AECOM Environment Stadium Capital Holdings November 2012

Midland Crescent Noise and Vibration Assessment

Prepared by: ...... Checked by:

Edward Robinson
Environmental Scientist

Nigel Triner
Associate Director

Approved by:

Nigel Triner
Associate Director

Midland Crescent Noise and Vibration Assessment

Rev No	Comments	Checked by	Approved by	Date

9th & 10th Floors, Sunley House, 4 Bedford Park, CR0 2AP
Telephone: 020 8639 3500 Website: http://www.aecom.com

Job No 60198251 Reference EWFR Date Created November 2012

Table of Contents

Capabilities on project:
Environment

1 Introduction

AECOM ltd was tasked by Stadium Capital Holdings Ltd to assess the suitability of a site on Finchley Road, London for development of student accommodation in terms of noise and vibration.

A noise survey was undertaken to evaluate the current noise levels at the site. The noise measurements were used to predict the propagation of noise across the site and suitability of the site for residential development was assessed using guidance within the National Planning Policy Framework and BS 8233 – '*Sound Insulation and Noise Reduction for Buildings – Code of Practice'.*

A vibration survey was undertaken to assess the vibration level from train movements on the rail track adjacent to the north and south boundaries of the proposed site. Daytime and night-time vibration levels were assessed following the principles of the guidance within BS 6472:2008 – '*Guide to evaluation of human exposure to vibration in buildings*'.

2 Assessment Methodology & Significance Criteria

2.1 Perception of Noise

Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in pascals, Pa). Because of this wide range a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140 dB.

The human auditory system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB(A).

Table 1 lists the sound pressure level in dB(A) for common situations.

Table 1: Noise Levels for Common Situations

Typical Noise Level, dB(A)	Example
0	Threshold of hearing
30	Rural area at night, still air
40	Public library, Refrigerator humming at 2m
50	Quiet office, no machinery, Boiling kettle at 0.5m
60	Normal conversation
70	Telephone ringing at 2m, Vacuum cleaner at 3m
80	General factory noise level
90	Heavy goods vehicle from the pavement, Powered lawnmower, operator’s ear

All values are A-weighted sound pressure levels in dB re 2 x 10^{-5} Pa

The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy motorway, the noise level may vary over a range of 5 dB(A), whereas in a suburban area this range may increase by up to 40 dB(A) or more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, night noise levels are significantly reduced by approximately 10 dB(A) compared to daytime levels. When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second to second variations.

The noise index $L_{A90,T}$ is widely used for assessing background noise level. This describes the noise level exceeded for 90% of the measurement period, T, and generally reflects the noise level in the lulls between individual noise events. Over a 1-hour period, the $L_{A90,1h}$ will be the noise level exceeded for a total of 54 minutes during that period.

The total noise or ambient noise at a location during a specific period is usually measured using the equivalent continuous A-weighted sound pressure level, L_{Aeq}, (as recommended by BS 7445). This is the single number that represents the sound energy measured over a given time period, T. $L_{Aeq,T}$ is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period, T. It is commonly used to express the energy level from individual sources that vary in level over their operational cycle.

The $L_{Amax,FAST,T}$ measurement parameter is the maximum instantaneous sound pressure level attained during the measurement period T, measured on the ‘FAST’ response setting of the sound level meter. It is generally used to assess the likelihood of night-time sleep disturbance.

In the UK the noise index traditionally used to assess the impacts of road traffic noise is the $L_{A10,18h}$. This is the arithmetic average of the 18-one hourly noise indices $L_{A10,1h}$, i.e. the arithmetic average of the noise level exceeded for 10% of each hourly period from 0600 to midnight. This noise index has been shown to provide a reasonable correlation with resident's disturbance from road traffic noise experienced in their homes.

Human subjects, under laboratory conditions, are generally capable of noticing changes in steady levels of about 1 dB(A) or more. It is generally accepted that a change of 10 dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. (These findings do not necessarily apply to transient, non-steady or intermittent noise sources). A list of acoustic terminology can be found in Appendix A.

2.2 National Policy – The National Planning Policy Framework

The National Planning Policy Framework (NPPF) was published on 27 March 2012, coming into immediate effect and replacing all previous Planning Policy Guidance notes (PPGs) and Planning Policy Statements (PPSs). As such the relevant paragraphs from the NPPF relating to noise are set out below.

Paragraph 109: The planning system should contribute to and enhance the natural and local environment by:

- preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability;

Paragraph 123: 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 impacts1 on health and 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 ; 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.

Paragraph143: In preparing Local Plans, local planning authorities should:

- set out environmental criteria, in line with the policies in this Framework, against which planning applications will be assessed so as to ensure that permitted operations do not have unacceptable adverse impacts on the natural and historic environment or human health, including from noise, dust, visual intrusion, traffic, tip- and quarry-slope stability, differential settlement of quarry backfill, mining subsidence, increased flood risk, impacts on the flow and quantity of surface and groundwater and migration of contamination from the site; and take into account the cumulative effects of multiple impacts from individual sites and/or a number of sites in a locality;
- when developing noise limits, recognise that some noisy short-term activities, which may otherwise be regarded as unacceptable, are unavoidable to facilitate minerals extraction.

Paragraph 144. When determining planning applications, local planning authorities should:

- ensure that any unavoidable noise, dust and particle emissions and any blasting vibrations are controlled, mitigated or removed at source , and establish appropriate noise limits for extraction in proximity to noise sensitive properties;

The National Planning Policy Framework (March 2012) replaces the following noise specific documents:

- Planning Policy Guidance 24: Planning and Noise (3 October 1994)
- Minerals Policy Statement 2: Controlling and Mitigating the Environmental Effects of Minerals Extraction In England. This includes its Annex 1: Dust and Annex 2: Noise (23 March 2005 - Annex 1: 23 March 2005 and Annex 2: 23 May 2005)

2.3 Consultation

Consultation with Claire Shepherd, who is an Environmental Health Officer of the London Borough of Camden, was carried out on 26th October 2012. It was advised that 'good' internal noise levels stated within BS 8233 would be desirable for the proposed development but there may be some scope for relaxing the noise level criteria if noise limits were not achievable.

2.4 Vibration Assessment Methodology

British Standard BS 6472: 2008 '*Guide to evaluation of human exposure to vibration in buildings*' provides guidance on predicting the human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. The standard uses the Vibration Dose Value (VDV), derived from frequency weighted vibration measurements, to estimate the probability of adverse comment from people exposed to vibration in buildings. Factors include periods of exposure and the type of building.

VDVs may be used to assess the severity of impulsive and intermittent vibration, such as experienced from blasting at quarries or from rail traffic, and steady vibration such as from a busy road or fixed plant.

