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NUFFIELD ORTHOPAEDIC HOSPITAL

WINDMILL RD

OXFORD

OX3 7LD

ENVIRONMENTAL SOUND SURVEY & PLANT NOISE EMISSIONS ASSESSMENT

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1.0 Introduction

1.1 An environmental sound survey has been undertaken to determine the prevailing background sound levels at the worst affected noise sensitive receiver with regard to the proposed plant installation at Nuffield Orthopaedic Hospital, and to establish appropriate noise emission criteria for new building services plant in accordance with local authority requirements.

1.2 This report serves to support the planning application for four new chillers associated with the refurbished MRI facility.

1.3 The proposed services plant are understood to operate 24-hours a day, seven days a week. Two chillers will be operational 24-hours a day, with the remaining two serving as back-up plant.

1.4 Plant noise emission limits have been established in accordance with local authority criteria at the worst affected noise sensitive receiver, and a plant noise emission assessment has been undertaken to determine the likely impact of the proposed new building services plant in accordance with BS 4142.

1.5 The local authority is Oxford City Council.

2.0 Site Description

2.1 The proposed plant location is adjacent to a courtyard area, which is overlooked by various occupied hospital buildings.

2.2 The worst affected noise sensitive receivers have been identified as the residential dwellings to the south of Old Road approximately 90 metres away from the proposed plant location.

3.0 Site Sound Survey

3.1 Instrumentation: NTI XL2 sound level meter (Serial No. A2A-10121-EO). The instrument was powered by an external battery and stored in a weather proof case. The instrument was checked for calibration before and after use with a Larson Davis type CAL 250 calibrator whereupon no calibration drift was recorded. The instrument was used in accordance with manufacturer's instructions.

3.2 Location: The sound monitor was located 1m from the northern façade of Joliffe House, 72 Old Road Oxford. The microphone was located on a tripod giving a measurement position 1.2m above local ground level. Refer to Appendix 1 for the site plan and sound monitoring location.

3.3 Periods: Sound level monitoring was continuous from approximately 12:00 hours on Thursday 18th March 2021 to approximately 02:00 hours on Friday 19th March 2021 with regard to night time levels, and 10:00 to 11:00 hours on Friday 19th March 2021 with regard to daytime levels. The sound level meter was configured to monitor sound levels continuously in fifteen-minute intervals.

3.4 Weather: The prevailing weather conditions over the survey period were dry and calm. Wind speed, although not recorded, was considered to be less than 5 m/s throughout the survey periods.

3.5 Site Sound Characteristics: The night time ambient noise level was characterised by distant plant noise from the hospital and distant road traffic noise with occasional contributions from local road traffic noise on Old Road. It is considered that no unusual events occurred during the survey period, and the data is a true representation of ambient noise levels in the area.

3.6 Surveyor: Bernard Templeman (MIOA)

3.7 Results: The results of the survey are summarised below in Table 1 showing the recorded values of background sound (L_{A90} dB). These results are considered façade noise levels.

Table 1: Summary of Sound Measurement Results

Description	**Lowest Measured Background Sound Level**
Daytime (10:00 – 11:00)	69 dB L_{A90} (15 minutes)
Night-time (00:00 to 02:00)	42 dB L_{A90} (15 minutes)

3.8 Refer to Appendix 4 for a glossary of terms.

4.0 Plant Noise Criteria

4.1 Guidance on sound from mechanical services plant is contained in British Standard 4142:2014 "*Method for rating and assessing industrial and commercial sound*". BS4142 sets out a method by which the likely magnitude of adverse impact of sound from a commercial or industrial use on residential premises can be determined.

4.2 The method is based upon establishing the existing background $L_{A90, t}$ sound levels at the noise sensitive properties against which the likely levels of sound from the proposed development are assessed. Sound from the proposed plant is assessed over a reference time interval of 1-hour during the day (07:00 hrs – 23:00 hrs) and 15-minutes during the night (23:00 hrs – 07:00 hrs).

4.3 The $L_{Aeq, 1hr}$ or $L_{Aeq, 15min}$ sound level from the proposed plant, as calculated to the noise sensitive properties, is the "*specific sound level*" of the plant. If it is likely that sound from the plant will be tonal at the receiver locations, or will be intermittent enough to attract attention, acoustic penalties will be added to the specific sound level. The specific sound level is also to be corrected to account for "on-time" during the reference time interval if the plant is not continuous.

