

Chapter 8: Noise and Vibration

NOISE AND VIBRATION	
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SUPPORTING APPENDIX	ES Volume 3: Appendix - Noise and Vibration Annex 1: Glossary; Annex 2: Legislative and Planning Policy Context; Annex 3: Noise survey data;
KEY CONSIDERATIONS	The following elements are the key noise and vibration issues relating to the Proposed Development: - Noise and vibration will be generated during the construction works of the Proposed Development as well as during any required enabling works which has the potential to affect nearby residential receptors. Whilst general construction activities are not likely to generate perceptible levels of vibration at the nearby sensitive receptors. However, piling and enabling structural bracing works may generate perceptible levels of construction vibration within the existing Broad Street Mall; - The Proposed Development has the potential to generate noise during operation that may affect nearby residential receptors such as new building services plant associated with the proposed residential units; and The Proposed Development site is exposed to noise from external noise sources (i.e. road traffic from the surrounding road network) ('site suitability').
CONSULTATION	An EIA Scoping Report was prepared and submitted to the RBC in September 2018 requesting a formal Scoping Opinion from the RBC on the scope of the EIA. A copy of the EIA Scoping Report is provided in ES Volume 3: Appendix- EIA Scoping. A Scoping Opinion has not been received at the time of preparing this ES. The EIA has proceeded in the absence of a formal opinion received. Hoare Lea liaised with RBC EHO Jodie Wilson in October 2018 to confirm acceptability of statistically representative background noise level as the basis for setting building services plant noise limits for the Proposed Development. This approach was confirmed to be acceptable on 9 October 2018.

ASSESSMENT METHODOLOGY

Defining the Baseline

Current Baseline Conditions

- 8.1 Noise monitoring has been carried out across the site to determine the noise environment and the potential impacts of existing noise levels on the Proposed Development and the suitability of the uses proposed. Figure 8.1 shows the baseline noise monitoring locations at which measurements were made.
- 8.2 Unattended noise monitoring was carried out at four positions within the site, L1 to L4, continuously between Wednesday 13th June 2018 and Monday 18th June 2018, equating to a total of five days.
- 8.3 Short term attended noise level measurements were conducted at three further locations within the site, S1 to S3, on Monday 18th June 2018.
- 8.4 **ES Volume 3: Appendix - Noise and Vibration (Annex 3)** provides full details of the survey and the equipment used, which in summary comprised continuous fifteen-minute measurements of ambient sound levels (L_{Aeq,15min}), maximum sound levels (L_{Amax(fast),15min}) and background sound levels (L_{A90,15 min}). The survey equipment was field calibrated immediately before and immediately after usage; no significant drift (<0.5 dB) in level was found to have occurred.
- 8.5 All measured noise levels have been processed and summarised to provide an overall level at each location for the whole survey period. Ambient sound levels have been logarithmically averaged for the day (07:00 – 23:00) and night (23:00 – 07:00) periods to present the overall L_{Aeq, 16hour} and L_{Aeq, 8hour} noise levels respectively.
- 8.6 Baseline noise level predictions have been made using the CadnaA noise mapping software to produce a spatial baseline noise model. The measured noise levels at the monitoring locations have been used to verify the outputs produced by the noise model.

Evolution of the Baseline

- 8.7 In addition to the assessment of the existing baseline conditions, consideration has been given to the evolution of the baseline condition due to future developments such as the committed Hosier Street Hotel development and the wider Hosier Street Development Framework plans. The outline of the evolution of the future baseline is described qualitatively.
- 8.8 Potential changes in road traffic flows are considered to have the biggest potential to affect the future baseline at the site. As the local area comprises a busy city centre district of Reading, to have a material impact on traffic noise levels, any increase in traffic flows would need to be significant; traffic flows would have to double to result in a 3 dB increase in road traffic noise levels. Although potential increases in road traffic can be derived from either natural population growth and / or new developments and infrastructure within the local and wider area of the borough and region, given the existing levels of road traffic noted around the site, it is not considered that there will be any significant increase in road traffic noise levels over time.

Impact Assessment Methodology

- 8.9 The assessment of the Proposed Development for both the period of demolition and construction works has been carried out via a desktop assessment. The assessment of the completed Proposed Development has been undertaken using the CadnaA noise mapping software to produce a spatial baseline noise model to generate noise level predictions.

Demolition and Construction

Construction Activities

- 8.10 **ES Chapter 5 - Construction and Demolition (Volume 1)** outlines the proposed demolition and construction works. The noise and vibration assessment is based on the broad assumptions set out in **ES Chapter 5 - Construction and Demolition (Volume 1)** and so may be subject to modification during any future detailed demolition and construction planning.
- 8.11 Demolition and construction works are understood to be phased. Phase 1 will comprise the delivery of Buildings A, B and C, followed by Phase 2 to deliver Building D, and Phase 3 to deliver Building E.
- 8.12 In all phases, the first stage of construction involves enabling works (building the setup of the site, including the disconnection of services), and partial localised demolition of the existing mall. Substructure works follows, including grubbing out of foundations. as well as piling and groundworks.
- 8.13 The confirmed build programme is to be carried out in sequence for each Building, starting with Building A and then overlapping with the start of each subsequent Building construction in sequence every few months. Therefore, construction work for all Phases will be largely simultaneous. The assessment is based on this.
- 8.14 Occupation of the site will follow the construction sequence. Landscaping works and access around each Building are assumed to be completed before the first occupation of each new building.
- 8.15 The analysis of likely construction noise has been undertaken in accordance with BS 5228-1¹, which provides methods for predicting construction noise levels based on reference data for the emissions of typical construction plant and activities.
- 8.16 Table 8A.1 within Annex A of this ES Chapter shows the construction stages (based on **ES Chapter 5 - Construction and Demolition (Volume 1)**) that would take place on site and the associated predicted sound power levels during these stages based on the plant/equipment expected to be in operation based on the information provided. These sound power levels are based on conservative assumptions which may over-state noise emissions in some cases (see section 'Assumptions and Limitations').
- 8.17 The resulting calculated construction noise levels in accordance with BS 5228-1 shall be compared with absolute noise threshold limits (defined in BS 5228-1) for temporary construction activities that are commonly regarded as providing an acceptable level of protection from the short-term noise levels associated with construction activities.

Construction Traffic

- 8.18 In addition, throughout the entire construction programme, HGV and other delivery vehicles will be accessing the site. **ES Chapter 5 - Construction and Demolition (Volume 1)** advises the highest number of vehicles per day (average) occurring during the construction programme is 20 HGV's and 14 LGV's, resulting in a total

¹ British Standards Institution, (2014) BS 5228 Code of practice for noise and vibration control on construction and open sites Parts 1 and 2, BSI Standards

of 68 two way movements. As a worst case this assessment will assume all vehicles to be HGVs as they are noisier than smaller delivery vehicles (i.e. vans).

