchen | 27                                                                                                              | 33  | 39  | 39  | 43 | 50 | 50 | 50 |
|                                              | Bedroom                 | 27                                                                                                              | 33  | 39  | 39  | 43 | 50 | 50 | 50 |

Should more than one ventilator be required per room the above element normalised level differences shall be increased by the following values:

| Number of Ventilators Required Per Room | Additional Performance Required Per Ventilator (dB) |
|-----------------------------------------|-----------------------------------------------------|
| 1                                       | 0                                                   |
| 2                                       | +3                                                  |
| 3                                       | +5                                                  |
| 4                                       | +6                                                  |

The table below presents typical configurations and  $D_{n,e,w}$  sound insulation values which may be expected to achieve the sound insulation performance specified above.

| Facade                                    | Room Type            | Typical Open $D_{n,e,w}$ Sound Insulation Value (dB) | Typical Configuration                                                                              |
|-------------------------------------------|----------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Front & Sides to Front (Rainforth Street) | Living Room/ Kitchen | 40                                                   | Acoustic Window Ventilators (e.g. Greenwood EAR42W)                                                |
|                                           | Bedroom              | 50                                                   | Acoustic Wall Ventilator (e.g. Greenwood MA3051)<br>Or Acoustically Treated Mechanical Ventilation |
| Rear & Sides to Rear                      | Living Room/ Kitchen | 40                                                   | Acoustic Window Ventilators (e.g. Greenwood EAR42W)                                                |
|                                           | Bedroom              | 40                                                   | Acoustic Window Ventilators (e.g. Greenwood EAR42W)                                                |

Should acoustically treated mechanical ventilation be considered to provide continuous background ventilation, the system should achieve noise levels of  $L_{Aeq} \leq 30\text{dB}$  in living rooms and bedrooms and  $L_{Aeq} \leq 35\text{dB}$  in kitchens and bathrooms where providing continuous background ventilation.

A ventilation engineer should be consulted to ensure that a suitable system is proposed that satisfies the requirements of Approved Document F, "Ventilation". Acoustic test data for the proposed ventilators (or other means) should be forwarded for review acoustically.

### 6.7.2 Summer Cooling Ventilation

In addition to background ventilation summer cooling ventilation is required in order to minimize the need for occupants to open windows during hot summer days/nights.

In order to provide this, mechanical ventilation featuring a user controllable 'boost' function which delivers increased air flow at the occupants discretion (or other means) should be considered.

Where providing continuous background ventilation also, the system should achieve noise levels of  $L_{Aeq} \leq 30\text{dB}$  in living rooms and bedrooms and  $L_{Aeq} \leq 35\text{dB}$  in dining rooms, kitchens and bathrooms.

A ventilation engineer should be consulted to ensure that a suitable system is proposed that satisfies the requirements of Approved Document O, "Overheating". Detailed proposals should be forwarded for review acoustically.

### 6.7.3 Purge Ventilation

Purge ventilation (to aid removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating or accidental releases such as smoke from burnt food or spillage of water) may be provided via openable windows at the occupants discretion. As such, the internal daytime and night-time requirements may potentially be exceeded during purge ventilation conditions.

A ventilation engineer should be consulted to ensure that a suitable system is proposed that satisfies the requirements of Approved Document F, "Ventilation". Detailed proposals should be forwarded for review acoustically.

## 7.0 Building Services Sound Limits

Plant selections for the proposed residential flats have not been made at this stage of the development. As such, it is not possible to assess atmospheric building services sound to the nearest noise sensitive receptors.

Based on the requirements of Manchester City Council detailed in Section 4.2 and the lowest representative  $L_{A90}$  sound levels measured during the environmental sound survey detailed in Section 5.5.4, it is proposed that cumulative atmospheric plant sound emissions should be designed to achieve the following limits at the nearest noise sensitive receptors.

| Nearest Noise Sensitive Receptor | <b><math>L_{Aeq}</math> Cumulative Atmospheric Plant Sound Emission Limits at Nearest Noise Sensitive Receptor (dB)</b> |                                     |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|                                  | <b>Daytime<br/>(07:00–23:00)</b>                                                                                        | <b>Night-time<br/>(23:00–07:00)</b> |
| To the west of the site          | 52                                                                                                                      | 36                                  |
| To the east of the site          | 50                                                                                                                      | 35                                  |

Plant sound emissions should be assessed in accordance with BS 4142:2014.

