HOARE LEA

Manor Road / Richmond

Noise & Vibration Impact Assessment

Hoare Lea

July 2020

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Manor Road.
Richmond.
Avanton Richmond Developments Ltd.

ACOUSTICS
REVISED NOISE & VIBRATION IMPACT ASSESSMENT

REVISION 08 – 29 JULY 2020

Audit sheet.

Rev.	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
00	14/12/2018	Draft issue for comment	BD	BJ	BJ
01	16/01/2019	Updated with comments	BD	VdH	BJ
02	06/02/2019	Updated with further comments	BD	MB	BJ
03	25/10/2019	Draft issue - Updated to include changes to scheme	BD	-	-
04	07/11/2019	Draft issue – Pre updated design of Block E following TfL feedback	BD	-	-
05	18/11/2019	Draft issue – Following Block E redesign	BD	BJ	BJ
06	21/11/2019	Final issue for revised scheme	BD	DF	BJ
07	17/07/2020	Updated to include further changes to scheme – Draft issue	BD	-	-
08	29/07/2020	Updated to include further changes to scheme – final issue	BD	DF	BJ

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Contents.

Executive summary.

There are plans to redevelop the Homebase site located at Manor Road, North Sheen within the London Borough of Richmond upon Thames (LBRuT). The proposals are to demolish the existing Homebase retail unit to provide a new mixed-use development across four new blocks. The new development will provide residential units, flexible retail/community/office uses, as well as public and private open spaces.

Environmental surveys.
Environmental sound and vibration surveys have been undertaken to establish the existing conditions. The results have been used to assess the impact of sound and vibration on the Amended Proposed Development. An assessment against LBRuT policy has been undertaken to identify any limits or specialist measures that may be required.

The environmental sound survey indicates that the site is exposed to relatively high levels of environmental sound, primarily governed by road and railway traffic activity in the local area. The results indicate that the background sound levels do not vary significantly between day to night periods.

The results of the environmental sound survey were used to validate a specialist acoustic model of the existing site. This modelling has been used to predict the sound levels incident on the proposed buildings and across the proposed site.

Control of external noise.
An assessment has been undertaken to understand the implications of the existing sound environment on the design of the facade and ventilation design. This has been summarised as follows:

- The sound reduction performance of the external façade will be controlled by the performance of the windows. Preliminary calculations have been undertaken and these indicate that, facades overlooking the road and railway lines will require high-performance double-glazed systems.
- Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

Impact on Manor Park.
The modelling has also been used to assess the impact of the proposed buildings on the neighbouring properties; particularly the residential properties to the south of the site on Manor Park. The modelling indicates that with the proposed buildings the noise levels incident on the properties on Manor Park are expected to remain the same as existing for the majority of the properties, even slightly decreasing for some properties.

Noise from building services.
Exact selections for the building services plant equipment are not available at this early stage. Guideline plant noise emission limits have been derived in line with LBRuT requirements. The plant emission limits proposed are not considered onerous and should be readily achieved with appropriate mitigation measures. It is reasonable to expect that these limiting levels can be enforced by a suitably worded planning condition.

Vibration from railways lines.
Vibration measurements have been undertaken at several ground floor locations, in-line with the proposed facades of buildings across the development. The results indicate that the levels of vibration measured on site from railway sources were below the threshold required by LBRuT and the British Standard threshold of *low probability of adverse comment*. As such, re-radiated sound from ground-borne vibration is not expected to require mitigation.

It is considered that any potentially significant environmental effects associated with the proposed development can be adequately controlled during the design stages, such that no significant effects would be likely.

1. Introduction.

This noise and vibration impact assessment has been prepared by Hoare Lea on behalf of Avanton Richmond Development Ltd ('the Applicant') following further amendments to the proposed scheme for the redevelopment of the Homebase store at 84 Manor Road, North Sheen ('the Site'). A planning application for the redevelopment of the Site was submitted to London Borough of Richmond Upon Thames (LBRuT) in February 2019 (ref. 19/0510/FUL) (the 'Original Proposed Development'), and was considered at LBRuT Planning Committee on 3 July 2019. The Planning Committee resolved that they were minded to refuse the Application, however, on 29 July 2019 it was confirmed that the Mayor of London would act as the local planning authority for the purposes of determining the application.

As part of the works undertaken for the Original Proposed Development, environmental sound and vibration surveys were conducted to establish the existing conditions. The results of the surveys remain valid for the Amended Proposed Development and have been used to assess the impact of sound and vibration on the proposed development. Comparisons have also been made with local authority policy to identify any limits or specialist measures that may be required.

The surveys and assessments have been undertaken in accordance with relevant British Standards, and this report has been prepared to support the planning application for the Amended Proposed Development.

A glossary of the acoustic terms used in the report is provided in Appendix A.

1.1 Proposed amendments.

Following review of LBRuT's reasons for refusal and discussions with Officers at the Greater London Authority (GLA) and Transport for London (TfL), the Applicant sought to review the scheme, with the principle aim of increasing the delivery of affordable housing through additional density and addressing other issues raised in the Mayor's Stage 2 Report. Initial scheme amendments were submitted in November 2019 ('the November 2019 Amendments') and increased the overall number of units by 48, primarily through the introduction of a new residential building known as Block E.

Following further discussions with TfL and the GLA, it was subsequently agreed that further revisions should be explored in order to deliver an improved scheme, without the need for this additional block.

The proposed changes are described in detail in the accompanying Design and Access Statement Addendum, however, of particular note is the increase in residential units from 385 within the Original Proposed Development to 454 within the Amended Proposed Development. This increases the total number of affordable units by 38 to a total of 172 affordable homes (40% by habitable room taking account of grant funding, increased from 35% as originally submitted). This increase in units and the higher affordable housing provision has been principally achieved through amendments to the height and internal layout in appropriate locations across the Site.

The proposed changes necessitate an amendment to the Application's description of development. The revised description of development (hereafter referred to as the 'Amended Proposed Development') is as follows:

Demolition of existing buildings and structures and comprehensive phased residential-led redevelopment to provide residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), provision of car and cycle parking, landscaping, public and private open spaces and all other necessary enabling works.

As a result of the proposed changes, this noise and vibration impact assessment has been updated in order to assess the Amended Proposed Development.

However, changes between the Original Proposed Development and the Amended Proposed Development are not considered particularly significant from a noise and vibration perspective. While the massing of the proposed blocks has been revised as part of the Amended Proposed Development, their location on the site, and in relation to surrounding sources of noise and vibration, has not changed significantly.

2. Site description.

2.1 Existing site.

The existing site is located on Manor Road, in North Sheen, London. The site is currently occupied by a Homebase retail unit, with supplementary surface level parking, and a bus terminal to the north east of the site.

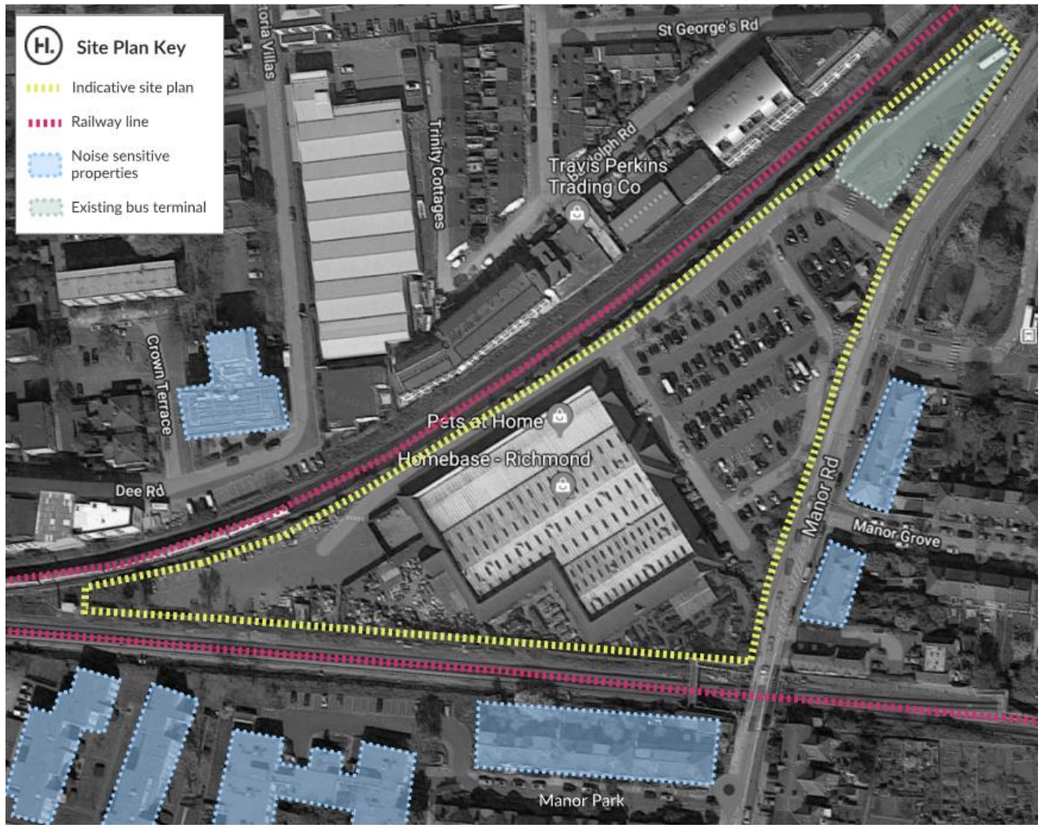


Figure 1 Indicative site plan

The site is bounded by railways to both the North and South. The east of the site is bounded by Manor Road.