The adoption of the VDV parameter is based on social studies undertaken in the 1980s and early 1990s into human response to vibration. BS 6472 requires that the VDV be determined separately for the 16-hour daytime (07.00-23.00) and 8-hour night-time (23.00-07.00) periods.

The VDV is given by the fourth root of the integral of the fourth power of the acceleration after it has been frequency-weighted, as follows:

$$VDV = \left(\int_0^T a^4\,(t)dt\right)^{0.25}$$

Where:

- VDV is the vibration dose value (in $ms^{-1.75}$),
- a(t) is the frequency-weighted acceleration (ms^{-2}), and:
- T is the total period of the day (in seconds) during which vibration may occur.

Even though the VDV is a form of energy averaging over time, it is much more sensitive to changes in vibration magnitude than duration i.e. the VDV has a time-dependency which means that a two-fold increase or decrease in vibration magnitude is equivalent to a 16-fold increase or decrease in the duration of the vibration.

The VDV is measured in each of the three geo-centric axes and the maximum from the three axes used. Where the vibration conditions are constant or regularly repeated only one representative period need be measured (or predicted) and the 16-hour daytime (or 8-hour night-time) overall VDV level may be calculated from the shortened data.

The VDV may then be compared to Table 1 of BS 6472, (reproduced below as Table 4), to identify the likely impact.

Table 2: BS 6472 Assessment Criteria

Location	**Low probability of adverse comment ($ms^{-1.75}$)**	**Adverse comment possible ($ms^{-1.75}$)**	**Adverse comment probable ($ms^{-1.75}$)**
Residential Buildings (07.00 – 23.00)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings (23.00 – 07.00)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

For example, for VDV values between 0.4 and 0.8 $ms^{-1.75}$ adverse comment regarding daytime vibration levels becomes possible, or when the VDV increases above 0.51 $ms^{-1.75}$ at night adverse comment becomes probable. For office and workshops, the suggested daytime limits above are relaxed by a factor of 2 and 4 respectively.

There are two important implicit assumptions about the subjective response to vibration which are incorporated in the VDV criteria in BS 6472, i.e. that:

- a doubling of vibration level (i.e. applying a factor of 2 to the acceleration or velocity curves) gives rise to a doubling of response; and
- the duration of continuous vibration or the number of discrete vibration events is relatively unimportant compared to the magnitude of the vibration (because the fourth root duration dependency implicit in the VDV algorithm means that a 16 fold increase in the duration of vibration is needed to double the VDV value and therefore the assumed community response).

BS 6472: 2008 may therefore be used to assess the likelihood of adverse comment arising at residential property from temporary or permanent vibration sources introduced into a residential area (demolition, construction, new industrial premises etc.), or from occupiers of future residential property proposed for a site subjected to existing vibration (proposed residential site adjacent to railway lines, for example).

3 Noise and Vibration Survey

3.1 Noise Survey

3.1.1 Measurement Parameters

Attended noise measurements were undertaken with a fully calibrated Norsonic 140 Sound Level Meter (SLM). The meter is subject to a valid UKAS accredited calibration certificate. Field calibration was undertaken using a B&K 4231 calibrator. Certificates of calibration can be found in Appendix B.

Measurement practice was undertaken in accordance with the principles of the relevant British and International Standards e.g. BS 7445 – '*Description and Measurement of Environmental Noise*'.

Various A-weighted statistical noise parameters were recorded including the equivalent continuous noise level, L_{Aeq}, the road traffic noise level, L_{A10}, and the background noise level, L_{A90}. The SLM was set to the 'fast' time response.

3.1.2 Monitoring Locations

The noise monitoring location was at the site boundary adjacent to Finchley Road. A plan of the site indicating the approximate measurement location can be seen in Figure 1.

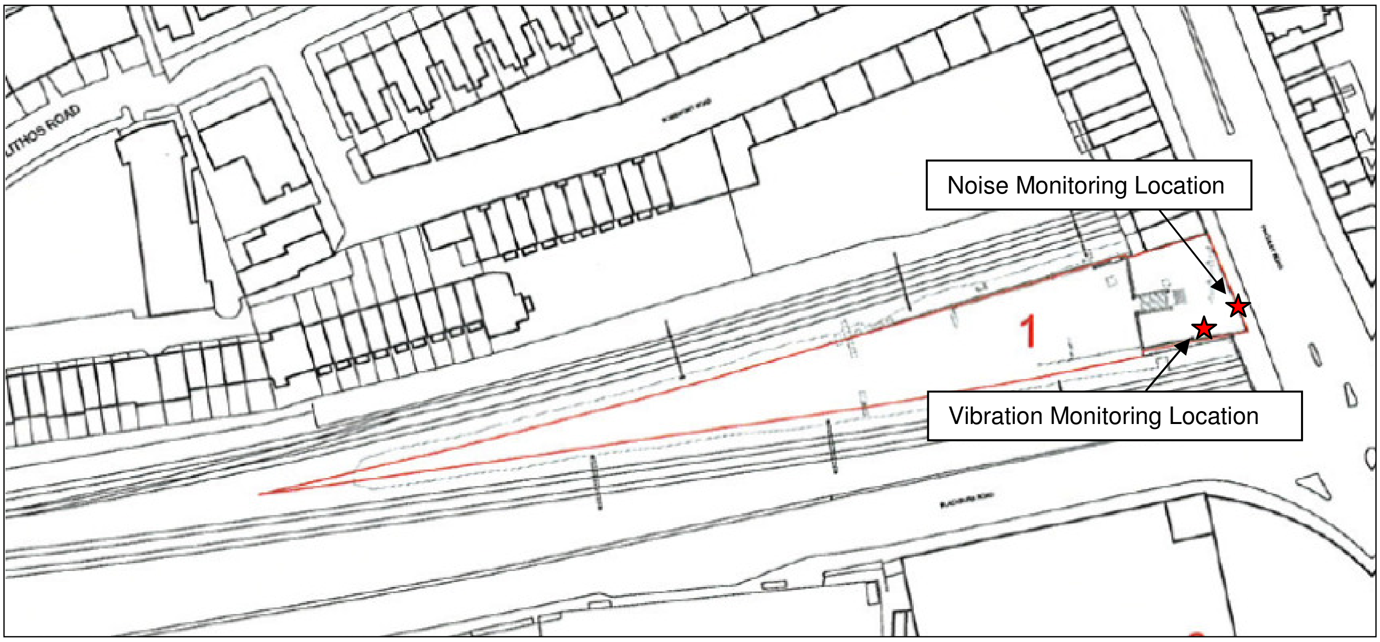


Figure 1: Noise and Vibration Monitoring Locations

3.1.3 Meteorological Conditions

During noise monitoring, weather conditions were dry throughout with an average wind speed of 3 m/s. These weather conditions are conducive for noise measurements.

3.1.4 Noise Sources

The dominant continuous source of noise at the noise monitoring location originated from road traffic on Finchley Road.