Plant sound limits for individual plant items will be dependent on the total number of plant items, the location of plant items in relation to nearest noise sensitive receptors and the proposed operational hours.

Once detailed design proposals are developed an assessment of atmospheric plant sound emissions from the proposed plant items to the nearest noise sensitive receptors should be undertaken. This will determine whether any attenuation measures are required in order to achieve the proposed limits.

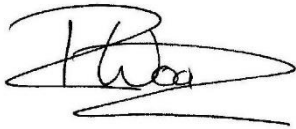
## 8.0 Conclusions

The Local Authority's acoustic requirements for the proposed development have been established.

A detailed environmental sound survey has been undertaken in order to establish existing environmental sound levels at the proposed development.

A detailed environmental sound assessment of the proposed residential development has been undertaken and acoustic specifications for glazing/ventilation elements have been provided in order to achieve the requirements of the Local Authority.

Atmospheric plant sound emission limits have been proposed at the nearest noise sensitive receptors for subsequent use in designing building services proposals in order to comply with the requirements of the Local Authority.

A handwritten signature in black ink, appearing to read 'R Wood', with a large, sweeping horizontal stroke underneath.

**Robin Wood**  
**LIGHTHOUSE ACOUSTICS**

| Term            | Derivation                                                      | Value (m <sup>2</sup> ) |
|-----------------|-----------------------------------------------------------------|-------------------------|
| S <sub>f</sub>  | Facde Area (including window) S <sub>wi</sub> + S <sub>ew</sub> | 7.2                     |
| S <sub>r</sub>  | Roof Area (exposed side)                                        | 2                       |
| S <sub>wi</sub> | Window Area                                                     | 1.5                     |
| S <sub>ew</sub> | Wall Area S <sub>f</sub> - S <sub>wi</sub>                      | 5.7                     |
| S <sub>rr</sub> | Ceiling Area                                                    | 2                       |
| S               | Total Area S <sub>f</sub> + S <sub>rr</sub>                     | 9.2                     |
| A <sub>0</sub>  | Ref. Absorption Area Given in BS EN ISO 10140-2                 | 10                      |
| K               | Correction Factor                                               | 3                       |

## BS 8233:2014 More Rigorous Calculation Method

|                 |                                           |
|-----------------|-------------------------------------------|
| <b>Project:</b> | 7 Rainforth Street, Manchester            |
| <b>Façade:</b>  | Front & Sides to Front (Rainforth Street) |
| <b>Room:</b>    | Bedroom                                   |
| <b>Zone:</b>    | -                                         |

$$L_{p,in} = L_{p,out(f)} + 10 \log_{10} \left( \frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}} + \frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{-\frac{R_{rr}}{10}} \right) + 10 \log_{10} \left( \frac{S}{A} \right) + 3$$

