Collis Primary School

Acoustic Feasibility Survey

26 October 2016

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Executive summary

An acoustic feasibility assessment has been undertaken for Collis Primary School in accordance with Building Bulletin 93, Acoustic design of schools: performance standards (BB93).

The assessment focuses on determining the existing noise environment at the site and the implications of this on ventilation strategy in the context of achieving required internal ambient noise levels within teaching and study accommodation.

A noise survey has been undertaken at the school site, to determine the existing noise climate.

Ambient noise levels around the site during the school day were found to fall within the range 49 to 59 dB $L_{Aeq,30min}$ (excluding break times and lunchtime).

Based on worst-case noise levels, the assessment found that noise levels around the site were such that a ventilation strategy based upon attenuated natural or mechanical ventilation is likely to be appropriate at the site.

Acoustic calculations should be undertaken by a suitably qualified professional during detailed design to confirm the internal ambient noise level criteria in Section 1 of BB93 will be met using the chosen ventilation strategy.

A noise rating level limit for any new fixed plant associated with the proposed development has been set for daytime and night-time periods. Noise limits have been set in accordance with the BS 4142:2014 methodology where, in the context of low background noise levels, a rating level of 35 dB(A) at the nearest noise-sensitive receptors is proposed.

WHO Guidelines for annoyance within outdoor living areas of nearby noise-sensitive receptors have been considered in the context of the measured noise levels and potential noise generating facilities at this educational site.

1 Introduction

As part of the Priority School Building Programme (PSBP), the Education Funding Agency (EFA) proposes to redevelop Collis Primary School, Fairfax Road, Teddington, TW11 9BS. Mott MacDonald has been commissioned by the EFA to provide an acoustic survey for the school to inform the development of the feasibility study for the proposed school development.

This assessment focuses on determining the existing noise environment at the site and the implications of this on ventilation strategy in the context of achieving required internal ambient noise levels within teaching and study accommodation.

The assessment also considers suitability of the site for outdoor teaching and proposes appropriate limits for external noise emission from new fixed building services plant associated with the proposed development. It does not consider other aspects of school internal acoustic design including sound insulation of separating constructions and control of reverberation time. These parameters are more properly considered during detailed design and will not be considered further within this report.

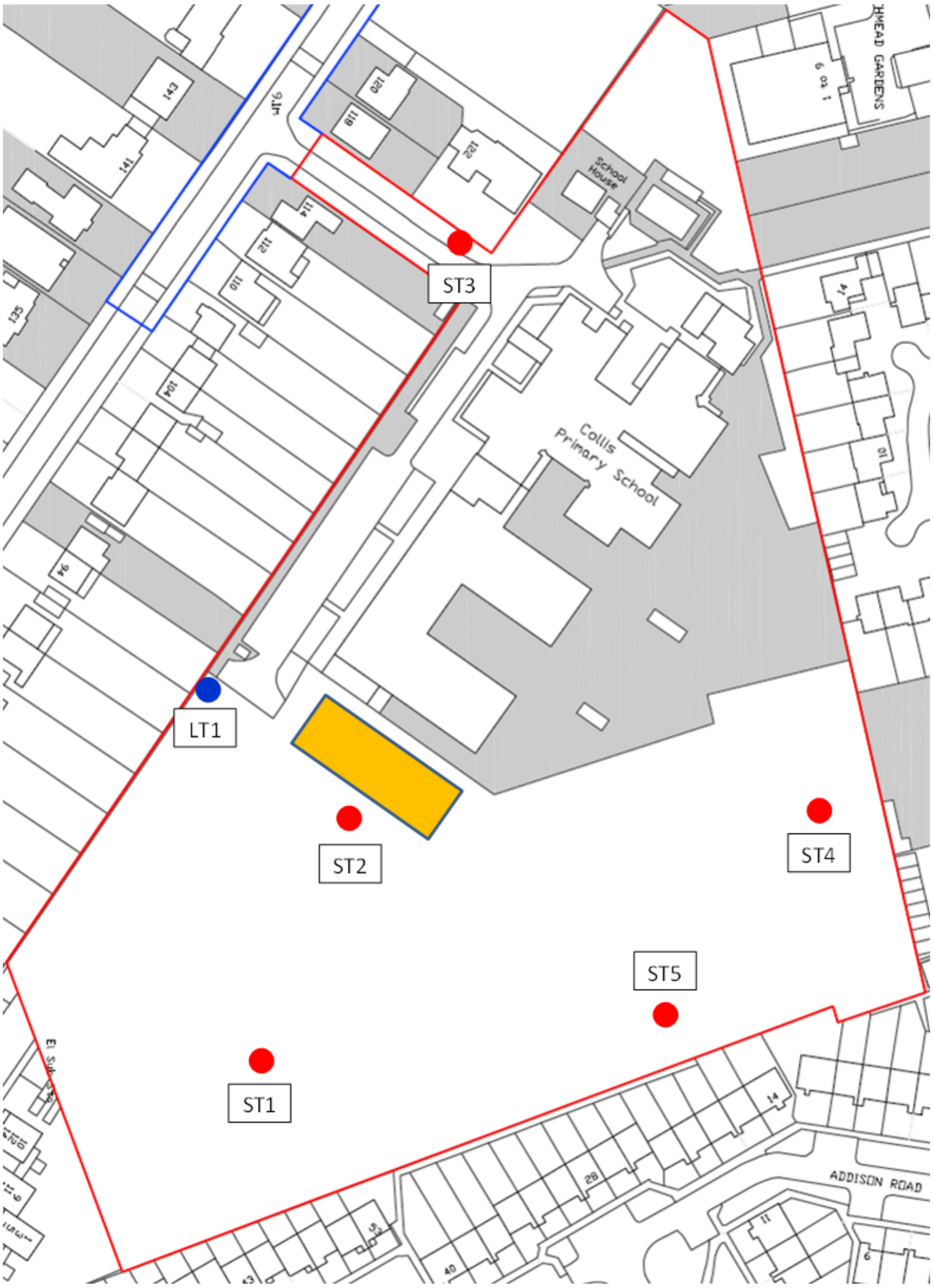
A glossary of acoustic terms may be found in Appendix C.