- 8.19** The noise impacts of the construction related traffic travelling along local surrounding roads (see **ES Chapter 5 - Construction and Demolition (Volume 1)** – section ‘Traffic Routes’) has been calculated using the accepted UK prediction methodology provided by the Calculation of Road Traffic Noise (CRTN)². The predicted change in road traffic noise with and without the construction vehicles is assessed against criteria listed in the Design Manual for Roads and Bridges (DMRB)³ for assessment of short term road traffic noise impacts.

Construction Vibration

- 8.20** Similarly to construction noise, vibration noise levels shall be assessed in accordance with BS 5228-2, and the resulting calculated levels compared against set maximum threshold of acceptability as defined within the standard as providing an acceptable level of protection from the short-term vibration levels associated with construction and demolition activities.

Assumptions and Limitations

- 8.21** The exact location of each of the specific construction activities or plant used is not available at this stage of the development. The construction noise assessment assumes that all plant and equipment used are operated continuously throughout the 10-hour working day and are located at the same distance from the nearest noise sensitive receptor. Two cases have been calculated assuming all plant is located at the shortest and the furthest possible distance to the receiver. This is considered unlikely to occur in practice and therefore represents a conservative assumption.
- 8.22** The number and type of delivery vehicles visiting the site is expected to vary throughout the construction programme. The assessment has adopted the approach of assessing the highest number of vehicles and assuming them all to be HGVs. This is considered to represent a worst-case scenario to assess noise from construction vehicles.
- 8.23** Vibration levels have been calculated to the closest point of entry of the existing building as a worst case. This has been regarded to be the closest wall of the existing Broad Street Mall building to one of the proposed excavation piling core pits for Buildings A, B and C, as well as the point of entry to the existing roof for the other Buildings, which do not require new foundation piling at ground level. These locations are representative of where the nearest piling will occur.

Completed Development

Building Services

- 8.24** When operational, the Proposed Development has the potential to generate noise associated with the proposed land uses, including the residential units and future retail units (see **ES Chapter 4: The Proposed Development (Volume 1)**). These uses have associated on-site activity, plant and / or deliveries in connection with their use, all of which have the potential to generate noise.
- 8.25** Noise levels from the operation of the commercial and residential building services plant within the Proposed Development have been assessed using BS 4142⁴ and the measured levels of existing background noise. In accordance with BS 4142, noise impacts have been determined by subtracting the noise rating level from the commercial use, including any corrections for acoustical features, from the existing background noise level.
- 8.26** Existing commercial units are currently located across the site (the Mall) at street level. If consented, this development would result in a like-for-like replacement of these units with new commercial provision as well as core access to the new residential buildings above street level. It is proposed that the assessment does not consider any potential reduction in noise from the removal of existing commercial operation as a conservative assumption given the dominance of road traffic noise around the site.
- 8.27** The proposed commercial premises at street level are currently proposed for A1 (shops and retail), A2 (offices) or A3 use (food and drink). It is understood that no amplified music is being considered at any of the commercial units included in the Proposed Development and as such an assessment of amplified noise egress has not been included.

Operational Traffic

- 8.28** Given the small number of retail units being created by the Proposed Development, some of them as a direct replacement of currently existing premises within a functioning mall, it is assumed that the existing level of delivery and operational traffic to the existing Mall will not change significantly as a result of the completed Proposed Development, given the established and retained commercial nature of the existing Mall. As such, operational delivery traffic movements associated with the Completed Development are not anticipated to have a significant impact on noise levels experienced at the nearest receptors and have not been assessed.
- 8.29** As the Proposed Development is not expected to be accessed by car and no parking provisions are being made for future residents on site. Operational residential access to the site is assumed to be by foot from the immediate surrounding area, and visitors and residents are expected to use the existing public transport links. As such, an assessment of road traffic has not been deemed relevant and has been scoped out of this assessment.
- 8.30** As the Proposed Development is not expected to be accessed by car and no parking provisions are being made for future residents on site, an assessment of road traffic has not been deemed relevant and has been scoped out of this assessment.

Site Suitability

- 8.31** The assessment of the site suitability for the Proposed Development has been undertaken using the CadnaA noise mapping software to produce a spatial baseline noise model to generate noise level predictions.
- 8.32** The impact of existing sources of noise upon future proposed residents has been assessed to determine the suitability of the noise climate for the proposed use.
- 8.33** The noise levels across the site have been assessed for suitability for residential use against appropriate criteria derived from the guidance set out in BS 8233⁵, World Health Organisation (WHO) Guidelines^{6 7}, ProPG⁸ and the AECOM guidance report⁹. Particular reference has been made to the Lowest Observed Adverse Effect Level (LOAEL) and Significant Observed Adverse Effect Level (SOAEL) guideline values to align the assessment with the National Planning Policy Framework¹⁰ and the observed effect terminology employed in the national Planning Practice Guidance¹¹ document. 8.33 summarises the criteria used.

Table 8.1 Road Traffic Noise Criteria - Site Suitability Assessment

External noise criterion (free-field)		Acceptability for residential development	Relation to Likely Adverse Effect Level
Day, dB L _{Aeq} , 16hour	Night, dB L _{Aeq} , 8hour		
≤ 55	≤ 45	Noise level considered acceptable.	LOAEL threshold
> 55 and ≤ 66	> 45 and ≤ 56	Considered to be acceptable provided reasonable internal noise levels can be achieved and each dwelling has access to an external amenity space which would be expected to experience noise levels of less than 55 dB L _{Aeq,16hr} during daytime hours.	Between LOAEL and SOAEL
67	> 56 and < 64	Considered to be at the upper end of acceptability provided reasonable internal noise levels can be achieved and each dwelling has access to an external amenity space which would be expected to experience noise levels of less than 55 dB L _{Aeq,16hr} during daytime hours.	Within SOAEL and threshold for cardiovascular health impacts (relevant to daytime road traffic noise only) not exceeded.
≥ 68	≥ 64	Most likely considered to be unacceptable, unless development of the site is desirable for other reasons (e.g. to address a lack of housing in the local area) and it can be demonstrated that reasonable internal noise levels can be achieved and each dwelling has access to an external amenity space which would be expected to experience noise levels of less than 55 dB L _{Aeq,16hr} during daytime hours.	Above SOAEL

² Department of Transport Welsh Office, (1988) Calculation of Road Traffic Noise, HMSO

³ The Highways Agency, (2008) Design Manual for Roads and Bridges – Part 7 – Noise and Vibration, HA

⁴ British Standards Institution, (2014) BS 4142 Methods for rating and assessing industrial and commercial sound, BSI Standards.

