9 Noise and Vibration

9.1 Introduction

9.1.1 This chapter considers the noise and vibration impacts of the demolition, construction and operational phases of the Bank Station Capacity Upgrade (BSCU).

9.1.2 The items covered by this assessment include:

- assessment of baseline conditions;
- prediction and assessment of impacts due to construction noise and vibration, including construction traffic noise;
- operational noise assessment of the plant and equipment associated with the BSCU; and
- an assessment of operational groundborne noise and vibration as a result of the proposed realignment of the southbound running tunnel.

9.1.3 Information regarding noise and vibration perception and terminology used within this report is provided in Appendix A9.1.

9.1.4 The approach to the assessment of effects has been updated slightly from that described in the issued EIA Scoping Report, implementing more recent interpretation regarding the application of the *Noise Policy Statement for England* (*NPSE*).

9.2 Legislative and Policy Context

Legislation and National Policy

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

9.2.1 The *National Planning Policy Framework (NPPF)* was introduced in March 2012. The document sets out the Government's planning policies for England and how these are expected to be applied.

9.2.2 *Paragraph 123* of the *NPPF* states that planning policies and decisions should aim to:

- *avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;*
- *mitigate and reduce to a minimum other adverse impacts on quality of life arising from noise from new development, including through the use of conditions;*

- *recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established [subject to the provisions of the Environmental Protection Act 1990 and other relevant law]; and*
- *identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason*.

9.2.3 With regards to 'adverse effects' and 'significant adverse effects', the *NPPF* refers to the *Noise Policy Statement for England (NPSE) Explanatory Note* (Defra, 2010).

9.2.4 The statement sets out the long term vision of the government's noise policy, which is to:

- *avoid significant adverse impacts on health and quality of life;*
- *mitigate and minimise adverse impacts on health and quality of life; and*
- *where possible, contribute to the improvements of health and quality of life.*

9.2.5 The long term policy vision and aims are designed to enable decisions to be made regarding what is an acceptable noise burden to place on society.

9.2.6 The *NPSE Explanatory Note* provides further guidance on defining 'significant adverse effects' and 'adverse effects' using the following concepts:

- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;
- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and
- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.

9.2.7 It is noted that the *NPPF* and *NPSE* policy vision refer to 'adverse impacts' whereas the *NPSE Explanatory Note* refers to 'adverse effects'. For the purposes of this assessment 'adverse effects' is used.

9.2.8 The *NPSE* recognises that it is not possible to have single objective noise-based measures that define the NOEL, LOAEL and SOAEL that are applicable to all sources of noise in all situations. The levels are likely to be different for different noise sources, receptors and at different times of the day.

9.2.9 The *NPPF* and associated *NPSE* provide the concepts for defining various levels of effect, but do not translate these into actual noise levels. Instead, it is

up to individual local authorities to interpret the concepts in the *NPPF* and *NPSE* and translate them into noise level criteria for development to be applied in their area. For the purposes of this assessment the LOAEL and SOAEL have been defined for each relevant potential noise and vibration effect. It should be noted that these are based on the specific circumstances of this development and may not be applicable in other situations.

Planning Practice Guidance (Department for Communities and Local Government, 2014)

9.2.10 In March 2014, the Department for Communities and Local Government (DCLG) released its *Planning Practice Guidance* (*PPG*) web-based resource to support the *NPPF*.

9.2.11 This guidance introduced the concepts of NOAEL (No Observed Adverse Effect Level), and UAEL (Unacceptable Adverse Effect Level). NOAEL differs from NOEL in that it represents a situation where the acoustic character of an area can be slightly affected (but not such that there is a perceived change in the quality of life). UAEL represents a situation where noise is '*noticeable*', '*very disruptive'* and should be '*prevented*' (as opposed to SOAEL, which represents a situation where noise is '*noticeable*' and '*disruptive*', and should be '*avoided*').

Regional Policy

The London Plan (Greater London Authority, 2011)

9.2.12 *Policy 5.3* of *The London Plan* states that major development proposals should include measures to achieve sustainable design principles through minimising pollution (including noise).

9.2.13 *Policy 7.15* states that development proposals should seek to reduce noise by:

- *minimising the existing and potential adverse impacts of noise on, from, within, or in the vicinity of, development proposals;*
- *separating new noise sensitive development from major noise sources wherever practicable through the use of distance, screening, or internal layout in preference to sole reliance on sound insulation; and*
- *promoting new technologies and improved practices to reduce noise at source.*

Draft Further Alterations to The London Plan (Greater London Authority, 2014)

9.2.14 *Policy 7.15* of the above consultation draft document expands on the above, stating that development proposals should seek to manage noise by:

- *avoiding significant adverse noise impacts on health and quality of life as a result of new development;*

- *mitigating and minimising the existing and potential adverse impacts of noise on, from, within, as a result of, or in the vicinity of, new development without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business;*
- *improving and enhancing the acoustic environment and promoting appropriate soundscapes (including identifying and protecting Quiet Areas and spaces of relative tranquillity);*
- *separating new noise sensitive development from major noise sources (such as road, rail, air transport and some types of industrial development) through the use of distance, screening or internal layout – in preference to sole reliance on sound insulation;*
- *where it is not possible to achieve separation of noise sensitive development and noise sources, without undue impact on other sustainable development objectives, then any potential adverse effects should be controlled and mitigated through the application of good acoustic design principles; and*
- *promoting new technologies and improved practices to reduce noise at source, and on the transmission path from source to receiver.*

Mayor's Transport Strategy (Greater London Authority, 2010)

9.2.15 *Policy 16* of the *Mayor's Transport Strategy* (*MTS*) states that: *The Mayor, through TfL, and working with the DfT, Network Rail, train operating companies, freight operators, London boroughs and other stakeholders, will seek to reduce noise impacts from transport*.

Local Policy

City of London Unitary Development Plan (City of London Corporation, 2002)

9.2.16 *Chapter 10, Paragraph 10.99* of the *Unitary Development Plan (UDP)* (2002) makes reference to a number of controls to protect amenity in and around buildings from excessive noise:

The Corporation has a number of controls on these matters under health and environment legislation, such as the restriction of noisy works on demolition and construction sites at appropriate times of day or night….Planning controls can be used to prevent nuisances occurring by ensuring that the design of a development minimises the effects of pollution, by the imposition of conditions to control emissions…

City of London Draft Local Plan (City of London Corporation, December 2013)

9.2.17 *Policy DM 15.7* of The City of London Corporation's *Local Plan* (Draft, December 2013) seeks to ensure potential noise impacts of developments are considered and minimised by developers, both in relation to deconstruction and construction activities, and as a result of heating and ventilation plant.

9.2.18 In terms of demolition and construction noise, reference is given to the City of London Corporation's *Code of Practice for Deconstruction and Construction Sites,* and in terms of building services plant, it is stated that *the level of noise emitted from any new plant should be below the background level by at least 10dBA.*

Noise Strategy 2012-2016 (City of London Corporation, 2012)

9.2.19 The aims of the *Noise Strategy 2012-2016* include to:

- *avoid or reduce noise, and noise impacts, which could adversely affect the health and well-being of City residents, workers and visitors;*
- *support the City of London Corporation to fulfil its statutory obligations for local noise management and assist others in fulfilling theirs; and*
- *balance minimisation of noise and noise impacts with the need to improve and update City infrastructure.*

9.2.20 Potential noise impacts associated with new developments, transport and street works are primarily addressed through the implementation of appropriate planning and licensing policies, designed to make the development acceptable in planning terms.

9.3 Assessment Methodology

9.3.1 This noise and vibration chapter considers the potential noise and vibration effects associated with the BSCU, concluding on the environmental significance of each. In line with the *NPPF* and associated *NPSE*, the LOAEL and SOAEL are defined for each potential effect, against which predicted noise and vibration levels are assessed, before mitigation measures are proposed where exceedances of the LOAEL and/or SOAEL are identified. The chapter does not attempt to define the NOEL or NOAEL, where *PPG* indicates that no specific (mitigation) measures are required.

Demolition and Construction Noise

Prediction Methodology

9.3.2 The noise levels generated by construction activities and experienced by any nearby sensitive receptors, depend upon a number of variables, the most significant of which are:

- the noise generated by plant or equipment used on-site, or on-site activities (i.e. the physical demolition), generally expressed as sound power levels (L_W);
- the periods of operation of the plant on the site, known as its 'on-time';
- the distance between the noise source and the receptor; and
- the attenuation provided by ground absorption and any intervening barriers.

9.3.3 Demolition and construction noise predictions have been undertaken, employing SoundPLAN (v7.1) noise modelling software, which employs the methodology outlined in *BS 5228-1: 2009+A1:2014 Code of practice for noise and vibration control on construction and open sites: Part 1: Noise (*BSI, 2014). *BS 5228-1: 2009+A1:2014* predicts noise as an equivalent continuous A-weighted sound pressure level over a period such as one hour ($L_{Aeq,1h}$).

9.3.4 *BS 5228-1: 2009+A1:2014* contains a database of the noise emissions from individual items of equipment, activities and routines to predict noise from demolition and construction activities at identified receptors. The prediction method gives guidance on the effects of different types of ground, barrier attenuation and how to assess the impact of fixed and mobile plant.

9.3.5 London Underground Limited's (LUL) contractor, Dragados, provided specific details pertaining to the likely demolition and construction schedule and a plant roster for use in the assessment.

Classification of Effects

9.3.6 The approach to the calculation and assessment of demolition and construction noise levels has been agreed in advance with the City of London Corporation Environmental Health Officers (EHOs), in addition to representative receptor locations and associated sensitivities. Due reference has been given to the City of London Corporation's *Code of Practice for Deconstruction and Construction Sites*, *British Standard BS 5228-1: 2009+A1:2014*, *and British Standard BS 8233: 2014 Guidance on sound insulation and noise reduction for buildings (BSI, 2014)*.

9.3.7 The assessment of demolition and construction noise effects at residential properties has been undertaken according to the 'example method 1 – the ABC method' as defined in *BS 5228-1: 2009+A1:2014, Annex E*. See Table 9.1,

which provides guidance in terms of appropriate threshold values for residential receptors, based upon existing ambient noise levels.

Table 9.1: Demolition and Construction Noise Level Thresholds of Potential Significant Effect at Dwellings

Assessment Category and Threshold Value Period	Threshold Value $L_{Aeq,T}$ (dB) facade		
	Category A (a)	Category B (b)	Category C (c)
Night-time (23:00 – 07:00)	45	50	55
Evenings and Weekends (d)	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
NOTE 1: A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level. NOTE 2: If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3dB due to site noise. NOTE 3: Applied to residential receptors only.			
(a) Category A: Threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values. (b) Category B: Threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as Category A values. (c) Category C: Threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than Category A values. (d) 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays, 07:00 – 23:00 Sundays.			

9.3.8 Example method 2 of *BS5228* ('5dB change method') has also been employed within a 'sensitivity assessment' to verify the prediction of potentially significant effects identified using the ABC method.

9.3.9 For residential properties where construction noise levels are predicted to exceed the ABC thresholds, the assessment of the significance of the effect is based on professional judgement, taking into account a range of other factors including:

- the layout and orientation of the property relative to the works;
- the number of receptors affected and the character of the impact; and
- the timing, duration, frequency or likelihood of the effect.

9.3.10 In accordance with the *NPPF* and *NPSE Explanatory Note* it is also important to identify receptors that exceed the LOAEL and SOAEL, and ensure adverse effects are mitigated and minimised.

9.3.11 In terms of the LOAEL and SOAEL for residential properties, these have been defined as in Table 9.2.

Table 9.2: Demolition and Construction Noise Effect Levels for Residential Buildings (facade levels)

Day	LOAEL $L_{Aeq,T}$ (dB)	SOAEL $L_{Aeq,T}$ (dB)
Daytime (07:00 – 19:00 and Saturdays 07:00 – 07:00 – 13:00)	60	75
Evenings and Weekends (19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	55	65
Any Night (23:00 – 07:00)	45	55

9.3.12 Should the existing ambient noise level already exceed the SOAEL, then on the basis that construction noise should not increase the ambient noise level by more than 3dB, the SOAEL is re-defined as equivalent to the ambient.

9.3.13 As the ABC assessment method is only applicable to residential receptors, a different approach to defining the SOAEL is required for non-residential receptors. The majority of non-residential receptors in the vicinity of the two main work sites are offices, although there is also a church and restaurant/private club adjacent to the Whole Block Site.

9.3.14 The LOAEL and SOAEL for these uses are defined for this assessment in Table 9.3.

9.3.15 With particular reference to non-residential receptors, further consideration of whether an effect is significant and requires mitigation has been undertaken using professional judgement, but taking account of:

- building use; and
- the duration/frequency or likelihood of the effect.