Train movements on the railway track adjacent to the north and south site boundaries also contributed to noise levels at the noise monitoring location. However, due to the difference in ground level between the site and the railway track, the ground provided a small degree of screening from rail traffic noise at the monitoring location. Additionally, the close proximity of the monitoring location to Finchley Road resulted in an overall contribution of sound energy from rail traffic that can be considered as secondary in comparison to the sound energy contribution from road traffic; although the intermittent peak noise levels from train pass-by were similar to those from road traffic on the Finchley Road.

Aircraft movements were also noted as a source of noise at the proposed site. However, it was considered that aircraft movements were infrequent and insignificant in terms of sound energy in comparison to road traffic noise and railway noise.

3.1.5 Results

The results of noise measurements taken on 16th March 2011 are presented in Table 5.

Table 3: Noise Monitoring Results

Date	L_{Aeq} dB(A)	L_{Amax} dB(A)	L_{A10} dB(A)	L_{A90} dB(A)
2011/03/16 13:16	79.3	101.7	82.6	69.7
2011/03/16 14:16	80.5	105.6	83.0	70.2
2011/03/16 15:16	78.6	100.4	81.6	70.6
Average	79.5	105.6	82.4	70.2

All values are sound pressure levels in dB(A) re: 2 x 10^{-5} Pa.

3.2 Vibration Survey

Vibration measurements of train movements on the rail track adjacent to the southern boundary of the site (see Figure 1) were carried out at a position approximately 7 metres from the nearside rail at the south boundary. A Rion VM-54 Tri-Axial vibration meter, s/n 00750087 was used to monitor the vibration levels on the proposed site due to train movements.

Measurements were carried out over approximately a 2.5 hour period between 13:30 and 16:00 on 16th March. Over this monitoring period, 32 train movements were observed in both directions. A full list of VDV measurements can be seen in Appendix C.

The highest measured VDV value for train movements was 0.19 $ms^{-1.75}$ on the Z-axis. The average measured value of Z-axis vibration for all train movements was 0.08 $ms^{-1.75}$

4 Assessment

4.1 Noise Modelling

4.1.1 Noise Modelling Methodology

Road traffic noise levels were predicted using the Cadna-A (Computer Aided Noise Abatement) software, which utilises the CRTN methodology. This model uses 18 hour annual average weekday traffic flow data (AAWT), along with the percentage of heavy goods vehicles and average speeds to produce the basic noise level.

4.1.1.1 Daytime Traffic Noise Source

The noise indices used daytime noise assessment is the $L_{Aeq,16h}$, which can be obtained using the shortened measurement procedure in the Calculation of Road Traffic Noise (CRTN) and a conversion factor found within PPG 24 (now withdrawn).

The shortened measurement procedure described within CRTN states:

"*Measurements of L_{10} are made over any three consecutive hours between 1000 and 1700 hours. Using L_{10} (3-hour) as the arithmetic mean of the three consecutive values of hourly L_{10}, the current value of L_{10} (18-hour) can be calculated from the relation:*

L_{10} (18-hour) = L_{10} (3-hour) – 1 dB(A)."

The $L_{A10,18h}$ road traffic noise model output is converted to $L_{Aeq,16h}$ using guidance within PPG 24 (now withdrawn) which advises that for road traffic noise, $L_{Aeq,16h} \sim L_{A10,18h}$ - 2 dB.

Using these conversion methods, the $L_{A10,3h}$ can be converted into an $L_{A10,18h}$ of 81.4 dB(A) and consequently into an $L_{Aeq,16h}$ of 79.4 dB(A). This is approximately equal to the measured $L_{Aeq,1h}$ of 79.5 dB(A) which indicates that road traffic along Finchley Road is consistent throughout the daytime period.

4.1.1.2 Night-time Traffic Source Term

An equation for the conversion of the daytime $L_{A10,18h}$ into the night-time $L_{Aeq,8h}$ can be found within the DEFRA document, Method for Converting the UK Road Traffic Noise Index $L_{A10,18h}$ to the EU Noise Indices for Road Noise Mapping. This provides formulas for road traffic noise on non-motorway roads and motorway roads.

Experience of road traffic flows in London indicates that Finchley Road should be treated as a motorway road in terms of noise. This is not only due to the three lane dual carriage way nature of the road but also the due to road traffic in London having a shorter 'quieter' night-time period in comparison to non-motorway roads in the UK outside of London (ref National Noise Incidence Study 2000 and London Noise Survey 2004). Consequently, the following equation has been selected to convert $L_{A10,18h}$ to $L_{Aeq,8h}$ (L_{night}):

$$L_{night} = 0.87 \times L_{A10,18h} + 4.24$$

Using the $L_{A10,18h}$ of 81.5 dB(A) derived from the noise measurements, an $L_{Aeq,8h}$ of 75 dB(A) is calculated, which is approximately 4.5 dB(A) below the measured $L_{Aeq,16h}$.

The equation used to convert $L_{A10,18h}$ into $L_{Aeq,8h}$ offers a UK wide methodology for road traffic noise calculations that may not be representative of the road traffic flows found in London during the night-time period as it is likely they are higher than the UK average.

Noise measurements made by BRE for the London Borough of Camden in 2006[1] and 2007[2] at Swiss Cottage on Finchley Road indicate a difference of approximately 2 dB(A) between daytime (2300-0700) and night-time (0700-2300) noise levels. Taking this as a guide to the difference between daytime and night-time noise levels on Finchley Road and applying it to the measured $L_{Aeq,16h}$ of 79.5 dB(A) results in an $L_{Aeq,8h}$ of 77.5 dB(A).

[1] Environmental Noise Monitoring in Camden March 2006, 21st April 2006

[2] Environmental Noise Monitoring in Camden February 2007, 22nd March 2007

The $L_{Aeq,8h}$ of 77.5 dB(A) offers a more precautionary 'worst case' method in assessing night-time noise levels and the method for deriving it is more relevant to the locality of the site. Consequently, it is considered reasonable to use this value as a basis for deriving the propagation of noise across the site during the night-time period.

4.1.1.3 Night-time L_{Amax} Source Terms

Noise source terms for the movement of a road vehicle and a freight train were taken from the AECOM noise measurement database. The sound power levels used for these source terms are presented in Table 5.

Table 4: Sound Power Levels used as L_{Amax} Source terms

Noise Source	Sound Power Level (L_{Amax}) dB
Road Vehicle	101
Freight Train	115

4.1.1.4 Rail Traffic Noise

The nearest station on the same railway line that passes adjacent to the north and south site boundaries that has associated freight train movement data is Cricklewood. A daily average of approximately 35 freight trains pass along the railway line at Cricklewood[3].

For the purposes of this assessment it has been considered that there is an even split of freight trains between daytime and night-time periods. As a worst case, it is considered that all freight trains will pass the site on the section of track adjacent to the south site boundary.