⁵ British Standards Institution, (2014) BS 8233 Guidance on Sound Insulation and Noise Reduction for Buildings, BSI Standards

⁶ World Health Organization, (2000) Guidelines for Community Noise, WHO

⁷ World Health Organization, (2009) Night Noise Guidelines for Europe, WHO

⁸ ANC Working Group, (2017) ProPG Professional Practice Guidance on Planning & Noise New Residential Development, ANC IOA & CIEH

⁹ AECOM, (2014) Possible Options for the Identification of SOAEL and LOAEL in Support of the NPSE, DEFRA

¹⁰ Department for Communities and Local Government, (2012) National Planning Policy Framework, DCLG

¹¹ Department for Communities and Local Government, (2014) Planning Practice Guidance, Noise, DCLG [Online], Available: <https://www.gov.uk/guidance/noise--2>

8.34 Reference in 8.33 of 'reasonable internal noise levels' that are to be achieved are considered to be:

- $L_{Aeq,16hour}$ 35 dB or lower during the day in living rooms and bedrooms; and
- $L_{Aeq,8hour}$ 30 dB or lower during night in bedrooms, based on advice in BS 8233.

8.35 The additional requirement for access to an external amenity space (referred to in 8.33) can apply to either private garden spaces or balconies for sole use by a household and/or a space used by a limited group of residents as part of their amenity of their dwellings and/or a publicly accessible amenity space within 5-minutes' walk away. This is in accordance with the ProPG guidance document.

8.36 Reference in 8.33 to a maximum threshold of $L_{Aeq,16hour}$ 55 dB within external amenity areas is based on advice from BS 8233.

Methodology for Defining Effects

Receptors and Receptor Sensitivity

8.37 The categories to determine sensitive receptors are based on the guidance contained in BS 8233, WHO Guidelines, and other relevant reference criteria (see **ES Volume 3: Appendix - Noise and Vibration (Annex 2)**).

8.38 Table 8.2 summarises the sensitivities for the different receptor types. Residential receptors are classed as high sensitivity, according to the classification system adopted and represent those closest to the Proposed Development. If any residual effects of adverse significance are experienced at these receptors, receptors located beyond are also assumed to experience the noise levels at these receptors.

Table 8.2 Definition of Sensitive Receptors

Sensitivity	Typical descriptors
High	Residential (dwellings as well as residential healthcare and educational establishments) Educational facilities (schools and colleges)
Medium	Non-residential healthcare and hospitals Noise-sensitive leisure (e.g. hotels, museums and libraries) Places of worship
Low	Commercial facilities (e.g. retail and office uses)
Negligible	Industrial receptors (e.g. workshops, warehouses)

Magnitude of Impact

8.39 The magnitude of impact will depend on the nature and characteristic of the noise that a listener is subjected to. Set out below are the various magnitudes of impact associated with:

- Temporary construction activities noise;
- Temporary construction traffic;
- Temporary construction vibration; and
- Completed development building services noise.

Construction Activities

8.40 Annex E of BS 5228¹² provides example criteria of absolute noise limits for construction activities and shall be used to determine the impact of construction noise impacts within this assessment. These criteria do not represent mandatory limits but rather a set of example approaches intended to reflect the type of methods commonly applied to construction noise. In broad terms, the example criteria are based on a set of fixed limit values which, if exceeded, may result in a significant effect unless ambient noise levels are sufficiently high to provide a degree of masking of construction noise.

8.41 The range of guidance values detailed in BS 5228 Annex E has been used to numerically define the magnitude levels, as per Table 8.3. BS 5228 Annex E provides varied definitions for the range of daytime working hours which can be grouped for equal consideration. This method classifies proposed development sites into a linear category scale (A to C) defined by the ambient noise levels prevalent at the development site, with Category A

representing quieter sites, and Category C representing very loud urban sites. According with the findings of the noise survey, the Proposed Development falls under Category B under this method. The values presented in Table 8.3 have therefore been informed by this and chosen to relate to daytime hours from 08:00 to 17:30 on weekdays, and 08:00 to 13:00 on Saturdays.

8.42 As construction noise will always be an introduction of a new noise source (albeit temporary), where impacts are identified they will be adverse.

Table 8.3 Magnitude of Construction Activities Noise Impacts

Magnitude	Noise level dB $L_{Aeq, T}$	Details
High	> 85	Trigger level for temporary rehousing, or reasonable cost thereof, as set out in E.4 of BS 5228.
Medium	> 75 ≤ 85	Trigger level for noise insulation works, or cost thereof, as set out in Table E.2 of BS 5228
Low	> 70 ≤ 75	Threshold of significance for the site based on measured noise levels and BS 5228 Annex E, category B.
Negligible	≤ 69	Noise is likely to be audible, but unlikely to change behaviour.

Construction Traffic

8.43 The magnitude of impact for construction traffic noise to be used for this assessment are shown in Table 8.4. This approach is based on DMRB, where the change in road traffic noise level when comparing the same year with and without construction traffic is assessed rather than setting an absolute noise level to determine the impact.

Table 8.4 Magnitude of Construction Traffic Noise Impacts

Magnitude	Noise Change dB $L_{A10, 18hour}$	Details
High	≥ 5.0	Change in short term noise would be clearly perceptible. Considered in DMRB to be a major magnitude.
Medium	≥ 3.0 ≤ 4.9	Change in short term level may be perceptible under normal conditions. Considered in DMRB to be a moderate magnitude.
Low	≥ 1.0 ≤ 2.9	Change in short term level may be perceived at the upper end of the range under certain conditions. Described in DMRB to be a minor magnitude.
Negligible	≤ 0.9	Imperceivable change. Described in DMRB to be of negligible magnitude.

Construction Vibration

8.44 The magnitude of impact of construction vibration has been determined from criteria set out in BS 5228-2. The values presented in Table 8.5 are based on human response to construction vibration levels in a residential environment.

Table 8.5 Magnitude of Construction Vibration Impacts

Magnitude	Vibration level PPV mm/s	Details
High	> 10.0	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.
Medium	> 1.0 ≤ 10.0	Vibration in this range will be perceptible and likely to cause complaint.
Low	≥ 0.3 ≤ 1.0	Vibration within this range would be perceptible in a residential environment and has the potential to cause complaint but may be tolerated if prior warning has been given.
Negligible	< 0.3	Vibration levels below this level are unlikely to be perceptible in residential environments

¹² British Standards Institution, (2014) BS 5228 Code of practice for noise and vibration control on construction and open sites Parts 1 and 2, BSI Standards

Completed Development – Building Services

8.45 The magnitude of noise impacts associated with the operation of any building services associated with the commercial and residential areas of the Proposed Development have been defined based on guidance found within BS 4142 and the requirements of policy EN 17 as stated in the draft Reading Borough Council (RBC) Local Plan¹³, which required building services noise to be controlled to no more than 10 dB above the prevalent background noise levels.