| Term                  | Description                                            | Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | A-weighted Level |
|-----------------------|--------------------------------------------------------|-----------------------------------|-----|-----|-----|----|----|----|----|------------------|
|                       |                                                        | 63                                | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                  |
| L <sub>p,out(f)</sub> | Free Field External Daytime L <sub>eq,16hour</sub>     | 67                                | 63  | 60  | 55  | 56 | 52 | 47 | 39 | 60               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>eq,8hour</sub>   | 58                                | 55  | 53  | 49  | 50 | 48 | 39 | 30 | 55               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.1   | 84                                | 82  | 83  | 80  | 80 | 83 | 70 | 56 | 83               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.2   | 83                                | 85  | 84  | 79  | 73 | 75 | 75 | 69 | 77               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.3   | 86                                | 83  | 81  | 74  | 74 | 73 | 67 | 59 | 73               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.4   | 84                                | 80  | 72  | 72  | 72 | 70 | 63 | 59 | 72               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.5   | 76                                | 75  | 80  | 73  | 67 | 60 | 50 | 48 | 72               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.6   | 77                                | 72  | 75  | 78  | 68 | 59 | 59 | 55 | 71               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.7   | 80                                | 83  | 74  | 68  | 72 | 67 | 55 | 47 | 70               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.8   | 78                                | 67  | 66  | 63  | 67 | 67 | 68 | 49 | 69               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.9   | 79                                | 68  | 67  | 64  | 70 | 65 | 53 | 42 | 69               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.10  | 76                                | 68  | 67  | 66  | 70 | 65 | 56 | 51 | 69               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.11  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.12  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.13  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.14  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.15  |                                   |     |     |     |    |    |    |    |                  |
| D <sub>n,e</sub>      | Greenwood MA3051                                       | 42                                | 48  | 46  | 49  | 54 | 65 | 65 | 65 |                  |
| R <sub>wi</sub>       | 10/12/6.4                                              | 23                                | 27  | 29  | 36  | 41 | 42 | 52 | 56 |                  |
| R <sub>ew</sub>       | Brick, cavity, insulation & plasterboard               | 32                                | 40  | 44  | 45  | 51 | 56 | 56 | 56 |                  |
| R <sub>rr</sub>       | Tiled with insulation in loft and plasterboard ceiling | 20                                | 28  | 34  | 40  | 45 | 49 | 49 | 49 |                  |
| A                     | Equivalent Absorption Area of Room (Calculated)        | 5                                 | 5   | 4   | 4   | 4  | 4  | 5  | 5  |                  |

| Term From Equation                         | Reference Letter of Result                                        | Octave Band Centre Frequency (Hz) |         |         |         |         |         |         |         | A-weighted Level |
|--------------------------------------------|-------------------------------------------------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|------------------|
|                                            |                                                                   | 63                                | 125     | 250     | 500     | 1k      | 2k      | 4k      | 8k      |                  |
| L <sub>p,out(f)</sub>                      | From Table Above                                                  | From Table Above                  |         |         |         |         |         |         |         |                  |
| D <sub>n,e</sub>                           |                                                                   | 42                                | 48      | 46      | 49      | 54      | 65      | 65      | 65      |                  |
| $\frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}}$   | B                                                                 | 0.00007                           | 0.00002 | 0.00003 | 0.00001 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |                  |
| R <sub>wi</sub>                            |                                                                   | 23                                | 27      | 29      | 36      | 41      | 42      | 52      | 56      |                  |
| $\frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}}$ | C                                                                 | 0.00082                           | 0.00033 | 0.00021 | 0.00004 | 0.00001 | 0.00001 | 0.00000 | 0.00000 |                  |
| R <sub>ew</sub>                            |                                                                   | 32                                | 40      | 44      | 45      | 51      | 56      | 56      | 56      |                  |
| $\frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}}$ | D                                                                 | 0.00039                           | 0.00006 | 0.00002 | 0.00002 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |                  |
| R <sub>rr</sub>                            |                                                                   | 20                                | 28      | 34      | 40      | 45      | 49      | 49      | 49      |                  |
| $\frac{S_{rr}}{S} 10^{-\frac{R_{rr}}{10}}$ | E                                                                 | 0.00217                           | 0.00034 | 0.00009 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 |                  |
| 10log(B + C + D + E)                       | F                                                                 | -25                               | -31     | -35     | -40     | -45     | -48     | -52     | -53     |                  |
| A (furnished)                              |                                                                   | 5                                 | 5       | 4       | 4       | 4       | 4       | 5       | 5       |                  |
| 10 log S / A                               | G                                                                 | 3                                 | 3       | 4       | 4       | 4       | 4       | 3       | 3       |                  |
| L <sub>p,in</sub>                          | Free Field External Daytime L <sub>eq,16hour</sub> + F + G + 3    | 48                                | 38      | 32      | 22      | 18      | 11      | 0       | -8      | 28               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>eq,8hour</sub> + F + G + 3  | 39                                | 30      | 25      | 16      | 12      | 7       | -8      | -17     | 21               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.1 + F + G + 3  | 65                                | 57      | 55      | 47      | 42      | 42      | 23      | 9       | 51               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.2 + F + G + 3  | 64                                | 60      | 56      | 46      | 35      | 34      | 28      | 22      | 50               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.3 + F + G + 3  | 67                                | 58      | 53      | 41      | 36      | 32      | 20      | 12      | 48               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.4 + F + G + 3  | 65                                | 55      | 44      | 39      | 34      | 29      | 16      | 12      | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.5 + F + G + 3  | 57                                | 50      | 52      | 40      | 29      | 19      | 3       | 1       | 45               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.6 + F + G + 3  | 58                                | 47      | 47      | 45      | 30      | 18      | 12      | 8       | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.7 + F + G + 3  | 61                                | 58      | 46      | 35      | 34      | 26      | 8       | 0       | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.8 + F + G + 3  | 59                                | 42      | 38      | 30      | 29      | 26      | 21      | 2       | 37               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.9 + F + G + 3  | 60                                | 43      | 39      | 31      | 32      | 24      | 6       | -5      | 38               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.10 + F + G + 3 | 57                                | 43      | 39      | 33      | 32      | 24      | 9       | 4       | 37               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.11 + F + G + 3 | -19                               | -25     | -28     | -33     | -38     | -41     | -47     | -47     | -31              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.12 + F + G + 3 | -19                               | -25     | -28     | -33     | -38     | -41     | -47     | -47     | -31              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.13 + F + G + 3 | -19                               | -25     | -28     | -33     | -38     | -41     | -47     | -47     | -31              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.14 + F + G + 3 | -19                               | -25     | -28     | -33     | -38     | -41     | -47     | -47     | -31              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.15 + F + G + 3 | -19                               | -25     | -28     | -33     | -38     | -41     | -47     | -47     | -31              |