The nearest noise sensitive properties to the site are the residential houses on Manor Park, directly to the south of the site. The site location, surrounding properties and the nearest noise sensitive receivers are illustrated in Figure 1.

2.2 Proposed development.

The revised proposals are to redevelop the existing Homebase retail unit to provide a new mixed-use development across four new blocks, ranging between four and eleven storeys in height.

The new development is to provide 454 residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), provision of car and cycle parking, landscaping, public and private open spaces.

The proposed ground floor level of the development is shown in Figure 2 overleaf.

Figure 2 Proposed ground floor of the new development

3. Basis of assessment.

The following policy and guidance have been used for the acoustic survey and assessment:

- London Boroughs of Hillingdon, Hounslow & Richmond Upon Thames, Supplementary Planning Document (SPD) 'Development Control for Noise Generating & Noise Sensitive Development', 2018.
- Mayor of London, adopted London Plan (2016) and Intend to Publish Draft London Plan, 2019.
- Mayor of London, Supplementary Planning Guidance (SPG) 'Sustainable Design and Construction', 2014.
- British Standard 8233, 'Guidance on sound insulation and noise reduction for buildings', 2014.
- British Standard 4142, 'Methods for rating and assessing industrial and commercial sound', 2014.
- National Planning Policy Framework (NPPF).
- World Health Organisation, 'Guidelines for Community Noise', 2012.
- British Standard 7445, 'Description and measurement of environmental noise', 2003.
- British Standard 6472, 'Guide to evaluation of human exposure to vibration in buildings', 2008.
- ANC Guidelines, Measurement & Assessment of Ground borne Noise & Vibration, 2nd edition, 2012.
- ISO/TS 14837-31, 'Mechanical vibration – Ground-borne noise and vibration arising from rail systems', 2017.
- Calculation of Railway Noise (CRN), 1995.
- Calculation of Road Traffic Noise (CRTN), 1988.

3.1 Internal sound levels.

3.1.1 Residential areas

The London Boroughs of Hillingdon, Hounslow & Richmond Upon Thames Supplementary Planning Document (SPD) *'Development Control for Noise Generating & Noise Generating Development'* sets out the following guidance for internal noise levels in line with British Standard BS8233.

Table 1 Local Authority guidance on internal sound levels

Situation	Location	Daytime 07:00 – 23:00 hrs	Night-time 23:00 – 07:00 hrs
Resting	Living room	35 dB $L_{Aeq,16hr}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16hr}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$
Sleeping	Bedroom	-	45 dB L_{AFmax} (several times in any one hour*)

**The SPD states that noise from individual events should not normally exceed 45 dB L_{AFmax} more than 10 times a night in sensitive rooms.*

For reference, the guidance given in the SPD on internal sound levels is reproduced in full in Appendix B.

3.1.2 Commercial areas

For retail spaces, it is advised that internal ambient sound criteria are set in accordance with BS 8233. This varies depending on use, therefore, in order to maintain maximum flexibility for the future, at criteria of 40-45 dB $L_{Aeq,T}$ is proposed.

3.2 External amenity spaces.

The Supplementary Planning Document indicates the following guidance for sound in external amenity spaces:

"The acoustic environment of external amenity areas shall always be assessed and noise levels should ideally not be above the range ***50 to 55dB*** $L_{Aeq,16hr}$*. It may be necessary to carefully locate and design amenity areas and/or to provide acoustic screening in order to meet this goal."*

The SPD also notes that in some circumstances it may be appropriate to vary, or not to apply, these goals in order to meet wider planning objectives in line with guidance in British Standard BS 8233.

For reference, the guidance given in the SPD on sound levels in external amenity spaces is reproduced in full in Appendix B.

3.3 Plant noise emissions.

The SPD sets out the following guidance for the control of building services noise for industrial and commercial developments in line with guidance in British Standard BS 4142.

Table 2 Local Authority guidance on plant noise emissions

Noise impact from relevant proposed industrial or commercial premises or plant	Development outcome
Rating level ($L_{Ar,Tr}$) is at least 5 dB below the background level L_{A90}	Normally acceptable
Rating level ($L_{Ar,Tr}$) is no more than 5 dB above the background level L_{A90}	Acceptable only if there are overriding economic or social reasons for development to proceed
Rating level ($L_{Ar,Tr}$) is more than 5 dB above the background level L_{A90}	Normally unacceptable

As such, for this development, the maximum emission level (dB $L_{Ar,Tr}$) should not exceed **5 dB** below the typical external background noise ($L_{A90,15min}$) at the nearest noise sensitive premises.

3.4 Vibration levels.

The Local Authority will normally require a vibration assessment where railways, either surface or underground, are within 30 m of a proposed development.

The SPD sets out guidance on acceptable levels of vibration within residential developments, in line with British Standard BS 6472-1, expressed in terms of vibration dose values (VDVs) and presented in Table 3.

Table 3 Local Authority guidance on vibration in residential areas

Location	Day-time 07:00 – 23:00 hrs	Night-time 23:00 – 07:00 hrs
Residential	< 0.2 $ms^{-1.75}$	< 0.1 $ms^{-1.75}$

These values are in line with the BS 6472-1 threshold of *'low probability of adverse comment'.*

The SPD also states that re-radiated noise, as a result of vibration from adjacent railways and other sources, shall not exceed **35 dB** L_{ASmax} within habitable residential rooms.

4. Environmental sound survey.

An acoustic survey has been carried out at the proposed site as part of works undertaken for the Original Proposed Development to establish the prevailing local environmental sound conditions. The results of the survey remain valid for the Amended Proposed Development.

4.1 Methodology.

The survey was undertaken between the 20th July and 25th July 2018 and comprised six days of unattended sound measurements by a single sound level meter with additional attended short-term sound measurements taken at various locations across the site. The measurement positions are illustrated in Figure 3.

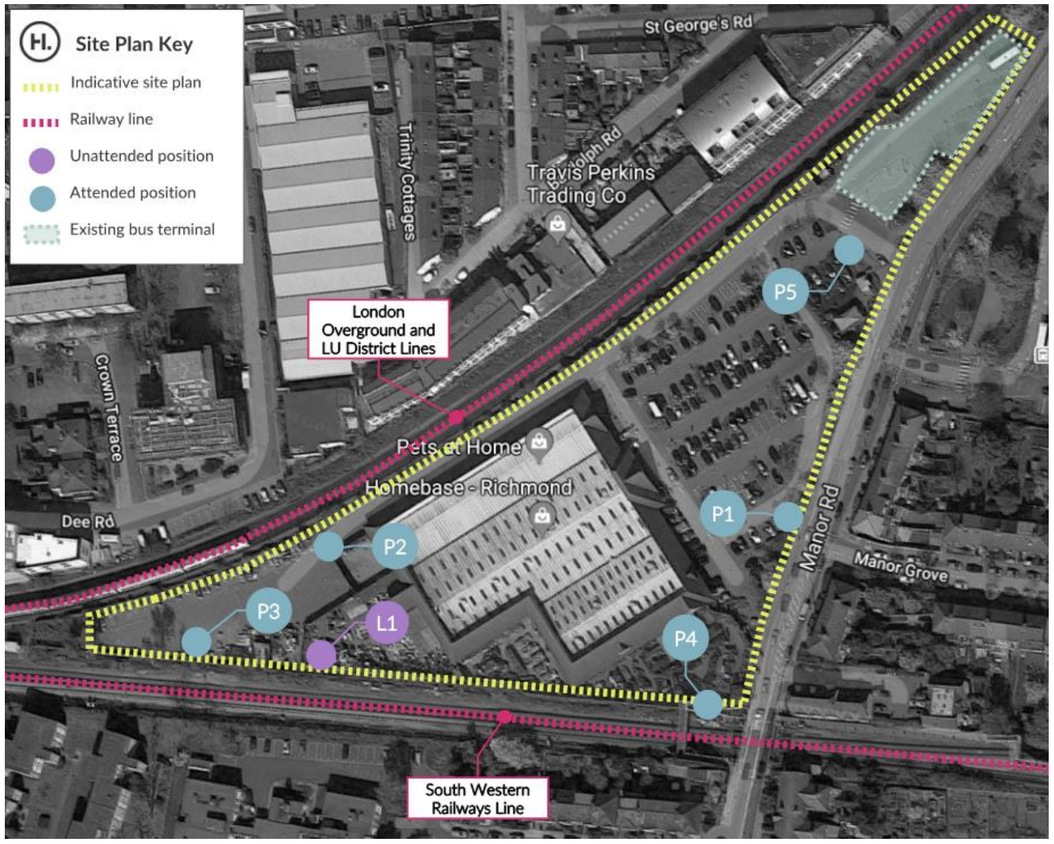


Figure 3 Measurement positions

A summary of the survey details and results are set out in the Sections below. Full details of the survey, measurement conditions and equipment details are provided in Appendix C.

4.1.1 Unattended measurements

The unattended measurement position L1 was located within the rear service yard of the Homebase on the existing site. The measurement location was deemed representative of the nearest residential receivers, the rear of the properties to the south of the site on Manor Park.

There are few train passes during night-time period. It is expected that background noise levels measured at position L1 during the night-time periods are representative of the nearby residential properties both to the north and the south of the site.