8.46 The impact of the sound of a commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the typical background sound level and the context in which the sound occurs. The impact can be estimated by subtracting the typical measured background sound level from the rating level. The magnitude of impact for this source of noise is given in Table 8.6.

Table 8.6 Magnitude of New Building Services Plant Noise Impact

Magnitude	Rating level – background (dB)	Details
High	≥ 10	A difference of +10 dB or more is likely to be an indication of a significant adverse impact, depending on context.
Medium	> 5 < 10	A difference of +5 dB is likely to be an indication of an adverse impact, depending on context.
Low	≤ 5 > -10	The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.
Negligible	≤ -10	Where the rating level is lower than 10 dB below the background sound level, this is an indication of the specific sound source not contributing to the overall noise climate, even if it emits constant noise and therefore would have a negligible impact. This is the required rating level – background difference by RBC.

Effect Nature

8.47 The following terms have been used to define the environmental effects:

- Adverse – resulting in a negative impact to environmental factors or receptors
- Negligible – resulting in an imperceptible impact to environmental factors or receptors
- Beneficial – resulting in a positive impact to environmental factors or receptors

Effect Scale

8.48 The resulting effect of a predicted impact (summarised in Table 8.7), is determined through a standard method of assessment based on professional judgement, taking into account the sensitivity of the receptor (as set out in Table 8.2) and the magnitude of change (as set out in Table 8.3 to Table 8.6).

8.49 Effects that are ‘Moderate’ and ‘Major’ are considered as ‘significant’ (shaded grey in Table 8.8), and ‘Negligible’ and ‘Minor’ effects are considered as ‘not significant’.

Table 8.7 Significance of effect matrix

Sensitivity	Magnitude of impact			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Negligible	Minor
Low	Negligible	Negligible	Minor	Minor
Medium	Negligible	Minor	Moderate	Moderate
High	Minor	Minor	Moderate	Major

Geographic Extent of Effect

8.50 The geographic extent of the effects is identified. At a spatial level, ‘site’ or ‘local’ effects are those affecting the site and neighbouring receptors, while effects upon receptors in the RBC beyond the vicinity of the site and its neighbours are at a ‘district’ level. Effects affecting Berkshire are at a ‘regional’ level, whilst those which affect different parts of the country, or England, are considered being at a ‘national’ level.

Effect Duration

8.51 For the purposes of the ES, effects that are generated as a result of the construction works (i.e. those that last for this set period of time) are classed as ‘temporary’; these may be further classified as either ‘short term’ or ‘medium-term’ effects depending on the duration of the construction works that generate the effect in question.

8.52 Effects that result from the completed and operational as of the Proposed Development are classed as ‘permanent’ or ‘long-term’ effects.

BASELINE CONDITIONS*Current Baseline Conditions*

8.53 Weather conditions were good for noise measurements, dry roads and low wind speeds, during both site visits (13th and 18th June 2018). **ES Volume 3: Appendix - Noise and Vibration (Annex 3)** contains the details of the noise survey and the data measured.

Unattended Monitoring (Long-Term)

8.54 Long term noise monitoring was carried out at locations L1 to L4 located 1 m from the existing facades of Broad Street Mall overlooking the roads below.

8.55 Road traffic along Oxford Road and St Mary’s Butts was identified as the dominant noise source at all survey locations. At survey locations S1 to S3 existing building services plant along the rooftop of Broad Street Mall were also observed.

8.56 Night-time activity linked to entertainment noise recorded along St Mary’s Butts is understood to be a dominant source of noise along the north and east boundaries of the site, particularly on weekend nights.

8.57 Table 8.8 and 0 provide a summary of the noise levels measured at the long term monitoring locations, L1 to L4, for the day and night respectively.

Table 8.8 Summary of Measured Noise Levels at Locations L1 to L4 - Day (07.00 – 23.00 hours)

Start Date	Day noise level, dB L _{Aeq, 16hour}			
	Location L1	Location L2	Location L3	Location L4
Wednesday 13/06/2018	66 ^[1]	66 ^[2]	58 ^[1]	60 ^[2]
Thursday 14/06/2018	67	67	59	60
Friday 15/06/2018	67	67	59	60
Saturday 16/06/2018	67	67	59	60
Sunday 17/06/2018	65	65	58	60
Monday 18/06/2018	67 ^[4]	67 ^[3]	58 ^[3]	61 ^[3]
Notes: ^[1] = survey during this period was 12.00 to 23.00 (11 hours) ^[2] = survey duration this period was 13.00 to 23.00 (10 hours) ^[3] = survey duration this period was 07.00 to 12:00 (5 hours) ^[4] = survey duration this period was 07.00 to 13:00 (6 hours)				

¹³ Reading Borough Council, (2018), Submission Draft Reading Borough Council Local Plan

Table 8.9 Summary of Measured Noise Levels at Locations L1 to L4 - Night (23.00 – 07.00 hours)

Start Date	Location L1		Location L2		Location L3		Location L4	
	dB L _{Aeq} , 8hour	dB L _{Amax} , fast	dB L _{Aeq} , 8hour	dB L _{Amax} , fast	dB L _{Aeq} , 8hour	dB L _{Amax} , fast	dB L _{Aeq} , 8hour	dB L _{Amax} , fast
Wednesday 13/06/2018	60	75	60	78	55	65	56	69
Thursday 14/06/2018	61	74	61	79	52	65	54	64
Friday 15/06/2018	61	76	61	84	52	67	54	64
Saturday 16/06/2018	62	74	52	83	53	68	54	65
Sunday 17/06/2018	60	72	60	76	53	65	55	64

8.58 0 also includes the night time noise events in terms of the L_{Amax,fast} parameter. The values shown are the 15th highest L_{Amax,fast} measured in 15 minute periods during each night time period.

8.59 The background noise in the area was also measured at the long-term measurement locations, L1 to L4. This data has been collated in terms of the statistically representative background noise levels measured during the daytime and night-time periods at all noise monitoring locations to comply with BS 4142 guidance. This approach was discussed with and approved by RBC¹⁴.