| Term            | Derivation                                                      | Value (m <sup>2</sup> ) |
|-----------------|-----------------------------------------------------------------|-------------------------|
| S <sub>f</sub>  | Facde Area (including window) S <sub>wi</sub> + S <sub>ew</sub> | 7.2                     |
| S <sub>r</sub>  | Roof Area (exposed side)                                        | 2                       |
| S <sub>wi</sub> | Window Area                                                     | 3                       |
| S <sub>ew</sub> | Wall Area S <sub>r</sub> - S <sub>wi</sub>                      | 4.2                     |
| S <sub>tr</sub> | Ceiling Area                                                    | 2                       |
| S               | Total Area S <sub>f</sub> + S <sub>tr</sub>                     | 9.2                     |
| A <sub>0</sub>  | Ref. Absorption Area Given in BS EN ISO 10140-2                 | 10                      |
| K               | Correction Factor                                               | 3                       |

**BS 8233:2014 More Rigorous Calculation Method**

|                 |                                           |
|-----------------|-------------------------------------------|
| <b>Project:</b> | 7 Rainforth Street, Manchester            |
| <b>Façade:</b>  | Front & Sides to Front (Rainforth Street) |
| <b>Room:</b>    | Livingroom/Kitchen                        |
| <b>Zone:</b>    | -                                         |

$$L_{p,in} = L_{p,out(ff)} + 10 \log_{10} \left( \frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}} + \frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}} + \frac{S_{tr}}{S} 10^{-\frac{R_{tr}}{10}} \right) + 10 \log_{10} \left( \frac{S}{A} \right) + 3$$

| Term                   | Description                                            | Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | A-weighted Level |
|------------------------|--------------------------------------------------------|-----------------------------------|-----|-----|-----|----|----|----|----|------------------|
|                        |                                                        | 63                                | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                  |
| L <sub>p,out(ff)</sub> | Free Field External Daytime L <sub>eq,16hour</sub>     | 67                                | 63  | 60  | 55  | 56 | 52 | 47 | 39 | 60               |
| D <sub>n,e</sub>       | Greenwood EAR 42W                                      | 27                                | 33  | 39  | 39  | 43 | 50 | 50 | 50 |                  |
| R <sub>wi</sub>        | 10/12/4                                                | 21                                | 25  | 22  | 33  | 40 | 43 | 44 | 48 |                  |
| R <sub>ew</sub>        | Brick, cavity, insulation & plasteboard                | 32                                | 40  | 44  | 45  | 51 | 56 | 56 | 56 |                  |
| R <sub>tr</sub>        | Tiled with insulation in loft and plasterboard ceiling | 20                                | 28  | 34  | 40  | 45 | 49 | 49 | 49 |                  |
| A                      | Equivalent Absorption Area of Room (Calculated)        | 7                                 | 7   | 6   | 3   | 3  | 2  | 3  | 3  |                  |