Measurements recorded consisted of contiguous fifteen-minute samples of ambient noise levels ($L_{Aeq,15min}$ in dB), maximum noise levels ($L_{Amax,15min}$ in dB) and background noise levels ($L_{A90,15min}$ in dB) between Friday 20th July 2018 and Wednesday 25th July 2018. The measurement position was at a height of approximately 1.2 metres above ground level and considered free-field.

4.1.2 Attended measurements

Short-term attended measurements were taken on Friday 20th July and Wednesday 25th July 2018 to acquire representative sound data from nearby transportation sources.

The measurement positions, as presented in Figure 3, were selected to capture the following sources:

- P1 - Continuous measurements of road traffic sound emissions over four hours.
- P2 - Measurements of sound from operational trains along the north boundary of the site, approximately 1.5 m above ground floor level.
- P3 - Measurements of sound from operational trains along the south boundary of the site, approximately 1.5 m above ground floor level.
- P4 - Measurements of sound from operational trains along the south boundary of the site, on the pedestrian bridge over the train line approximately 4 m above ground level.
- P5 - Measurements of sound from bus movements from the bus terminal towards the northeast corner of the site, approximately 1.5 m above ground floor level.

All attended measurement positions were considered free-field.

4.2 Results.

4.2.1 Unattended measurements

A summary of the unattended measurements recorded at position L1 is provided in Table 4. Full detailed results and a time history are shown in Appendix C.

Table 4: Summary of long-term noise monitoring at position L1

Period,T	Typical average ambient sound level, dB $L_{Aeq,T}$	Typical maximum event level*, dB $L_{Afmax,15min}$	Typical background noise level, dB $L_{A90,15min}$
Day (07:00-23:00)	62	87	41
Night (23:00-07:00)	59	83	39

** Typical maximum is based on the highest 90th percentile of the measured data*

4.2.2 Attended measurements

The results of the short-term measurements are summarised in Figure 4.

The sound levels presented for the railway sources were undertaken for the duration of a train pass-by. Each event varied in duration from approximately 10 – 30 seconds. A sample of at least ten events were measured at each location.

The different types of trains measured at the various measurement locations were as follows:

- P2 (along the north boundary of the site) - London Overground and London Underground District Line trains
- P3 (along the south boundary of the site) – South Western Railways and Freight trains
- P4 (on the pedestrian bridge over the southern train line) – South Western Railways

The average sound pressure levels presented for the road traffic sources at position P1 are based on measurements taken over a three-hour period, in line with the guidance provided in the *Calculation of Road Traffic Noise* document dated 1988 (CRTN).

The sound levels presented for bus sources at position P5 were undertaken for the duration of a bus pass-by. Each event varied in duration from approximately 6 – 13 seconds.

For each measurement position both average levels in terms of $L_{Aeq,T}$, and maximum levels in terms of L_{AFmax}, are given.

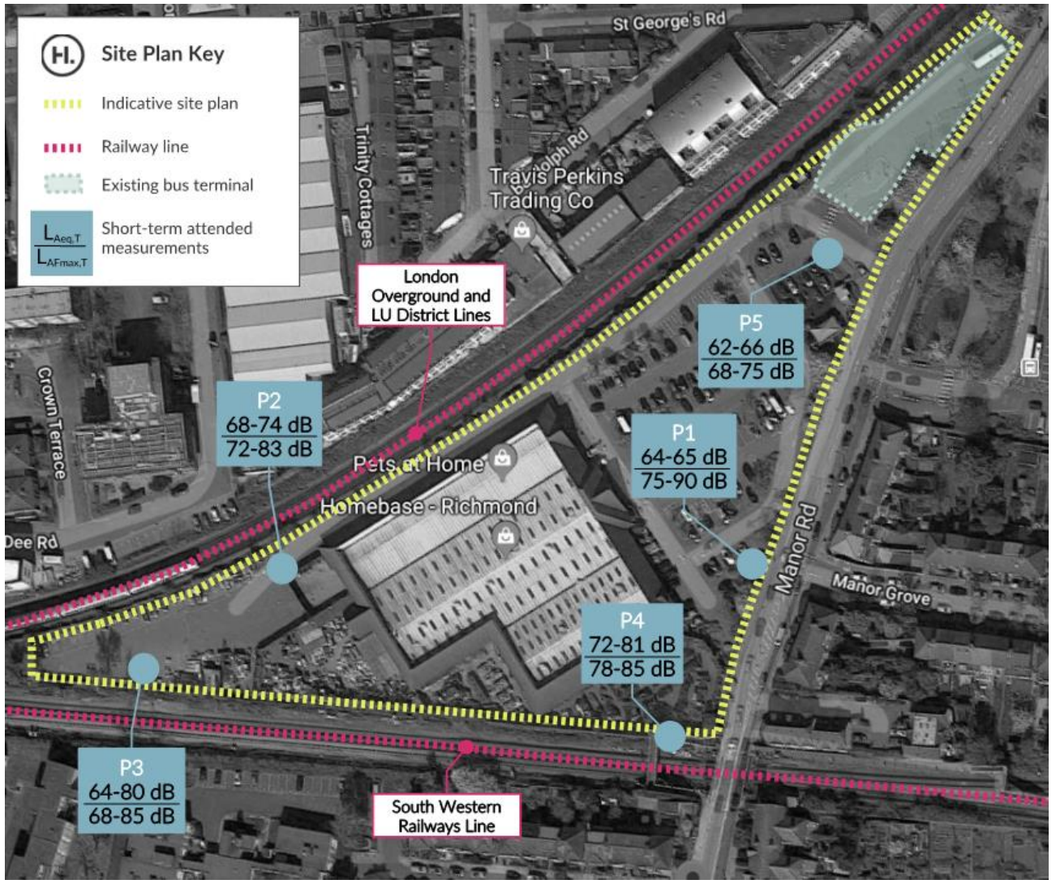


Figure 4 Summary of short-term attended measurement results

The dominant sources of sound local to the site are from road traffic on Manor Road and railway traffic on the London Overground and South Western Rail lines. Some aircraft activity was noted while on site, however the associated sound levels did not impact noticeably on the measured levels, when compared to the road and railway traffic sources.

The results of the above measurements were used to calculate the average sound levels over a full day (07:00 – 23:00) and night (23:00 – 07:00) at the site from both railway lines and road traffic.

The average sound levels from trains and rail traffic were calculated using the methodology set out in the *Calculation of Railway Noise* document dated 1995 (CRN), while the road traffic sound levels were predicted following the methodology set out in the *Calculation of Road Traffic Noise* document dated 1988 (CRTN).

The predicted average daytime and night time sound levels from railway and road traffic sources at the various measurement positions are presented in Table 5.

A correction factor, accounting for differences in height and relative distance from the railway line has been applied to all measurements at 1.5 m above ground level, in accordance with CRTN methodology. This is equivalent to an increase of 3.5 dB to all results at positions P2 and P3.

Table 5 Predicted average daytime and night time sound levels from railway and road traffic sources

Measurement location	Sound source	Calculated average sound levels from road traffic and railway sources (dB)	
		Daytime (07:00 – 23:00), $L_{Aeq,16hr}$	Night time (23:00 – 07:00), $L_{Aeq,8hr}$
P1	Road	67	57
P2	Railway	65	60
P3		62	56
P4		66	61

5. Implications of environmental sound.

The existing sound levels in the vicinity of the site have implications on the design of the façades and the ventilation strategy of the Amended Proposed Development. These are discussed in the following sections.

5.1 Specialist acoustic modelling.

The results of the environmental sound survey were used to validate a specialist acoustic computer model of the existing site developed using Cadna-A software. The model methodology is in accordance with CRN and CRTN. The model was then used to predict the variation in sound levels that would affect different parts of the Original Proposed Development. The modelling has been updated to include the changes to the scheme as part of the Amended Proposed Development. An image of the updated model results for the average daytime $L_{Aeq,T}$ are shown in Figure 5 below.

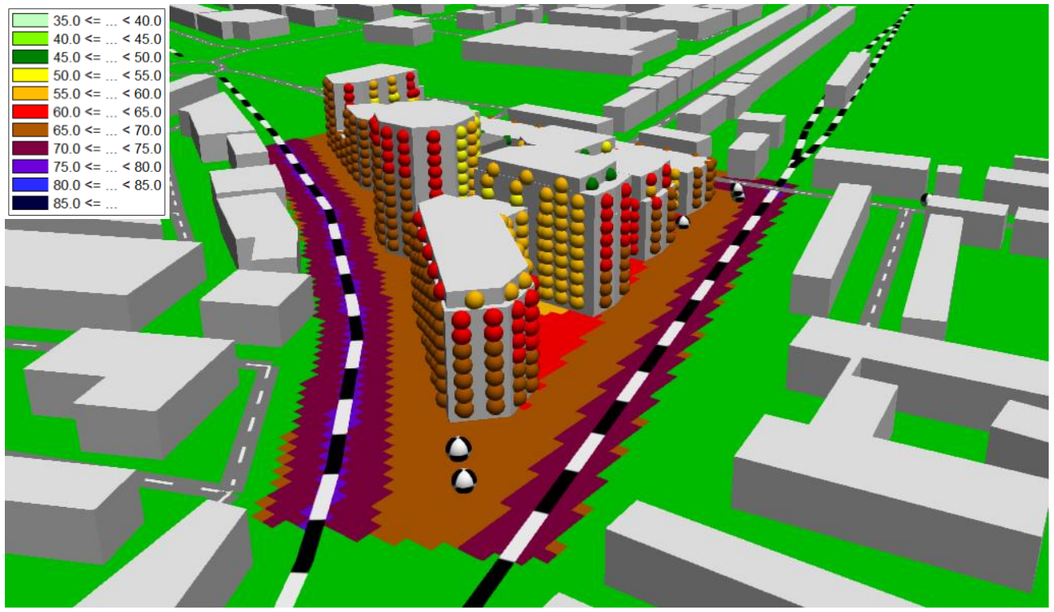


Figure 5 Image from specialist acoustic model, looking northwest – Predicted daytime levels L_{Aeq}.