9.3.16 While *BS 5228-1: 2009+A1:2014* specifies the prediction of noise levels 1m from a façade, the City of London Corporation recommends internal noise levels within offices below 65dB(A) to avoid ‘annoyance and interference’. This has been considered in the assessment of potential significance of construction noise.

Table 9.3: Demolition and Construction Noise Level Thresholds of Potential Significant Effect at Non Residential (outdoor façade levels)

Use	Time	LOAEL ($L_{Aeq,T}$)	SOAEL ($L_{Aeq,T}$)
Offices	All time periods when in normal use	80~	90*
Restaurant/Private Club#		65	70
Place of worship+		55	65
* Based on the City of London Corporation recommendation that internal noise levels in offices should not exceed 65dB (L_{Aeq}) otherwise it is likely to cause 'annoyance and interference'. This has been converted to an external façade L_{Aeq} of 90dB based on a conservative estimate of the sound reduction provided by closed windows of 25dB.			
~ Based on the guidance from the Wilson Committee on acceptable daytime noise levels during construction in urban areas near main roads, taking account of improvements in glazing since the guidance was issued in the 1960s.			
#SOAEL equals ambient where ambient > 70dB. LOAEL & SOAEL values are based on the design range for acoustic privacy in restaurants in BS 8233:2014, and a conservative assumption of the sound reduction provided by closed windows of 25dB.			
+SOAEL equals ambient where ambient > 65dB. LOAEL equals ambient minus 5dB where ambient exceeds defined LOAEL. These LOAEL & SOAEL values are based on the lowest daytime criteria in the ABC method, the guidance on reasonable listening conditions in *BS 8233:2014,* and an assumption on the sound reduction provided by single panel stained glass windows of 20dB.			

9.3.17 The City of London Corporation criterion of 65dB is both specific to construction noise and the City, where the majority of potentially affected receptors are offices or commercial. It is reasonably assumed that the defined level takes into account the particular character of construction noise and the general nature of the existing noise climate in London. The defined noise level threshold is therefore considered a pragmatic one, which accepts that elevated noise levels are an inevitable consequence of construction work, but balances the threshold level with a requirement to adhere to 'quiet hours' at particular times during the day to provide an additional measure of protection for potentially affected businesses in the area.

Construction Working Hours

9.3.18 Standard working hours for the construction of the BSCU will be:

- 08:00 - 18:00 hours on weekdays (excl. public holidays); and
- 08:00 - 13:00 hours on Saturdays.

9.3.19 Mobilisation and demobilisation activities may be undertaken respectively for a period of up to one hour before and one hour after the standard working hours.

9.3.20 Certain elements of the construction works will need to be undertaken 24 hours a day, seven days a week. These works will include:

- below ground works associated with tunnelling excavation;
- surface operations undertaken in support of the tunnelling excavation (including transport of excavated material from site); and
- certain works to divert utilities and undertake protective works where required.

Demolition and Construction Vibration

Prediction Methodology

9.3.21 The effects of human response to whole body vibration in buildings are defined in *BS 6472-1: 2008* (BSI, 2008). This gives effects in terms of Vibration Dose Value (VDV). However, for human response to construction related vibration, it is considered more appropriate to use the Peak Particle Velocity (ppv) measure, as suggested in *BS 5228-2:2009+ A1:2014 Code of practice for noise and vibration control on construction and open sites* (BSI, 2014)*. Part 2: Vibration*.

9.3.22 The limit of human perception to vibration is between about 0.15mms^{-1} and 0.3mms^{-1} ppv. The sensitivity of the human body also varies according to different frequencies of vibration, with perception generally possible between 1Hz to 80Hz

9.3.23 The vibration ppv due to specific construction works has been estimated at sensitive receptors using example measured source data and the appropriate propagation relationship taken from *BS 5228-2: 2009 + A1:2014*.

Classification of Effects – Whole Body Vibration

9.3.24 Guidance on the annoyance effects of vibration is provided in *BS 5228-2:2009 + A1:2014* Annex B, adapted as Table 9.4.

9.3.25 The estimated ppv values due to construction works on-site have been compared to the levels specified in Table 9.4 to determine the vibration effects in terms of annoyance. The onset of significant effects (the SOAEL) is classified as 1mms^{-1} ppv, the level at which construction vibration can be tolerated with prior warning. The LOAEL is set for this assessment at 0.3mms^{-1} ppv, at the point at which construction vibration is likely to become perceptible.

Table 9.4: Guidance on Effects of Vibration Levels

Vibration Level ppv mms^{-1}	Description of Effect	Effect
<0.3	Vibration is unlikely to be perceptible in even the most sensitive situations for most vibration frequencies associated with construction.	Negligible
0.3 to 1	Increasing likelihood of perceptible vibration in residential environments.	Minor
1 to 10	Increasing likelihood of complaint in residential environments, but can be tolerated at the lower end of the scale if prior warning and explanation has been given to residents.	Moderate
>10	Vibration is likely to be intolerable for any more than a very brief exposure to a level of $10mms^{-1}$.	Major

9.3.26 In line with the requirements from the City of London Corporation, residents, office workers and users of the church and restaurant/private club are deemed equally sensitive to annoyance effects from construction vibration. Further consideration of whether an effect is significant is undertaken using professional judgement, taking account of the duration and frequency of the effect, as well as the time of day.

Classification of Effects – Building Damage

9.3.27 *BS 7385-2: 1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration* (BSI, 1993) provides guidance on vibration levels likely to result in cosmetic damage, and is referenced in *BS 5228-2: 2009 + A1:2014*. Guide values for transient vibration, above which cosmetic damage could occur, are given in Table 9.5.

Table 9.5: Transient Vibration Guide Values for Cosmetic Damage

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or framed structures	$50mms^{-1}$ at 4Hz and above	
Industrial and heavy commercial buildings	$15mms^{-1}$ at 4Hz increasing to $20mms^{-1}$ at 15Hz	$20mms^{-1}$ at 15Hz increasing to $50mms^{-1}$ at 40Hz and above
NOTE 1: Values referred to are at the base of the building. NOTE 2: For un-reinforced or light framed structures and residential or light commercial buildings, a maximum displacement of 0.6mm (zero to peak) is not to be exceeded.		

9.3.28 *BS7385-2:1993* states that the probability of building damage tends to zero for transient vibration levels less than 12.5mms^{-1} ppv. For continuous vibration the threshold is considerably less at around half this value.

9.3.29 It is also noted that these values refer to the likelihood of cosmetic damage. *ISO 4866:2010* (ISO, 2010) defines three different categories of building damage:

- *cosmetic – formation of hairline cracks in plaster or drywall surfaces and in mortar joints of brick/concrete block constructions;*
- *minor – formation of large cracks or loosening and falling of plaster or drywall surfaces or cracks through brick/block; and*
- *major – damage to structural elements, cracks in support columns, loosening of joints, splaying of masonry cracks.*

9.3.30 *BS 7385-2:1993* defines that minor damage occurs at a vibration level twice that of cosmetic damage and major damage occurs at a vibration level twice that of minor damage. Therefore, this guidance can be used to define the magnitude of impact identified in Table 9.6.

Table 9.6: Magnitude of Impact for Building Vibration

Continuous Vibration Level, ppv mms^{-1}	Damage Risk	Magnitude of Impact
6	Negligible	Very Low
7.5	Cosmetic	Low
15	Minor	Medium
30	Major	High

9.3.31 To determine what effects are caused by these vibration impacts, the sensitivity of the receptor has also been considered. Residential buildings and places of worship are classed as high sensitivity; commercial premises including offices, hotels and restaurants are classed as medium sensitivity. There are no low sensitivity receptors identified within the study area. See Table 9.7.

9.3.32 These guideline values refer to buildings and above ground structures. The effects of vibration on buried services are defined in section B4.4 of *BS 5228-2: 2009 +A1:2014* which recommends that a limit value of 15mms^{-1} ppv should be applied to buried services for continuous vibration in the absence of specific criteria from statutory undertakers. Telecommunications and computer equipment are generally not considered to be sensitive to the levels of vibration produced by construction works inside adjacent buildings.

Table 9.7: Classification of Effect

Sensitivity of Resource/ Receptor	Magnitude of Impact			
	High	**Medium**	**Low**	**Very Low**
Very High	Major	Major	Moderate	Moderate
High	Major	Moderate	Moderate	Minor
Medium	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible

9.3.33 Following the categorisation of effects using this methodology, further consideration of whether a vibration effect is significant is carried out, with major and moderate effects generally considered significant, but with professional judgement applied, taking account of the duration and frequency of the effect.

Construction Groundborne Noise

Prediction Methodology

9.3.34 Construction of new tunnels and passages for the BSCU will use a technique called sprayed concrete lining (SCL) to encase and so form a permanent structural support for excavated spaces.

9.3.35 There are no recognised methods for the prediction of vibration and groundborne noise due to these types of works. However, to give an indication of the expected magnitude of groundborne noise levels, empirical data from sites where similar works have been carried out have been used to estimate the likely levels of vibration and groundborne noise that these works could produce.

Classification of Effects

9.3.36 There are no nationally recommended criteria (for example, within British Standards or industry guidance) for groundborne noise from underground construction works.

9.3.37 The potential for significant groundborne noise effects is limited to those buildings where pile interceptions will occur. All such buildings are in office use. A noise level of 55dB L_{ASmax} is regarded as an appropriate threshold for offices for the onset of potentially significant effects from groundborne noise associated with underground construction works. The exception to this is the 'quiet hours' defined in the City of London Corporation's Noise Strategy as 10.00-12.00 and 14.00-16.00 (Monday to Friday) where noise disturbance to businesses should be restricted. During these periods, 45dB L_{ASmax} is regarded as an appropriate threshold for the onset of potentially significant effects.

9.3.38 Further details on the background to this are provided in Appendix A9.5.

Construction Traffic Noise

Prediction Methodology

9.3.39 The BSCU has the potential to influence traffic flows on existing roads in the area surrounding the BSCU Work Sites during its construction.

9.3.40 The Highways Agency *Design Manual for Roads and Bridges Volume 11 Section 3 Part 7-Traffic Noise and Vibration* (DMRB) (Highways Agency, 2011) provides guidance on the appropriate level of assessment to be used when considering the noise and vibration impacts arising from all road projects, including new construction, improvements and maintenance.

9.3.41 The *Calculation of Road Traffic Noise (CRTN)* (Department of Transport/Welsh Office, 1988) is the standard methodology adopted in the UK for the calculation of noise levels from road traffic. The basic noise level (BNL) is the predicted noise level at an arbitrary reference distance, based on flow and percentage HDV. However, where traffic flows are so low as to fall outside the scope of CRTN (i.e. <50vehicles/h or 1000/18h day) $L_{Aeq,T}$ levels have been predicted using the *Noise Advisory Council* prediction methodology (Noise Advisory Council, 1978).

Classification of Effects

9.3.42 Criteria for assessing the impact of road traffic noise are provided in the *DMRB Volume 11, Section 3, Part 7*. The DMRB short-term criteria have been adapted to produce the criteria presented in Table 9.8 which have been used in this assessment for all receptors.

Table 9.8: Criteria for Assessment of Changes in Road Traffic Noise Levels

Change in Traffic Noise Level $L_{A10,18h}$ (dB)	Effect
0	No Effect
≤ 1	Negligible
>1 - 3	Minor
> 3 - 5	Moderate
> 5	Major

9.3.43 Given the predicted levels of construction traffic, a negligible or minor change in noise levels is predicted. It is therefore considered unnecessary to define absolute noise levels to represent LOAEL or SOAEL.

Operational Plant Noise Assessment

Prediction Methodology

9.3.44 Acoustic modelling software has been employed that implements the *ISO 9613-2: 1996* (ISO 1996) prediction methodology for industrial noise sources. Input data for the model include:

- ground elevation and building height data for the site and surroundings;
- proposed site layout plan and elevation drawings; and
- sound power level data for all plant items.

9.3.45 The model includes a detailed three dimensional representation of the completed BSCU (including associated fixed plant) and predicts the propagation of noise towards the closest noise sensitive receptor locations, taking account of the topography and surrounding structures.

Classification of Effects

9.3.46 *BS 4142: 1997, Method for rating industrial noise affecting mixed residential and industrial areas* (BSI, 1997) is commonly used for the assessment of operational fixed plant noise.