| Term From Equation                         | Reference Letter of Result                                     | Octave Band Centre Frequency (Hz) |         |         |         |         |         |         |         | A-weighted Level |
|--------------------------------------------|----------------------------------------------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|------------------|
|                                            |                                                                | 63                                | 125     | 250     | 500     | 1k      | 2k      | 4k      | 8k      |                  |
| L <sub>p,out(ff)</sub>                     | From Table Above                                               | From Table Above                  |         |         |         |         |         |         |         |                  |
| D <sub>n,e</sub>                           |                                                                | 27                                | 33      | 39      | 39      | 43      | 50      | 50      | 50      |                  |
| $\frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}}$   | B                                                              | 0.00217                           | 0.00054 | 0.00014 | 0.00014 | 0.00005 | 0.00001 | 0.00001 | 0.00001 |                  |
| R <sub>wi</sub>                            |                                                                | 21                                | 25      | 22      | 33      | 40      | 43      | 44      | 48      |                  |
| $\frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}}$ | C                                                              | 0.00259                           | 0.00103 | 0.00206 | 0.00016 | 0.00003 | 0.00002 | 0.00001 | 0.00001 |                  |
| R <sub>ew</sub>                            |                                                                | 32                                | 40      | 44      | 45      | 51      | 56      | 56      | 56      |                  |
| $\frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}}$ | D                                                              | 0.00029                           | 0.00005 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |                  |
| R <sub>tr</sub>                            |                                                                | 20                                | 28      | 34      | 40      | 45      | 49      | 49      | 49      |                  |
| $\frac{S_{tr}}{S} 10^{-\frac{R_{tr}}{10}}$ | E                                                              | 0.00217                           | 0.00034 | 0.00009 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 |                  |
| 10log(B + C + D + E)                       | F                                                              | -21                               | -27     | -26     | -35     | -40     | -45     | -46     | -47     |                  |
| A (furnished)                              |                                                                | 7                                 | 7       | 6       | 3       | 3       | 2       | 3       | 3       |                  |
| 10 log S / A                               | G                                                              | 1                                 | 1       | 2       | 4       | 5       | 6       | 5       | 5       |                  |
| L <sub>p,in</sub>                          | Free Field External Daytime L <sub>eq,16hour</sub> + F + G + 3 | 50                                | 40      | 39      | 27      | 24      | 16      | 9       | 0       | 33               |

| Term            | Derivation                                                      | Value (m <sup>2</sup> ) |
|-----------------|-----------------------------------------------------------------|-------------------------|
| S <sub>f</sub>  | Facde Area (including window) S <sub>wi</sub> + S <sub>ew</sub> | 7.2                     |
| S <sub>r</sub>  | Roof Area (exposed side)                                        | 2                       |
| S <sub>wi</sub> | Window Area                                                     | 1.5                     |
| S <sub>ew</sub> | Wall Area S <sub>f</sub> - S <sub>wi</sub>                      | 5.7                     |
| S <sub>rr</sub> | Ceiling Area                                                    | 2                       |
| S               | Total Area S <sub>f</sub> + S <sub>rr</sub>                     | 9.2                     |
| A <sub>0</sub>  | Ref. Absorption Area Given in BS EN ISO 10140-2                 | 10                      |
| K               | Correction Factor                                               | 3                       |

### BS 8233:2014 More Rigorous Calculation Method

|                 |                                |
|-----------------|--------------------------------|
| <b>Project:</b> | 7 Rainforth Street, Manchester |
| <b>Façade:</b>  | Rear & Sides to Rear           |
| <b>Room:</b>    | Bedroom                        |
| <b>Zone:</b>    | -                              |

$$L_{p,in} = L_{p,out(f)} + 10 \log_{10} \left( \frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}} + \frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{-\frac{R_{rr}}{10}} \right) + 10 \log_{10} \left( \frac{S}{A} \right) + 3$$