By defining the sound level at the façades of the new buildings, the sound insulation requirements of the façades and the ventilation strategy can be established. These are discussed in the sections below.

Results of the updated predicted façade levels across the development are presented in more depth in Appendix D.

5.2 Design of façade.

At the planning application stage, allowance should be made for high performance double glazed window systems of circa 45 dB R_w on those elevations most exposed to rail and road traffic noise.

It is expected that windows on other façades of these blocks, more screened from the rail and road noise, are likely to require a lower performance. The window specification will be refined as the design develops through the RIBA stages post planning.

Solid elements of the façade and the roofs should achieve a performance of at least 55 dB R_w. This is achievable with both traditional and suitably built-up light-weight systems.

5.2.1 Ventilation strategy

Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

It is considered that appropriate internal noise levels can be achieved with good acoustic design to the façade elements.

5.3 External Transportation Noise Risk Assessment.

The Supplementary Planning Document describes the initial site noise risk assessment procedure to be followed and the concept of Noise Significance Risk Categories (NSRC). The site noise risk assessment table from the SPD is reproduced below.

Noise Significance Risk	Noise Significance (without mitigation)	Indicative Noise Levels	Pre-Planning Application Advice
Negligible	No adverse noise effect	L_{Aeq}, 16hr <50dB L_{Aeq}, 8hr < 40dB	Low noise levels indicate that the development site is likely to be acceptable from a noise perspective.
Low	Increasing risk of adverse effect	L_{Aeq}, 16hr 50-63dB L_{Aeq}, 8hr 40-55dB	Noise levels in this region mean that the development site is likely to be acceptable from a noise perspective, provided that good acoustic design is followed and demonstrated in an Acoustic Design Statement which confirms how the adverse impacts of noise will be mitigated and minimised in the completed development.
Medium		L_{Aeq}, 16hr 63-69dB L_{Aeq}, 8hr 55-60dB	As noise levels increase, the site is less likely to be suitable for development from a noise perspective and planning consent is more likely to be refused unless a good acoustic design process is demonstrated in a detailed Acoustic Design Statement which confirms how adverse noise impacts will be mitigated and minimised, and which clearly demonstrates that any significant adverse noise impacts will be avoided in the completed development.
High		L_{Aeq}, 16hr >69dB L_{Aeq}, 8hr >60dB	High noise levels indicate that there is an increased risk that development may be refused on noise grounds. The risk of refusal may be reduced by following a good acoustic design process. Applicants are strongly advised to seek expert advice and discuss the proposals in advance with the Local Authority.

Figure 6 Reproduction of Initial Site Noise Risk Assessment table from SPD

The predicted daytime and night-time façade levels, as reported in Appendix D, are compared with the Noise Significance Risk Categories in Table 6 and Table 7 below.

Table 6 Comparison of predicted daytime residential facade levels against Noise Significance Risk Categories

Predicted external daytime noise level, dB(A)	Noise Significance Risk Category (NSRC)	Comments
65 – 69	2 - Medium	– This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions for internal noise levels within apartments in line with the SPD.
60 – 64	1 - Low to 2 - Medium	
50 – 59	1 - Low	
< 50	0 – Negligible	– These areas are within the internal courtyard of the proposed buildings to the north of the site.

Table 7 Comparison of predicted night-time residential facade levels against Noise Significance Risk Categories

Predicted external night-time noise level, dB(A)	Noise Significance Risk Category (NSRC)	Comments
60 – 63	2 - Medium to 3 - High	– There are limited areas, at low level, where predicted façade sound levels are 1-3 dB above the medium NSRC. – A difference of this magnitude would not normally be a perceptible difference outside of laboratory conditions. – This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions for internal noise levels within apartments in line with the SPD.
55 – 59	2 - Medium	– This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions for internal noise levels within apartments in line with the SPD.
40 – 54	1 - Low	

5.4 External amenity areas

Both the National Planning Policy Framework and the Greater London Authority (under the Draft London Plan, 2019) advise to identify and protect amenity areas from noise.

The World Health Organisation (WHO) provides guidance on noise levels for outdoor areas, advising that to avoid annoyance to most people a level of less than 55 dB and ideally less than 50 dB L_{Aeq} should be targeted.

An image from the model is presented in Figure 7 showing the predicted daytime L_{Aeq} sound levels across some of the proposed ground level external amenity areas. As it can be seen, sound levels within the majority of the main ground level landscaped areas are expected to exceed 55 dB, with the exception of the more screened internal courtyard of Block A.

It is therefore recommended that screening to noise from the site boundary is incorporated into the landscaping design. Screening would be most effective along the boundaries of the two railway lines and along the boundary of Manor Road. In order to provide sufficient acoustic benefit, the screening along the boundaries should be solid (i.e. close border timber fencing) and be at a height of at least 2.5m.

Balconies would also be exposed to higher levels of noise than ideal. Where balconies are proposed to offer occupants breakout space, reductions in noise level could be achieved with mitigation measures such as, increased balustrade heights to provide a barrier to noise and the incorporation of acoustic absorption to the soffit of the balcony above.

There are also several rooftop terrace areas proposed across the scheme. Noise levels on roof terrace areas more heavily screened from the railway and road noise sources are not expected to exceed 55 dB.

Roof terrace areas overlooking the railway lines and Manor Road are expected to be exposed to higher levels of noise than ideal. These areas would benefit from additional screening in the form of increased parapets or balustrades heights to provide a barrier to noise.

BS 8233 advises that a level of 50-55 dB L_{Aeq} is desirable within external amenity areas, but recognises that these levels may not be achievable in all circumstances. It further advises that in higher noise areas, such as city centres and urban areas adjoining strategic transport networks, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.

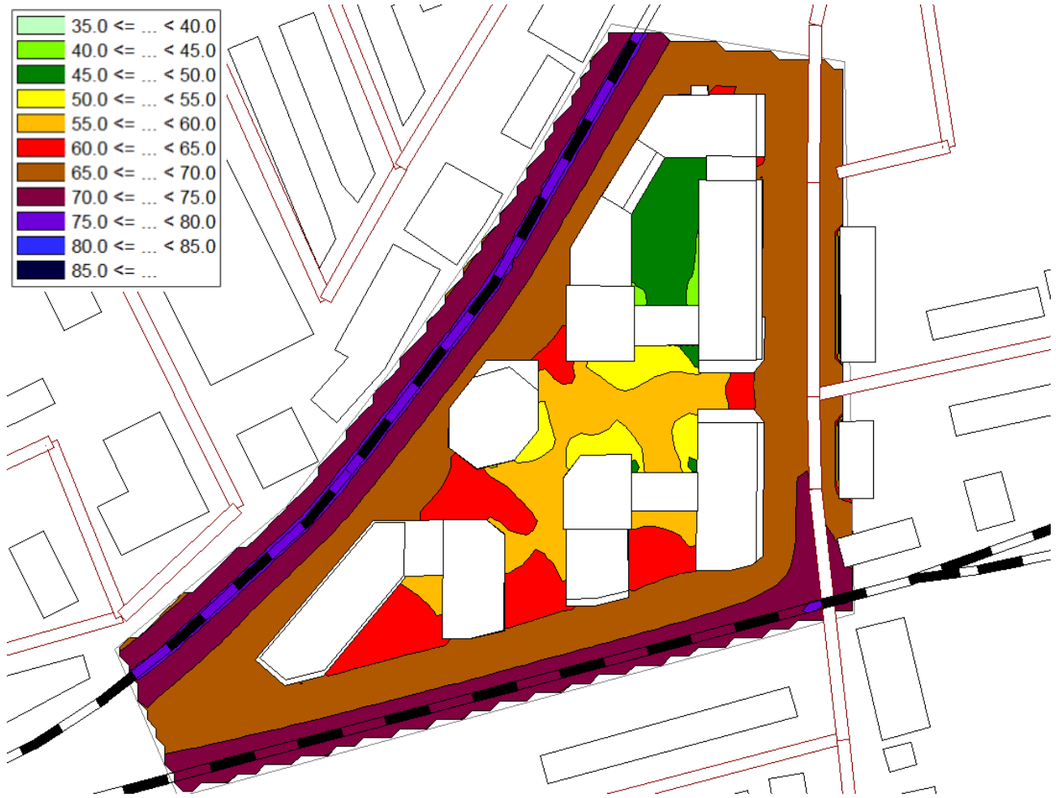


Figure 7 Image from model showing predicted daytime L_{Aeq} sound levels across the proposed ground level external amenity areas

5.5 Noise impact on residential properties to the south of the site.

It is understood that concerns have been raised with regard to the effect of introducing buildings opposite the residential properties to the south of the site, on Manor Park, and the extent to which this may increase noise levels at the properties from the existing railway line due to additional reflected noise.