During the vibration monitoring, an average of 13 trains per hour were noted to pass on the track adjacent to the south boundary of the site. It is estimated that passenger trains will operate from the hours of 0600 to 0030. Combining this estimation of passenger train movement data with the estimation of freight train movements provides the total estimated number of rail traffic movements. This data was used to predict noise from rail traffic on the railway lines bordering the site to the north and the south and can be seen in Table 6.

Table 5: Estimated Train Movement Data

Period	Passenger Trains	Freight Trains
Daytime	208	18
Night-time	33	18

4.1.2 Model Settings

Noise predictions have been made at a heights representative of each floor of the proposed development buildings. One order of reflection has been included within the modelling process to account for significant reflections, with all building facades being set as acoustically reflective. With regard to road surfaces, all roads have been set as being of impervious bituminous construction. No allowance has been made for absorbent ground within the modelling process, which is considered worst-case.

4.2 Noise Assessment

4.2.1 Daytime Noise

Results of noise predictions during the daytime period are displayed graphically in Figure D.1 of Appendix D. A summary of predicted noise levels at each floor of each facade can be seen in Table 7.

[3] Network Analysis of Freight Trains, MDS Modal Ltd, September 2009

Table 6: Range of Predicted Daytime Noise Levels

Floor	Range of Predicted $L_{Aeq,16h}$ Noise Levels (dB)		
	East	**North**	**South**
Basement -2	-	49-67	62-68
Basement -1	-	53-66	62-68
Ground Floor	79-80	47-66	61-75
1st Floor	79	50-65	60-75
2nd Floor	78	51-64	59-74
3rd Floor	77	55-64	59-74
4th Floor	57-76	59-62	65-73

4.2.2 Night-time Noise

Results of noise predictions during the night-time period are displayed graphically in Figure D.2 of Appendix D. A summary of predicted noise levels at each floor of each facade can be seen in Table 8.

Table 7: Range of Predicted Night-time Noise Levels

Floor	Range of Predicted $L_{Aeq,8h}$ Noise Levels (dB)		
	East	**North**	**South**
Basement -2	-	51-66	61-67
Basement -1	-	51-66	61-67
Ground Floor	77-78	53-65	60-73
1st Floor	77	53-64	59-73
2nd Floor	76	54-64	58-72
3rd Floor	75	55-63	57-72
4th Floor	56-74	52-58	65-71

4.2.3 Night-time L_{Amax} Noise

Results of L_{Amax} noise predictions for individual road vehicle and freight train movements during the night-time period are displayed graphically in Figure D.3, D.4, and D.5 of Appendix D. A summary of predicted noise levels at each floor of each facade can be seen in Table 9.

Table 8: Worst Case Predicted Night-time L_{Amax} Noise Levels

Floor	Worst Case Predicted L_{Amax} Noise Levels (dB)		
	East (Road Vehicle Source)	**North (Freight Train Vehicle Source)**	**South (Freight Train Vehicle Source)**
Basement -2	-	87	83

Basement -1	-	85	83
Ground Floor	78	83	83
1st Floor	76	81	81
2nd Floor	73	80	80
3rd Floor	71	78	78
4th Floor	68	71	71

4.3 Vibration Assessment

Vibration levels on the site were calculated for night-time and daytime periods using the rail traffic data in Table 6.

The following formula was used to calculate the total daytime and night-time VDVs from passenger and freight train movements using the highest measured VDV_n value of 0.19 $ms^{-1.75}$ to represent vibration from a freight train and the average measured VDV_n value of 0.08 $ms^{-1.75}$ to represent vibration from a freight train.

$$VDV_{day} = \left(\int_1^N VDV_n{}^4\right)^{0.25}$$

The results of calculations gave a daytime VDV of 0.42 $ms^{-1.75}$. According to guidance within Table 4, daytime vibration levels of this magnitude will result in 'adverse comments possible'.

The results of calculations gave a night-time VDV of 0.4 $ms^{-1.75}$. According to guidance within Table 4, daytime vibration levels of this magnitude will result in 'adverse comments probable'.

It can be seen from the results of vibration calculations that, despite the significantly higher number of passenger trains during the daytime period, daytime and night-time vibration levels are similar. This is due to the VDV being weighted towards the highest vibration levels so the vibration contribution to the overall VDV from freight trains results in the VDV contribution due to passenger trains being marginal.

4.4 Mitigation

Plots showing the predicted noise level incident on each floor of the proposed building facades can be seen in Appendix D. These plots show the predicted daytime $L_{Aeq,16h}$, night-time $L_{Aeq,8h}$, and night-time L_{Amax}. The plots are colour coordinated to indicate what kind of noise mitigation would be required for each noise metric. This colour coding is summarised in Table 10

Table 9 Appendix H Colour Coding

Colour	Mitigation
Grey	No mitigation required
Green	Ventilation required to allow windows to be kept closed whilst providing background ventilation
Red	Acoustic glazing and ventilation required.

4.4.1 Noise Mitigation

Noise mitigation has been recommended based on the worst case noise metric for each floor on each facade. The worst case noise metric has been defined depending on recommended 'good' internal noise levels set out by BS 8233 (see Table 2). The proposed rooms on each floor of each facade have been summarised in Table 10. It should be notes that there is no worst case noise metric for the entrance as there is no recommended ambient noise level for a building entrance in noise guidance.

Table 10: Worst Case Noise Metric per Room Designation

Floor	East		South		North	
	Rooms	Worst Case Noise Metric	Rooms	Worst Case Noise Metric	Rooms	Worst Case Noise Metric
Basement -2	-	-	Restaurant	67 dB $L_{Aeq,16h}$	Restaurant	68 dB $L_{Aeq,16h}$
Basement -1	-	-	Accommodation	85 dB L_{Amax}	Accommodation	73 dB $L_{Aeq,8h}$
Ground Floor	Entrance	-	Accommodation	83 dB L_{Amax}	Accommodation	73 dB $L_{Aeq,8h}$
1st Floor	Accommodation	79 dB $L_{Aeq,16h}$	Accommodation	81 dB L_{Amax}	Accommodation	72 dB $L_{Aeq,8h}$
2nd Floor	Accommodation	78 dB $L_{Aeq,16h}$	Accommodation	80 dB L_{Amax}	Accommodation	72 dB $L_{Aeq,8h}$
3rd Floor	Accommodation	77 dB $L_{Aeq,16h}$	Accommodation	78 dB L_{Amax}	Accommodation	72 dB $L_{Aeq,8h}$
4th Floor	Common Room	76 dB $L_{Aeq,16h}$	Common Room	62 dB $L_{Aeq,16h}$	Common Room	73 dB $L_{Aeq,16h}$

The worst case noise metric for each floor of each facade have been used to estimate the required worst case glazing mitigation, which are presented in Table 11. These noise mitigation requirements are based on noise criteria from BS 8233 set out in Table 2. It has been assumed that the common room will not be a quiet environment so 'reasonable' noise criteria for living rooms of 40 dB(A) is applicable in this circumstance.