| Term                  | Description                                            | Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | A-weighted Level |
|-----------------------|--------------------------------------------------------|-----------------------------------|-----|-----|-----|----|----|----|----|------------------|
|                       |                                                        | 63                                | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                  |
| L <sub>p,out(f)</sub> | Free Field External Daytime L <sub>eq,16hour</sub>     | 61                                | 61  | 58  | 55  | 52 | 46 | 39 | 33 | 56               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>eq,8hour</sub>   | 54                                | 55  | 53  | 50  | 48 | 41 | 36 | 35 | 52               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.1   | 77                                | 80  | 83  | 84  | 82 | 83 | 84 | 85 | 90               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.2   | 69                                | 70  | 67  | 73  | 76 | 68 | 56 | 48 | 76               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.3   | 69                                | 67  | 78  | 77  | 72 | 64 | 59 | 51 | 76               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.4   | 72                                | 72  | 71  | 73  | 68 | 63 | 57 | 56 | 73               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.5   | 74                                | 73  | 69  | 73  | 67 | 58 | 57 | 52 | 70               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.6   | 75                                | 75  | 68  | 73  | 67 | 58 | 53 | 50 | 70               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.7   | 70                                | 67  | 67  | 62  | 65 | 60 | 55 | 53 | 67               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.8   | 71                                | 77  | 67  | 64  | 61 | 58 | 50 | 45 | 63               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.9   | 74                                | 76  | 71  | 61  | 52 | 53 | 45 | 41 | 62               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.10  | 71                                | 65  | 64  | 65  | 58 | 54 | 46 | 41 | 62               |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.11  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.12  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.13  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.14  |                                   |     |     |     |    |    |    |    |                  |
| L <sub>p,out(f)</sub> | Free Field External Night-time L <sub>max</sub> No.15  |                                   |     |     |     |    |    |    |    |                  |
| D <sub>n,e</sub>      | Greenwood EAR 42W                                      | 27                                | 33  | 39  | 39  | 43 | 50 | 50 | 50 |                  |
| R <sub>wi</sub>       | 10/12/4                                                | 21                                | 25  | 22  | 33  | 40 | 43 | 44 | 48 |                  |
| R <sub>ew</sub>       | Brick, cavity, insulation & plasteboard                | 32                                | 40  | 44  | 45  | 51 | 56 | 56 | 56 |                  |
| R <sub>rr</sub>       | Tiled with insulation in loft and plasterboard ceiling | 20                                | 28  | 34  | 40  | 45 | 49 | 49 | 49 |                  |
| A                     | Equivalent Absorption Area of Room (Calculated)        | 5                                 | 5   | 4   | 4   | 4  | 4  | 5  | 5  |                  |