4.4 The rating sound level is then referenced to the background sound level and the difference noted. The likelihood of adverse impact is determined from the BS4142 method as indicated below;

a) *Typically, the greater this difference, the greater the magnitude of the impact.*

b) *A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.*

c) *A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.*

d) *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.*

5.0 Mechanical Plant Noise Emission Limits

5.1 It is understood Oxford City Council's policy with regard to plant noise egress generally requires new plant to achieve 5 dB below the lowest measured background sound levels for the given hours of operation when assessed to 1m from the worst affected window of the nearest noise sensitive receiver. However, where the plant is tonal, plant noise egress is required to achieve 10 dB below the lowest measured background sound levels when assessed to 1m from the worst affected window of the nearest noise sensitive receiver.

5.2 The proposed services plant are to operate throughout the night time period, 24-hours a day, seven days a week. Note, chillers are considered to have tonal acoustic features.

5.3 The lowest background sound level measured during the survey was 42 $L_{A90\ (15\ minutes)}$. Therefore, the plant should be designed to see that noise emissions do not exceed a rating level of 32 dB L_{Aeq} when assessed to a location 1m from the worst affected window of the nearest noise sensitive receiver. In accordance with BS 4142, achieving this criterion is considered to be an indication of negligible impact.

5.4 This equates to a plant noise limit of 67 dB L_{pA} measured 1mfrom the plant, or 47 dB L_{pA} measured 10m from the plant.

6.0 Plant Noise Emissions Assessment

6.1 The proposed chiller locations and data sheets are shown in Appendix 3 and 4. The selected chillers are understood to have a sound pressure level of 58 dB L_{pA} at 10m.

6.2 The chillers are understood to operate 24-hours a day, seven days a week. Two chillers will be operational 24-hours a day, with the remaining two units serving as back-up plant.

6.3 The worst affected sensitive receivers have been identified as the worst affected window of the residential dwellings on Old Road approximately 90m away from the proposed plant location.

6.4 Calculations have been performed, based upon the information provided, in order to determine the likely plant noise rating level 1m from the worst affected window of the nearest noise sensitive receiver. The assessment results have been compared to local authority criteria, with corrections for distance attenuation and acoustic features. A summary of the assessment calculations are outlined in the table below.

6.5 It can be seen that the local authority criteria for noise emissions for tonal plant i.e. 10 dB below the lowest measured background sound level for the given operational period, is exceeded by 10 dB.

Table 2: BS 4142 Noise Assessment (night time assessment)

Plant	**A-weighted Calculation Summary, dB**
Chiller, L_{pA} at 10m	58
2 units operating continuously 24 hours a day, L_{pA} at 10m	61
Operational diversity (to account for reduced night time cooling load)	-3
Distance attenuation 90m 20 x log(90/10)	-19
Facade correction	3
Specific noise level 1m from window, L_s	**42**
Lowest night time background noise level, L_{A90}	42
Oxford City Council tonal plant criteria (background – 10 dB)	32
Excess above plant noise emissions criterion	**+10**

6.6 In order to achieve the local authority plant noise emissions criteria for tonal plant, a scheme of noise mitigation works which achieves a 10 dB reduction in A-weighted sound pressure will be necessary for the chillers. This could be achieved installation of a proprietary sound attenuating acoustic package, or by installation of a solid, continuous, imperforate timber fence with a minimum mass of 15 kg/m^2 which extends 1m above the top of the plant and blocks line of sight from the plant to the highest window of the residential buildings on Old Road.