Table 11: Worst Case Recommended Glazing to Achieve 'Good' BS 8233 Standard

Floor	Recommended Minimum Specification Glazing R_w+C_{tr} (dB(A))		
	East	North	South
Basement -2 (Accommodation)	-	27	28
Basement -1 (Restaurant)	-	40	43
Ground Floor (Accommodation)	-	38	42
1st Floor (Accommodation)	49	36	42
2nd Floor (Accommodation)	48	35	42

Floor	Recommended Minimum Specification Glazing R_w+C_{tr} (dB(A))		
	East	North	South
3rd Floor (Accommodation)	47	33	42
4th Floor (Common Room)	36	22	33

It should be noted that Table 11 displays the highest glazing specification for each facade and predicted noise levels vary at different locations along each facade. This is most apparent at the south facade due to the cumulative noise from rail traffic and road traffic at the eastern most section of the south facing facade. The total noise level, and the subsequent noise mitigation requirement, on the south facade reduces moving west along the facade thus reducing the contribution from road traffic decreases.

The highest level of glazing attenuation with an R_w+C_{tr} of 49 dB(A) is required at the 1st floor of the east facing facade. An example of high end secondary acoustic glazing provided by IAC Ltd UK with an R_w+C_{tr} of 51 dB(A) can be achieved by Noise-Lock secondary acoustic glazing with a configuration of 12.8 mm – 215 mm – 10.8 mm.

Opening windows for ventilation in habitable rooms could result in unacceptable internal noise levels. Consequently, it would be necessary to specify acoustic ventilation, capable of performing to the same acoustics standard as the glazing in habitable rooms to enable residents to ventilate rooms without negating the acoustic performance of the glazing by opening windows.

4.5 Vibration Mitigation

Ground-borne vibration levels at the proposed building location have been assessed using guidance within BS 6472 which rates the level of vibration at the proposed building location as likely to cause adverse comments. Consequently, vibration mitigation should be implemented in to the building design.

Buildings have different characteristics relative to structure-borne vibration, although the general rule-of-thumb is the more massive the building, the lower the levels of ground-borne vibration will transfer through the building. Base Isolation (mounting a building on a resilient foundation) is commonly assumed to be the most appropriate solution to vibration problems. Building isolation can be achieved using materials such as steel springs or rubber pads. Alternative vibration control options, directed at the source, propagation path and receiver should also be considered.

A summary of potential vibration mitigation options are summarised below:

- Avoid floor resonance with dominant peaks in ground vibration spectrum
- Solid ground bearing slabs may be preferential to suspended slabs
- A floor may constructed on isolators (e.g. a floating floor)
- Select structural form for optimum damping (e.g. concrete in preference to steel)
- Constrained layer floor damping treatments
- Heavier forms of construction

5 Summary

5.1 Noise Assessment

Noise predictions have been carried out to provide an indication of mitigation requirements that would provide acceptable noise levels within the proposed development. Noise mitigation has been recommended to address worst case predicted noise levels at each floor of each building facade. These worst case R_w+C_{tr} values are summarised in Table 12 and would achieve ‘good’ (according to BS 8233) standard of noise level in all habitable rooms

5.2 Vibration Assessment

Calculations of daytime and night-time levels using vibration measurements indicate that levels of vibration due to train movements are likely to cause adverse comments. Consequently, vibration mitigation should be implemented into the building design to reduce the transmission of ground-borne vibration into the proposed building. This is likely to be most readily achievable using a high mass building construction and/or isolation of the building foundations.

6 Appendices

Appendix A: Acoustic Terminology

An explanation of the specific acoustic terminology referred to within this report is provided below.

dB Sound levels from any source can be measured in frequency bands in order to provide detailed information about the spectral content of the noise, i.e. whether it is high-pitched, low-pitched, or with no distinct tonal character. These measurements are usually undertaken in octave or third octave frequency bands. If these values are summed logarithmically, a single dB figure is obtained. This is usually not very helpful as it simply describes the total amount of acoustic energy measured and does not take any account of the ear's ability to hear certain frequencies more readily than others.

dB(A) Instead, the dB(A) figure is used, as this is found to relate better to the loudness of the sound heard. The dB(A) figure is obtained by subtracting an appropriate correction, which represents the variation in the ear's ability to hear different frequencies, from the individual octave or third octave band values, before summing them logarithmically. As a result the single dB(A) value provides a good representation of how loud a sound is.

L_n A noise level which varies over a given time period may be described in terms of the length of time for which a particular noise level is exceeded. A common noise index used for assessing road traffic noise is the $L_{A10,1h}$ index. This is defined as the A-weighted noise level that is exceeded for 10% of the time over a period of one hour i.e. a total time period of 6 minutes.

$L_{A10,18h}$ The most common noise index used in the UK for assessing road traffic noise in the $L_{A10,18h}$ index. This index is defined as the arithmetic average of the 18 one-hour, $L_{A10,1h}$ values between 06:00 to midnight.

L_{A90}, is the noise level exceeded for 90% of the measurement period, and is the usual descriptor for underlying background noise.

L_{Amax} is the highest noise level measured.

Capabilities on project:
Environment

Appendix B: Calibration Certificates

Calibration Report

Certificate number 5678

Norsonic Type : 140 Serial no : 1402919

Customer:	AECOM Ltd
Department:	Enterprise House
Place:	160 Croydon Road
City:	Beckenham, Kent BR3 4DE
Order No:	12532
Contact Person:	Eddie Robinson
Phone/Mail:	

Microphone :	Norsonic	Type : 1225	Serial no : 79587	Sens:-26.42dB
Pre amplifier	Norsonic	Type : 1209	Serial no : 12501	
Calibrator :	Brüel and Kjær	Type : 4231	Serial no : 2385082	Level:93.9dB
Wind screen	Norsonic	Type : Nor1451 (ø 60mm)		

Measured with Pre Amplifier Mains adapter was included
RS232 cable was included
This sound level meter has been calibrated as specified in BS 7580. PART 1 : 1997.
Measurement Results:

DIN 45 657 : Statistical Distribution Test - According to DIN45 657 #3.3	Passed
Noise test - BS 7580 #5.5.2	Passed
Level Linearity Test - BS 7580, #5.5.3	Passed
Frequency weightings: A Network - BS 7580 #5.5.4	Passed
Frequency weightings: C Network - BS 7580 #5.5.4	Passed
Time weightings F and S - BS7580 #5.5.5	Passed
Peak response - BS7580 #5.5.6	Passed
RMS accuracy - BS7580 #5.5.7	Passed
Time weighting I - BS7580 #5.5.8	Passed
Integrating Test : Time averaging - BS7580 #5.5.9	Passed
Integrating Test : Pulse range - BS7580 #5.5.10	Passed
Integrating Test : Sound exposure level - BS7580 #5.5.11	Passed
Overload SPL Test - BS 7580 #5.5.12	Passed
Overload Leq Test - BS 7580 #5.5.12	Passed
Acoustic tests - BS 7580 #5.4 and 5.6	Passed
Summation of acoustic tests - BS 7580 #5.5.4	Passed

The sound level meter in the configuration tested
conforms to the requirements of BS 7580:1997 Part 1.