| Term From Equation                         | Reference Letter of Result                                        | Octave Band Centre Frequency (Hz) |         |         |         |         |         |         |         | A-weighted Level |
|--------------------------------------------|-------------------------------------------------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|------------------|
|                                            |                                                                   | 63                                | 125     | 250     | 500     | 1k      | 2k      | 4k      | 8k      |                  |
| L <sub>p,out(f)</sub>                      | From Table Above                                                  | From Table Above                  |         |         |         |         |         |         |         |                  |
| D <sub>n,e</sub>                           |                                                                   | 27                                | 33      | 39      | 39      | 43      | 50      | 50      | 50      |                  |
| $\frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}}$   | B                                                                 | 0.00217                           | 0.00054 | 0.00014 | 0.00014 | 0.00005 | 0.00001 | 0.00001 | 0.00001 |                  |
| R <sub>wi</sub>                            |                                                                   | 21                                | 25      | 22      | 33      | 40      | 43      | 44      | 48      |                  |
| $\frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}}$ | C                                                                 | 0.00130                           | 0.00052 | 0.00103 | 0.00008 | 0.00002 | 0.00001 | 0.00001 | 0.00000 |                  |
| R <sub>ew</sub>                            |                                                                   | 32                                | 40      | 44      | 45      | 51      | 56      | 56      | 56      |                  |
| $\frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}}$ | D                                                                 | 0.00039                           | 0.00006 | 0.00002 | 0.00002 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |                  |
| R <sub>rr</sub>                            |                                                                   | 20                                | 28      | 34      | 40      | 45      | 49      | 49      | 49      |                  |
| $\frac{S_{rr}}{S} 10^{-\frac{R_{rr}}{10}}$ | E                                                                 | 0.00217                           | 0.00034 | 0.00009 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 |                  |
| 10log(B + C + D + E)                       | F                                                                 | -22                               | -28     | -29     | -36     | -41     | -46     | -47     | -48     |                  |
| A (furnished)                              |                                                                   | 5                                 | 5       | 4       | 4       | 4       | 4       | 5       | 5       |                  |
| 10 log S / A                               | G                                                                 | 3                                 | 3       | 4       | 4       | 4       | 4       | 3       | 3       |                  |
| L <sub>p,in</sub>                          | Free Field External Daytime L <sub>eq,16hour</sub> + F + G + 3    | 45                                | 39      | 36      | 26      | 18      | 7       | -2      | -9      | 30               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>eq,8hour</sub> + F + G + 3  | 38                                | 33      | 31      | 21      | 14      | 2       | -5      | -7      | 25               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.1 + F + G + 3  | 61                                | 58      | 61      | 55      | 48      | 44      | 43      | 43      | 57               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.2 + F + G + 3  | 53                                | 48      | 45      | 44      | 42      | 29      | 15      | 6       | 45               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.3 + F + G + 3  | 53                                | 45      | 56      | 48      | 38      | 25      | 18      | 9       | 49               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.4 + F + G + 3  | 56                                | 50      | 49      | 44      | 34      | 24      | 16      | 14      | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.5 + F + G + 3  | 58                                | 51      | 47      | 44      | 33      | 19      | 16      | 10      | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.6 + F + G + 3  | 59                                | 53      | 46      | 44      | 33      | 19      | 12      | 8       | 44               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.7 + F + G + 3  | 54                                | 45      | 45      | 33      | 31      | 21      | 14      | 11      | 39               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.8 + F + G + 3  | 55                                | 55      | 45      | 35      | 27      | 19      | 9       | 3       | 41               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.9 + F + G + 3  | 58                                | 54      | 49      | 32      | 18      | 14      | 4       | -1      | 42               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.10 + F + G + 3 | 55                                | 43      | 42      | 36      | 24      | 15      | 5       | -1      | 37               |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.11 + F + G + 3 | -16                               | -22     | -22     | -29     | -34     | -39     | -41     | -42     | -26              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.12 + F + G + 3 | -16                               | -22     | -22     | -29     | -34     | -39     | -41     | -42     | -26              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.13 + F + G + 3 | -16                               | -22     | -22     | -29     | -34     | -39     | -41     | -42     | -26              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.14 + F + G + 3 | -16                               | -22     | -22     | -29     | -34     | -39     | -41     | -42     | -26              |
| L <sub>p,in</sub>                          | Free Field External Night-time L <sub>max</sub> No.15 + F + G + 3 | -16                               | -22     | -22     | -29     | -34     | -39     | -41     | -42     | -26              |

| Term            | Derivation                                                      | Value (m <sup>2</sup> ) |
|-----------------|-----------------------------------------------------------------|-------------------------|
| S <sub>f</sub>  | Facde Area (including window) S <sub>wi</sub> + S <sub>ew</sub> | 7.2                     |
| S <sub>r</sub>  | Roof Area (exposed side)                                        | 2                       |
| S <sub>wi</sub> | Window Area                                                     | 3                       |
| S <sub>ew</sub> | Wall Area S <sub>r</sub> - S <sub>wi</sub>                      | 4.2                     |
| S <sub>tr</sub> | Ceiling Area                                                    | 2                       |
| S               | Total Area S <sub>f</sub> + S <sub>tr</sub>                     | 9.2                     |
| A <sub>0</sub>  | Ref. Absorption Area Given in BS EN ISO 10140-2                 | 10                      |
| K               | Correction Factor                                               | 3                       |