As part of the specialist acoustic modelling undertaken on the Original Proposed Development, a comparison was made of the predicted noise levels incident on the properties on Manor Park, with the existing buildings on the site and with the proposed buildings associated with the development. As the changes to the development are limited to the south of the site this assessment remains valid for the Amended Proposed Development. Figure 8 shows the predicted noise levels incident on the properties for both scenarios.

Figure 8 Comparison of L_{Aeq} noise levels incident on properties on Manor Park with existing buildings (top) and proposed buildings (bottom)

It can be seen that, with the proposed buildings, the predicted noise levels incident on the majority of the properties on Manor Park remain the same, even slightly decreasing for some properties. This is due to the fact that the façades of the proposed buildings are actually set back further from the railway line than the existing Homebase building.

As part of the proposed mitigation strategy, a solid fence along the southern boundary of the site is recommended to help control noise from the railway line. The modelling considered a second scenario where a solid barrier of height 2.5m was introduced at the site boundary. As a result of reflections from this barrier, noise levels incident on the properties on Manor Park would potentially increase by a maximum of 1 dB. A difference of this magnitude would not normally be perceptible outside of laboratory conditions and can be considered a marginal effect.

6. Noise emissions of fixed plant.

Noise emissions from any equipment introduced in the area will need to be controlled to minimise the impact on the local sound environment as required by the local authority.

Noise levels due to building services associated with the proposed development are advised to meet the following noise level criteria (expressed as “free-field”) shown below in Table 8. These noise limits are proposed at one metre from the nearest noise sensitive receptors as indicated in Figure 1.

The limits are based on the typical background noise levels measured at position L1, which are deemed representative of the closest façade of the nearest noise sensitive receptor on Manor Park.

Table 8 Building services noise emission limits to properties on Ashby Street

Period	Typical prevailing background noise level $L_{A90,15min}$ dB	Noise emission limit calculation $L_{Ar,Tr}$ dB
Daytime (07:00 – 23:00)	41	36
Night-time (07:00 – 23:00)	39	34

It should be noted that these are the combined operational noise levels of plant at the nearest noise sensitive façade. As such, the combined operational noise levels of all plant are required to achieve the noise limits defined within Table 8.

For plant noise that is tonal, contains a specific character or is intermittent, the limits of Table 8 above need to include a character correction as defined within BS 4142: 2014.

The plant emission limits proposed are not considered particularly onerous and should be achievable with appropriate mitigation measures.

7. Ground-borne vibration survey.

The site is bounded to the north by the London Overground and London Underground District lines and to the south by the South Western Railways line, which also carries freight trains. Due to this, the risk of ground-borne vibration to the site needs to be assessed.

7.1 Methodology.

A vibration survey was undertaken on the 20th July 2018 as part of the Original Proposed Development with measurements of ground-borne vibration taken concurrently with the airborne sound measurements at locations P2 and P3 indicated in Figure 9. The results of the survey remain valid for the Amended Proposed Development.

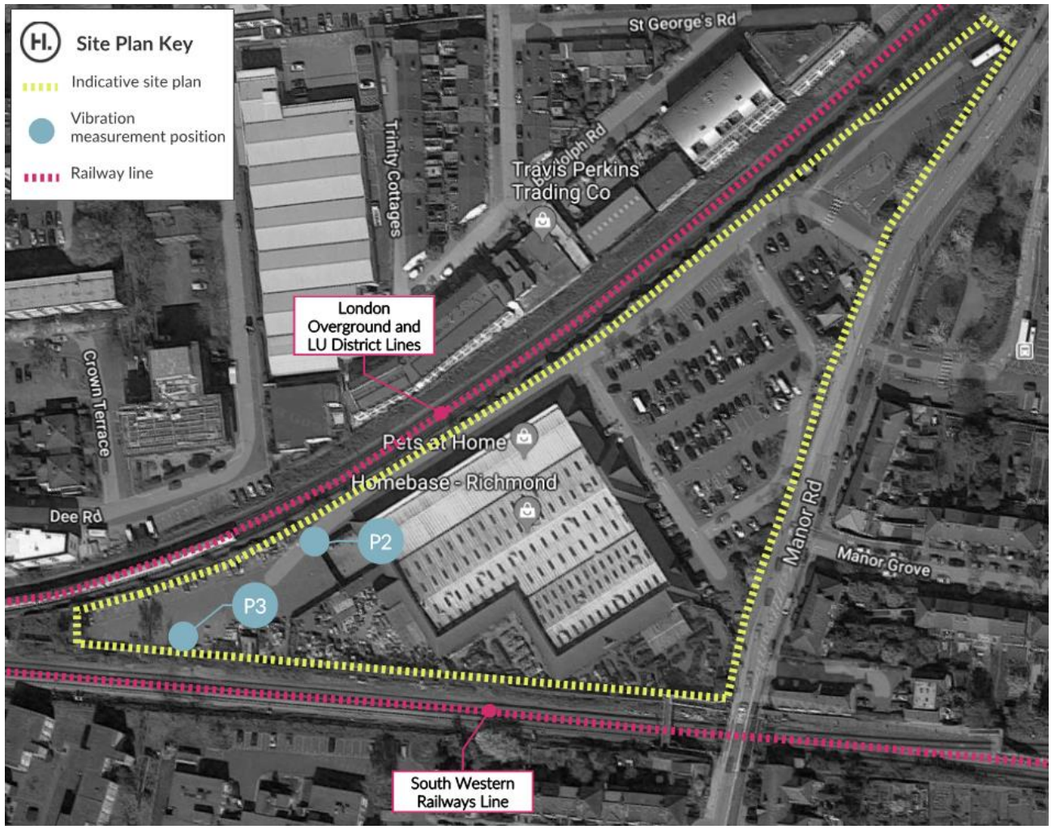


Figure 9 Vibration measurement positions

The survey was undertaken with the intent of quantifying the vibration levels generated from the various train movements. Vibration dose values (VDV) and rms-acceleration values were recorded at 30 seconds intervals, in the vertical direction only (Z-axis).

During the survey, the meter confirmed distinct ‘vibration events’, occurring at both positions. The vibration events were not perceptible to touch.

A more detailed description of the survey, including measurement times and instrumentation has been included in Appendix E. The measurement data has not been included in its entirety but is available on request.

7.2 Results.

The results of the vibration measurements are summarised in Table 9.

The VDVs presented are the range of values measured from train pass events at each measurement position. Each train pass event varied in duration from approximately 10 – 30 seconds.

The different types of trains measured at the various measurement locations were as follows:

- P2 (along the north boundary of the site) - London Overground and London Underground District Line trains
- P3 (along the south boundary of the site) – South Western Railways and Freight trains

Table 9 Summary of vibration measurement results

Measurement Location	Measured vibration dose values, $m/s^{1.75}$ for train pass event
P2	0.004 – 0.008
P3	0.003 – 0.026

7.3 Vibration impact assessment.

The average VDVs for day and night time periods have been calculated based on the London Overground, London Underground District Line, South Western Railways and Freight train timetables available online, and on the guidance provided in BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings, Part 1: vibration sources other than blasting*.

The rms-acceleration values measured have been used to calculate the regenerated noise levels due to ground-borne vibration transmission from the rail tracks that will likely be experienced by the proposed residences. The assessment assumes that residences will start on the ground floor of the building. The regenerated noise levels from train pass-bys were calculated in accordance with the methodology given in the Association of Noise Consultants' *Measurement and Assessment of Groundborne Noise & Vibration* dated 2012.

As the proposals for the building substructure are in their early stages of development, no corrections have been applied for the losses associated with the building foundations and can therefore be considered worst case. The predicted day time and night time VDVs and regenerated noise levels at positions P2 and P3 are reported in Table 10.

Table 10 Predicted vibration dose values and regenerated noise levels in the future level 1 residences

Measurement Location	Predicted vibration dose values, $m/s^{1.75}$		Predicted re-radiated noise level, L_{ASmax} (dB
	Daytime (07:00 – 23:00)	Night time (07:00 – 23:00)	Low amplification factor (such as expected for concrete framed buildings)
P2	0.04	0.03	< 31
P3	0.10	0.09	< 34

The predicted VDVs at both measurement locations given in Table 10 fall well below the BS 6472:2008 threshold of *low probability of adverse comment* and specialist mitigation measures would not normally be considered necessary.

There is potential for individual train events, particularly South Western Railway and Freight train passes on the nearside track of the southern railway line, to be perceptible by some people

The predicted levels of re-radiated noise at both measurement positions are below the Local Authorities required limit of 35 dB L_{ASmax} and as such are unlikely to cause disturbance. As such, specialist mitigation measures would not normally be considered necessary. Impact of vibration and re-radiated noise on the development from trains would not therefore be considered significant.

8. Summary and conclusion.

Environmental sound and vibration surveys have been undertaken to establish the existing conditions. The results have been used to assess the impact of sound and vibration on the Amended Proposed Development. Comparisons have also been made with LBRuT policy to identify any limits or specialist measures that may be required.

The environmental sound survey indicates that the site is exposed to relatively high levels of environmental sound, primarily governed by road and railway traffic activity in the local area. The results indicate that the background sound levels do not vary significantly between day to night periods.

The results of the environmental sound survey were used to validate a specialist acoustic model of the existing site. This modelling has been used to predict the sound levels incident on the proposed buildings and across the proposed site.

The modelling has also been used to assess the impact of the proposed buildings on the neighbouring properties; particularly the residential properties to the south of the site on Manor Park. The modelling indicates that with the proposed buildings the noise levels incident on the properties on Manor Park will remain the same as existing for the majority of the properties, even slightly decreasing for some properties.