9.3.47 The basis of the standard is a comparison between the background noise level in the vicinity of residential locations and the rating level of the noise source under consideration. The relevant parameters in this instance are as follows:

- Background Noise Level – $L_{A90,T}$ – defined in the Standard as *the 'A' weighted sound pressure level of the residual noise at the assessment position which is exceeded for 90 % of the given time interval, T, measured using time weighting F;*
- Specific Noise Level – $L_{Aeq,Tr}$ – *the equivalent continuous 'A' weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval*; and
- Rating Level – $L_{Ar,Tr}$ – *the specific noise level plus any adjustment made for the characteristic features of the noise*.

9.3.48 A single correction of +5dB is made to the specific noise level if one or more of the features noted below is considered to be present:

- the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.);
- the noise contains distinct impulses (bangs, clatters or thumps); or
- the noise is irregular enough to attract attention.

9.3.49 The potential application of this acoustic feature correction correlates well with the requirements of the *PPG*, which require consideration of tonal or other particular characteristics when assessing the potential impact of noise from proposed developments.

9.3.50 Once any adjustments have been made, the background and the rating noise levels are compared. The standard states that the greater the difference, the greater the likelihood of complaints, so that:

- a difference of around +10dB or more indicates that complaints are likely;
- a difference of around +5dB is of marginal significance; and
- if the rating level is more than 10dB below the measured background level, this is a positive indication that complaints are unlikely.

9.3.51 The standard specifies the specific noise level as L_{Aeq} with a one hour assessment period during the day and a five minute assessment period during the night.

9.3.52 It is noted that a revised draft of *BS4142* is currently out for public consultation. Although proposed amendments include: clarifications on how the background noise level should be defined; changes to the application of acoustic feature corrections; and how the results are interpreted, the principles remain generally the same i.e. the Standard still compares the background noise level and the rating level of the noise source(s) under consideration to determine likely disturbance at receptor locations.

9.3.53 Table 9.9 illustrates the adopted scale of significance. At the request of City of London Corporation, the sensitivity of offices and other non-residential receptors is considered to be equivalent to residential properties for impacts during the day.

Table 9.9: Operational Plant Noise Significance Criteria

Rating level – background noise level (dB)	Effect / Significance
<-10	Negligible/Not significant
-10 to +5	Minor/Not significant
+5 to +10	Moderate/Significant
>+10	Major/Significant

9.3.54 Considering that the operational plant will be mitigated at detailed design stage so as to meet The City of London Corporation requirements (i.e. a rating level of 10dB or more below the background noise level), negligible effects would be anticipated and it is considered unnecessary to define absolute LOAEL and SOAEL values as a result.

Operational Vibration and Groundborne Noise

9.3.55 The BSCU will introduce a new southbound running tunnel which has the potential to cause new groundborne noise and vibration impacts in overlying properties close to the tunnel. However, any identified noise and vibration sensitive locations within 50m of the alignment of the tunnel have also been considered.

Prediction Methodology

9.3.56 Vibration levels that occur inside buildings close to the existing LUL Northern Line have been measured. These levels form the basis of a prediction model which includes all aspects of the vibration transfer path from the track through the soil into the buildings, and the response of the building to the incoming vibration.

9.3.57 Special attention has been given to the locations where existing piled foundations will be altered to enable the construction of the new running tunnel.

9.3.58 A full description of the prediction methodology used is provided as Appendix A9.8.

Significance Criteria

9.3.59 The significance criteria that apply for groundborne vibration have been based on the guidance provided in *BS 6472-1: 2008*, which gives guidance on human response to whole body vibration inside residential buildings. This provides the following relationship for assessing the magnitude of the impact, see Table 9.10.

Table 9.10: Magnitude of Groundborne Vibration

Vibration Dose Value, $ms^{-1.75}$		BS 6472-1: 2008 Rating	Magnitude of Impact
Daytime	Night-time		
< 0.2	< 0.1	Adverse comment not expected	Very Low
0.2 – 0.4	0.1 – 0.2	Low probability of adverse comment	Low
0.4 – 0.8	0.2 – 0.4	Adverse comment possible	Medium
0.8 – 1.6	0.4 – 0.8	Adverse comment probable	High

9.3.60 The guidance values in the table above relate to response within residential environments. *BS 6472-1:2008* recommends that the thresholds for office accommodation are increased by a factor of 2 from those given in Table 9.10.

9.3.61 The significance of the effect is considered by combining the magnitude of the impact with the sensitivity of the receptor, as per Table 9.11. High sensitivity receptors are considered to be residential properties, hotels and places of

worship. Medium sensitivity receptors are considered to be commercial premises including offices and shops, subject to professional judgement.

Table 9.11: Classification of Effect

Sensitivity of Resource / Receptor	Magnitude of Impact			
	High	Medium	Low	Very Low
Very High	Major	Major	Moderate	Minor
High	Major	Moderate	Minor	Minor
Medium	Moderate	Minor	Minor	Negligible
Low	Minor	Minor	Negligible	Negligible

This table reflects the necessary consideration of British Standards and guidance to classify the significance of effect

9.3.62 Following the categorisation of effects using this methodology, further consideration of whether a groundborne vibration effect is significant has been carried out with major and moderate effects generally considered significant, but with professional judgement applied.

9.3.63 For residential and other high sensitivity receptors, the LOAEL has been defined as a vibration dose value of 0.2m/s$^{1.75}$ during the daytime and a vibration dose value of 0.1m/s$^{1.75}$ during the night. The SOAEL has been defined as a vibration dose value of 0.8m/s$^{1.75}$ during the daytime and 0.4m/s$^{1.75}$ during the night.

9.3.64 For groundborne noise, the significance criteria have been based on the criteria used in other recent underground railway projects such as the Northern Line Extension to Battersea. Table 9.12 provides the following relationship for the magnitude of impact which is applied to all receptor types.

Table 9.12: Magnitude of Groundborne Noise Impact

Internal Groundborne Noise Level due to Single Train Pass By, dB L_{AFmax}	Magnitude of Impact
≤ 35	Very low
36 – 40	Low
41 – 45	Medium
≥ 46	High

9.3.65 The significance of the effect is considered by combining the magnitude of the impact with the sensitivity of the receptor using Table 9.13, in the same way as was described earlier.

Table 9.13: Classification of Effect

Sensitivity of Resource / Receptor	Magnitude of Impact			
	High	Medium	Low	Very Low
Very High	Major	Major	Moderate	Minor
High	Major	Moderate	Minor	Minor
Medium	Moderate	Minor	Minor	Negligible
Low	Minor	Minor	Negligible	Negligible

This table reflects the necessary consideration of British Standards and guidance to classify the significance of effect

9.3.66 Following the categorisation of effects using this methodology, further consideration of whether a groundborne noise effect is significant has been carried out using professional judgement. Major and moderate effects are generally considered significant.

9.3.67 LUL guidance, *Noise and Vibration Asset Design Guidance G1323* (Transport for London, 2012), includes a significance threshold of 40dB L_{AFmax} for residential properties with a requirement to use reasonable endeavours to design to 35dB L_{AFmax} for residential premises. This aligns with the significance threshold defined in Table 9.12 and Table 9.13. There are no numerical values provided for building uses other than residential; however, reference is given to *BS 8233:1999*. Within *BS 8233:1999*, the requirements for office accommodation are typically 5dB greater than those for residential environments. This suggests a significance threshold for offices of 45dB L_{AFmax}. This aligns with the significance threshold defined in Table 9.12 and Table 9.13 when considering offices as medium sensitivity operational groundborne noise receptors. However, other recent rail projects have used a significance threshold of 40dB L_{ASmax} for offices and as such a level of 40dB L_{AFmax} has been adopted for the BSCU.

9.3.68 In addition, the threshold for St Mary Abchurch, which for the purposes of the operational groundborne noise assessment has been classified as a very high sensitivity receptor, has a significance threshold of 35dB L_{AFmax}. This is equivalent to the significance threshold used by other recent rail projects for places of worship.

9.3.69 Based on experience of other recent railway projects, the LOAEL has been defined as 42dB L_{AFmax} and the SOAEL has been defined as 45dB L_{AFmax}. The LOAEL level has been based on the WHO Night Noise Guidelines for Europe. The design target required by London Underground Limited is such that all groundborne noise levels will be controlled to less than LOAEL. The level used for the SOAEL is based on the precedent set by the High Speed 2 project.

9.4 Baseline Conditions

9.4.1 In order to establish the prevailing noise and vibration conditions, a series of long term unattended (where secure sites were identified) and short-term attended noise and vibration surveys were undertaken at selected locations around the BSCU area. These locations are listed in Tables 9.14 and 9.15 respectively, and illustrated on Figure 9.1 (within the ES Figures volume). Full details regarding dates, instrumentation, monitoring protocol and meteorological conditions are provided in Appendix A9.2.

Table 9.14: Noise Monitoring Locations

Reference	Survey Location	Long-term (LT) or Short-term (ST)
N1	10 King William Street	LT
N2	Daiwa Offices, 5 King William Street	LT
N4	10 Arthur Street (representative of 28 Martin Lane)	LT
N5	10 Arthur Street (representative of 6 Martin Lane)	LT
N6	1, Abchurch Yard	LT
N7	St Mary Abchurch	ST
N8	Travelodge, Sherbourne Lane	ST
N9	Fishmonger's Hall, Upper Thames Street	ST
N10	Laurence Pountney Lane	ST
N11	15 Abchurch Lane	ST
N12	81 King William Street	ST
N13	18 Nicholas Lane	ST
N14	110 Cannon Street	ST
N15	12 Arthur Street	ST
N16	The Walbrook Building, Walbrook	ST
N17	St Stephen's Church, Walbrook	ST
N18	Mansion House (western façade)	ST
N19	1-6 Lombard Street	ST
N20	Mansion House (north east corner)	ST

Table 9.15: Vibration (and Groundborne Noise) Monitoring Locations

Reference	Survey Location
V1*	7 Prince's Street
V2	1-6 St Swithin's Lane
V3	Adelaide House
V4	St Mary Abchurch
V5*	St. Clement's Church
V6	8-10 Mansion House Place
V7*	Mansion House

*Groundborne noise measured in addition to vibration

Summary of Noise Measurements

9.4.2 Tables 9.16 and 9.17 provide a summary of the noise measurements at each of the 19 noise monitoring locations.

Table 9.16: Long-Term Noise Monitoring Summary (Façade Noise Levels)

Long-term Monitoring Location	Time Period	$L_{Aeq,T}$	$L_{A90,1h}$ Avg	$L_{A90,1h}$ Min
N1	weekday (07:00 - 19:00) and Saturdays (07:00 – 13:00)	70	65	59
	weekday evening (19:00 - 23:00) and weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	68	60	55
	night (23:00 - 07:00)	66	57	51
	16 hr day (07:00 – 23:00, including weekends)	69	63	55
	12 hr weekday (07:00 – 19:00)	70	65	64
N2	weekday (07:00 - 19:00) and Saturdays (07:00 – 13:00)	62	59	57
	weekday evening (19:00 - 23:00) and weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	63	57	53
	night (23:00 - 07:00)	62	55	52
	16 hr day (07:00 – 23:00, including weekends)	63	58	53
	12 hr weekday (07:00 – 19:00)	63	59	57
N4	weekday (07:00 - 19:00) and Saturdays (07:00 – 13:00)	70	65	62

Long-term Monitoring Location	Time Period	$L_{Aeq,T}$	$L_{A90,1h}$ Avg	$L_{A90,1h}$ Min
	weekday evening (19:00 - 23:00) and weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	68	63	61
	night (23:00 - 07:00)	68	61	57
	16 hr day (07:00 – 23:00, including weekends)	70	64	61
	12 hr weekday (07:00 – 19:00)	71	66	64
N5	weekday (07:00 - 19:00) and Saturdays (07:00 – 13:00)	66	60	57
	weekday evening (19:00 - 23:00) and weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	64	57	55
	night (23:00 - 07:00)	62	55	53
	16 hr day (07:00 – 23:00, including weekends)	65	59	55
	12 hr weekday (07:00 – 19:00)	66	60	59
N6	weekday (07:00 - 19:00) and Saturdays (07:00 – 13:00)	63	57	54
	weekday evening (19:00 - 23:00) and weekends (13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays)	64	56	52
	night (23:00 - 07:00)	62	53	51
	16 hr day (07:00 – 23:00, including weekends)	63	57	52
	12 hr weekday (07:00 – 19:00)	63	58	55

9.4.3 The L_{Aeq} values in Table 9.16 have been derived by logarithmically averaging all the measured L_{Aeq} values within the stated time periods. The $L_{A90,1h}$ average and minimum values represent the arithmetic average and lowest of all the $L_{A90,1h}$ data within the stated time periods.

9.4.4 In addition to the exclusion of data from analysis during periods of unacceptable weather (noted in Appendix A9.2), additional daytime data at N2 (Daiwa Offices) has been excluded due to unrepresentative scaffolding works (not normally present) in the immediate vicinity (5th to 13th November), as reported by Anderson Acoustics.