Comment :
Correct level with associated calibrator is 93.9 dB(A).

Environmental conditions:

Pressure :	Temperature :	Relative humidity :
99.875 kPa	23.7 °C	55.1 %RH

Date of calibration: 24/08/2009
Date of issue: 24/08/2009
Supervisor: David Egan
Engineer

Darren Batten Tech IOA

Campbell Associates
www.campbell-associates.co.uk

Acoustic Calibration Services Limited,
Unit 6F, Diamond Industrial Centre,
Works Road, Letchworth Garden City,
Hertfordshire SG6 1LW

Tel: 01462-610085/87 Fax: 01462-610087
e-mail: cal@acousticcalibration.co.uk
web: www.acousticcalibration.co.uk

ACSL
Acoustic Calibration Services Limited

CERTIFICATE OF CALIBRATION

Model: B&K 4231 **Serial Number:** 2385082

Organisation: AECOM Limited, Enterprise House, 160 Croydon Road
Beckenham, Kent BR3 4DE

Job Number: 1809 **Customer Order Reference:** 12987

The acoustic calibrator was run for a period of time until a stable level was measured. The output level was compared to the certified level of the laboratory measurement references. The measurements were repeated 5 times and the average value calculated.

The ambient temperature during calibration was 24.0 ± 1°C.
The barometric pressure was 101.8 to 101.9 kPa.

The output of the acoustic calibrator when applied to the *B&K 4188* is *93.8dB* at the lower level and *113.8dB* at the higher level
The signal output frequency of the acoustic calibrator operates at *1000Hz*.

All ACSL's calibration instrumentation is fully traceable to National Standards. The acoustic references are calibrated by laboratories which are UKAS accredited for the purpose.

Certificate No: **13383**
Date of Issue: **13th April, 2010**

Signature:
Print Name: **Trevor Lewis**

Appendix C: Full List of Vibration Measurements (16th March 2011)

Time	Duration (seconds)	X-axis VDV $ms^{-1.75}$	Y-axis VDV $ms^{-1.75}$	Z-axis VDV $ms^{-1.75}$
13:34:06	15	0.00357	0.00402	0.0566
13:39:36	15	0.0043	0.00609	0.09396
13:51:51	15	0.00342	0.00432	0.05709
13:53:21	15	0.00313	0.00394	0.05953
13:59:21	15	0.00352	0.00499	0.06125
14:01:36	15	0.00435	0.00529	0.11206
14:03:21	15	0.00311	0.00404	0.04924
14:09:36	15	0.0046	0.00632	0.09541
14:11:36	**15**	**0.0056**	**0.00772**	**0.18944**
14:21:36	15	0.00438	0.00632	0.11754
14:24:06	15	0.00504	0.00679	0.09707
14:28:06	15	0.00373	0.00399	0.06349
14:29:36	15	0.00305	0.00398	0.04683
14:31:21	15	0.00417	0.00419	0.07188
14:51:06	15	0.00344	0.00359	0.06242
14:54:21	15	0.00368	0.00437	0.06879
14:57:06	15	0.00402	0.00441	0.06457
14:58:51	15	0.00297	0.00442	0.05297
15:00:51	15	0.00507	0.00599	0.13097
15:06:06	15	0.0057	0.00708	0.1647
15:19:36	15	0.00422	0.00587	0.10466
15:22:21	15	0.00387	0.00409	0.06207
15:28:06	15	0.00406	0.00424	0.06914
15:28:51	15	0.00286	0.0047	0.04491
15:34:21	15	0.00305	0.0049	0.05146
15:38:06	15	0.00428	0.00558	0.08004
15:49:06	15	0.00434	0.00443	0.07273
15:52:06	15	0.00373	0.00387	0.05839
15:56:21	15	0.004	0.00436	0.0626
15:58:51	15	0.0034	0.0049	0.05312
15:59:51	15	0.0053	0.00753	0.16525