An assessment has been undertaken to understand the implications of the existing sound environment on the design of the facade and ventilation design. This has been summarised as follows:

- The sound reduction performance of the external façade will be controlled by the performance of the glazing. Preliminary calculations have been undertaken and these indicate that, facades overlooking the road and railway lines will require high-performance double-glazed window systems in the region of 45 dB R_w.
- Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

Exact selections for the building services plant equipment are not available at this early stage. Guideline plant noise emission limits have been derived in line with local authority requirements. The plant emission limits proposed are not considered particularly onerous and should be readily achieved with appropriate mitigation measures. The need to control noise to these limiting levels can be enforced by a suitably worded condition.

Vibration measurements were undertaken several ground floor locations, in-line with the proposed facades of building across the development. The results indicated that the levels of vibration measured on site from railway sources were below the threshold required by the Local Authority and the BS 6472:2008 threshold of *low probability of adverse comment.* As such, perceptible vibration and re-radiated sound from ground-borne vibration is not expected to require mitigation.

It is considered that any potentially significant environmental effects associated with the proposed development can be adequately controlled during the design stages, such that no significant effects would be likely.

Appendix A – Acoustic terminology.

Sound

Sound is produced by mechanical vibration of a surface, which sets up rapid pressure fluctuations in the surrounding air.

The Sound Pressure

The Sound Pressure is the force (N) of sound on a surface area (m^2) perpendicular to the direction of the sound. The SI-units for the Sound Pressure are Nm^{-2} or Pa (Pascal).

Sound is measured with microphones responding proportionally to the sound pressure – *p*. The power is proportional to the square of the sound pressure.

The Sound Pressure Level

The human ear has an approximately logarithmic response to sound pressure over a very large dynamic range. The lowest audible sound pressure approximately 2×10^{-5} Pa (2 ten billionths of an atmosphere) and the highest is approximately 100 Pa.

It is therefore convenient to express the sound pressure as a logarithmic decibel scale related to this lowest human audible sound, where:

$$L_p = 10\ log\left(\frac{p^2}{{p_{ref}}^2}\right) = 10\ log\left(\frac{p}{p_{ref}}\right)^2 = 20\ log\left(\frac{p}{p_{ref}}\right)$$

Where: L_p *= sound pressure level (dB)*

p *= sound pressure (Pa)*

$p_{ref} = 2 \times 10^{-5}$ *– reference sound pressure (Pa)*

In accordance with the logarithmic scale, doubling the sound pressure level gives an increase of 6 dB.

Decibel (dB)

The decibel is the unit used to quantify sound pressure levels as well as sound intensity and power levels.

In accordance with the logarithmic scale, an increase of 10 dB in sound pressure level is equivalent to an increase by a factor of 10 in the sound pressure level (measured in Pa). Subjectively, this increase would correspond to a doubling of the perceived loudness of the sound.

Frequency

The rate at which the pressure fluctuations occur determines the pitch or frequency of the sound. The frequency is expressed in Hertz (Hz) or cycles per second.

Octave and Third Octave Bands

An octave is the interval between two points where the frequency at the second point is twice the frequency of the first.

There are many methods of describing the frequency content of a noise. The most common methods split the frequency range into defined bands, in which the mid-frequency is used as the band descriptor and in the case of octave bands is double that of the band lower. For example, two adjacent octave bands are 250 Hz and 500 Hz.

Third octave bands provided a fine resolution by dividing each octave band into three bands. For examples, third octave bands would be 160 Hz, 250 Hz and 315 Hz for the same 250 Hz octave band.

The human ear is sensitive to sound over a range of frequencies between approximately 20 Hz to 20 kHz and is generally more sensitive to medium and high frequency than to low frequencies within the range. This is the basis of the A-weighting.

A-Weighting

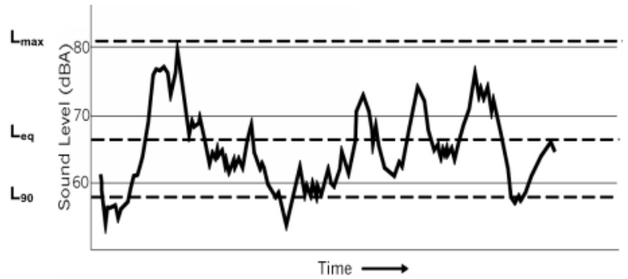
The A-weighting is a correction term applied to the frequency range in order to mimic the sensitivity of the human ear to noise. It is generally used to obtain an overall noise level from octave or third octave band frequencies.

An A weighted value would be written as dB(A), or including A within the parameter term.

Noise Units

In order to assess environmental noise, measurements are carried out by sampling over specific periods of time, such as five minutes, the statistically determined results being used to quantify various aspects of the noise.

The figure below shows an example of sound level varying with time. Because of this time variation the same period of noise can be described by several different levels. The most common of these are described below.



$L_{eq,T}$

The $L_{eq,T}$ is a parameter defined as the equivalent continuous sound pressure level over a defined time period 'T'. It is the sound pressure level equivalent to the acoustic energy of the fluctuating sound signal.

The $L_{eq,T}$ can be thought of as an 'average' sound pressure level over a given time period (although it is not an arithmetic average). Typically the $L_{eq,T}$ will be an A-weighted noise level in dB(A) and is commonly used to describe all types of environmental noise sources.

$L_{01,T}$

The $L_{01,T}$ is a parameter defined as the sound pressure level exceeded for 1% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter.

$L_{10,T}$

The $L_{10,T}$ is a parameter defined as the sound pressure level exceeded for 10% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe road traffic noise.

$L_{90,T}$

The $L_{90,T}$ is a parameter defined as the sound pressure level exceeded for 90% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe the prevailing background noise level.

$L_{max,T}$

The $L_{max,T}$ is a parameter defined as the maximum noise level measured during the specified period 'T'.

Specific Noise Level, $L_{Aeq,Tr}$

This is the equivalent continuous A-weighted sound pressure level at the assessment position due to a specific noise source operating over a given time interval.

Free Field

A measurement taken in the free field is at least 3.5m from reflecting vertical surfaces and 1.2m from the ground.

Façade

A measurement is influenced by the reflection of sound from the façade of a building within 3.5m. A façade measurement is made 1m in front of the vertical building surface.

R_w

A single-number quantity which characterizes the airborne sound insulation of a material or building element in the laboratory. See BS EN ISO 717-1: 1997.

Appendix B – London Borough of Richmond upon Thames planning policy.

Internal design noise levels
Richmond Upon Thames Supplementary Planning Document (SPD) *'Development Control for Noise Generating & Noise Sensitive Development'* sets out the following guidance for internal noise levels:

5.2 Stage 2 – Internal Design Noise Levels

The Borough will normally expect applicants to achieve the design noise levels contained in Table 4 of BS8233:2014 (and to consider the impact and effect of any noise events) in all noise-sensitive rooms. It should be noted that the acoustic performance of the building envelope will be reduced in the event windows are opened for ventilation or cooling purposes, typically reducing the insulation to no more than 10 to 15 dB(A). Most residents value the ability to open windows at will, for a variety of reasons, and the Borough normally requires that designers principally aim, through the use of good acoustic design, to achieve the internal noise level guidelines in noise-sensitive rooms with windows open. On certain sites the Borough may agree to assess the proposal assuming windows are closed.

Table 1: Internal Ambient Noise Levels for Dwellings

Situation	Location	07:00 – 23:00 hrs.	23:00 – 07:00 hrs.
Resting	Living room	35 dB LAeq,16 hour	-
Dining	Dining room/area	40 dB LAeq, 16 hour	-
Sleeping (daytime resting)	Bedroom	35 dB LAeq,16 hour	30 dB LAeq, 8 hour

Notes:

(i) The internal LAeq target levels shown in the Table are based on the existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. In cases where local conditions do not follow a typical diurnal pattern, an appropriate alternative period, e.g. 1 hour, may be used, but the level should be selected to ensure consistency with the internal LAeq target levels recommended in the Table.

(ii) These levels are based on annual average data and do not have to be achieved in all circumstances. For example, it is normal to exclude occasional events, such as fireworks night or New Year's Eve.

(iii) Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. *In noise-sensitive rooms at night (e.g. bedrooms) individual noise events should not normally exceed 45dB L_{AFmax} more than 10 times a night.* This guideline is supported by advice contained in the WHO Community Noise Guidelines (2000).

(iv) Designing the site and the dwellings so that the internal LAeq target levels are achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet the LAeq target levels with windows open then special care must be taken with building design (see below).

(v) Where development is considered necessary or desirable, despite external noise levels above guidelines, the internal LAeq target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved. The more often internal LAeq levels start to exceed the internal target LAeq levels by more than 5 dB, the more that most people are likely to regard them as "unreasonable". Once internal LAeq levels exceed the target levels by more than 10 dB they are highly likely to be regarded as "unacceptable" by most people. Development will be prevented where such levels are likely to occur frequently.

Design noise levels for external amenity spaces
Richmond Upon Thames Supplementary Planning Document (SPD) *'Development Control for Noise Generating & Noise Sensitive Development'* sets out the following guidance for external amenity noise levels:

5.3 Stage 3 – Design Noise Levels for External Amenity Spaces

The acoustic environment of external amenity areas shall always be assessed and noise levels should ideally not be above the range 50 to 55 dB LAeq,16hr. It may be necessary to carefully locate and design amenity areas and/or to provide acoustic screening in order to meet this goal.