7.0 Conclusion

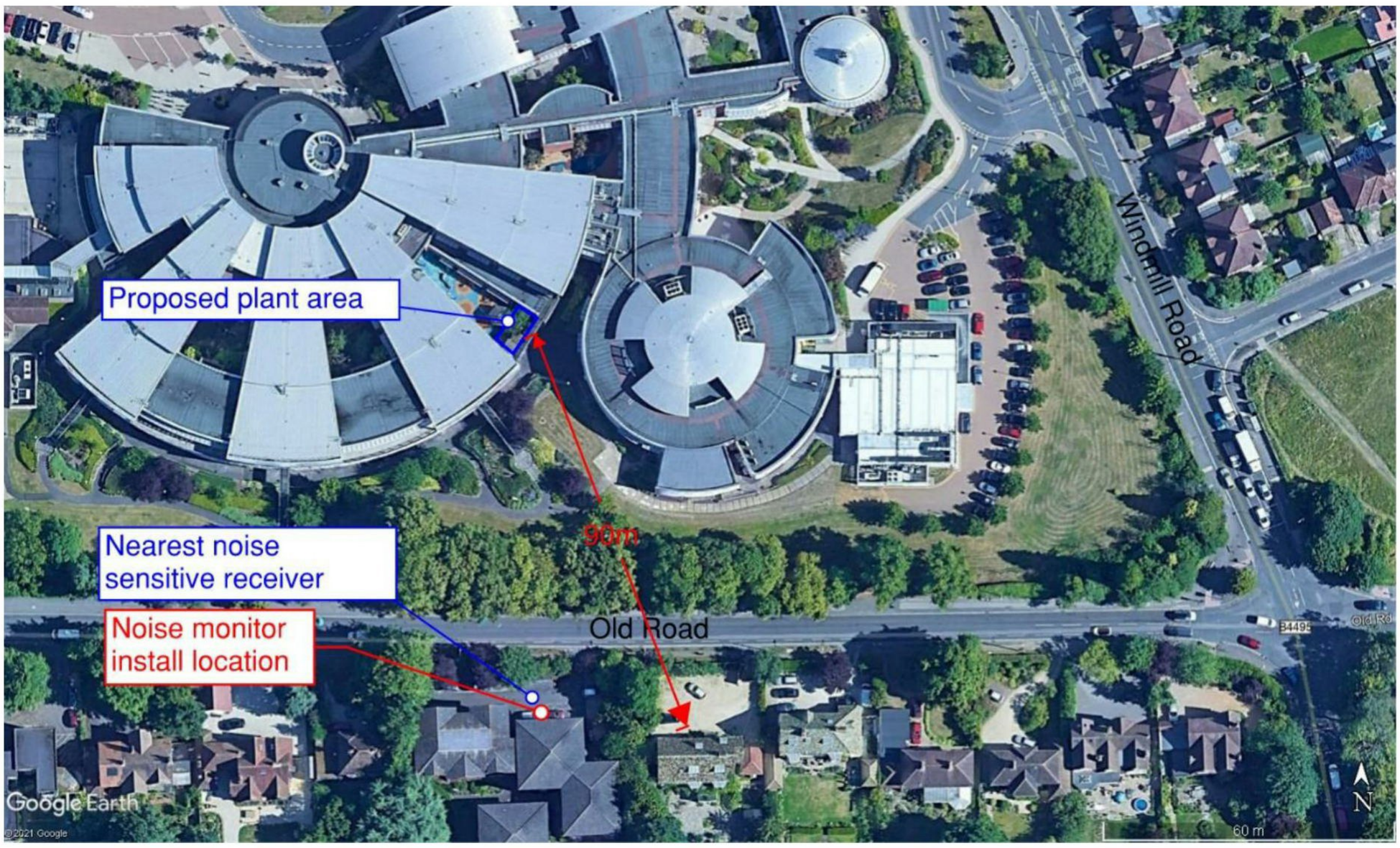
7.1 A sound monitoring survey has been undertaken in the vicinity of the proposed plant installation at Nuffield Orthopaedic Hospital to establish the prevailing background sound levels at the site with regard to the proposed installation of new building services plant equipment. The general location of the worst affected noise sensitive receiver(s) are considered to be the residential properties on Old Road.