Figure 1.1 presents the location of the site and shows noise measurement locations. The school is set in a residential area in the area of Teddington, Richmond, London. The school is bounded by residential properties at all boundaries; the nearest roads to the boundaries include Fairfax Road to the west, Cromwell Road to the north, the A310 to the east, and St Mark's Road to the south. Significant noise sources in the area include, but are not limited to:

- Air traffic associated with Heathrow Airport
- Road traffic associated with Fairfax Road

The nearest residential receptors to the proposed site of construction (shown in Figure 1.1) are located at Fairfax Road. Additional residential receptors are located on Borland Road, Addison Road, Kingston Close, and Kingsmead Close. These properties are deemed to be less susceptible to an increase in background noise levels from fixed plant noise emissions due to the increased distance from the proposed site of construction, relative to the properties on Fairfax Road.

Figure 1.1: Illustration of school and surrounding environment, including proposed site of construction (orange), long-term unattended measurement location (LT1) and short-term attended measurement locations (ST1-ST5).



2 Guidelines and Policy

2.1 Building Bulletin 93 Acoustic design of schools: Performance Standards

Section 1 of BB93 (EFA, 2015) provides acoustic design criteria and guidance for new build teaching and study accommodation in order to satisfy requirement E4 of the Building Regulations 2010 (Crown, 2010). BB93 supersedes, 'Acoustic Performance Standards for the Priority Schools Building Programme' June 2013, version 1.7 (EFA, 2013), although the performance criteria within are equivalent.

BB93 also provides acoustic design criteria for refurbishment of school accommodation. Refurbishment, where there has not been a material change of use, does not fall within the scope of requirement E4 of the Building Regulations. The refurbishment criteria should therefore be regarded as guideline values rather than a requirement.

At feasibility stage the scope of work is:

- A noise survey to establish external noise levels across the site;
- Consideration of the implications of the measured noise levels for design of building envelope, including ventilation strategy;
- Consideration of the implications of measured noise levels for outdoor teaching; and,
- Determination of appropriate reference background sound level, expressed as $L_{A90,T}$ to allow limits for emission of noise from new external building services plant associated with the proposal to be developed.

2.1.1 Internal Ambient Noise Levels (IANL)

Table 1 of BB93 presents the upper limit for the indoor ambient noise level (IANL) for the possible types of room within a school. The specified levels refer to the highest 30-minute equivalent continuous A-weighted sound pressure level (dB $L_{Aeq,30min}$) likely to occur during normal teaching hours. For this assessment these hours are assumed to be 9:00 to 15:30.

In terms of IANL in unoccupied space, BB93 aims to provide suitable conditions for:

- clear communication of speech between teacher and student;
- clear communication between students; and,
- learning and study activities.

It includes contributions from sources such as:

- external sources outside the school premises (road, rail and air traffic noise, etc.);
- building services (ventilation systems, plant, drainage etc.); and,
- actuator and damper noise.

It does not, however include contributions from:

- teaching activities within the school premises;
- equipment used in the space (machine tools, computers, projectors, etc.) as these noise sources are considered as operational noise; and,

- rain noise.

A summary of IANL criteria for a selection of typical school spaces listed in Table 1 of BB93 is shown in Table 2.1.

Table 2.1: Maximum Indoor Ambient Noise Level Criteria for Specific Room Types.

Room Type	Upper Limit for Indoor Ambient Noise Level $L_{Aeq,30min}$ (dB)	
	New Build	Refurbishment
Teaching space intended specifically for students with special hearing and communication needs, music ensemble room, recording studio	30	35
Multi-purpose hall, primary school classroom, secondary school classroom, general teaching area, class base, small group room, seminar room, tutorial room, language laboratory, lecture room, primary music room, secondary music classroom, small and large music practice room, performance/recital room, drama studio	35	40
ICT, design and technology, science laboratory, open plan teaching and resource areas, libraries, study room, sports hall, gymnasium, meeting room, interviewing counselling room, offices*, staff room*	40	45
Dining room*	45	45
Kitchen*, Toilets*, changing areas*	50	50

Source: BB93: acoustic design of schools - performance standards

*These performance standards are guidelines only since Part E of the Building Regulations only applies to teaching and learning spaces and is not intended to cover administration and ancillary spaces.