Capabilities on project:
Environment

Appendix D: Noise Contour Plots

Figure D.1: Daytime $L_{Aeq,16h}$ Noise Levels

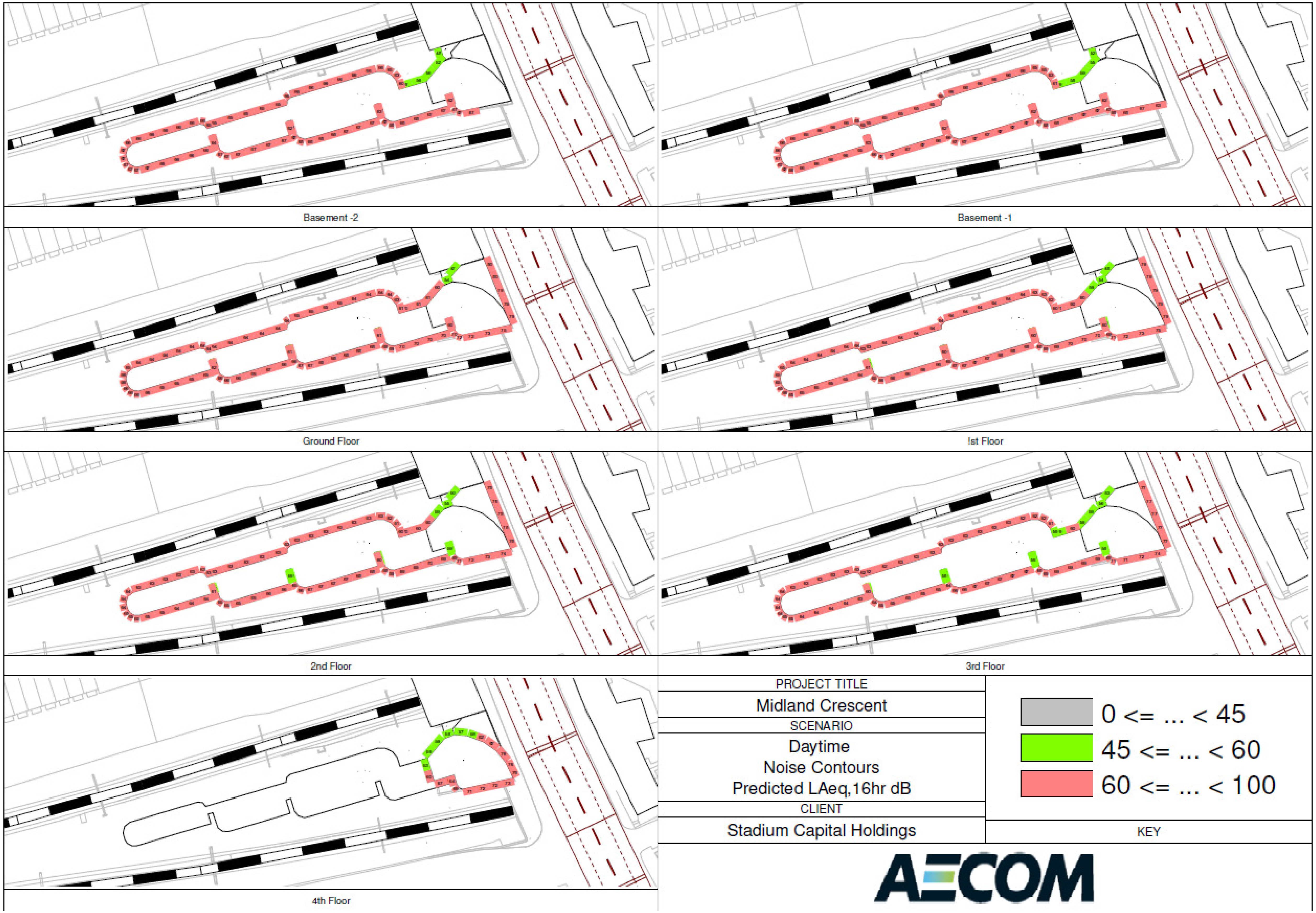
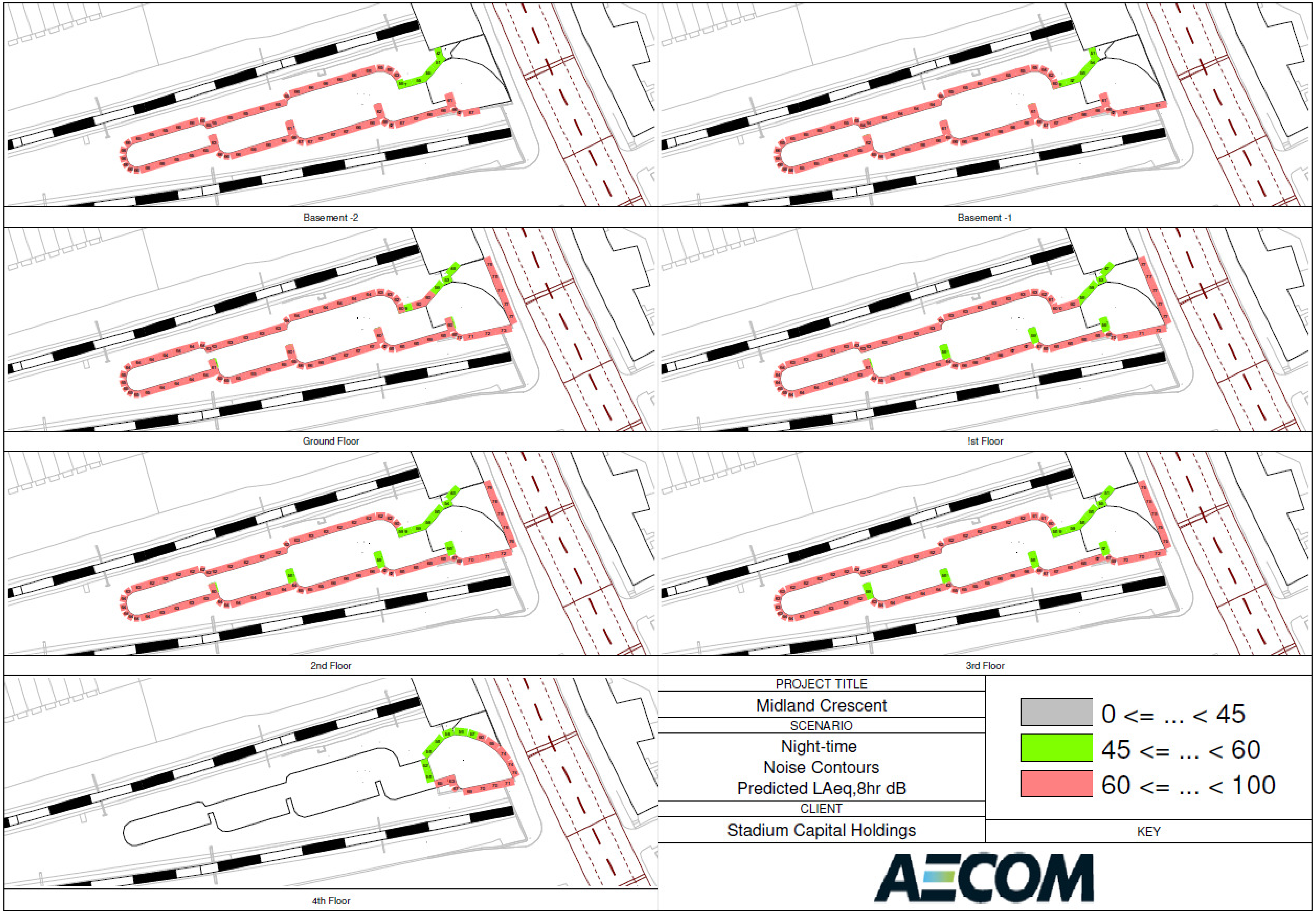