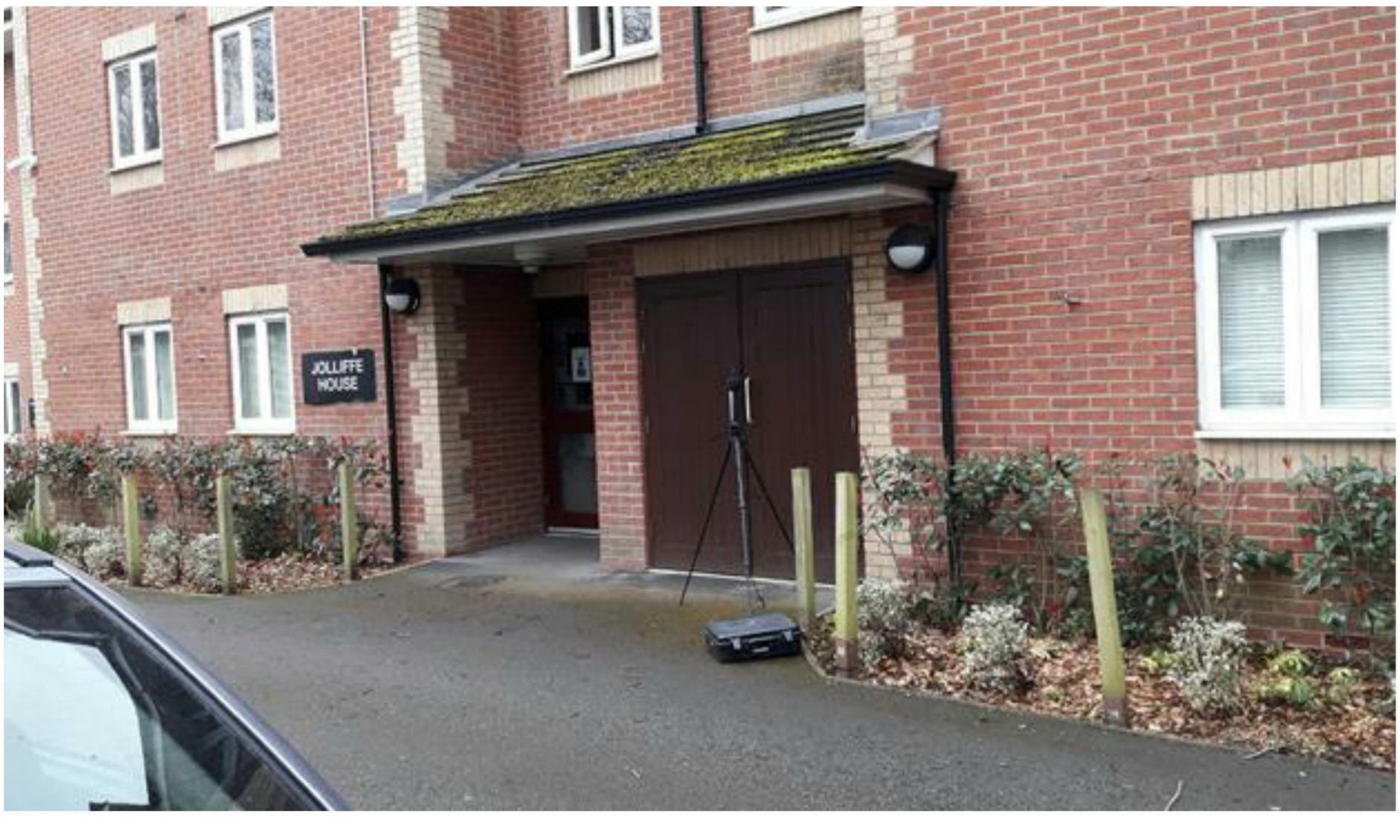
7.2 A plant noise assessment has been undertaken, considering the proposed chiller locations and data provided, with regard to noise egress to the worst affected window of the nearest noise sensitive receiver. The assessment results have been compared to the measured survey data, and local authority requirements.

7.3 Without mitigation the local authority criteria for tonal plant, 10 dB below the lowest measured background noise level for the given operational period, is exceeded by 10 dB.