Table 2 of BB93 provides guidance on relaxation of the IANL where natural or hybrid ventilation strategies are employed, or where boost ventilation is required, either to avoid overheating during summertime conditions or to facilitate intermittent boost ventilation, for example to dilute fumes during practical activities.

In the case of natural ventilation, a +5dB relaxation of the IANL criteria from Table 1 of BB93 is considered acceptable during ‘normal’ ventilation conditions for spaces where the BB93 criteria is less than $L_{Aeq,30min}$ 45 dB.

Footnote 2 to Table 2 of BB93 contains the following statement which forms the basis of the assessment of noise level within Section 3 of this report:

“Where external ambient free field noise levels at the facade expressed as the $L_{Aeq,30mins}$, do not exceed the IANL figures given in Table 1 (of BB93) by more than 16 dB for single sided ventilated spaces and 20 dB for cross ventilated or roof ventilated spaces, the criteria for natural ventilation can usually be achieved.”

For full consideration of IANL in the context of different ventilation strategies designers should refer to Section 1.1.3 of BB93.

2.2 Acoustics of Schools: a design guide

The Institute of Acoustic (IOA) and the Association of Noise Consultants (ANC) jointly publish the *“Acoustics of Schools: a design guide”* (IOA and ANC, 2015). This provides supporting guidance to BB93 on acoustics in schools. This guidance includes advice on noise survey work and Section 2.2 of that document, provides guideline noise criteria for external teaching areas. The document states:

“For new schools, 60 dB $L_{Aeq,30min}$ should be regarded as an upper limit for external noise at the boundary of external areas used for formal and informal outdoor teaching and recreation.”

It further states:

"Noise levels in unoccupied playgrounds, playing fields and other outdoor areas should not exceed 55 dB $L_{Aeq,30min}$ and there should be at least one area suitable for outdoor teaching activities where noise levels are below 50 dB $L_{Aeq,30min}$."

2.3 British Standard 4142 Methods for rating and assessing industrial and commercial sound (BS 4142)

British Standard 4142 (BSI, 2014) provides a means of assessing the likelihood of adverse impacts from the introduction of a new sound source to an area.

The level of sound from proposed new plant, the 'rating level' $L_{Ar,T}$, is predicted in terms of $L_{Aeq,T}$, and compared to the existing background sound level, expressed in terms of $L_{A90,T}$. If the new source is impulsive, intermittent or tonal in nature, then the 'rating level' includes a penalty, to account for the character of the sound.

The following conclusions may be drawn based upon the difference between the rating level and background sound level:

- *"Typically, the greater this difference, the greater the magnitude of the impact;*
- *A difference of around +10 dB or more is likely to be an indication of a significant adverse impact depending on the context;*
- *A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context; and,*
- *The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context."*

2.4 World Health Organization (WHO)

The WHO Guidelines for Community Noise (WHO, 1999) is a broad document that gives information and annual average guideline noise levels for residential areas. The levels given represent the results of scientific studies that have been undertaken with regard to the health impacts that can occur as a result of different noise levels that occur for different reasons within a community.

For residential areas the WHO Guidelines recommend during the daytime period when educational establishments are operational, that annual average external noise level does not exceed 50 to 55 dB $L_{Aeq,16hr}$ within outdoor living areas to prevent moderate to serious annoyance respectively.

2.5 Consultation

Mott MacDonald contacted the Environmental Health Officer (EHO) at London Boroughs of Richmond upon Thames & Merton by e-mail on 31/08/2016 and again by telephone on 13/10/2016 in order to consult on the assessment at this site.

It was agreed that new fixed plant installations should be designed such that the Rating Level as defined in BS 4142:2014, at the nearest noise sensitive receptors, is set at 35 dB(A) for daytime and night-time periods.

3 Noise Survey

A noise measurement survey was undertaken during the period 10:23 on Tuesday 20 September 2016 to 16:30 on Wednesday 21 September 2016.

All measurements were undertaken by consultants competent in environmental noise monitoring, and completed in accordance with the principles of BS 7445:2003 *Description and measurement of environmental noise* (BSI, 2003). All acoustic measurement equipment used during the noise survey was designed to be in conformance with the BS EN ISO 61672-2:2013 *Electroacoustics. Sound level meters. Specifications* (BSI, 2013) to the requirements of the Class 1 standard.

All meters and field calibrators used held current calibration certificates obtained under laboratory conditions traceable to UK and International Standards. Before and after the measurement session the reference calibration level of the sound level meter was checked using a field calibrator.

At each position the microphone was supported using a tripod and was fitted with a windshield suitable for outdoor use. The sound level meters were positioned at ground floor level with the microphone at a height of 1.5m above local ground level.

All measurements were free field unless started otherwise in Section 3.1.

A full inventory of this equipment is shown in Table 3.1.