8.60 **ES Volume 3: Appendix - Noise and Vibration (Annex 3)** provides a statistical analysis graph for the day and night periods measured at each of the locations which presents the distribution of the background noise levels during each day and night periods recorded during the survey. Table 8.10 presents the values deemed to be statistically representative of the background levels at each location at during the day and night periods. It should be noted that a time-weighting period of 15-minutes has been used for both the day¹⁵ and night and that BS 4142 uses this period of the night-time only and a 1-hour period for the day.

Table 8.10 Statistically Representative Background Noise Levels at Locations L1 to L4

Period	Representative background noise level, dB L _{A90} , 15 minutes			
	Location L1	Location L2	Location L3	Location L4
Day	62	60	55	57
Night	50	50	47	49

Attended Monitoring (Short-Term)

8.61 In addition to the long term survey, short sample measurements were taken at location S1, S2 and S3 on Monday 18th June 2018. These locations were selected to measure noise from existing mall retail unit fans and included measurements in 1/3 octave bands between 12.5 Hz and 12,500 Hz.

8.62 The 1/3 octave band data measured at S1 to S3 are summarised in Table 8.11 to Table 8.13 below respectively. These tables present the logarithmic average of a 2-minute reading taken during the day, located 1m from the termination of each fan.

Table 8.11 Summary of Measured 1/3 Octave Band Noise Levels at Location S1

1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min
12.5	76	80	66	500	82	3,150	69
16	74	100	70	630	78	4,000	67
20	72	125	84	800	76	5,000	65
25	71	160	85	1,000	75	6,300	64
31.5	73	200	77	1,250	75	8,000	63
40	76	250	88	1,600	73	10,000	61
50	78	315	86	2,000	71	12,500	60
63	70	400	82	2,500	69		

Table 8.12 Summary of Measured 1/3 Octave Band Noise Levels at Location S2

1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min
12.5	60	80	66	500	61	3,150	54
16	61	100	66	630	62	4,000	53
20	68	125	64	800	63	5,000	51
25	62	160	66	1,000	62	6,300	49
31.5	64	200	61	1,250	59	8,000	44
40	66	250	65	1,600	59	10,000	43
50	65	315	66	2,000	58	12,500	39
63	64	400	61	2,500	59		

Table 8.13 Summary of Measured 1/3 Octave Band Noise Levels at Location S3

1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min	1/3 Octave band, Hz	Noise level, dB L _{Zeq} , 10min
12.5	66	80	69	500	62	3,150	52
16	67	100	73	630	61	4,000	50
20	70	125	73	800	58	5,000	48
25	71	160	74	1,000	58	6,300	47
31.5	70	200	71	1,250	59	8,000	44
40	73	250	64	1,600	58	10,000	41
50	70	315	70	2,000	56	12,500	37
63	66	400	66	2,500	53		

8.63 Extract and supply fans have the potential to produce noise that contains a tonal element. Using the 1/3 octave band described in BS 4142, low frequency tones were detected at position S1 and S2. Subjective analysis from the site visit at the time of the survey corroborates the presence of a low frequency tone at position S1.

8.64 As the tonal fan recorded at position S2 is understood to lie within the footprint of the proposed Building E, it is assumed that either this fan will be relocated or removed as part of the works for the Proposed Development. The impact from this element can therefore be scoped out.

8.65 The fan at position S1 is understood to be an exhaust fan for the existing restaurant unit in the existing Mall below. In addition to the tonal element noted, the measured noise levels at 1 m from this fan were very high, L_{Aeq} 88 dB.

¹⁴ Environmental Health Officer Jodie Wilson, email correspondence dated 9 October 2018

¹⁵ Using a 15 minute period during the day results in lower background noise levels and therefore a more stringent assessment

RECEPTORS AND RECEPTOR SENSITIVITY

Existing Receptors and Receptors within the Evolved Baseline

- 8.66 The list of existing noise-sensitive receptors is not intended to be exhaustive and it aims to contain a representative selection of the closer, more sensitive receptors in each direction from the site.
- 8.67 Table 8.14 contains the nearest sensitive receptors that would be present at the time of construction of the Proposed Development. Figure 8.1 illustrates the location of the receptors and survey locations.

Table 8.14 Existing Nearest Noise-Sensitive Receptors

Reference	Name	Receptor use	Distance to site	Sensitivity
R1	42 Oxford Street	Residential	20 m	High
R2	Mcilroys building	Residential	20 m	High
R3	City Wall House Aparthotel	Hotel	40 m	Medium
R4	59-61 St Marys Butts	Residential	30 m	High
R5	Allied Arms Public House	Assumed tenanted residential	30 m	High
R6	Castle Street flats	Residential	90 m	High
R7	The Sun Inn Public House	Assumed tenanted residential	90 m	High
R8	Queens Court student accommodation	Residential	18 m	High
R9	Pentahotel Reading	Hotel	60 m	Medium
R10	Travelodge Reading Central	Hotel	88 m	Medium

- 8.68 In addition to the above, the existing Broad Street Mall is an immediately adjacent receptor to the Proposed Development site and is understood to form part of a long-term strategy for the development of the existing site, which includes the mall retail premises.
- 8.69 On the basis of the above, the commercial nature of the retained site and that the existing retail users will be consulted with regarding the demolition and construction works, it is considered that the existing commercial premises constitute a negligible receptor unlikely to be experience significant adverse effects from a temporary increase in noise level.

Figure 8.1 Survey and Receptor Locations



Introduced Onsite Receptors

- 8.70 The Proposed Development will introduce new noise-sensitive receptors. Table 8.15 presents the introduced receptors to be used in the assessment.

Table 8.15 Introduced Noise-Sensitive Receptors

Name	Receptor use	Sensitivity
BuildingBuilding A	Residential	High

POTENTIAL EFFECTS

Demolition and Construction

Construction Activities

- 8.71 Noise generated during the demolition and construction works of the Proposed Development has the potential to adversely affect nearby residential receptors. In the absence of mitigation and management, activities relating to these works may have a high magnitude of impact at highly sensitive receivers (i.e. residential), and could result in a significant effect experienced.
- 8.72 Table 8.16 shows the predicted L_{Aeq} construction noise levels for the periods of working at the selected noise sensitive receptor locations identified in Figure 8.1.
- 8.73 Predicted noise levels are also shown to account for the new residential receptors within Building A (introduced receptor) whilst works across the remainder of the site are in progress, and is expected to come into full occupation simultaneously with final Phase 2 and Phase 3 construction activity.
- 8.74 A conservative noise assessment of the predicted construction noise levels based on the construction programme at the receptors identified in Table 8.14 has been carried out, and a summary of the calculated incident noise levels at each receptor is presented in Table 8.16.
- 8.75 The assumed construction activities for each residential receptor, for which predicted noise levels are provided in Table 8.16, representing the noise generating scenarios based on the construction programme (see **ES Chapter 5 – Demolition and Construction (Volume 1)**) are detailed in Table 8A.2 within Annex A of this ES Chapter.