Table 9.17: Short-Term Noise Monitoring Summary (Façade Noise Levels)

Short-term Monitoring Location	Time Period	$L_{Aeq,T}$	$L_{A90, 5min}$ Avg	$L_{A90, 5min}$ Min
N7	day (10:20 – 11:20 and 12:10 – 13:10)	64	58	56
	evening (19:00 – 20:00)	69	66	65
	Sunday (10:25 – 11:35)	60	54	53
N8	day (10:20 – 11:20 and 12:15 – 13:15)	68	56	53
	evening (19:00 – 20:00)	65	56	55
	night (02:00 – 04:00)	54	46	44
N9	day (11:00 – 12:00 and 12:00 – 13:00)	76	69	64
	evening (19:04 – 20:04)	77	67	64
	night (02:00 – 04:00)	72	62	59
N10	day (11:00 – 12:00 and 12:40 – 13:40)	61	57	56
	evening (19:00 – 20:00)	59	54	53
	night (02:00 – 04:00)	54	51	50
N11	day (12:33 – 13:33 and 14:40 – 15:40 and 18:11 – 19:11)	64	59	57
N12	day (10:18 – 11:18 and 12:23 – 13:23)	73	66	62
N13	day (10:18 – 11:18 and 12:15 – 13:15)	73	66	62
N14	day (11:20 – 12:20 and 14:33 – 15:33)	72	64	60
N15	day (11:29 – 12:29 and 13:28 – 14:28 and 15:37-16:37)	76	66	63
N16	day (5 x 15min periods between 09:35 and 15:55)	70*	-	-
N17	day (14:06 – 14:21)**	64	61	60
N18	day (14:10 – 15:10)	69	64	63
	night (02:05 – 02:35)	63	54	52
N19	day (11:45 – 12:45)	72	66	64
N20	day (11:41 – 12:41)	69	64	62
	night (02:06 – 02:36)	64	55	52

*Data from southern end of Walbrook and taken from 2011 Bloomberg Square Baseline Noise Report, which quotes noise measurements taken in 2006. Actual noise levels (and in the absence of construction activities) are expected to reduce with increasing distance from Cannon Street.

**15 minute measurement only due to interference from Bloomberg construction site

9.4.5 At all monitoring locations and during all monitoring periods, existing road traffic noise was noted as the dominant element.

Summary of Vibration Measurements

9.4.6 Table 9.18 derives the daytime VDV_b (in accordance with *BS 6472*) and the ppv measured within buildings.

Table 9.18: Vibration Measurement Summary

Reference	Survey Location	Derived Daytime VDV_b ($ms^{-1.75}$)	ppv (mms^{-1})
V1	6-8 Prince's Street	0.01	-
V2	1-6 St Swithin's Lane	0.01	0.09
V3	Adelaide House	0.01	-
V4	St Mary Abchurch	0.01	0.15
V5	St. Clement's Church	0.02	0.12
V6	8-10 Mansion House Place	0.01	0.09
V7	Mansion House	0.02	0.04

9.4.7 The derived baseline VDV_b are noted to be significantly below those at which adverse comment may be expected.

9.4.8 The highest ppv levels have been measured as $0.15ms^{-1}$ at St Mary Abchurch and $0.12ms^{-1}$ at St. Clement's Church. These baseline levels are significantly below the levels provided in *BS 7385-2:1993* relating the likelihood of cosmetic damage and are unlikely to be perceptible.

Summary of Groundborne Noise Measurements

9.4.9 Table 9.19 shows the measured range of groundborne noise levels due to existing underground trains. The values are presented as a range due to the inherent variability between different train events.

Table 9.19: Groundborne Noise Measurement Summary

Reference	Survey Location	Typical groundborne noise levels, dB L_{AFmax}
V1	6-8 Prince's Street	40-45
V5	St. Clement's Church	40-45
V7	Mansion House	38-45

9.4.10 The monitoring within Mansion House comprised measurements of trains on both the Northern Line and the Central Line. These measurements show that buildings along the route of the existing Northern Line are currently exposed to groundborne noise levels of up to 45dB L_{AFmax} due to some train events.

9.5 Incorporated Mitigation

Construction

9.5.2 A draft CoCP has been developed (Appendix A4.1), drawing upon the City of London Corporation's *Code of Practice for Deconstruction and Construction Sites – May 2013* (City of London Corporation, 2013), which commits to the use of 'Best Practicable Means' (BPM). Works will be undertaken in accordance with the controls outlined within section 6 of the CoCP document.

9.5.3 Such BPM measures to minimise noise and vibration levels include the following:

- careful selection of plant employing only modern, quiet and well-maintained equipment and low impact techniques;
- considered sequencing of work in order to minimise potential noise impact to neighbours;
- fixed items of construction plant to be electrically powered from the mains supply where possible, in preference to the employment of generators;
- avoidance of unnecessary noise (such as engines idling between operations, shouting, loud radios or excessive revving of engines) by effective site management;
- vehicles and mechanical plant utilised on site for any activity associated with the construction works to be fitted with effective exhaust silencers, be maintained in good working order and operated in a manner such that noise emissions are controlled and limited as far as reasonably practicable;
- the contractor will, as far as reasonably practicable, ensure that the noise from reversing / warning alarms is controlled and limited; and
- where control at source is not practicable or adequate, the distance between noise / vibration sources and sensitive neighbours will be maximised and the transmission path interrupted as practicable.

9.5.4 While the benefits of these mitigation options cannot be quantified, their purpose is to minimise the potential noise/vibration impacts as far as reasonably practicable.

9.5.5 Site perimeter hoarding of 3.6m height is proposed around both main work sites offering protection to all surrounding receptors. This hoarding will be provided for the full duration of the main demolition and construction activities.

9.5.6 For the purposes of the assessment, calculations have been undertaken with the hoarding in place. When compared to predictions without the hoarding in place, the predicted ground floor façade levels are mitigated by around 10 to 15dB at all the surrounding receptors. At higher floor levels, the benefits of the

hoarding are reduced where line of sight is not broken between source and receptor.

9.5.7 Where practicable, stationary plant items shall be contained within enclosures, providing a beneficial noise reduction. Those plant items assumed to be enclosed are identified within Appendix A9.4, together with a note of the assumed noise reduction.

9.5.8 It is also proposed within the CoCP that the contractor shall, as far as reasonably practicable, monitor, control and limit noise and vibration levels. Noise and vibration monitoring schemes shall be determined in consultation with City of London Corporation.

9.5.9 Where there is a requirement to work outside standard hours (08:00 to 18:00 Monday to Friday and 08:00 to 13:00 Saturday), this will be agreed in advance with the City of London Corporation. Similarly, the City of London Corporation's 'quiet hours' (10:00 to 12:00 and 14:00 to 16:00 Monday to Friday) for 'noisy' works are acknowledged. Where work is required during these periods, for example where there is an overriding justification in terms of safety or engineering practicality, discussions will be held between the contractor and the City of London Corporation.

9.5.10 Full details of proposed best practicable means, working hours and commitment to monitor noise and vibration levels during demolition and construction activities are provided in the draft CoCP, included as Appendix A4.1. The implementation of the CoCP will benefit all receptors identified as experiencing adverse effects (significant or otherwise) during construction.

9.5.11 The CoCP also details proposals for a liaison and consultation strategy. Designed to inform all interested parties of all aspects of the proposed works, including the type, location and duration of activities, it will advertise contact details from where additional information can be sourced and will detail a complaints procedure.

Operation

9.5.12 The design of the new southbound tunnel incorporates a number of features to inherently reduce vibration generation and transmission. These measures will reduce the groundborne noise levels that will be received in the buildings above and close to the route. The most important of these is the design of the tunnel and its alignment. Specifically, the size of the tunnel has been reduced and the alignment has been carefully selected to minimise the interaction with the piles of existing buildings. Further, the tunnel's curvature has been smoothed out so that the need for check rail (a second rail placed inside the main running rails to assist with traversing tight curves) is avoided, lessening the potential for wheel squeal. The new running tunnel will also be fitted with a resilient baseplate track system to reduce vibration levels further.

9.5.13 In locations where the tunnel directly intercepts the piles of existing buildings, the design has been progressed to reduce the potential for groundborne noise to be transmitted via this pathway. However, a higher performance track system is expected to be required. For the purposes of the ES, the higher performance track system has been assumed to provide a 10dB reduction in groundborne noise levels when compared to a standard resilient baseplate track system.

9.6 Assessment of Effects

Demolition and Construction Noise – Whole Block Site

Selected Receptor Locations – Whole Block Site

9.6.1 Noise levels resulting from demolition and construction activities at the Whole Block Site have been predicted at ten selected receptor locations:

- R1 - 133 Cannon Street (offices);
- R2 -1 Abchurch Yard (residential);
- R3 - Sherbourne House, Abchurch Yard (offices);
- R4 - St Mary Abchurch (place of worship);
- R5 - Travelodge, Sherbourne Lane (residential);
- R6 -15 Abchurch Lane (bar/restaurant/private club);
- R7 - Daiwa building, Abchurch Lane/King William Street (offices);
- R8 - ICCB, 81, King William Street (offices);
- R9 - Phoenix House, Nicholas Lane/King William Street (offices); and
- R10 - BBVA Bank, 108 Cannon Street (offices).

9.6.2 These receptor locations, which are also considered representative of immediately adjacent premises, are illustrated in Figure 9.2 (see ES Figures Volume).

Demolition and Construction Activities – Whole Block Site

9.6.3 The main activities at the Whole Block Site have been identified as follows:

- a1 - demolition;
- a2 – piling, continuous flight auger (CFA);
- a3 - excavation/creation of the station box;
- a4 - installation of shell and core of the station; and
- a5 – evening / weekend / night-time support operations.

Construction Noise – Arthur Street Site

Selected Receptor Locations – Arthur Street Site

9.6.4 Noise levels resulting from construction activities at the Arthur Street Work Site have been predicted at nine selected receptor locations:

- R11 - 5, Laurence Pountney Lane (residential);
- R12 - 7a Laurence Pountney Lane (residential);
- R13 - 6 Martin Lane (residential, above the Old Wine Shades public house);
- R14 - 28 Martin Lane (residential);
- R15 - 10 Arthur Street (offices);
- R16 - 24 King William Street (offices);
- R17 - 33 King William Street (offices - although currently empty, these will potentially be occupied post 2017);
- R18 - Fishmongers Hall (residential on 2nd and 3rd floor - Clerks and Stewards Flats); and
- R19 - 12 Arthur Street (offices).

9.6.5 These receptor locations, which are also considered representative of immediately adjacent premises, are illustrated in Figure 9.2 (see ES Figures Volume).

Construction Activities – Arthur Street Site

9.6.6 The main activities at the Arthur Street Site have been identified as follows:

- a6 – piling (sheet);
- a7 – shaft creation;
- a8 – tunnelling/excavation (including surface level spoil removal activities); and
- a9 – installation of the gantry crane.

9.6.7 Appendix A9.4 contains information relating to the data sources, noise modelling inputs and assumptions employed in the demolition and construction noise level predictions at both the Whole Block Site and the Arthur Street Site. This includes the plant items (and numbers) anticipated, and percentage on-time per typical one hour period.

Demolition and Construction Noise Level Thresholds

9.6.8 In order to define the noise level criteria in accordance with the ABC method of *BS5228*, the measured daytime ambient noise levels (façade) have been

analysed and categorised within Table 9.20 for residential receptors. Office locations (R1, R3, R7-10, R15 -17 and R19), the church (R4) and the restaurant/private club (R6) are not included because they have not been assessed using the ABC method, which is only applicable to residential premises.

Table 9.20: Determination of Construction Noise Level Thresholds (Daytime*)

Residential Receptor Location	Existing Daytime Ambient Noise Level ($L_{Aeq,T}$ dB façade)	$L_{Aeq,T}$, rounded to the Nearest 5dB	ABC Assessment Category	Threshold Value ($L_{Aeq,T}$ dB façade)	LOAEL ($L_{Aeq,T}$ dB facade)	SOAEL ($L_{Aeq,T}$ dB facade)
R2	63	65	B	70	60	75
R5	68	70	C	75	60	75
R11	61	60	A	65	60	75
R12	61	60	A	65	60	75
R13	66	65	B	70	60	75
R14	70	70	C	75	60	75
R18	76	75	C	76˜	60	76

*Daytime = Weekdays 07:00 to 19:00 and Saturdays 07:00 to 13:00 (BS 5228)

˜ Site noise level, which when added to ambient, will not result in the total noise level exceeding ambient + 3dB

9.6.9 Due to the proposals for below ground tunnelling activities to continue on a 24/7 basis with 24/7 surface support operations and removal of excavated material outside standard hours, Tables 9.21 and 9.22 identify (for residential premises) the corresponding noise level thresholds for evening and weekend, and night-time working.