Table 3.1: Inventory of Noise Measurement Equipment

Item	Make & model	Serial number	Calibrated
Calibrator	Larson Davies CAL200	12460	22 August 2016
Sound level meter (SLM) 1	Rion NL-52	00743137	8 October 2014
Sound level meter (SLM) 2	Larson Davis	1500	19 January 2016

3.1 Measurement Locations

An unattended noise logger was deployed for 24 hours from 10:23 Tuesday 20 September 2016 to 16:30 Wednesday 21 September 2016 at the southern boundary of the site at one metre from the rear façades of the nearest residential receptors.

This measurement position (referenced LT1) was selected to be representative of the background sound level at the nearest noise sensitive receptors, as well as recording the noise levels incident upon that part of the school site.

Attended noise measurements were carried out at a number of additional locations around the school site (referenced ST1 – ST5). These locations were selected in order to quantify likely noise levels incident upon school facades and outdoor teaching areas.

The data collected at the unattended location LT1 represents a façade-level measurement, whereas free-field measurements were taken at all other locations.

All measurement positions are shown in Figure 1.1. Photographs of each measurement position are provided in Appendix A.

3.2 Measurement Conditions

The weather conditions during the survey were dry with temperatures in the range 17°C to 22°C. Wind speeds were measured at <5m/s. Road surfaces were dry throughout the measurement days. Cloud cover during the measurement periods ranged from 30% to 90%. The conditions were considered suitable for noise measurement.

3.3 Noise Measurement Results

The unattended noise measurements are summarised graphically in Figure 3.1.

A summary of the school daytime noise measurements are provided in Table 3.2 and octave-band noise measurement data from the short term attended measurements is summarised in Table 3.3. Data unduly influenced by noise from within the school site such as pupil noise during break and lunchtimes and noise from sports lessons has been excluded from the data in Tables 3.2 and 3.3.

Full details of the noise measurements are provided in Appendix B

Figure 3.1: Unattended Façade Noise Measurement Results (Position LT1)

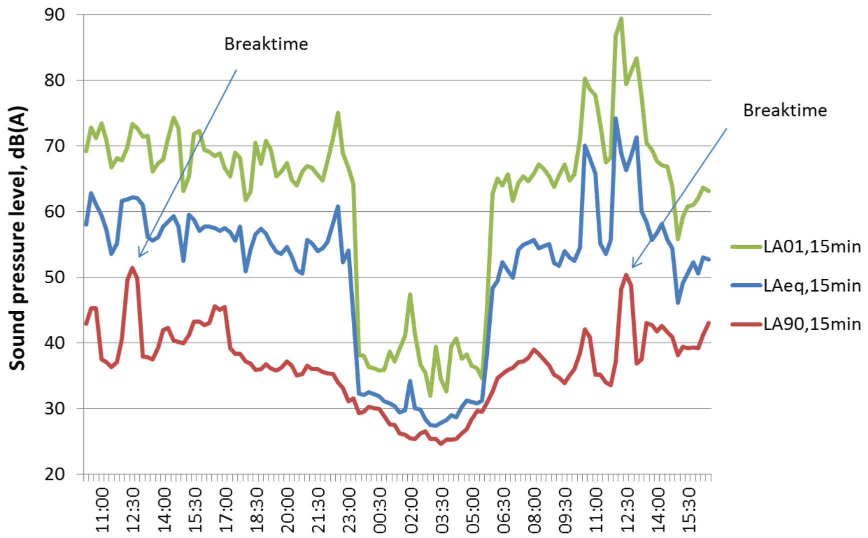


Table 3.2: Summary of Broadband Measurements During School Day (All Free Field Equivalent)

Position	Parameter	dB	Measurement Date and Time	
LT1	Max $L_{Aeq,30min}$	56.7	20/09/2016	15.00
	Max $L_{A01,15min}$	68.3	20/09/2016	11:15
	Typical $L_{A90,15min}$	35.0*	-	-
ST1	Max $L_{Aeq,30min}$	58.6	20/09/2016	11:07
	Max $L_{A01,30min}$	73.2	20/09/2016	11:07
	Typical $L_{A90,30min}$	38.2	20/09/2016	11:07

Position	Parameter	dB	Measurement Date and Time	
ST2	Max $L_{Aeq,30min}$	55.4	20/09/2016	11:43
	Max $L_{A01,30min}$	68.2	20/09/2016	11:43
	Typical $L_{A90,30min}$	38.1	20/09/2016	11:43
ST3	Max $L_{Aeq,30min}$	57.8	20/09/2016	12:44
	Max $L_{A01,30min}$	70.3	20/09/2016	12:44
	Typical $L_{A90,30min}$	44.9	20/09/2016	12:44
ST4	Max $L_{Aeq,30min}$	49.2	20/09/2016	13:26
	Max $L_{A01,30min}$	61.6	20/09/2016	13:26
	Typical $L_{A90,30min}$	34.7	20/09/2016	13:26
ST5**	Max $L_{Aeq,10min}$	50.1	20/09/2016	14:04
	Max $L_{A01,10min}$	59.1	20/09/2016	14:04
	Typical $L_{A90,10min}$	40.3	20/09/2016	14:04

*Modal value rounded to the nearest whole value.
**The measurement was stopped after 14 minutes due to an outdoor PE lesson, however the noise levels captured during this time period are deemed to be representative.