**BS 8233:2014 More Rigorous Calculation Method**

|                 |                                |
|-----------------|--------------------------------|
| <b>Project:</b> | 7 Rainforth Street, Manchester |
| <b>Façade:</b>  | Rear & Sides to Rear           |
| <b>Room:</b>    | Livingroom/Kitchen             |
| <b>Zone:</b>    | -                              |

$$L_{p,in} = L_{p,out(ff)} + 10 \log_{10} \left( \frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}} + \frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}} + \frac{S_{tr}}{S} 10^{-\frac{R_{tr}}{10}} \right) + 10 \log_{10} \left( \frac{S}{A} \right) + 3$$

| Term                   | Description                                            | Octave Band Centre Frequency (Hz) |     |     |     |    |    |    |    | A-weighted Level |
|------------------------|--------------------------------------------------------|-----------------------------------|-----|-----|-----|----|----|----|----|------------------|
|                        |                                                        | 63                                | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                  |
| L <sub>p,out(ff)</sub> | Free Field External Daytime L <sub>eq,16hour</sub>     | 61                                | 61  | 58  | 55  | 52 | 46 | 39 | 33 | 56               |
| D <sub>n,e</sub>       | Greenwood EAR 42W                                      | 27                                | 33  | 39  | 39  | 43 | 50 | 50 | 50 |                  |
| R <sub>wi</sub>        | 10/12/4                                                | 21                                | 25  | 22  | 33  | 40 | 43 | 44 | 48 |                  |
| R <sub>ew</sub>        | Brick, cavity, insulation & plasteboard                | 32                                | 40  | 44  | 45  | 51 | 56 | 56 | 56 |                  |
| R <sub>tr</sub>        | Tiled with insulation in loft and plasterboard ceiling | 20                                | 28  | 34  | 40  | 45 | 49 | 49 | 49 |                  |
| A                      | Equivalent Absorption Area of Room (Calculated)        | 7                                 | 7   | 6   | 3   | 3  | 2  | 3  | 3  |                  |

| Term From Equation                         | Reference Letter of Result                                     | Octave Band Centre Frequency (Hz) |         |         |         |         |         |         |         | A-weighted Level |
|--------------------------------------------|----------------------------------------------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|------------------|
|                                            |                                                                | 63                                | 125     | 250     | 500     | 1k      | 2k      | 4k      | 8k      |                  |
| L <sub>p,out(ff)</sub>                     | From Table Above                                               | From Table Above                  |         |         |         |         |         |         |         |                  |
| D <sub>n,e</sub>                           |                                                                | 27                                | 33      | 39      | 39      | 43      | 50      | 50      | 50      |                  |
| $\frac{A_0}{S} 10^{-\frac{D_{n,e}}{10}}$   | B                                                              | 0.00217                           | 0.00054 | 0.00014 | 0.00014 | 0.00005 | 0.00001 | 0.00001 | 0.00001 |                  |
| R <sub>wi</sub>                            |                                                                | 21                                | 25      | 22      | 33      | 40      | 43      | 44      | 48      |                  |
| $\frac{S_{wi}}{S} 10^{-\frac{R_{wi}}{10}}$ | C                                                              | 0.00259                           | 0.00103 | 0.00206 | 0.00016 | 0.00003 | 0.00002 | 0.00001 | 0.00001 |                  |
| R <sub>ew</sub>                            |                                                                | 32                                | 40      | 44      | 45      | 51      | 56      | 56      | 56      |                  |
| $\frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}}$ | D                                                              | 0.00029                           | 0.00005 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |                  |
| R <sub>tr</sub>                            |                                                                | 20                                | 28      | 34      | 40      | 45      | 49      | 49      | 49      |                  |
| $\frac{S_{tr}}{S} 10^{-\frac{R_{tr}}{10}}$ | E                                                              | 0.00217                           | 0.00034 | 0.00009 | 0.00002 | 0.00001 | 0.00000 | 0.00000 | 0.00000 |                  |
| 10log(B + C + D + E)                       | F                                                              | -21                               | -27     | -26     | -35     | -40     | -45     | -46     | -47     |                  |
| A (furnished)                              |                                                                | 7                                 | 7       | 6       | 3       | 3       | 2       | 3       | 3       |                  |
| 10 log S / A                               | G                                                              | 1                                 | 1       | 2       | 4       | 5       | 6       | 5       | 5       |                  |
| L <sub>p,in</sub>                          | Free Field External Daytime L <sub>eq,16hour</sub> + F + G + 3 | 44                                | 38      | 37      | 27      | 20      | 10      | 1       | -6      | 31               |