9.6.10 At a number of locations, existing ambient noise levels can already be described as ‘high’, reflected in the consequent threshold value and the defined SOAEL.

Table 9.21: Determination of Construction Noise Level Thresholds (Evening and Weekend*)

Residential Receptor Location	Existing Evening / Weekend Ambient Noise Level ($L_{Aeq,T}$ dB façade)	$L_{Aeq,T}$, rounded to the Nearest 5dB	ABC Assessment Category	Threshold Value ($L_{Aeq,T}$ dB façade)	LOAEL ($L_{Aeq,T}$ dB facade)	SOAEL ($L_{Aeq,T}$ dB facade)
R2	64	65	C	65	55	65
R5	65	65	C	65	55	65
R11	59	60	C	65	55	65
R12	59	60	C	65	55	65
R13	64	65	C	65	55	65
R14	70	70	C	70˜	55	70
R18	77	80	C	77˜	55	77

*Evening and Weekend = Weekdays 19:00 to 23:00, Saturdays 13:00 to 23:00 and Sundays 07:00 to 23:00 (BS 5228)

˜ Site noise level, which when added to ambient, will not result in the total noise level exceeding ambient + 3dB

Table 9.22: Determination of Construction Noise Level Thresholds Night-time*

Residential Receptor Location	Existing Night-time Ambient Noise Level ($L_{Aeq,T}$ dB façade)	$L_{Aeq,T}$, rounded to the Nearest 5dB	ABC Assessment Category	Threshold Value ($L_{Aeq,T}$ dB façade)	LOAEL ($L_{Aeq,T}$ dB facade)	SOAEL ($L_{Aeq,T}$ dB facade)
R2	62	60	C	62˜	45	62
R5	54	55	C	55	45	55
R11	54	55	C	55	45	55
R12	54	55	C	55	45	55
R13	62	60	C	62˜	45	62
R14	68	70	C	68˜	45	68
R18	72	70	C	72˜	45	72

*Night-time = 23:00 to 07:00 (BS 5228)

˜ Site noise level, which when added to ambient, will not result in the total noise level exceeding ambient + 3dB

Predicted Noise Levels

9.6.11 Tables A9.4.14 and A9.4.15 in Appendix A9.4 provide the predicted noise levels for each floor, at each receptor, as a result of the defined activities. Table 9.23 summarises the predicted noise levels at the worst affected floor of buildings in the vicinity of the Whole Block Site.

9.6.12 The predicted one hour noise levels are based on the on-times within Tables A9.4.1 to A9.4.10 in Appendix A9.4. Assuming this is a representative hour in terms of construction activities, this predicted noise level will be applicable over any longer time period. It is noted that the City of London Corporation have 'quiet hours' within which 'noisier' activities are not usually permitted, and that while adherence to these will likely result in a lower noise level when defined over a longer time period, this is not readily quantifiable at this stage. Consequently, the predictions within the following tables can be considered to represent a reasonable worst case in comparison to the noise level over longer time periods than 1 hour.

Table 9.23: Predicted Maximum Demolition and Construction Noise Levels, Whole Block Site

Receptor Location	Predicted Façade Noise Levels for defined activities, dB $L_{Aeq,T}$				
	a1	a2	a3	a4	a5
R1	79	67	71	69	45
R2	74	64	68	67	32
R3	72	56	59	57	29
R4	67	62	58	55	37
R5	55	55	53	54	39
R6	79	77	72	69	54
R7	78	76	72	69	53
R8	77	74	70	69	54
R9	83	76	77	76	58
R10	78	69	72	70	51

9.6.13 At R1 (133 Cannon Street, offices) the derived daytime SOAEL and LOAEL of 90dB and 80dB respectively, are not exceeded during any of the defined activities. Offices generally are not considered sensitive receptors during evening/weekend or night-time periods; work may be undertaken during these periods, but usually not on the same scale as during normal working hours. Consequently, no significant adverse effects are anticipated at R1.

9.6.14 At R2 (1 Abchurch Yard, residential), the derived daytime threshold of 70dB is exceeded during activity a1 (demolition), but the SOAEL of 75dB (free-field) is not exceeded. The derived daytime LOAEL of 60dB is exceeded during activities a1 to a4. However, based on the understanding that there are no habitable rooms on the exposed façade of 1 Abchurch Yard, the predicted noise levels are not considered to result in a significant adverse effect. During night-time periods neither the derived threshold or SOAEL of 62dB nor the LOAEL of 45dB are exceeded during activity a5. Consequently, no significant adverse effects are anticipated at R2.

9.6.15 At R3 (Sherbourne House, offices), the derived daytime SOAEL and LOAEL of 90dB and 80dB respectively, are not exceeded during any of the defined activities. Offices are generally not considered sensitive receptors during evening/weekend or night-time periods. Consequently, no significant adverse effects are anticipated at R3.

9.6.16 At R4 (St Mary Abchurch), the derived daytime SOAEL of 65dB is exceeded during activity a1 (demolition) and the derived daytime LOAEL of 55dB is exceeded during activities a1 to a3. St Mary Abchurch is not considered a noise sensitive receptor during night-time periods. Therefore, significant adverse construction noise effects are expected at receptor R4. Further mitigation measures are recommended to reduce noise levels as a result of activity a1 (demolition) and these are discussed further within Section 9.7. Implementation of the CoCP and associated best practice measures will result in the minimisation of noise levels from all defined activities to the lowest levels practicable.

9.6.17 At R5 (Travelodge hotel), the derived daytime threshold and SOAEL of 75dB and LOAEL of 60dB are not exceeded during any of the defined activities. The derived night-time threshold and SOAEL of 55dB and LOAEL of 45dB are not exceeded during activity a5. The relatively low predicted noise levels are primarily as a result of increased distance and shielding due to intervening buildings. Consequently, no significant adverse effects are anticipated at R5.

9.6.18 At R6 (15 Abchurch Lane, restaurant/club) the derived daytime SOAEL of 70dB is exceeded during activities a1 to a3 and the derived daytime LOAEL of 65dB is exceeded during activities a1 to a4. 15 Abchurch Lane is not considered a noise sensitive receptor during night-time periods. Therefore, significant adverse construction noise effects are expected at receptor R6 during activities a1, a2 and a3. Further mitigation measures, where practicable, are recommended to reduce noise levels as a result of activities a1 to a4, minimising the potential for adverse effects, and these are discussed further within Section 9.7.

9.6.19 At R7, R8 and R10 (Daiwa building, 81 King William Street and 108 Cannon Street, offices) the derived daytime SOAEL and LOAEL of 90dB and 80dB

respectively are not exceeded during any of the defined activities. Offices are not considered sensitive receptors during evening/weekend or night-time periods. Consequently, no significant adverse effects are anticipated at R7, R8 and R10.

9.6.20 At R9 (Phoenix House, offices) the derived daytime SOAEL of 90dB is not exceeded during any of the defined activities. The derived daytime LOAEL of 80dB is exceeded during activity a1 (demolition). The period of time for which the LOAEL is exceeded will be limited. Implementation of the CoCP and associated best practice measures will result in the minimisation of noise levels arising from all defined activities. R9 is not considered a noise sensitive receptor during evening/weekend or night-time periods. Taking into account the marginal exceedances of the daytime LOAEL, and the worst-case nature of the noise predictions, no significant adverse effects are anticipated at R9.

9.6.21 Table 9.24 summarises the predicted noise levels at the worst affected floor of buildings in the vicinity of the Arthur Street Site.

Table 9.24: Predicted Maximum Construction Noise Levels, Arthur Street Site

Receptor Location	Predicted Façade Noise Levels for defined activities, dB $L_{Aeq,T}$				
	a6	a7	a8*	a8**	a9
R11	44	44	39	38	42
R12	40	41	37	36	38
R13	50	52	51	50	49
R14	74	73	70	68	72
R15	73	72	72	70	72
R16	83	82	75	75	81
R17	77	77	70	71	76
R18	46	47	42	42	45
R19	55	59	58	58	55

*standard hours **outside standard hours

9.6.22 At R11 and R12 (5 and 7a, Laurence Pountney Lane, residential), the derived daytime threshold and SOAEL of 65dB and 75dB and LOAEL of 60dB are not exceeded during any of the defined construction activities. The same is true for the derived evening/weekend threshold and SOAEL of 65dB and LOAEL of 55dB, and for the night-time threshold and SOAEL of 55dB and LOAEL of 45dB. The relatively low predicted noise levels are primarily as a result of increased distance and shielding due to intervening buildings. Consequently, significant adverse effects are not anticipated at R11 or R12.

9.6.23 At R13 (6 Martin Lane, residential) the derived daytime threshold and SOAEL of 70dB and 75dB and LOAEL of 60dB are not exceeded during any of the

defined construction activities. The same is true for the derived evening/weekend threshold and SOAEL of 65dB and LOAEL of 55dB, and for the night-time threshold and SOAEL of 62dB. The night-time LOAEL of 45dB is exceeded during activity a8. However, considering the existing ambient noise climate and the consequent threshold level of 62dB, no significant adverse effects are anticipated at R13.

9.6.24 At R14 (28 Martin Lane, residential) the derived daytime threshold and SOAEL of 75dB are not exceeded during any of the defined construction activities. The derived daytime LOAEL of 60dB is exceeded during all activities. The derived evening/weekend threshold and SOAEL of 70dB are not exceeded. The night-time threshold and SOAEL of 68dB are not exceeded during activity a8, although the night-time LOAEL is exceeded. Consequently, predicted noise levels during the daytime, evening and weekend periods are not considered significant. Implementation of the CoCP and associated best practice measures will result in the minimisation of noise levels as a result of all defined activities.

9.6.25 At R15 and R17 (10 Arthur Street and 33 King William Street) the derived daytime SOAEL and LOAEL of 90dB and 80dB respectively are not exceeded during any of the defined construction activities. Offices are not considered sensitive receptors during evening/weekend or night-time periods. Consequently, the predicted effects at R15 and R17 are not expected to be significant.

9.6.26 At R16 (24 King William Street, offices) the derived daytime SOAEL of 90dB is not exceeded during any of the defined construction activities. The derived daytime LOAEL of 80dB is exceeded during activities a6, a7 and a9. This is primarily due to the proximity of the receptor to the shaft site. R16 is not considered a noise sensitive receptor during evening/weekend or night-time periods. Implementation of the CoCP and associated best practice measures, will result in the minimisation of noise levels as a result of all defined activities. Taking into account the marginal exceedances of the daytime LOAEL, and the worst-case nature of the noise predictions, no significant adverse effects are anticipated at R16.

9.6.27 At R18 (Fishmonger's Hall, partially residential) the derived daytime threshold and SOAEL of 76dB and LOAEL of 60dB respectively are not exceeded during any of the defined construction activities. The same is true of the evening/weekend threshold and SOAEL of 77dB and LOAEL of 55dB, and the night-time threshold and SOAEL of 72dB. The relatively low predicted noise levels are primarily as a result of increased distance and shielding from intervening buildings. Consequently, significant adverse effects are not anticipated at R18.

9.6.28 At R19 (12 Arthur Street, offices) the derived daytime SOAEL and LOAEL of 90dB and 80dB respectively are not exceeded during any of the defined construction activities. R19 is not considered a noise sensitive receptor during evening/weekend or night-time periods. Consequently, significant adverse effects are not anticipated at R19.

Method 2 (5dB change) 'Sensitivity Tests'

9.6.29 Sensitivity tests, employing method 2 of *BS5228* (undertaken for residential, hotel/hostel and religious building receptors) have identified the following:

- At 15 Abchurch Lane (R6), using method 2 of *BS5228* identifies a potential significant effect during activity a4 (installation of shell and core of station) i.e. ambient plus site noise is +6dB above the measured ambient. However, the defined SOAEL of 70dB is not exceeded.
- At 28 Martin Lane (R14), using method 2 of *BS5228* identifies a potential significant effect during activity a6 (piling) i.e. ambient plus site noise is +5dB above the measured ambient of 70dB. However, the +5dB threshold is exceeded by less than 0.5dB and the defined SOAEL of 75dB is not exceeded and, therefore, not considered to be significant.
- Potentially significant noise levels are not identified at any other receptors which fall within the scope of method 2 of *BS 5228*, and which have not already been identified as subject to potentially significant noise levels when using method 1 (the ABC method).