Table 3.3: Summary of Octave Band Measurements (All Free Field except LT1)

Position	Measurement Start Date and Time	Maximum A-weighted Octave-Band $L_{Aeq,30min}$ (dB)*							
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	$L_{Aeq,30min}$ dB
ST1	20/09/2016 11:07	37.7	46.6	50.9	53.9	53.3	50.0	36.3	58.6
ST2	20/09/2016 11:43	31.8	40.7	46.1	49.7	50.7	48.8	41.1	55.4
ST3	20/09/2016 12:44	34.9	43.4	48.5	51.4	53.4	51.6	41.2	57.8
ST4	20/09/2016 13:26	29.5	35.9	43.2	44.5	43.7	38.1	27.7	49.2
ST5	20/09/2016 14:04	29.6	36.7	41.0	44.0	43.6	43.9	40.7	50.1

3.4 Observations

During teaching hours, the existing noise climate at the site was dominated by air traffic associated with Heathrow Airport, which is located 5 miles to the north-west of the site. Subsidiary contributions included road traffic noise from Fairfax Road, domestic noises from the nearby residential properties, and birdsong. Road traffic noise from the A310 was faintly audible during lulls in air traffic, but is effectively screened by residential properties.

During the measurement periods at ST1 and ST3, low-flying commercial aircraft passed directly over the school at approximately 11:18 and 12:55 respectively. These measurements are therefore deemed representative of worst-case air traffic noise at the site.

3.5 Uncertainty in Acoustic Measurements

Inevitably there is a degree of uncertainty in measured noise levels. Contributory factors to this uncertainty include tolerances in instrumentation readings, meteorological conditions and the inherent variation in the acoustic environment during the course of a day and indeed over longer periods as the noise sources influencing a given location vary. Any acoustic measurement is representative of the noise climate at the time of the measurement. Every effort has been made to limit uncertainty in the measurements reported. Measures taken to limit uncertainty include:

- Undertaking surveys with appropriately qualified and trained acoustic engineers;
- Use of measurement equipment calibrated to appropriate standards by accredited bodies and checked on site using calibrated reference sound sources;
- Following best practice methodology for environmental noise measurement set out in BS 7445;
- Measuring under appropriate meteorological conditions; and,
- In the school context, measuring at times and locations that are representative of the noise levels that are likely to be incident upon the future building façade.

4 Assessment

4.1 BB93 Assessment – Implications of Noise Levels on Façade Design and Ventilation Strategy

At this time, no information regarding the room layout for the proposed development is available and therefore only outline advice can be given regarding the sound insulation of facades required to achieve the internal noise targets of BB93.

With typical modern façade constructions, noise break-in of external noise into school premises is generally driven by the sound insulation performance of the glazing system used and by ventilation strategy.

The measured external ambient noise levels expressed in terms of $L_{Aeq,30min}$ reported in Section 3 have been used to evaluate which ventilation strategy is likely to be practical while maintaining the IANL requirements from Section 1 of BB93. As discussed in Section 2.1.1, guidance from footnote 2 of Table 2 of BB93 has been used to determine whether an unattended natural ventilation strategy is appropriate. Table 4.1 sets out the criteria used to determine appropriate ventilation strategy.

Table 4.1: Criteria to Determine Appropriate Ventilation Strategy

Difference Between External Noise Level and IANL Requirement from Table 1 of BB93 (dB)	Appropriate Ventilation Strategy
+16	Non-attenuated side ventilation
+16 to +20	Non-attenuated cross ventilation
>+20	Consider attenuated natural vent or mechanical ventilation

Source: BB93: acoustic design of schools - performance standards

The assessment of ventilation strategy suitable for facades exposed to noise levels measured at the various locations around the site is presented in Table 4.2.

Table 4.2: Assessment of Ventilation Strategy

Representative Measurement Position	Representative Measured Noise Level $L_{Aeq,30min}$ (dB)	Suitable Ventilation Strategy by IANL Requirement (from Table 1 of BB93)		
		$L_{Aeq,30min}$ 30dB	$L_{Aeq,30min}$ 35dB	$L_{Aeq,30min}$ 40dB
LT1	57	Consider attenuated natural vent or mechanical ventilation	Consider attenuated natural vent or mechanical ventilation	Non-attenuated cross ventilation
ST1	59*	Consider attenuated natural vent or mechanical ventilation	Consider attenuated natural vent or mechanical ventilation	Non-attenuated cross ventilation
ST2	55	Consider attenuated natural vent or mechanical ventilation	Non-attenuated cross ventilation	Non-attenuated side ventilation
ST3	58*	Consider attenuated natural vent or mechanical ventilation	Consider attenuated natural vent or mechanical ventilation	Non-attenuated cross ventilation
ST4	49	Non-attenuated cross ventilation	Non-attenuated side ventilation	Non-attenuated side ventilation
ST5	50	Non-attenuated cross ventilation	Non-attenuated side ventilation	Non-attenuated side ventilation

*These measured noise levels are deemed to be worst-case at the site.