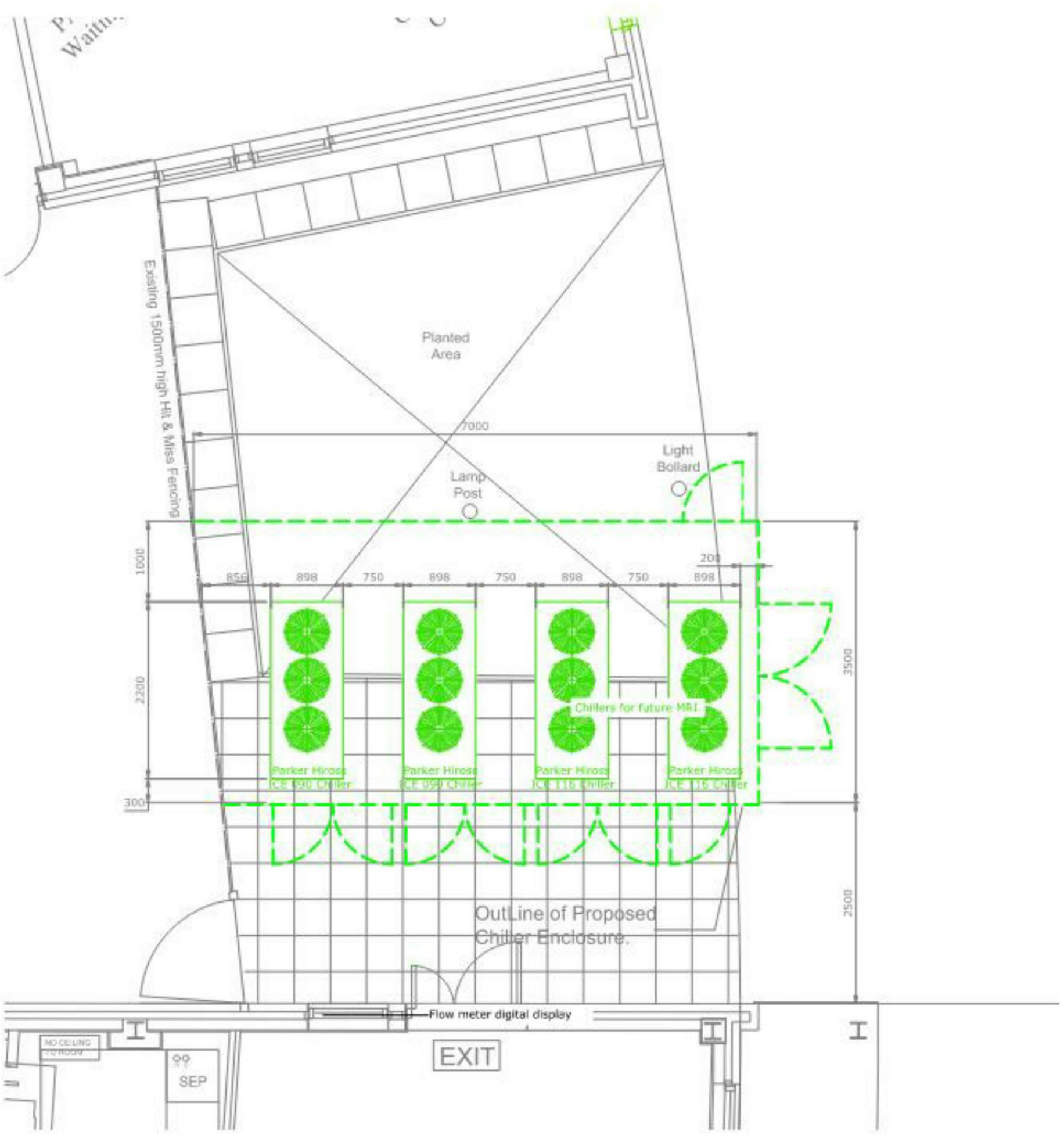
7.4 In order to achieve the local authority plant noise criteria for tonal plant, a scheme of noise mitigation works which achieves a 10 dB loss is required for the chillers. This could be achieved installation of a proprietary sound attenuating acoustic package, or by installation of a solid, continuous, imperforate timber fence with a minimum mass of 15 kg/m^2 which extends 1m above the top of the plant and blocks line of sight from the plant to the highest window of the residential buildings on Old Road.