Demolition and Construction Vibration

9.6.30 CFA piling is proposed at the Whole Block Site. This is a non-impact or vibratory piling technique.

9.6.31 Whilst recognising the difficulties of predicting vibration levels due to uncertainties regarding ground conditions, source vibration data has been taken from *BS5228-2* to facilitate the estimation of vibration levels at various distances from source.

9.6.32 A ppv level of $0.2mms^{-1}$ at 9 m from the piling source has been taken as a worst case (Reference 102 of Table D.6 of *BS 5228-2*).

9.6.33 Table 9.25 illustrates the estimated vibration levels at various distances from the piling activity.

Table 9.25: Estimated CFA Piling Vibration Levels at the Whole Block Site

Distance (m)	Estimated ppv (mms^{-1})
5	0.4
6	0.3
10	0.2
15	0.1
20	0.1

9.6.34 In terms of annoyance to occupiers, the estimated ppv levels at greater than 5m are noted to be at or below perceptible levels in even the most sensitive situations, and are therefore at or below the LOAEL of $0.3mms^{-1}$ ppv.

9.6.35 In terms of building damage, levels are significantly below those at which cosmetic damage could reasonably be expected. Levels are also well below the damage threshold of $15mms^{-1}$ ppv that is set for underground services.

9.6.36 All other demolition and construction plant at the Whole Block Site are considered to carry significantly less risk of elevated vibration levels.

9.6.37 Potential effects as a result of the proposed piling activities at the Whole Block Site are therefore assessed as negligible, both in terms of annoyance and building damage, and no significant adverse effects are predicted.

9.6.38 At the Arthur Street Site, sheet piling is proposed. However, rather than percussive or vibratory techniques, it is proposed to undertake 'pressed in' piling.

9.6.39 As confirmed in *BS 5228-2 Appendix F*, *paragraph F.3.2.4,* the levels of vibration associated with pressed-in piling are minimal as the processes do not involve rapid acceleration or deceleration of tools in contact with the ground but relies to a large extent on steady motions. Consequently, significant adverse effects are not anticipated.

9.6.40 Should it be necessary to employ any impact or vibratory techniques in the initial stages, these would be short-term, temporary, and not expected to result in significant effects, particularly if timed to occur in less sensitive time periods.

9.6.41 All other demolition and construction plant at the Arthur Street Site is considered to carry significantly less risk of elevated vibration levels.

Groundborne Noise from Underground Construction

9.6.42 The removal of the temporary tunnel face, which is sprayed on a daily basis and removed less than 24 hours after spraying, is primarily carried out using the bucket of an excavator. Other techniques include use of roadheaders,

which are machines developed for the mining industry that use large rotating mill heads to scour rock faces (or in this case, concrete).

9.6.43 Experience on other tunnelling projects shows that breakout of temporary tunnel face is unlikely to create noise levels within buildings above 45dB L_{ASmax}.

9.6.44 Where the SCL is to be constructed using a pilot tunnel, the use of a pulverizer allows the SCL to be broken out as the main tunnel progresses. As with breakout of the temporary tunnel face, the removal of pilot SCL with a pulverizer is unlikely to create noise levels within buildings above 45dB L_{ASmax}.

9.6.45 Where the SCL to be removed has hardened further, such as due to a planned stop of the tunnelling works, such as for extended breaks in construction works, or a change in tunnelling direction, the breakout requirements are more intensive. The noise predictions carried out for SCL works indicate that generally, the use of percussive breakers is likely to create noise levels in the order of 45dB L_{ASmax} which is 10dB below the 55dB L_{ASmax} threshold for periods outside the Corporation's quiet hours, but equal to the threshold for these quiet periods.

9.6.46 However, where there is connectivity between the tunnel and overlying buildings as a result of a pile interception, the noise level could be in the order of 57dB L_{ASmax}. In these situations, quieter breakout techniques could be required.

9.6.47 Therefore, for the majority of buildings close to the BSCU tunnels, groundborne noise levels due to tunnelling works are not expected to be significant. The exceptions are the locations where there are identified pile interceptions, namely 6-8 Prince's Street, 8-10 Mansion House Place, Newcourt St Swithin's Lane and 33 King William Street. In these locations, the predicted groundborne noise levels have the potential to be significant and as such require mitigation.

Construction Traffic Noise

9.6.48 Road traffic flows represent baseline and predicted 18h Annual Average Weekday Traffic (AAWT) 2-way flows on links surrounding the construction sites and beyond. Where 18h AAWT flows are below the scope of CRTN, 16h AAWT flows have been provided.

9.6.49 Tables A9.6.1 and A9.6.2 within Appendix A9.6 detail these flows and show predicted traffic noise level changes as a result of the diversions during construction works. Table 9.26 provides a summary of the links identified which are predicted to experience traffic flow changes which will result in an increase in traffic noise level of 1dB or greater.

9.6.50 The traffic flows presented in Appendix A9.6 are considered to present a worst case scenario that is likely to occur on the first few days of the closure of Arthur

Street only. Analysis undertaken using the TfL 'ONE' model and presented in the Transport Assessment (Appendix A8.1) shows that once drivers recognise the impact of the diversion route it is expected that they will disperse more widely with a reduced impact across the highway network.

Table 9.26: Road Traffic Noise Changes During Construction Works

Link	Baseline		During Construction		Percentage Change	Noise Level Change (dB)
	18h AAWT	% HDV	18h AAWT	% HDV	18h AAWT	
Cannon St	9745	20	12206	21	25	+1.1
Cannon St (east of Abchurch Lane junction)	9716	21	12365	21	27	+1.1
Cannon St (west of Abchurch Lane junction)	9821	20	12282	21	25	+1.0
Cannon St (between King William street and Nicholas Lane)	9891	20	12684	20	28	+1.1
Cannon St (west of Nicholas Lane junction)	10139	20	12932	20	28	+1.1
Cannon St (east of Queen Victoria Street)	10852	19	13645	19	26	+1.0
Queen Victoria Street west	15000	9	17793	11	19	+1.1
Castle Baynard Street / slip to A3211	2227	15	4644	19	109	+4.1

9.6.51 With reference to Table 9.8, a noise level change of ≤1dB represents a negligible impact, 1-3dB a minor impact and >3dB a moderate impact. Consequently, road traffic flow changes on sections of Cannon Street and Queen Victoria Street are predicted to result in a minor adverse and therefore insignificant effect.

9.6.52 Castle Baynard Street is noted to be in a tunnel along its length until it emerges at the southern end of Lambeth Hill, and merges with the adjacent and more heavily trafficked A3211. Consequently, the +4.1dB increase which would suggest a moderate impact is not considered to be so, as the noise will be contained within the tunnel, resulting in an insignificant effect.

9.6.53 In order to assess the potential impact of HGV movement associated with the removal of excavated material from the Arthur Street Site outside of standard project construction hours, additional road traffic flow data has been provided by the traffic consultant in terms of hourly 'baseline' and hourly 'with 'muck-away' vehicles'.

9.6.54 Table A9.6.3 and A9.6.4 in Appendix A9.6 identify these hourly flows and associated percentage HDV (Heavy Duty vehicles i.e. including buses and coaches). Table A9.6.5 in Appendix A9.6 calculate the associated hourly basic noise levels with Table A9.6.6 illustrating the predicted change.

9.6.55 The relatively few additional HGV (Heavy Goods Vehicles) movements per hour have resulted in no significant adverse effect being identified. Sections of King William Street are predicted to experience a very slight increase (<1dB) in hourly noise level (although more as a result of diversions from the closed Arthur Street link than from 'muck-away' vehicles).

Utilities Works and Compensation Grouting Shafts

9.6.56 In order to construct the BSCU, there are a number of associated enabling utility works that may require to be undertaken. These utility works can be divided into three categories:

- Arthur Street works – diversion and protection of buried utilities prior to the main construction shaft excavation. These works are proposed during standard construction hours only;
- sewer shafts – excavation is required to access major sewers for installing protective linings. One (Low Level 2 Sewer) is located on Walbrook, adjacent to the Walbrook Building (offices). The majority of works are proposed at this site during standard construction hours only, although some below ground strengthening works may be required at other times. The other shaft (to access the London Bridge Sewer) is located at the western end of Lombard Street, adjacent to 1-6 Lombard Street (offices). This work site is required to access an existing sewer shaft and works are proposed during night-time periods only, as full road closure will be required; and
- general utility works - e.g. excavation of trenches, surveying, duct/pipe-laying and connections commissioning. These works are proposed during standard construction hours only.

9.6.57 Grout shafts may be constructed for the purposes of compensation grouting in two locations, at the northern end of Walbrook (adjacent to the Mansion House) and 10 King William Street, which is within the boundary of the Whole Block Site. The majority of works are proposed at these sites during standard construction hours only, although 'grouting' may be required outside these times.

9.6.58 Tables A9.4.11, A9.4.12 and A9.4.13 in Appendix A4 illustrate the anticipated activities and plant associated with the Arthur Street works, sewer shaft and grout shaft construction sites.

9.6.59 Figure 9.2 (see ES Figures Volume) illustrates the locations of the sewer and grout shaft work sites.

9.6.60 The general utilities works are considered relatively minor in comparison to the sewer and potential grout works, with no shaft construction, and compliance with the CoCP requirements is envisaged to be sufficient to mitigate the noise from these works. Quantitative assessment of these works is therefore limited to the assessment of road traffic flow changes.

9.6.61 Table 9.27 identifies receptor locations around the Arthur Street, sewer and potential grout shaft work sites, and the associated assessment criteria.

Table 9.27: Noise Assessment Criteria (façade) – Arthur Street Utility Diversions and Sewer and Potential Grout Shaft Works

Receptor Location	$L_{Aeq,T}$ (dB) above which 'potentially significant' according to BS 5228				LOAEL $L_{Aeq,T}$ (dB)		SOAEL $L_{Aeq,T}$ (dB)	
	Method 1 (ABC method) for residential receptors		Method 2 (5dB change method)					
	Day	Night	Day	Night	Day	Night	Day	Night
R20 - The Walbrook Building (offices)	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R21 - St Stephen's Church, Walbrook	n/a	n/a	67	n/a	59	n/a	65	n/a
R22 - Mansion House western façade (some residential use)	75	n/a	72	n/a	60	45	75	63
R23 - 1-6 Lombard Street (offices)	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R24 - St Mary Woolnoth Church and cafe	n/a	n/a	75	n/a	67	n/a	72	n/a
R25 - Mansion House north-east corner (some residential use)	75	64	72	67	60	45	75	64
R26 - City of London Magistrates Court	n/a	n/a	72*	n/a	64***	n/a	72**	n/a
R4 - St. Mary Abchurch	n/a	n/a	67	n/a	59	n/a	65	n/a
R6 - 15 Abchurch Lane (Capital Club)	n/a	n/a	67	n/a	65	n/a	70	n/a

Receptor Location	$L_{Aeq,T}$ (dB) above which 'potentially significant' according to BS 5228				LOAEL $L_{Aeq,T}$ (dB)		SOAEL $L_{Aeq,T}$ (dB)	
	Method 1 (ABC method) for residential receptors		Method 2 (5dB change method)					
	Day	Night	Day	Night	Day	Night	Day	Night
R7 - Daiwa offices	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R8 - 81 King William St offices	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R14 – 28 Martin Lane (residential)	75	n/a	73	n/a	60	n/a	75	n/a
R15 – 10 Arthur Street (offices)	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R16 – 24 King William Street (offices)	n/a	n/a	n/a	n/a	80	n/a	90	n/a
R17 – 33 King William Street (offices)	n/a	n/a	n/a	n/a	80	n/a	90	n/a

*assumed to be 'community use' as referenced in BS 5228 method 2 **based on method 2 ***5dB less than ambient

9.6.62 Where 'n/a' is specified in Table 9.27, either the identified receptor is not considered noise sensitive or works are not proposed in the vicinity within the stated time period.

9.6.63 Table 9.28 identifies the predicted noise levels at identified receptor locations in proximity to the Arthur Street work site. 2.3m Heras type fencing with acoustically insulated panels is assumed around the work site.

Table 9.28: Arthur Street Works Predicted Noise Levels, at Worst Affected Floor

Receptor	Activity	Daytime façade $L_{Aeq,1h}$ (dB)
R14 – 28 Martin Lane (residential)	Excavation	72
	Utility Works	75
	Re-instatement	75
R15 – 10 Arthur Street (offices)	Excavation	71
	Utility Works	75
	Re-instatement	75
R16 – 24 King William Street (offices)	Excavation	80
	Utility Works	84
	Re-instatement	85
R17 – 33 King William Street (offices)	Excavation	76
	Utility Works	80
	Re-instatement	80

9.6.64 Predicted noise levels associated with the Arthur Street works do not exceed the threshold considered potentially significant (BS 5228 Method 1 criteria or the SOAEL) at 28 Martin Lane. The assessment is based on a worst-case assumption that all plant will operate within the same 1-hour period. Such an occurrence is very unlikely and no significant effect is expected.