Table 8.16 Predicted Construction Noise Levels at Noise-Sensitive Receptors

Noise sensitive receptor	Construction noise level incident at receptor, $L_{Aeq, T}$ dB
R1	70
R2	79
R3	70
R4	78
R5	78
R6	69
R7	69
R8	77
R9	69
R10	68
Building A	61

- 8.76 The predicted noise levels in Table 8.16 show that, as a worst case (unmitigated), a medium magnitude of impact is predicted at receptors R2, R4, R5 and R8. These receptors are residential with high sensitivity which results in a **Moderate Adverse** effect (significant).
- 8.77 The predicted noise levels in Table 8.16 show that, as a worst case (unmitigated), a negligible to low magnitude of impact is predicted at the other residential receptors. These receptors are residential with high sensitivity.

Construction Traffic

8.78 Construction traffic passing to and from the site along St Mary’s Butts and Hosier Street will also represent a potential source of noise to surrounding properties. In reality, the amount of construction traffic is likely to be small in comparison to the existing flow on these roads. It is reasonable to assume that at the peak of the construction 68 HGVs will access the site in a day. This amount of additional HGVs would result in 0.1 dB or less increase in road traffic, which is a negligible magnitude of change. Such a magnitude of impact, which in highly sensitive receptors creates a **Minor Adverse** effect (not significant).

Construction Vibration

8.79 The partial demolition works as part of the enabling works at Buildings A, B and C will be carried out by hand and therefore are expected to be of negligible impact to the immediately adjacent retail premises within Broad Street Mall. As these have been deemed to be negligible sensitivity receptors, this results in a **Negligible** effect (not significant).

8.80 The main source of vibration during construction is anticipated to come from the piling of foundations at Buildings A, B and C. The proposed piling method to achieve this is via use of a Continuous Flight Auger (see **ES Chapter 5 – Demolition and Construction (Volume 1)**). As stated in Annex F of BS5228-2, the levels of vibration associated with this type of augering are minimal as the process relies on slow steady motions.

8.81 The minimum distance between a vibration sensitive residential receiver and location at which piling is assumed to take place is 18m. Based on the PPV values given in Annex D of BS 5228-2 for augering, PPV levels from construction of the Proposed Development are not expected to exceed 0.1 mm-s⁻¹ at the nearest residential receptors. This would be a negligible magnitude of impact, which in high sensitive receptors is a **Minor Adverse** effect (not significant).

Completed Development

Building Services

8.82 Any proposed new fixed building services plant associated with the Proposed Development shall be specified such that the total cumulative Rating Level from the proposed building services items, as determined in accordance with policy EN 17 as stated in the draft Reading Borough Council (RBC) Local Plan¹⁶, does not exceed 10 dB below the background noise level at the nearest sensitive receptors.

8.83 Cumulative noise contributions from the building services scheme, including future provision for the commercial units created as part of the Proposed Development at low-level, will be controlled through the selection of adequate items of plant and the provision of suitable attenuation and screening packages if required

8.84 This will ensure that all noise from the operation of the building services plant is of negligible magnitude of impact at highly sensitive receptors, resulting in a **Minor Adverse** effect.

8.85 In accordance with the above, the services plant for the Proposed Development will be designed such that the limits presented in Table 8.18 are not exceeded.

Table 8.17 Maximum permissible cumulative plant noise limits at sensitive receptors

Period	Maximum permissible cumulative plant noise limits at sensitive receptors, dB L _{Aeq} , 15 minutes			
	Receptors across and along Oxford Road	Receptors across and along St Mary’s Butts	Receptors across and along Dusseldorf Way / Hosier Street	Receptors across and along Queen’s Walk
Day	52	50	45	47
Night	40	40	37	39

Deliveries

8.86 As discussed in the Impact Methodology section of this ES Chapter, commercial deliveries and traffic activity related to the completed Proposed Development will be equivalent to the baseline scenario. This is a negligible magnitude of impact, which in high sensitivity receptors is a **Minor Adverse** effect (not significant).

Site Suitability

8.87 The site as part of the existing commercial Mall located in the Reading town centre, is exposed to noise from external noise sources (i.e. commercial activities, road traffic from the surrounding road network).

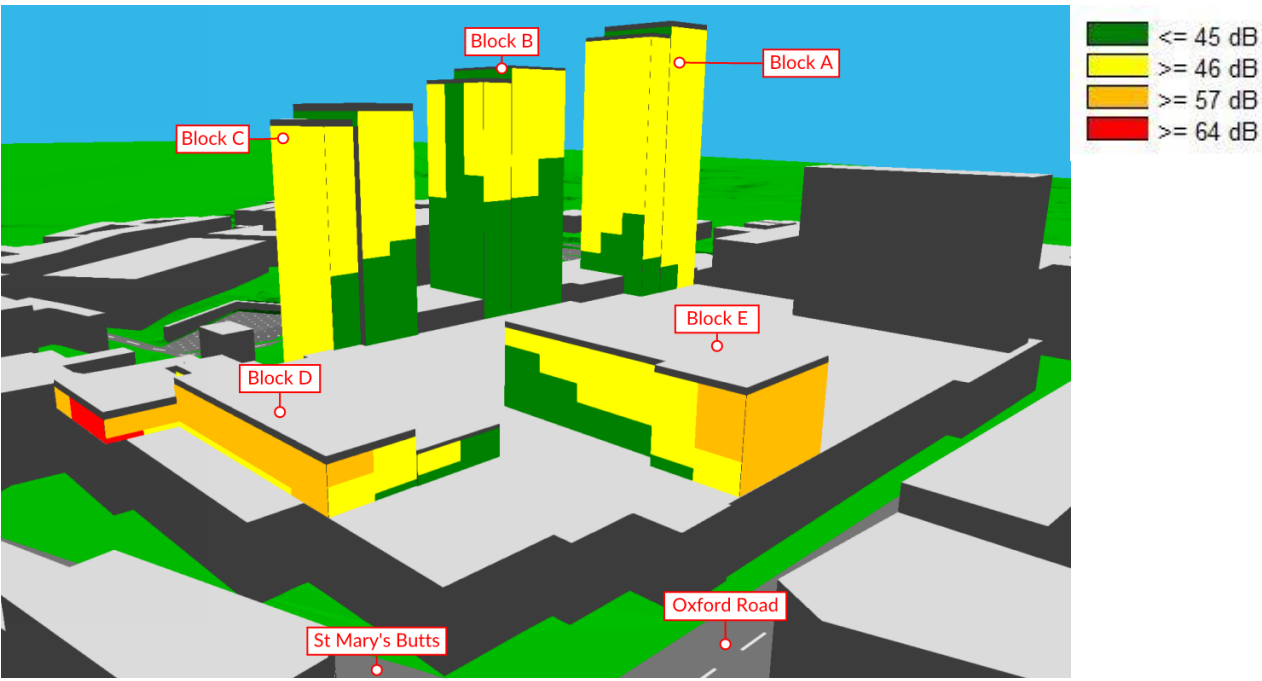
Building Envelope

8.88 Calculations have been undertaken using the CadnaA noise mapping software to produce a spatial baseline noise model to generate noise level predictions for the site and surrounding area. Figure 8.2 and Figure 8.3 illustrate the worst-case external noise levels calculated across the facades of the Proposed Development during the day (07:00 – 23:00) and night (23:00 – 07:00) respectively.