Developers are encouraged to enter into pre application discussion where noise levels in proposed amenity spaces are likely to be above 55 dB LAeq,16hr. In such cases, the availability of reasonable access to an outdoor recreational area away from but close to the development site, that meets the above target external levels will be taken into account in deciding whether the scheme is acceptable in noise terms.

Soundscape management techniques, including psychological masking, may also help to provide a suitable outdoor acoustic environment in otherwise noisy locations. It is accepted that, in some circumstances it may be appropriate to vary, or not to apply, these goals in order to meet wider planning objectives.

BS8233:2014 (Section 7.7.3.2 Design criteria for external noise) contains the following guidance:

"For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB $_{LAeq,T}$, with an upper guideline value of 55 dB $_{LAeq,T}$ which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited."

Other locations, such as balconies, roof gardens and terraces, are also important in residential buildings where normal external amenity space might be limited or not available, i.e. in flats, apartment blocks, etc. In these locations, specification of noise limits is not necessarily appropriate. Small balconies may be included for uses such as drying washing or growing pot plants, and noise limits should not be necessary for these uses. However, the general guidance on noise in amenity space is still appropriate for larger balconies, roof gardens and terraces, which might be intended to be used for relaxation. In high-noise areas, consideration should be given to protecting these areas by screening or building design to achieve the lowest practicable levels. Achieving levels of 55 dB $_{LAeq,T}$ or less might not be possible at the outer edge of these areas, but should be achievable in some areas of the space."

Appendix C – Environmental sound survey.

An environmental sound survey was undertaken by Hoare Lea between the 20th July and 25th July 2018. The survey comprised long term unattended monitoring on site and short-term attended measurements.

Weather conditions
The weather conditions on site during both survey periods were dry with approximately 50%-80% cloud cover. The wind speeds were lower than 5 ms^{-1} as recommended by the guidance.

Equipment details
The measurement equipment was calibrated before and after the survey. No significant drift has been observed. The equipment used for the survey has been summarised in Table C1. The instruments used for the survey were in calibration during the survey and their calibration certificate numbers have been included in the table for reference.

Table C1: Instrumentation details

Survey details	Instrumentation description	Manufacturer	Model	Serial Number	Date of Calibration	Certificate Number
Long term survey Position L1	Sound Level Meter	Rion	NL-52	00832187	10/11/2017	UCRT17/2011
	Microphone	Rion	UC-59	10815	10/11/2017	UCRT17/2011
	Pre-amp	Rion	NH-25	32215	10/11/2017	UCRT17/2011
	Acoustic Calibrator	Rion	NC-74	34557134	12/10/2017	UCRT17/1880
Short term measurements	Sound Level Meter	Rion	NA-28	01260200	29/08/2017	UCRT17/1731
	Microphone	Rion	UC-59	00280	29/08/2017	UCRT17/1731
	Pre-amp	Rion	NH-23	60103	29/08/2017	UCRT17/1731
	Acoustic Calibrator	Rion	NC-74	34172704	29/06/2017	UCRT17/1544

Long term unattended monitoring results
The results of the unattended measurements have been calculated into daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) equivalent levels, and are shown with the associated measured typical minimum background noise level ($L_{A90,15min}$) and maximum instantaneous measured noise level ($L_{Amax,T}$) in Table C2 below.

Table C2 Measured noise levels at Position L1

Measurement Position		Position L1					
		Daytime			Night-time		
Measurement Date	Time	$L_{Aeq,T}$ dB	Max $L_{Amax,T}$ dB	Min $L_{A90,15min}$ dB	$L_{Aeq,8hr}$ dB	Max $L_{Amax,T}$ dB	Min $L_{A90,15min}$ dB
Fri 20th Jul 2018	16:00 – 23:00	60	87	41	-	-	-
21st Jul 2018	23:00 – 07:00	-	-	-	60	83	39
Sat 21st Jul 2018	07:00 – 23:00	63	82	41	-	-	-
22nd Apr 2018	23:00 – 07:00	-	-	-	59	80	39
Sun 22nd Jul 2018	07:00 – 23:00	62	83	41	-	-	-
23rd Apr 2018	23:00 – 07:00	-	-	-	59	80	40
Mon 23rd Jul 2018	07:00 – 23:00	63	85	41	-	-	-
24th Apr 2018	23:00 – 07:00	-	-	-	58	79	39
Tues 24th Jul 2018	07:00 – 23:00	63	83	41	-	-	-
25th May 2018	23:00 – 07:00	-	-	-	58	80	39
Wed 25th Jul 2018	07:00 – 15:00	61	86	42	-	-	-

A time history of the L_{Aeq}, L_{A90} and L_{Amax} from the unattended measurements recorded is presented overleaf.

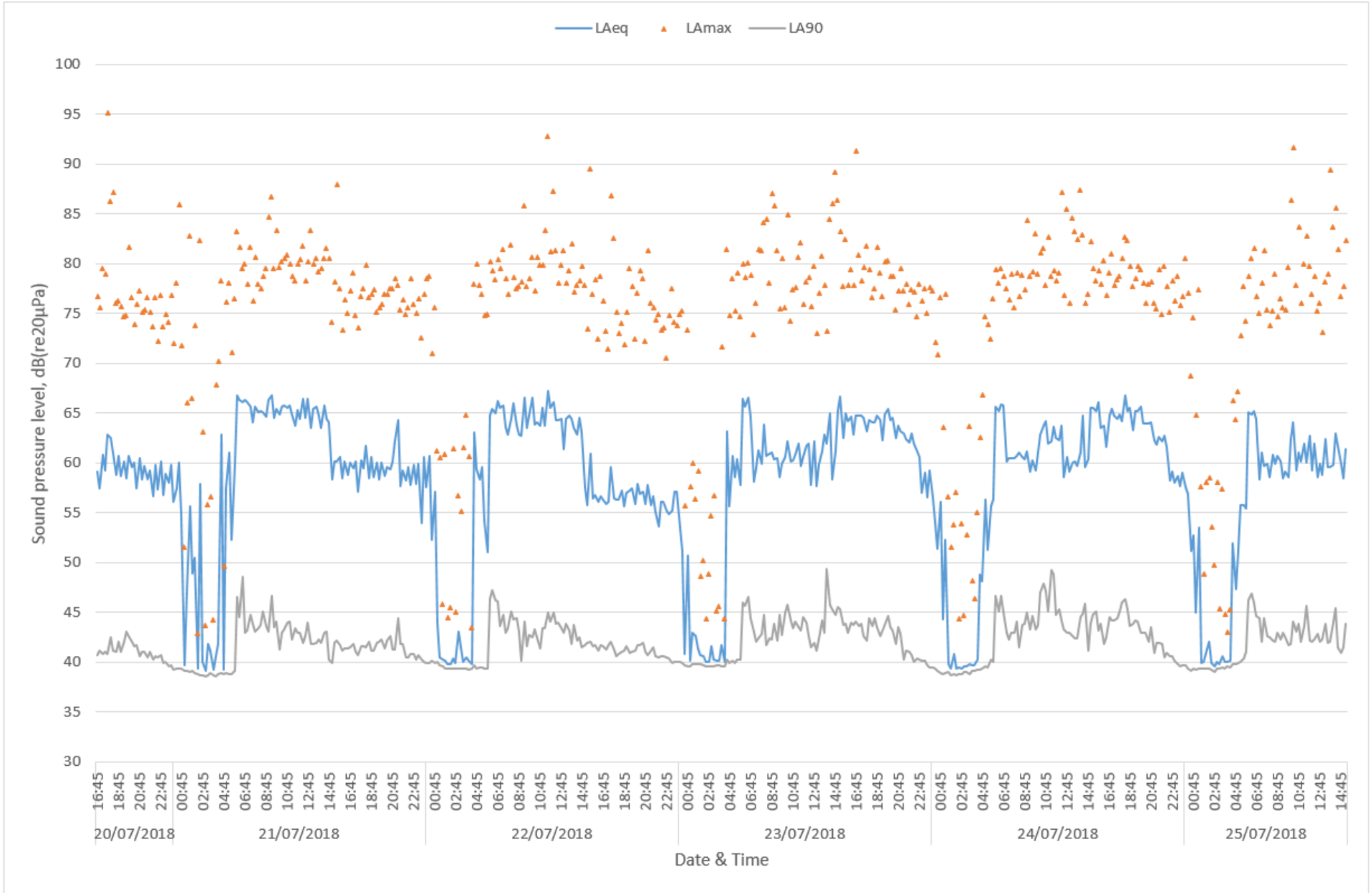


Figure C1 Time history results from unattended monitoring position L1

Short term attended monitoring

The results of the attended road traffic measurements taken at position P1, along Manor Road, are shown in terms of average ($L_{Aeq,T}$) noise levels measured with the associated maximum instantaneous noise level ($L_{Amax,T}$) and noise level exceeded for 10% of the measurement period (L_{A10}) in Table C3 below.

Table C3 Attended measurement results - Position P1 - Road traffic on Manor Road

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Afmax}	Level exceeded for 10% of time, dB (L_{A10})	Measurement Description
20/07/2018 11:45:00	01:00:00	64	90	69	Road traffic measurements
20/07/2018 12:45:00	01:00:00	65	87	69	
20/07/2018 13:45:00	01:00:00	65	83	69	
20/07/2018 14:45:00	01:00:00	66	90	69	

The results of the attended railway traffic measurements taken at position P2, P3 and P4 are shown in terms of average ($L_{Aeq,T}$) noise levels measured with the associated maximum instantaneous noise level ($L_{Amax,T}$) and sound exposure level (L_{AE}) in Table C4, C5 and C6 below.