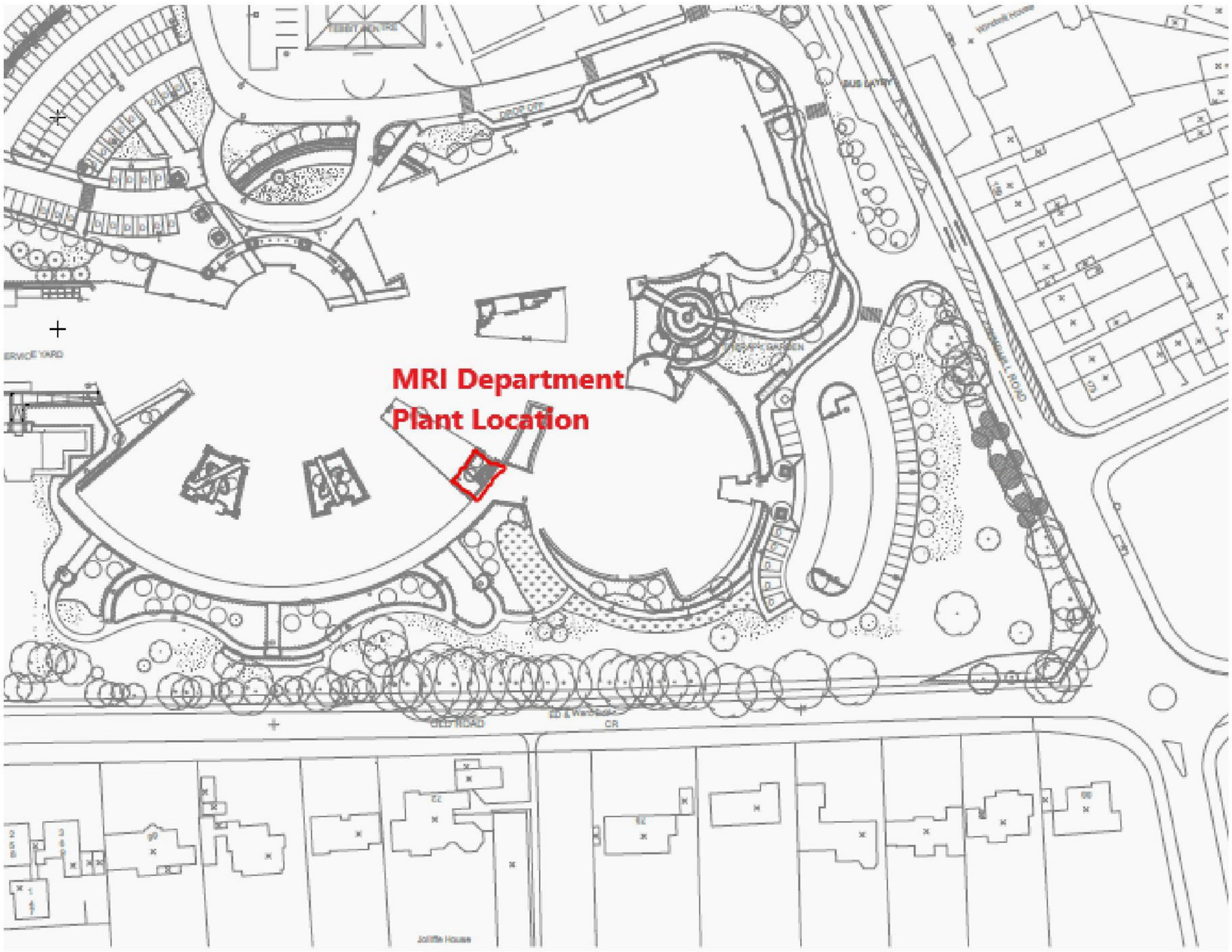
Appendix 1: Site Plan & Measurement Location





Appendix 2: Proposed Plant Location




MRI Department
Plant Location


Proposed
plant area

Appendix 3: Proposed Chiller Data

Technical data

Model ICE		076	090	116	150	183	230	310	360
Cooling capacity[1]	kW	76,0	90,2	115,5	149,2	182,3	228	309	360
Compressor abs. power[1]	kW	15,4	20,3	24,9	30,8	40,1	51,4	65	82
Power supply	V/ph/Hz	400/3/50 no neutral							
Protection index		54							
Refrigerant		R407C							
Compressors									
Type		Hermetic scroll							
Compressors/circuits		2/2			4/2				
Max abs. power - 1 comp.	kW	11,1	13,7	16,8	11,1	13,7	16,8	23,3	28,7
Axial fans									
Quantity	n°	3			2		3	4	
Max abs. Power - 1 fan	kW	0,78	0,78	0,78	2	2	2	2	2
Air flow	m^3/h	25500	25000	26400	47000	46000	66000	88000	88000
Centrifugal fans									
Quantity	N°	3			3			N.A.	
Max abs. Power - 1 fan	kW	1,5	1,5	1,5	3	3	3		
Air flow	m^3/h	25500	25000	26400	47000	46000	66000		
Head pressure	Pa	100	100	100	180	180	130		
Water cooled version									
Condenser water flow	m^3/h	11,1	11,5	16,6	19,2	31,0	33,0	N.A.	
Condensers connections	in	1 ¼"	1 ¼"	1 ¼"	1 ¼"	1 ¼"	1 1/2"		
Pump P30									
Max abs.power	kW	2,5	2,7	2,7	4,5	4,5	4,5	8,4	8,4
Water flow (nom/max)[1]	m^3/h	13/31	15/27	20/27	25/50	30/50	39/50	53/90	62/90
Head pressure (nom/min)[1]	m H_2O	23/13	28/16	25/16	34/20	32/20	26/20	26/19	23/19
Dimensions and weight									
Width	mm	898	898	898	1287	1287	1287	1500	1500
Depth	mm	2200	2200	2200	3000	3000	3260	4200	4200
Height	mm	1984	1984	1984	2298	2298	2298	2240	2240
Connections in/out	in	2"	2"	2"	2 ½"	2 ½"	2 ½"	4"	4"
Tank capacity	l	500	500	500	1000	1000	1000	400	400
Weight (axial)	kg	800	900	1000	1500	1800	2100	2900	3100
Weight (centrif.)	kg	950	1050	1150	1700	2000	2300	N.A.	
Weight (water cooled)	kg	800	900	1000	1500	1800	2100		
Noise level									
Sound pressure (axial)[2]	dB(A)	58	58	58	62	62	64	65	65