Figure 8.2 Façade Noise Levels – Day L_{Aeq} (north east view)



Figure 8.3 Façade Noise Levels – Night L_{Aeq} (north east view)



¹⁶ Reading Borough Council, (2018), Submission Draft Reading Borough Council Local Plan

- 8.89** Table 8.18 presents the calculated façade noise levels for the new build elements comprising the Proposed Development. Where façade noise levels at or above SOAEL are predicted, the values in Table 8.18 are labelled in **red** for ease of reference.

Table 8.18 Summary of the Highest Calculated Noise Levels Across the Proposed Facades

Façade	Building A		Building B		Building C		Building D		Building E	
	Day dB L _{Aeq, 16hr}	Night dB L _{Aeq, 8hr}	Day dB L _{Aeq, 16hr}	Night dB L _{Aeq, 8hr}	Day dB L _{Aeq, 16hr}	Night dB L _{Aeq, 8hr}	Day dB L _{Aeq, 16hr}	Night dB L _{Aeq, 8hr}	Day dB L _{Aeq, 16hr}	Night dB L _{Aeq, 8hr}
North	60	50	57	50	55	52	62	57	67	61
East	56	49	53	47	56	52	67	67	62	57
South	64	55	62	54	60	54	46	42	47	42
West	64	55	62	53	59	50	47	41	61	56

- 8.90** The facades overlooking Oxford Road and St Mary's Butts will be exposed to noise levels at or above SOAEL (orange and red zones in Figure 8.2 and Figure 8.3), and the other facades are exposed to levels of noise below SOAEL and in most cases LOAEL.
- 8.91** The results show the majority of the highest noise levels per façade fall between LOAEL and SOAEL, with the noise levels along the East elevation of Building D exceeding SOAEL for both the day and night periods.
- 8.92** Further consideration of the façade design is required for those exposed to noise levels above LOAEL to provide acceptable internal noise levels within dwellings.
- 8.93** The sound insulation performance of the building envelope will be driven by the performance of the glazed elements within the build-up. On the basis that the solid non-glazed elements of the building envelope will achieve a minimum sound insulation performance of R_w 58 dB, Table 8.19 provides guidance on the likely required sound insulation performance for the glazed elements of the facades throughout the Proposed Development.

Table 8.19 Recommended Minimum Sound Insulation Performance of Façade Glazed Elements

Building	Rooms	Recommended Sound insulation performance, R_w (R_w+C_{tr}) (dB)	
		Single aspect	Double aspect
A	Living rooms	32 (27)	37 (33)
	Bedrooms	37 (33)	-
B	Living rooms	32 (27)	37 (33)
	Studios / Bedrooms	37 (33)	-
C	Living rooms	32 (27)	32 (27)
	Studios / Bedrooms	32 (27)	-
D	Living rooms	37 (33)	37 (33)
	Bedrooms	37 (33)	-
E	Living rooms	37 (33)	37 (33)
	Bedrooms	37 (33)	-

- 8.94** The indicative levels of sound insulation presented in Table 8.19 would typically be achievable with standard thermal double glazing configurations when closed. It is understood that a full-house mechanical ventilation strategy will be provided to all residential units within the Proposed Development capable of providing background ventilation as well as additional thermal comfort to address overheating, with openable windows only relied upon for purge ventilation.

Outdoor Amenity

- 8.95** A shared outdoor residential space is provided at Podium level (bottom of Buildings A, B and C) located at the existing rooftop of Broad Street Mall. This outdoor amenity area extends from the southern perimeter of the site (along Dusseldorf Way) and to the northern elevations of the residential tower Buildings.

- 8.96** The results of the noise modelling indicated that the outdoor amenity areas are expected to be below $L_{Aeq,16hr}$ 55 dB and are therefore considered suitable.

MITIGATION AND MONITORING MEASURES

Demolition and Construction

- 8.97** Under the assumed absolute worst-case assessment presented within this ES Chapter, adverse effects due to construction noise have been identified and therefore require some forms of mitigation to reduce potential impacts at receptor locations. As the construction activity is not finalised at this stage, it is not possible to identify specific mitigation measures prior to formulation of a detailed construction programme, in addition to detailed planning and logistics.
- 8.98** In general, construction noise and vibration would be managed using best practicable means (BPM), i.e. the use of all reasonable measures to minimise construction noise and vibration. Measures to mitigate construction noise and vibration is presented in **ES Chapter 13: Mitigation and Monitoring (Volume 1)**.
- 8.99** It is expected that, by use of BPM, the adverse impacts from construction activities is likely to be mitigated so that the likelihood for adverse effects would be reduced to appropriate levels and not be significant.

Completed Development

- 8.100** Noise effects as a result of the operational development due to changes in road traffic flows and building service plant have been identified as not significant. Consequently, no mitigation measures have been recommended.

RESIDUAL EFFECTS

8.101 The residual effects resulting from the Proposed Development are summarised in Table 8.20.

Table 8.20 Summary of Residual Effects

Receptor	Description of the Residual Effect	Scale and Nature Geographic Extent	Significance	D I	P T	R IR	St Mt Lt
Demolition and Construction							
Existing residential dwellings	Construction activity noise	Minor Adverse Local	Not Significant	D	T	R	St
Existing residential dwellings	Construction activity vibration	Minor Adverse Local	Not Significant	D	T	R	St
Existing residential dwellings	Construction traffic noise	Minor Adverse Local	Not Significant	D	T	R	St
Building A of the Proposed Development	Construction activity noise	Minor Adverse Local	Not Significant	D	T	R	St
Completed Development							
Existing residential dwellings	Building services noise	Minor Adverse Local	Not Significant	D	P	R	Lt
Existing residential dwellings	Change in operational road traffic	Minor Adverse Local	Not Significant	D	P	IR	Lt
Notes: Scale = Negligible / Minor / Moderate / Major Nature = Beneficial or Adverse Geographic Extent = Site or Local, District / Borough, Regional, National +ve = Positive / -ve = Negative D = Direct / I = Indirect P = Permanent / T = Temporary R = Reversible / IR= Irreversible St = Short Term / Mt = Medium Term / Lt = Long Term n/a = not applicable / not assessed							

LIKELY SIGNIFICANT EFFECTS

8.102 No likely significant effects have been identified for the Proposed Development.

CLIMATE CHANGE

8.103 Most of the impacts that have been determined in the previous sections are not dependent or reliant on weather conditions, therefore a change in weather patterns will not result in any variations to the derived significance of effects for most of the points covered in this ES Chapter.