4.2 Assessment of Suitability of Site for Outdoor Teaching

Outdoor areas within the existing school grounds generally do not satisfy the Acoustics of Schools: a design guide, criteria that "*Noise levels in unoccupied playgrounds, playing fields and other outdoor areas should not exceed 55 dB $L_{Aeq,30min}$*" [1].

The criteria that, "*there should be at least one area suitable for outdoor teaching activities where noise levels are below 50 dB $L_{Aeq,30min}$*" is not satisfied at this site[1].

4.3 External Noise from New Building Services Plant

Typical day-time and night time background sound levels expressed as $L_{A90,15min}$ which are representative of the nearest noise sensitive receptors have been determined from the unattended 24-hour measurement presented in Figure 3.1. These sound levels have been determined by determining the modal values of the measured $L_{A90,15min}$ and are presented in Table 4.3.

Table 4.3: Typical Background Sound Levels Representative of Nearest Noise Sensitive Receptors.

Time of day	Typical Background Noise Level $L_{A90,T}$ (dB)
Day-time (07:00 – 23:00)	34
Night-time (23:00 – 07:00)	27

In line with consultation with the Local Authority presented in Section 2.5 above, new fixed plant installations should be designed such that the Rating Level as defined in BS 4142:2014 does not exceed 35 dB(A) at the noise-sensitive receptors.

[1] These assessments are based on the worst-case air traffic noise levels. During lulls in air traffic, the criteria will be satisfied.

If the plant contains tonal, intermittent, impulsive or other character features additional penalties are applied to the specific sound level to determine the rating level. This correction may be up to +18 dB, therefore the design should seek to avoid character features where reasonably practical. This will minimise the potential for adverse impact from noise emission from fixed plant at nearby noise sensitive receptors.

4.4 External Noise Levels at Noise Sensitive Receptors in the Context of the WHO Guidelines.

The noise levels measured at the site indicate that noise levels currently exceed the WHO Guideline for serious annoyance within outdoor living areas.

It is important to ensure that the proposed development does not result in significantly elevated noise levels at nearby noise sensitive receptors where this may increase noise levels above the WHO thresholds.

Consideration should be given to boundaries with noise sensitive receptors when positioning new hard play areas (MUGA's), new sports pitches, new car-parking facilities or new fixed plant installations, to ensure that noise impacts are minimised.

5 Conclusions

A noise measurement survey has been conducted around the current school site. Daytime noise levels range between $L_{Aeq,30min}$ 49 and 59 dB (excluding break times and lunchtime).

During teaching hours the existing noise climate at the site is dominated by air traffic with subsidiary contributions from road traffic and domestic sounds. The assessment was conducted based on the worst-case air traffic noise levels at the site.

Review of the noise measurements indicates that typical modern façade and roof constructions will result in acceptable internal ambient noise levels.

An attenuated natural ventilation system or mechanical ventilation will be required for all areas of the site.

Noise levels at the site do not fall within the range recommended in Acoustics of Schools: a design guide as being acceptable for playgrounds, playing fields and other outdoor areas.

Although noise levels measured at position ST4 were below 50 dB $L_{Aeq,30min,}$ the measured levels are not deemed to be worst-case due to lulls in air traffic. Furthermore, the measured noise levels are very close to 50 dB $L_{Aeq,30min}$ even for scenarios that are not worst-case. Therefore, it is concluded that there is not an area "*suitable for outdoor teaching activities where noise levels are below 50 dB* $L_{Aeq,30min}$."

A day-time limit for Rating Level for new fixed plant installations of 35 dB(A) at the nearest noise sensitive receptors is proposed.

A night-time for Rating Level for new fixed plant installations of 35 dB(A) at the nearest noise sensitive receptors is proposed.

WHO Guidelines for annoyance within outdoor living areas of nearby noise sensitive receptors have been considered in the context of the measured noise levels and potential noise generating facilities at this educational site.