9.6.65 At office receptors R15, R16 and R17 the predicted noise levels are noted to be below the defined SOAEL but above the defined LOAEL and as such are not considered to be significant.

9.6.66 Table 9.29 identifies the predicted noise levels at identified receptor locations in proximity to the Low Level 2 sewer shaft site. 2.4m solid hoarding is assumed around the work site.

9.6.67 Noise levels associated with the Low Level 2 Sewer shaft are predicted to marginally exceed the (daytime) SOAEL at St Stephen's Church (R21), which is significant. The other identified receptors in proximity are not predicted to experience noise levels exceeding the defined SOAELs, although the LOAEL at the Walbrook Building (offices) is exceeded. This is not considered to be significant; however, the requirements of the CoCP will be applied to minimise noise as much as practicable.

Table 9.29: Low Level 2 Sewer Shaft Predicted Noise Levels, at Worst Affected Floor

Receptor	Daytime façade $L_{Aeq,1h}$ (dB)
R20 - The Walbrook Building (offices)	85
R21 - St Stephen's Church, Walbrook	68
R26 - City of London Magistrates Court	62
R22 - Mansion House western façade (some residential use)	53

Note: Other buildings are located off Walbrook, including the Walbrook dining club at 37A. However, the significant shielding afforded by the Walbrook building itself will result in insignificant noise effects at this location.

9.6.68 Conservatively assuming that the same plant may operate outside standard construction hours (for below ground strengthening works only), the predicted noise level of 53dB is not considered significant at the western façade of the Mansion House (R22), which currently experiences relatively high ambient night-time noise levels and has a defined SOAEL of 63dB.

9.6.69 Table 9.30 identifies the predicted noise levels at identified receptor locations in proximity to the London Bridge sewer shaft site. 2.3m Heras type fencing with acoustically insulated panels is assumed around the shaft site.

Table 9.30: London Bridge Sewer Shaft Predicted Noise Levels, at Worst Affected Floor

Receptor	Night-time façade $L_{Aeq,1h}$ (dB)
R25 - Mansion House north-east corner (some residential use)	55

Note: Other buildings are located close to the London Bridge sewer shaft, including the offices at 1-6 Lombard Street and St Mary Woolnoth Church and cafe, however, only the Mansion House is considered sensitive during the night-time period.

9.6.70 Predicted (night-time) noise levels, associated with the London Bridge Sewer shaft are below those considered potentially significant according to *BS 5228* and below the defined SOAEL at the Mansion House. There are no other receptors in the vicinity considered noise sensitive at night. Consequently, effects are not considered to be significant.

9.6.71 Table 9.31 identifies the predicted noise levels at identified receptor locations in proximity to the potential Walbrook grout shaft site. All predictions assume 2.4m solid hoarding around the anticipated work site.

Table 9.31: Walbrook Grout Shaft Predicted Noise Levels, at Worst Affected Floor

Receptor	Activity	Façade $L_{Aeq,1h}$ (dB)
R22 - Mansion House western façade (some residential use)	Initial Works	78
	Shaft Excavation Works	83
	Grouting	79
	Reinstatement	83
R21 - St Stephen's Church, Walbrook	Initial Works	69
	Shaft Excavation Works	72
	Grouting	72
	Reinstatement	72
R26 - City of London Magistrates Court	Initial Works	79
	Shaft Excavation Works	82
	Grouting	81
	Reinstatement	82

9.6.72 Due to the close proximity of the potential Walbrook grout shaft, predicted noise levels at the Mansion House (R22), St Stephen's Church (R21) and the Magistrates Court (R26) exceed the defined daytime SOAELs. Therefore, based on the currently identified list of anticipated plant, significant adverse effects are expected at these three receptor locations. Should 'grouting' activities occur outside standard construction hours, additional significant adverse effects are expected at the Mansion House. The application of the CoCP will minimise adverse effects as much as practicable. Due to the nature and location of the works, no further mitigation is considered practicable.

9.6.73 Table 9.32 identifies the predicted noise levels at identified receptor locations in proximity to the proposed 10 King William Street grout shaft site. All predictions assume 2.4m solid hoarding around the anticipated work site.

9.6.74 Noise levels associated with the grout shaft at 10 King William Street are predicted to exceed the (daytime) SOAEL during excavation and reinstatement works at St Mary Abchurch (R4) and 15 Abchurch Lane (R6), which is considered to be significant. At the nearest identified office receptors (81 King William Street (R8) and Daiwa offices (R7)) neither the LOAEL or SOAEL is exceeded and the predicted noise levels are not considered to be significant.

9.6.75 Assuming compliance with the CoCP document, including the employment of best practicable means, adverse noise effects will be minimised from the Arthur Street works and the sewer and potential grout shaft sites.

Table 9.32: 10 King William Street Grout Shaft Predicted Noise Levels, at Worst Affected Floor

Receptor	Activity	Façade $L_{Aeq,1h}$ (dB)
R4 - St Mary Abchurch	Initial Works	64
	Shaft Excavation Works	68
	Grouting	65
	Reinstatement	67
R6 - Capital Club (15 Abchurch Lane)	Initial Works	70
	Shaft Excavation Works	74
	Grouting	68
	Reinstatement	74
R7 - Daiwa Offices	Initial Works	73
	Shaft Excavation Works	77
	Grouting	76
	Reinstatement	77
R8 - 81 King William Street offices	Initial Works	72
	Shaft Excavation Works	75
	Grouting	75
	Reinstatement	75

General Utility Works – Road Traffic Noise

9.6.76 Although the general utilities works are considered relatively minor in terms of potential noise impact, they may have an impact on road traffic flows on surrounding links due to additional HGV movements and necessary diversions. Therefore, a quantitative assessment has been undertaken.

9.6.77 The scenarios for which road traffic data has been provided are described in Appendix A8.3 (Utilities ES Highways Assessment), and are:

1. Cannon Street westbound diversion;
2. King William Street southbound diversion;
3. King William Street southbound and Gresham Street eastbound diversion;
4. King William Street southbound and Gresham Street westbound diversion; and
5. King William Street southbound and Prince's Street southbound diversion.

9.6.78 The majority of the flows are provided as 18hr AAWT flows, as required by the CRTN prediction methodology. However, where the 18hr flows are below 1000, and therefore outside the range of CRTN, 16hr flow data and the NAC methodology have been used.

9.6.79 Road traffic flows, provided in terms of baseline flows and flows as a result of construction traffic and associated diversions are provided in Table A9.6.7 in Appendix A9.6. Table A9.6.8 in Appendix A9.6 illustrates the predicted basic noise level, and the consequent change in traffic noise levels as a consequence of each scenario.

9.6.80 With the exception of Mansion House Place (south arm), predicted traffic noise levels on any identified link during any scenario do not increase by 3dB or more and are therefore considered to be no more than a minor effect, and as such not significant. On Mansion House Place (south arm) the increase of 4.9dB suggests a moderate effect. However, the baseline and construction traffic flows on this link are very low at less than 50 vehicles; therefore the predicted traffic noise levels (using the NAC method) are very low. Predicted traffic noise levels at receptors along this link are therefore likely to be considerably below the existing measured noise levels in this area which are well over 60dB L_{Aeq} (façade), during the day due to road traffic on Mansion House Street and Lombard Street/King William Street. Therefore, even with the addition of HGVs on this link, overall noise levels are not expected to increase significantly due to the existing influence of road traffic noise from adjacent primary roads.

9.6.81 Consequently, the effect on existing traffic noise levels due to construction traffic and diversions is considered a minor adverse effect and is not significant.

Blockade

9.6.82 In order to minimise the impacts of the ‘total blockade’ (April/May 2020) and ‘partial blockade’ (May/August 2020) upon services and passengers, LUL are developing a package of potential mitigation measures.

9.6.83 In terms of the potential noise and vibration consequences, anticipated additional bus movements and London Underground services have been considered.

Bus services

9.6.84 Table 9.33 identifies the anticipated additional bus movements.

Table 9.33: Blockade Road Traffic Noise Assessment

Link	Additional Buses (2-way per AM peak hour)		Additional Buses (2-way per PM peak hour)	
	Total Blockade	Partial Blockade	Total Blockade	Partial Blockade
A3200 York Road	6	-	4	-
A201 Blackfriars Bridge	6	-	6	6
A3 Borough High Street	16	16	8	10
Nine Elms to Vauxhall Station corridor	10	10	10	10
A200 St Thomas Street	-	-	2	2
A100 Tower Bridge Road	-	-	10	6

9.6.85 The minimal additional traffic flows in Table 9.33 are considered insignificant in environmental noise terms, relative to existing peak hourly flows on the identified links, and will therefore not result in any significant effects.

London Underground Services

9.6.86 Increased London Underground flows are proposed on the Charing Cross branch of the Northern Line. Table 9.34 identifies these flows and the consequent change in predicted 16h VDV.

Table 9.34: Blockade London Underground Service Hourly Flows (07:00 to 10:00) and Percentage Change in 16h VDV

Link	Baseline		During (Total) Blockade		% Flow Change	16h VDV % change
	Northbound	Southbound	Northbound	Southbound		
Charing Cross Branch	24	24	32	32	33	+1

9.6.87 This low percentage increase in the 16h VDV is not considered significant.

Operational Noise (Fixed Plant)

9.6.88 For noise from building services and/or other fixed plant, the City of London Corporation requires rating level at facades of the closest noise sensitive

properties to be 10dB below the background noise level. This is considerably below the LOAEL of equal to background, and the SOAEL of +10dB above background.

9.6.89 Using the same receptor locations as for the demolition and construction assessment in the vicinity of the Whole Block Site, Table 9.35 lists the minimum background noise levels either measured directly or derived from measurements taken at comparable locations. Measured background noise levels at R2 (N6) have been assigned also to R1 and R3; R7 (N2) has been assigned also to R6; and R9 (N1) has been also assigned to R8 and R10.

9.6.90 Table 9.35 also presents the rating level required to satisfy the City of London Corporation's requirements. Daytime levels are given for all locations; night-time noise levels are included for the residential receptors only.

Table 9.35: Background Noise Levels and Required Rating Levels

Receptor Location	Minimum Measured dB $L_{A90,T}$ Façade (Daytime)	Minimum Measured dB $L_{A90,T}$ Façade (Night-time)	Required Façade Rating Level (Daytime) dB $L_{Ar,1h}$	Required Façade Rating Level (Night-time) dB $L_{Ar,5min}$
R1	55	-	45	-
R2	52	51	42	41
R3	55	-	45	-
R4	53	-	43	-
R5	53	44	43	34
R6	53	-	43	-
R7	57	-	47	-
R8	64	-	54	-
R9	64	-	54	-
R10	64	-	54	-
At office locations (R1, R3 and R7-10), measured weekday 12 hr levels (07:00 to 19:00) are stated. At residential location R2, measured 16 hr daytime levels (07:00 to 23:00 including weekends) are stated. At the Travelodge (R5) the lowest of the short-term day and evening measurements are stated. At St Mary Abchurch (R4) the lowest of the short-term day, evening and Sunday measured levels are stated. At 15 Abchurch Lane (R6), measured 16 hr daytime levels (07:00 – 23:00 including weekends) are stated to represent the opening hours of the restaurant/private members club.				
T = 1h at R1-R3 and R6-R10 i.e. receptors based on long term monitoring sites. T = 5min at R4 and R5 i.e. receptors based on short term monitoring sites.				

9.6.91 The lowest ratings that would need to be achieved are therefore 34dB and 41dB, which can be assumed as proxy design standards for fixed plant.

9.6.92 In order to demonstrate that these noise limits can be achieved, SoundPLAN noise modelling software has been employed to predict worst-case noise levels incident at the selected receptor locations as a result of operation of known plant and breakout from proposed louvres around the Whole Block Site, and on that basis, to identify likely noise attenuation requirements.

9.6.93 Appendix A9.7 provides details on this modelling exercise, in terms of the noise source data employed and the locations of the various associated louvres (Figure A9.7.1). Assuming 24 hour operation, attenuation requirements to meet the proxy noise standards are summarised in Table 9.36. The predictions conservatively assume incorporation of a 5dB acoustic feature correction in accordance with *BS 4142.*

Table 9.36: Fixed Plant Noise Attenuation Requirements

Plant Item	Attenuation Requirement (dB)
Travelator Fan	48
Air Release Fan	24
Heat Rejection Plant	23
Transformer Room Fan	14
Supply Fan	25
Air Handling Unit (discharge)	0

9.6.94 The attenuation requirements identified in Table 9.36 are considered achievable with appropriate attenuation (e.g. silencers, acoustic louvres) to be determined at detailed design stage. Consequently, and assuming incorporation of the required attenuation, the predicted noise levels will be negligible and no significant adverse noise effects are anticipated.