Figure D.2: Night-time $L_{Aeq,8h}$ Noise Levels



Capabilities on project:
Environment

Figure D.3: Night-time L_{Amax} Noise Levels at East Facade

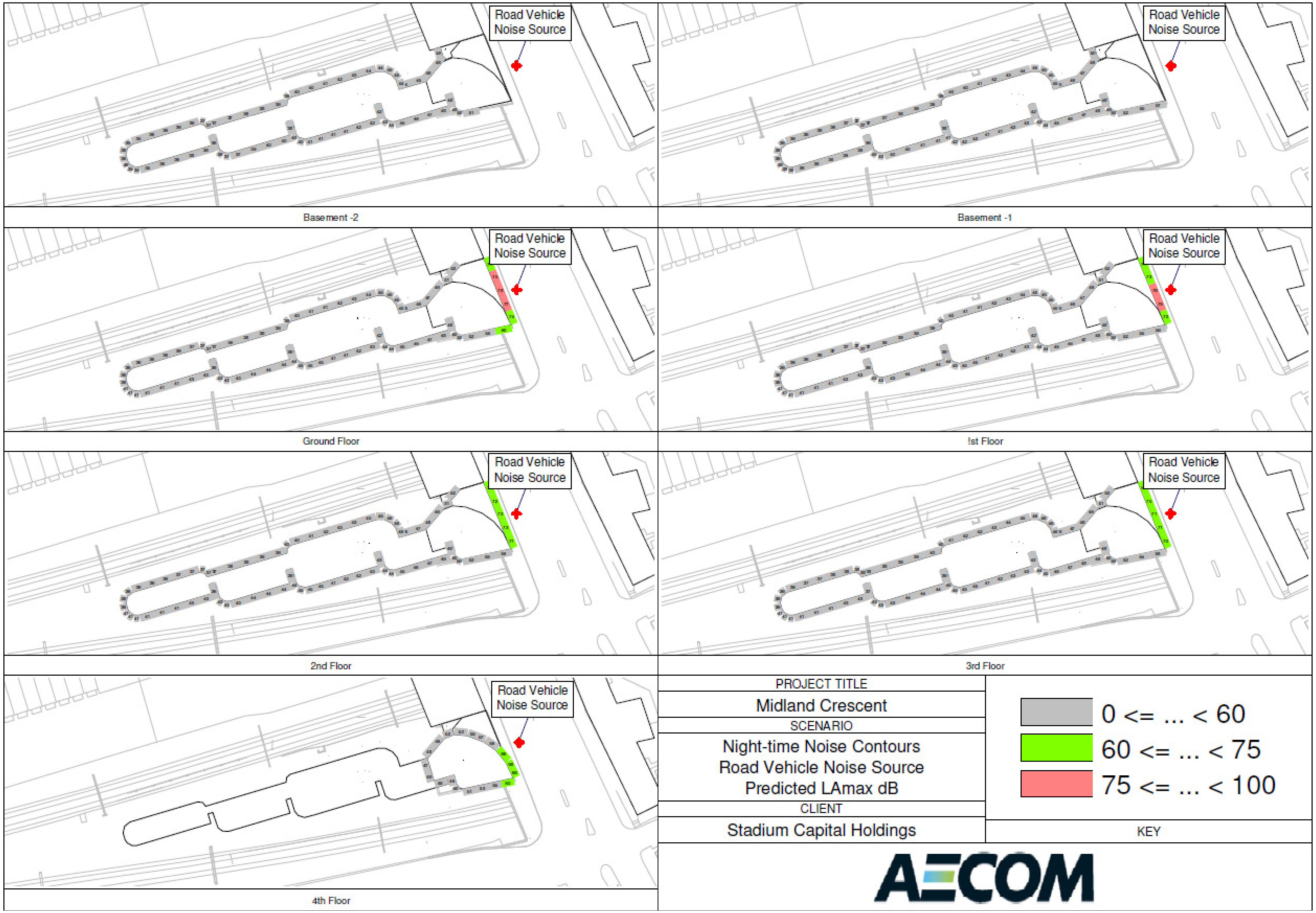


Figure D.4: Night-time L_{Amax} Noise Levels at North Facade

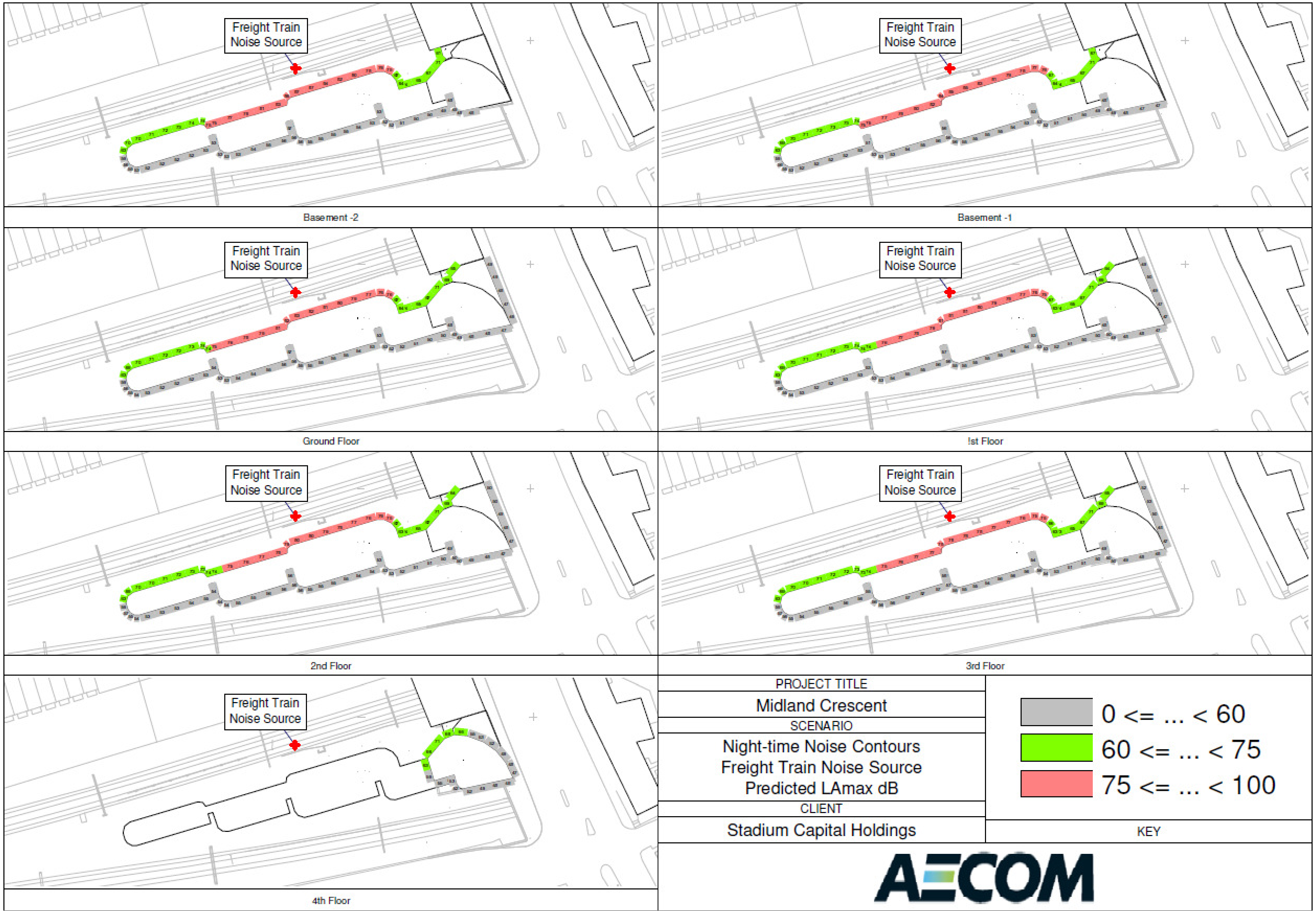


Figure D.5: Night-time L_{Amax} Noise Levels at South Facade