Appendix A. Photographs of Noise Measurement Positions

Figure A.1: Measurement Position LT1

Figure A.2: Measurement Position ST1

Figure A.3: Measurement Position ST2

Figure A.4: Measurement Position ST3

Figure A.5: Measurement Position ST4

Figure A.6: Measurement Position ST5

Appendix B. Noise Measurements

Table B.1: Measurements from Unattended Measurement Position LT1

Start Date and Time		$L_{Aeq,15min}$ (dB)	$L_{A01,15min}$ (dB)	$L_{A90,15min}$ (dB)
20-9-2016	10:23	58.1	69.2	43.0
20-9-2016	10:30	62.9	72.9	45.3
20-9-2016	10:45	61.2	71.3	45.3
20-9-2016	11:00	59.5	73.5	37.5
20-9-2016	11:15	57.2	70.8	37.1
20-9-2016	11:30	53.6	66.8	36.4
20-9-2016	11:45	55.2	68.2	37.1
20-9-2016	12:00	61.7	67.9	40.6
20-9-2016	12:15	61.9	69.9	49.7
20-9-2016	12:30	62.2	73.4	51.5
20-9-2016	12:45	62.1	72.7	49.9
20-9-2016	13:00	61.0	71.5	38.0
20-9-2016	13:15	56.2	71.6	37.9
20-9-2016	13:30	55.6	66.2	37.5
20-9-2016	13:45	56.2	67.4	39.3
20-9-2016	14:00	57.8	68.0	42.0
20-9-2016	14:15	58.5	71.2	42.3
20-9-2016	14:30	59.4	74.3	40.4
20-9-2016	14:45	57.8	72.8	40.2
20-9-2016	15:00	52.5	63.2	40.0
20-9-2016	15:15	59.6	65.4	41.3
20-9-2016	15:30	58.8	71.9	43.3
20-9-2016	15:45	57.1	72.3	43.3
20-9-2016	16:00	57.8	69.5	42.7
20-9-2016	16:15	57.7	69.1	43.1
20-9-2016	16:30	57.5	68.5	45.6
20-9-2016	16:45	57.1	68.9	45.1
20-9-2016	17:00	57.5	66.7	45.5
20-9-2016	17:15	56.9	65.4	39.2
20-9-2016	17:30	55.6	69.0	38.4
20-9-2016	17:45	57.8	68.2	38.4
20-9-2016	18:00	50.9	61.8	37.2
20-9-2016	18:15	54.2	63.1	36.9
20-9-2016	18:30	56.6	70.5	35.9
20-9-2016	18:45	57.4	67.3	36.1
20-9-2016	19:00	56.7	70.8	36.8
20-9-2016	19:15	55.2	69.5	36.2

Start Date and Time		$L_{Aeq,15min}$ (dB)	$L_{A01,15min}$ (dB)	$L_{A90,15min}$ (dB)
20-9-2016	19:30	53.9	65.4	35.8
20-9-2016	19:45	53.6	66.2	36.3
20-9-2016	20:00	54.7	67.4	37.2
20-9-2016	20:15	53.2	64.9	36.6
20-9-2016	20:30	51.2	64.0	35.1
20-9-2016	20:45	50.6	66.2	35.3
20-9-2016	21:00	55.7	67.0	36.6
20-9-2016	21:15	55.2	66.7	36.1
20-9-2016	21:30	54.0	65.6	36.1
20-9-2016	21:45	54.5	64.8	35.6
20-9-2016	22:00	55.4	67.7	35.4
20-9-2016	22:15	58.3	71.3	35.3
20-9-2016	22:30	60.8	75.1	34.0
20-9-2016	22:45	52.3	68.9	33.2
20-9-2016	23:00	54.1	66.7	31.2
20-9-2016	23:15	44.2	64.2	31.6
20-9-2016	23:30	32.3	38.2	29.3
20-9-2016	23:45	32.1	38.1	29.6
21-9-2016	00:00	32.5	36.4	30.3
21-9-2016	00:15	32.2	36.2	30.1
21-9-2016	00:30	31.9	35.8	30.0
21-9-2016	00:45	31.2	35.9	28.9
21-9-2016	01:00	30.8	38.7	27.6
21-9-2016	01:15	30.4	37.2	27.5
21-9-2016	01:30	29.5	39.1	26.3
21-9-2016	01:45	29.8	41.2	26.1
21-9-2016	02:00	34.2	47.4	25.5
21-9-2016	02:15	30.1	41.5	25.4
21-9-2016	02:30	29.9	36.7	26.3
21-9-2016	02:45	28.4	35.5	26.6
21-9-2016	03:00	27.5	32.0	25.4
21-9-2016	03:15	27.4	39.5	25.4
21-9-2016	03:30	27.9	34.6	24.7
21-9-2016	03:45	28.3	32.7	25.3
21-9-2016	04:00	29.0	39.6	25.3
21-9-2016	04:15	28.7	40.7	25.4
21-9-2016	04:30	30.3	37.6	26.3
21-9-2016	04:45	31.3	38.3	26.9
21-9-2016	05:00	31.1	36.6	28.4
21-9-2016	05:15	30.8	36.2	29.7
21-9-2016	05:30	31.3	34.7	29.6
21-9-2016	05:45	38.4	45.2	30.9
21-9-2016	06:00	48.4	62.8	32.6
21-9-2016	06:15	49.5	65.1	34.7
21-9-2016	06:30	52.3	64.0	35.3
21-9-2016	06:45	51.1	65.7	35.9
21-9-2016	07:00	50.0	61.7	36.3