Operational Vibration and Groundborne Noise

9.6.95 The prediction of groundborne noise and vibration from the operation of trains in the new running tunnel is derived from predictions for vibration experienced inside the overlying buildings. The results presented in this section are due to the operation of the new southbound tunnel only. Since the BSCU will not alter the other underground railways within the study area, the vibration and groundborne noise levels due to these other railways will not change as a result of the BSCU. Similarly, the baseline levels inside buildings will not change unless the predicted levels from the new southbound tunnel result in an increase above the existing baseline.

9.6.96 In addition, the removal of operational trains through a section of the existing southbound running tunnel has the potential to provide a slight beneficial impact to properties close to these sections of the existing tunnels.

9.6.97 The assessment of effects from groundborne noise and vibration is based on the absolute level of predicted noise or vibration at the lowest floor of the building, where effects would be greatest. The predictions have been undertaken for the identified receptor locations along the route of the new southbound running tunnel. The predictions have considered the buildings that are most sensitive to groundborne noise and vibration, which are primarily residential and ecclesiastical buildings. In addition, the study has considered the locations where building piles will be intercepted by the new tunnel, see Figure 9.3 (ES Figures Volume).

Vibration

9.6.98 The vibration predictions have considered the buildings that are most sensitive to groundborne vibration, which are primarily residential buildings. In addition, the study has considered the locations where building piles will be intercepted by the new tunnel.

9.6.99 The vibration predictions are provided in terms of the day and night VDV, which have been estimated for each receptor. The results of the predictions are provided in Table 9.37.

Table 9.37: Predicted Groundborne Vibration Levels

Receptor	Building Usage	Predicted Vibration Dose Values, $ms^{-1.75}$	
		Day (07:00-23:00)	Night (23:00-07:00)
6-8 Prince's Street	Office	0.067	0.048
Mansion House	Residential	0.012	0.008
8-10 Mansion House Place	Office	0.067	0.048
New Court, St Swithin's Lane	Office	0.067	0.048
St Mary Abchurch	Ecclesiastical	0.012	0.008
28 Martin Lane	Residential	0.012	0.008
33 King William Street	Office	0.067	0.048

9.6.100 These results show that vibration dose values are all predicted to be well below $0.2ms^{-1.75}$ during the daytime and $0.1ms^{-1.75}$ during the night, which is below LOAEL and means, according to *BS 6472-1:2008,* that adverse comment would not be expected. As such, these predicted vibration levels would have a very low impact, which at high sensitivity receptors (i.e. residential properties

and places of worship), would give rise to a minor effect, which is not significant. Effects would be negligible at the medium sensitivity receptors (i.e. commercial premises including offices and shops).

Groundborne Noise

9.6.101 The assessment of effects from groundborne noise is based on the absolute level of predicted noise at the lowest floor of the building, where effects would be greatest.

9.6.102 The predictions have been undertaken for the identified receptor locations along the route of the new running tunnel. The results of the predictions are shown in Table 9.38.

Table 9.38: Predicted Groundborne Noise Levels

Receptor	Building Usage	Predicted Groundborne Noise Level, dB L_{AFmax}
6-8 Prince's Street	Office	35
Mansion House	Residential	34
8-10 Mansion House Place	Office	35
New Court, St Swithin's Lane	Office	35
St Mary Abchurch	Ecclesiastical	34
28 Martin Lane	Residential	34
33 King William Street	Office	35

9.6.103 The assessment assumes that the new tunnel intercepts the piled foundations of 6-8 Prince's Street, 8-10 Mansion House Place, New Court and 33 King William Street. As such, the predictions assume a high performance trackform at these locations, which will reduce the vibration transfer into the intercepted piles. At the remaining locations, the predictions have assumed that the tunnel will be constructed with a standard trackform including resilient baseplates.

9.6.104 These predictions demonstrate that the expected groundborne noise levels are no more than 35dB L_{AFmax}. Therefore, the magnitude of the impact is considered to be very low, which when considered at high sensitivity receptors such as residential dwellings, results in a minor effect, which is not considered to be significant. At medium sensitivity receptors, such as offices, the predicted noise level results in a negligible effect which is not considered to be significant. At St Mary Abchurch, where the significance threshold is 35dB L_{AFmax}, predicted groundborne noise levels are 34dB L_{AFmax}, which are 1dB below the threshold and are considered to be a minor adverse effect which is not significant.

9.7 Mitigation

Demolition and Construction

9.7.2 In addition to the incorporated mitigation identified within Section 9.5, additional mitigation at the Whole Block Site in the form of acoustically insulated scaffold hoarding is proposed along the length of Abchurch Lane during the demolition of the adjacent buildings.

9.7.3 This will block the line of sight between noise source and receiver as the existing building is reduced down in size. As the building reduces in height, so will the scaffolding and hoarding, down to a height of 3.6m.

9.7.4 No additional mitigation is required for receptors affected by works at the Arthur Street Work Site.

Below ground Construction

9.7.5 Wherever possible, SCL breakout will be avoided or minimised, including through careful profiling control during SCL construction. Where pile interceptions occur, LUL will seek to undertake nearby and associated SCL breakout outside of core office hours to minimise disturbance. Alternatively, quieter breakout techniques will be employed.

9.7.6 Although percussive breakout may be the most efficient breakout method it is accepted that there are quieter techniques that could potentially be employed in certain circumstances should that be necessary and practicable.

Operation

9.7.7 The assessment of effects of fixed plant noise has shown that the design is capable of meeting the design target and as such no specific mitigation is required.

9.7.8 The assessment of effects due to operational groundborne noise and vibration has shown that the proposed tunnel and track design reduces groundborne noise levels to below the threshold of significance at all receptors. As such, the assessment has not identified the need for any additional mitigation for operational groundborne noise and vibration.

9.8 Residual Effects

Demolition and Construction

9.8.2 With the implementation of acoustically insulated scaffold hoarding along the Abchurch Lane perimeter of the Whole Block Site during demolition activities, resultant noise levels at receptors to the west are predicted to reduce by approximately 10dB for the period of time when line of sight will be blocked between source and receiver.

9.8.3 Therefore, although the worst-case predicted noise levels will remain when the hoarding is reduced to 3.6m, the duration when significant effects are likely will be reduced to a minimum, estimated in weeks rather than months. As such, there remains a significant adverse effect due to construction noise at receptors R4 (St Mary Abchurch) and R6 (15 Abchurch Lane), although it should be noted that the period of time for which there is a significant adverse effect at these receptors is reduced with the implementation of the proposed mitigation.

9.8.4 With regard to potential compensation grouting works, significant adverse effects are predicted at the same receptors (R4 and R6) as a result of the works associated with the shaft within the Whole Block Site. The proximity of the potential compensation grouting work site at Walbrook to nearby receptors means that significant adverse effects are also predicted during the day and night at the Mansion House (R22), and during the day at St Stephen's Church (R21) and the Magistrates Court (R26).

9.8.5 The implementation of the CoCP and best practicable control measures will minimise the negative effects at all surrounding receptors throughout the duration of all demolition and construction activities.

Below Ground Construction

9.8.6 At the locations of known pile interceptions, the use of alternative SCL breakout methods will be employed where it is not possible to avoid a significant groundborne noise effect by undertaking the works when the buildings are not in maximum occupation. Through the adoption of alternative working hours, or breakout techniques, it is considered that significant effects are unlikely.

Operation

9.8.7 With the incorporation of bespoke mitigation measures for all fixed plant associated with the development, which will be finalised at detailed design stage, the effects are as previously presented and are not significant.

9.8.8 There are no mitigation measures, beyond those included in the incorporated mitigation section, required for operational groundborne noise and vibration. As such, the residual effects are as presented in Section 9.7 Assessment of

Effects, which demonstrates that groundborne noise and vibration are not significant.

9.9 Inter-relationships and Cumulative Effects

9.9.1 Within 500m of the BSCU Work Sites, there are a number of proposed developments where a planning application has been submitted, a resolution to grant permission given or where construction has commenced. These are listed in Chapter 17: Inter-relationships and Cumulative Effects, and have the potential to result in cumulative noise or vibration effects.

9.9.2 However, given the distances between these and the BSCU Work Sites, acoustic shielding afforded by intervening buildings, and the levels of existing noise in the area as a result of road traffic, it is considered reasonable to assume that adverse or significant adverse cumulative effects of noise or vibration would not result, either during construction or operation of these developments.

9.9.3 By commencement of Arthur Street works in 2016, the 33 King William Street development is anticipated to be largely complete, with only cladding and fit-out work on-going to shortly beyond Q1 2016. Adverse cumulative effects are therefore considered unlikely.

9.9.4 Consideration has also been given to the potential cumulative effects relating to the OSD, particularly during the period where the current construction programme may overlap with that of the OSD i.e. Q2 2020 to Q2 2021 – when the final stages of the BSCU may overlap with sub-structure, superstructure and fit-out activities associated with the OSD development.

9.9.5 It is considered that the greatest likelihood for adverse or significant adverse cumulative noise effects would result from construction traffic, as construction noise from non-traffic related sources would generally be shielded by intervening buildings (and the OSD building) and minimised through the application of the CoCP.

9.9.6 However, with regard to construction traffic, it is considered that due to the existing high traffic flows on surrounding road links, and the relatively few movements associated with the construction works, that the cumulative noise impact at any receptor location would be negligible. Evidence of this can be found within Chapter 8: Transport and Movement, which indicates insignificant percentage changes in 12 hour flows of between zero and two per cent. Therefore no adverse cumulative traffic noise effects (significant or otherwise) are anticipated.

9.9.7 In terms of operational (plant) noise, preliminary assessment of the plant likely to be installed on the roof of the OSD development has identified no significant cumulative effect. Bespoke mitigation, particularly to potential adiabatic coolers

will ensure rating levels at surrounding receptor locations (including the upper floors of the Travelodge on Sherbourne Lane) will not exceeded the CoL requirements.

9.9.8 Therefore, while the OSD has its own environmental noise effects, no significant cumulative effect is anticipated as a result of the BSCU.

9.10 Assumptions and Limitations

9.10.1 For the demolition and construction assessment, a number of assumptions have been made in terms of activities, associated plant, on-times, working combinations, and locations. Assessments have been made based on the best information available in consultation with LUL's contractors and other informed parties, and designed to represent reasonably worse than likely scenarios.

9.10.2 With regard to the assessment of fixed plant associated with the development, a number of assumptions have been agreed with informed parties in order to enable quantitative assessment. Although final details will not be determined until detailed design stage, the assessment illustrates that the required target ('rated') noise levels are achievable.

9.11 Conclusions

9.11.1 Surveys have been undertaken at selected locations surrounding the BSCU Work Sites, enabling a comprehensive understanding of the existing noise and vibration climate.

9.11.2 This understanding has facilitated the assessment of demolition, construction and operational noise and vibration by means of comparing predicted noise and vibration levels against determined thresholds, including the LOAEL and SOAEL, and assessing the consequent significance of effects.

9.11.3 Following the incorporation of proposed mitigation measures, an assessment of demolition and construction noise, including those associated with utility works and potential compensation grouting, has identified that the majority of the activities can be undertaken without giving rise to significant adverse effects at the majority of receptor locations. However, significant residual adverse effects remain at receptors R4 and R6 due to works at the Whole Block Site and at receptors R21, R22 and R26, as a result of possible grout shaft works; however, these effects are considered to be mitigated and minimised as far as practicable.

9.11.4 An assessment of vibration as a result of proposed piling techniques at both main work sites has identified no significant adverse effects.

9.11.5 The assessment of groundborne noise from below ground construction has shown there is the potential for significant effects to arise within the buildings

where pile interceptions will occur. However, through the adoption of alternative working hours, or breakout techniques, it is considered that significant effects are unlikely.

9.11.6 An assessment of road traffic flows during construction activities and associated diversions, including the removal of excavated material by HGVs during the night-time periods, and relating to general utility works, has identified no significant adverse effects.

9.11.7 An assessment of additional bus movements and London Underground services during the proposed blockade has identified no significant adverse effects in terms of noise or vibration.

9.11.8 With the incorporation of bespoke mitigation measures for all fixed plant associated with the development (to be determined at detailed design stage) no significant adverse effects are anticipated.

9.11.9 The track within the new running tunnel will be designed and constructed to ensure that operational groundborne noise and vibration will not be significant at all identified noise sensitive receptors within the study area.

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