Table C4 Attended measurement results - Position P2 - Railway traffic on London Overground line

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Afmax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 12:31	00:00:18	72	77	85	Near track, westbound
20/07/2018 12:35	00:00:17	71	76	83	Far track, eastbound
20/07/2018 12:40	00:00:15	72	76	84	Near track, westbound
20/07/2018 12:41	00:00:13	74	79	85	Far track, eastbound
20/07/2018 12:49	00:00:19	72	78	84	Near track, westbound
20/07/2018 12:55	00:00:14	72	76	84	Far track, eastbound
20/07/2018 12:58	00:00:31	70	77	85	2 trains - Both near & far tracks
20/07/2018 13:05	00:00:12	74	78	85	Far track, eastbound
20/07/2018 13:11	00:00:33	74	84	89	2 trains - Both near & far tracks
20/07/2018 13:23	00:00:21	68	72	81	Near track, westbound
20/07/2018 13:29	00:00:13	74	79	85	Far track, eastbound
20/07/2018 13:31	00:00:29	73	83	88	Near track, westbound

Table C5 Attended measurement results - Position P3 - Railway traffic on South Western Railway line

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Afmax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 13:50	00:00:16	70	74	82	Near track, eastbound
20/07/2018 13:58	00:00:15	76	85	87	Near track, eastbound
20/07/2018 14:00	00:00:17	68	72	80	Far track, westbound
20/07/2018 14:06	00:00:11	71	75	82	Far track, westbound
20/07/2018 14:11	00:00:22	66	71	80	Far track, westbound
20/07/2018 14:16	00:00:18	71	77	83	Far track, westbound
20/07/2018 14:17	00:00:28	66	71	81	Near track, eastbound. Train slowed down to halt just before site then sped up past the site
20/07/2018 14:21	00:00:39	69	75	85	2 trains - 1 overground westbound, 1 south westbound
20/07/2018 14:25	00:00:31	80	85	95	FREIGHT TRAIN - Far track, westbound
20/07/2018 14:28	00:00:15	64	68	76	Far track, westbound
20/07/2018 14:29	00:00:19	67	72	80	Near track, eastbound

Table C6 Attended measurement results - Position P4 - Railway traffic on pedestrian railway bridge

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Afmax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 15:16	00:00:20	76	81	89	Near track, eastbound
20/07/2018 15:19	00:00:12	80	84	91	Far track, westbound
20/07/2018 15:20	00:00:18	76	82	89	Near track, eastbound
20/07/2018 15:28	00:00:37	77	84	93	2 trains - 1 Near track, eastbound, 1 Far track, westbound
20/07/2018 15:35	00:00:26	72	79	86	Near track, eastbound
20/07/2018 15:38	00:00:16	78	82	90	Far track, westbound
20/07/2018 15:44	00:00:18	73	80	85	Far track, westbound
20/07/2018 15:45	00:00:19	78	84	91	Near track, eastbound
20/07/2018 15:47	00:00:14	81	85	93	Far track, westbound
20/07/2018 15:52	00:00:25	72	78	86	Near track, eastbound

The results of the attended measurements of bus movements taken at position P5, are shown in terms of average ($L_{Aeq,T}$) noise levels measured with the associated maximum instantaneous noise level ($L_{Amax,T}$) in Table C7 below.

Table C7 Attended measurement results - Position P1 - Road traffic on Manor Road

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Afmax}	Measurement Description
20/07/2018 12:05	00:00:13	80.4	67.6	Bus pulling in
20/07/2018 12:07	00:00:12	80.4	68.6	Bus pulling out
20/07/2018 12:14	00:00:13	79	75.0	Bus pulling out
25/07/2018 15:49	00:00:11	65	68.4	Bus pulling out
25/07/2018 15:50	00:00:05	82.5	69.8	Bus pulling in
25/07/2018 15:55	00:00:14	81.5	72.8	Bus pulling out

Appendix D – Predicted façade levels.

Figure D1 Predicted first floor facade levels – Daytime L_{Aeq}

Figure D2 Predicted first floor facade levels - Night-time L_{Aeq}

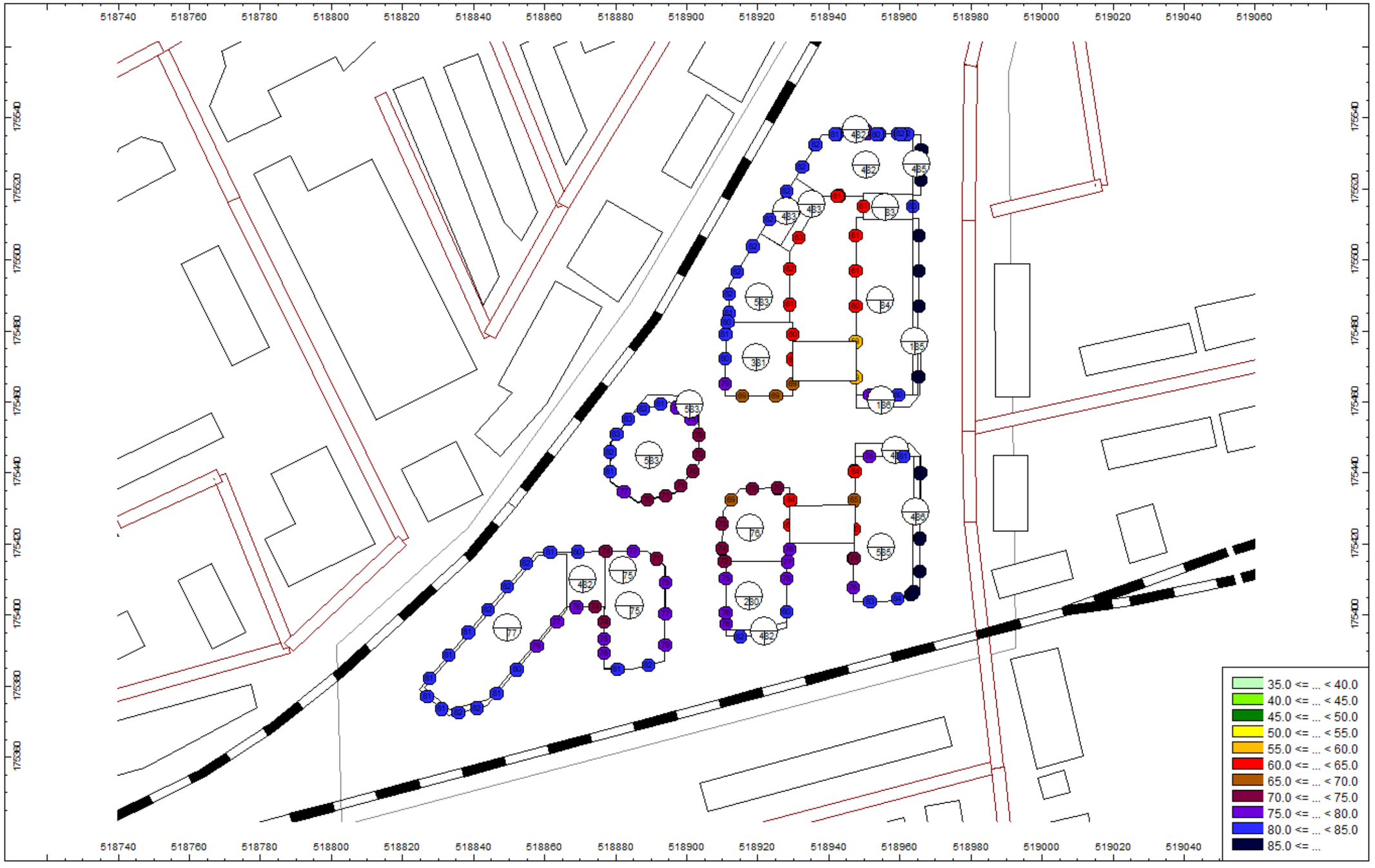


Figure D3 Predicted first floor facade levels - Night-time L_{AFmax}

Appendix E – Environmental vibration survey.

A vibration survey was undertaken at two positions on the 20th July 2018 using a fixed vibration monitor in the vertical axis. The measurement positions, one to the north of the site and one to the south of the site, have been summarised in Section 7 of this report.

The first measurement was undertaken at the northern position between from 12:49 until 13:32 on the 20th July 2018. The Dytran 3191A1 accelerometer was attached to a steel mounting block, which was bonded to the existing floor. Distinct 'vibration events' were observed at this position but they were low in magnitude.

The second measurement was undertaken between 13:49 and 14:30 on the 20th July 2018. The Dytran 3191A1 accelerometer was again attached to a steel mounting block, which was bonded to the existing floor. Distinct 'vibration events' were observed at this position but they were low in magnitude.

The equipment used for the survey has been summarised in Table E1.

Table E1: Instrumentation details for Vibration survey

Survey details	Instrumentation description	Manufacturer	Model	Serial Number	Date of Calibration	Certificate Number
Vibration Survey	Vibration Meter	SVAN	959	00841830	23/01/2017	1701042
	Accelerometer	Dytran	3191A1	1906	23/01/2017	1701041
	Vibration Calibrator	APT	AT01	7001	20/01/2017	1701033

Full measurement results have not been included within this report but are available upon request.

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