Start Date and Time		$L_{Aeq,15min}$ (dB)	$L_{A01,15min}$ (dB)	$L_{A90,15min}$ (dB)
21-9-2016	07:15	54.2	64.5	37.1
21-9-2016	07:30	55.0	65.4	37.2
21-9-2016	07:45	55.3	64.7	37.8
21-9-2016	08:00	55.7	65.8	39.0
21-9-2016	08:15	54.5	67.2	38.4
21-9-2016	08:30	54.8	66.6	37.5
21-9-2016	08:45	55.1	65.4	36.6
21-9-2016	09:00	52.2	63.8	35.2
21-9-2016	09:15	51.8	65.5	34.8
21-9-2016	09:30	54.0	67.2	33.9
21-9-2016	09:45	53.1	64.8	35.1
21-9-2016	10:00	52.5	65.7	36.1
21-9-2016	10:15	54.6	71.2	38.5
21-9-2016	10:30	70.1	80.3	42.1
21-9-2016	10:45	68.2	78.7	40.9
21-9-2016	11:00	65.8	77.8	35.2
21-9-2016	11:15	55.2	73.4	35.2
21-9-2016	11:30	53.6	67.5	34.0
21-9-2016	11:45	55.7	68.3	33.6
21-9-2016	12:00	74.2	86.8	37.1
21-9-2016	12:15	68.9	89.5	48.3
21-9-2016	12:30	66.4	79.5	50.4
21-9-2016	12:45	68.5	81.4	48.8
21-9-2016	13:00	71.4	83.4	36.9
21-9-2016	13:15	60.1	77.6	37.5
21-9-2016	13:30	58.5	70.5	43.1
21-9-2016	13:45	55.7	69.5	42.8
21-9-2016	14:00	56.8	67.7	41.8
21-9-2016	14:15	58.2	67.1	42.6
21-9-2016	14:30	55.7	66.9	41.7
21-9-2016	14:45	54.5	63.8	40.9
21-9-2016	15:00	46.2	55.8	38.2
21-9-2016	15:15	49.1	59.2	39.5
21-9-2016	15:30	50.6	60.8	39.2
21-9-2016	15:45	52.3	61.1	39.3
21-9-2016	16:00	50.6	62.1	39.2
21-9-2016	16:15	53.1	63.7	41.3
21-9-2016	16:30	52.7	63.2	43.1

Table B.2: Measurements from Short Term Attended Measurement Positions

Location	Start date and time	$L_{Aeq,30min}$ (dB)	Max $L_{A01,10min}$ (dB)	Typical $L_{A90,10min}$ (dB)	Octave band $L_{Aeq,30min}$ (dB)							
					31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
ST1	20-9-2016 11.07	58.6	76.7	38.3	26.8	37.7	46.6	50.9	53.9	53.3	50.0	36.3
ST2	20-9-2016 11.43	55.4	71.7	37.9	19.3	31.8	40.7	46.1	49.7	50.7	48.8	41.1
ST3	20-9-2016 12.44	57.8	75.2	45.2	23.7	34.9	43.4	48.5	51.4	53.4	51.6	41.2
ST4	20-9-2016 13.26	49.2	63.3	35.8	17.0	29.5	35.9	43.2	44.5	43.7	38.1	27.7
ST5[2]	20-9-2016 14.04	50.1	58.9	40.3	15.2	29.6	36.7	41.0	44.0	43.6	43.9	40.7

[2] 10-minute measurement period.

Appendix C. Glossary of Terms

A-weighting

The human ear also has a non-linear frequency response, being most sensitive in the frequency range 1 kHz to 4 kHz and is less sensitive at higher and lower frequencies. The A-weighting is a frequency function commonly applied to the linear output of a microphone to simulate the subjective response of the ear. A-weighted levels are usually indicated by a subscript A or postscript (A).

Ambient noise

This is the total sound for a given scenario where the acoustic field is affected by a variety of sources.

Decibel

Sound and noise are commonly described using the decibel (dB) scale, which is logarithmic in nature to relate to the response of the human ear. The range of human hearing commonly varies from the threshold of audibility (0 dB) to the threshold of pain (120 dB). Such limits are seldom experienced in practice and typical levels might vary between 30 dB in a quiet bedroom at night to 90 dB at the kerbside of a busy road.

Equivalent continuous noise level L_{eq}

Time-varying noise such as that from industrial or construction operations may not best be described using the statistical approach described above. The equivalent continuous noise level, $L_{Aeq,T}$, may be used, which is the notional level of a steady sound which, at a given position and over the same period of time (T), would deliver the same sound energy as the fluctuating one.

Façade sound level

The received sound level which is measured or calculated immediately adjacent to a building façade, normally at 1m distance. Sound is reflected by the hard surfaces of a façade producing a slightly higher sound level (2.5 to 3.0 dB) than would occur in the absence of the building.

Free field sound level

The sound level which is measured or calculated within an acoustic field which is free of significantly reflective surfaces (except the ground plane).

Maximum sound pressure level $L_{(max)}$

The highest A-weighted sound level reached within the measurement period. “Fast” denotes that the level is weighted to the response time of the ear (125 ms) instead of to 1 second (denoted “Slow”).

Rating noise level

Noise level of an industrial noise source with any appropriate corrections applied for the presence of distinct acoustic features.

Sound power level

This is a measure of the sound energy radiated by an acoustic source per unit time. It is a characteristic of the source alone and independent of the properties of the acoustic field.

Statistical noise level L_N

Noise which fluctuates with time may be described using a statistical approach. The statistical level LAN is the level in dB exceeded for N % of the overall measurement period. L_{A90} is the noise level exceeded for 90 % of the sampling period and is a measure the lower levels in the absence of higher level transient events. It is commonly used to describe the ambient or background noise. The L_{A10} is the noise level exceeded for 10 % of the sampling period and is a measure the higher levels. In the UK, it is commonly used to describe road traffic noise and, when considered over the 18-hour period 06:00 to 24:00 is referred to as the traffic noise index.