8.104 Climate change has the potential to intensify heat in the summer and cold in the winter, therefore as a result there is the potential for an increase in the use of heating and cooling functions of air handling type plant and a potential for receptors to open windows for longer durations.

ASSESSMENT OF FUTURE ENVIRONMENT

Evolution of the Baseline Scenario

8.105 The baseline noise levels in the immediate surrounding area to the Proposed Development are dominated by road traffic.

8.106 A significant change is deemed unlikely to occur in the noise climate at the site of the Proposed Development.

Cumulative Effects Assessment

8.107 This section identifies the effects of the Proposed Development in combination with the effects of other Committed Developments within the surrounding area (identified in **ES Chapter 2: EIA Methodology (Volume 1)**).

8.108 A hotel development is proposed within close distance to the Proposed Development immediately to the south along Hosier Street, although no planning application is understood to have been submitted for RBC consideration. This is understood to be the sole significant cumulative scheme in relation to noise and vibration to the Proposed Development.

Demolition and Construction

Construction Activities

8.109 If planning permission is granted to the Hosier Street Hotel development, it is assumed there may be an overlap between the demolition and construction works at the Hosier Street Hotel and the latter stages of construction associated with Phase 1 of the Proposed Development.

8.110 As such, and depending on the duration of the construction programme at this cumulative concurrent site, there is a potential for high noise generating activities to temporarily affect the Phase 1 residences of the Proposed Development. It is assumed however, that best practicable means methods of work and mitigation will be put in place at this site just as they will be at the Proposed Development, therefore minimising any potential impact on the completed residences of the Proposed Development.

8.111 Given their location with regards to the two concurrent schemes, receptors R4 and R6 along St Mary’s Butts to the East and R6 and R7 along Castle Street to the South may be adversely impacted by cumulative construction noise. However, under the assumption of both schemes carrying out best practicable means and methods to control construction activity noise and the shorter programme assumed for the Hosier Street Hotel, while the cumulative impact may not be negligible, it is deemed to result in a not significant adverse impact at these receptors.

8.112 Similarly, the potential concurrent cumulative construction noise activity from the Proposed Development and the Hosier Street Hotel site is assumed to be adequately mitigated by the employment of best practice methods and suitable mitigations measures at both sites, thereby incurring a negligible impact at all other identified receptors.

Construction Traffic

8.113 Given the relatively small scale of the Hosier Street Hotel development the cumulative traffic noise level from both sites is anticipated to remain of negligible impact to the surrounding receptors.

Completed Development

Building Services

8.114 It is assumed that any building services noise associated with cumulative schemes shall be controlled in accordance with the requirements of RBC, as previously stated. As a result, the cumulative effects of building services noise is likely to remain negligible adverse.

8.115 Any cumulative schemes, including the proposed Hosier Street Hotel, shall have to consider the 5 highly sensitive residential receptors formed by the Proposed Development and demonstrate that future residential amenity will not be adversely impacted.

Deliveries and Operational Traffic

- 8.116** The cumulative impact of delivery noise from the Proposed Development to the surrounding area is anticipated to be negligible even when taking into account the expectable volumes of operational traffic from the Hosier Street Hotel.

Hosier Street Area Development Framework (HSADF)

- 8.117** Under the HSADF plans therein, the Proposed Development comprises the first phase of delivery. Further phases would see the area immediately to the south of the site undergo mainly residential-led regeneration.
- 8.118** It is anticipated that the Proposed Development will be completed before the following Phases of the HSADF come into effect. As such, any further developments within this proposed Framework will need to account for the 5 highly sensitive receptors being created as part of the Proposed Development. Depending on future proposals, adequate assessments of future development impact shall be required as part of any future planning applications for which the Proposed Development may be considered a relevant noise sensitive receptor.

ANNEX A

Table 8A.1 Construction plant and equipment and assumed sound power level

Work Stage	Plant / Equipment Assumed to be in Operation	Sound Power Level assumed dB L _{WA}
Enabling works and site establishment, including partial demolition works	1 No breaker/cutter; 1 No. loader; 3 tower cranes; 2 No tipper lorries; 3 No. mobile access equipment; 1 No wheel wash; 3 No. concrete vibrator; and 1 No. mini skid-steer loader; 3 No. mobile floodlights; 6 passenger/goods hoists; 2 No. mobile cranes; - CFA piling rig; - Lorry mounted concrete pump; 2 No. fork lift.	114
Superstructure	3 No. mobile floodlights; 6 passenger/goods hoists; - Lorry mounted concrete pump 2 No. fork lift. 3 tower cranes; 3 No. mobile access equipment; 3 No. concrete vibrator; and	111
Building envelope	3 No. mobile floodlights; 2 No. mobile cranes; - Lorry mounted concrete pump; 2 No. fork lift. 6 passenger/goods hoists; 3 No. mobile access equipment; 3 No. concrete vibrator; and	111
Fit-out and external landscaping	3 No. mobile floodlights; 2 No. mobile cranes; - Lorry mounted concrete pump; 2 No. fork lift. 6 passenger/goods hoists; 3 No. mobile access equipment; 3 No. concrete vibrator; and	105
Handover	Negligible noise levels expected	N/A

Table 8A.2 Worst-case simultaneous construction stages at noise sensitive receptors

Noise sensitive receptor	Assumed scenario
R1, R2, R3 and R10	Enabling works and site establishment at Building A, superstructure at Building B, superstructure at Building C, building envelope at Building D, building envelope at Building E
R4 and R5	Building envelope at Building A, superstructure at Building B, enabling works and site establishment at Building C and enabling works and site establishment at Building D
R6 and R7	Building envelope at Building A, superstructure at Building B, enabling works and site establishment at Building C and enabling works and site establishment at Building D
R8 and R9	Building envelope at Building A, superstructure at Building B, and enabling works and site establishment at Building C.
Building A	Fit out and external landscaping at Buildings D and E