1) at water in/out temperature = 20/15 °C, glycol 0 %, either 25 °C ambient temperature (air-cooled models) or 25 °C condenser water inlet temperature with 35°C condensing temperature (water-cooled models).
2) referred to axial fan version in free field conditions at a distance of 10m from unit, measured on condenser side, 1m from ground.

Appendix 4: Glossary of Terms

Term	Description	Explanation
	Sound	Unwanted sound. In the explanation given below the words 'sound' and 'sound' can often be used interchangeably, depending on context.
dB	The decibel scale	The decibel (or dB) scale is the scale on which sound pressure levels are commonly measured. It is a logarithmic scale and is used for convenience to compress the audible range of sound pressures into a manageable range, from 0 dB to 140 dB. The zero of the scale, 0 dB, corresponds to the threshold of hearing, 0.00002 Pa, and the upper limit, 140 dB, corresponds to 20 Pa, the threshold of pain.
	Sound pressure	Sound is a disturbance or fluctuation in air pressure, and sound pressure, measured in pascals (Pa), is used as a measure of the magnitude of the sound. The human ear can detect sound pressures in the range from 0.00002 Pa to 20 Pa. This is an enormously wide range and so for convenience sound pressures are commonly measured on a decibel (dB) scale.
Lp	Sound pressure level	Instantaneous value of Sound Pressure Level (Lp).
	Sound power	The sound energy radiated per unit time by a sound source, measured in watts (W)
L_w	Sound power level	Sound power measured on a decibel scale: $L_W = 10\log(W/W_0)$, where W_0 is the reference value of sound power, 10^{-12} W.
f	Frequency	The frequency of a musical note is what gives it its pitch. It is the number of cycles of the fluctuating sound pressure which occur each second, and is measured in cycles per second, or Hertz (Hz). The human ear can detect frequencies in the range 20 to 20 000 Hz. Most sounds and sounds are a mixture of all frequencies, called broad-band sound.
	Octave bands Octave band spectra	In order investigate the frequency content of broad band sounds, called its frequency spectrum, measurements of sound pressure are carried out over a range of frequency bands. The most common method is to split the audio frequency range into 8 or 9 octave bands. An octave is a frequency range from one particular frequency to double that frequency.
	Free-field	A free field sound level measurement is one which is unaffected by the presence of any sound reflecting surfaces. In an outdoor situation this is usually taken to mean with no sound reflecting surfaces within 3 m. of the source.
	Facade correction Factor	The difference between the façade level and the free field level (in the absence of the façade) is called the façade correction factor.
A	A-weighting	One of the three frequency weightings (A, C and Z) used in sound level meters, and defined in BS EN ISO 61672-1; a very widely used method of producing a single figure measure of a broad band sound which takes into account, in an approximate way at least, the frequency response of the human hearing system. The idea is that sound levels measured in this way should give an indication of the loudness of the sound.
L_A (dBA)	A- weighted sound pressure level	The value of the sound pressure level, in decibels, measured using an A-weighting electronic circuit built into the sound level meter. The vast majority of sound measurements are carried out in this way.
$L_{Aeq,T}$	Equivalent continuous sound level	It represents a measure of the 'average' sound level over the measurement period. It corresponds to the steady level of sound which, over the same period of time, T, would contain the same amount of (A-weighted) sound energy as the time varying sound. Also known as the Average sound level. This is the most common method of measuring time varying sound, and within certain limits gives the best correlation with human response to sound, for example with annoyance.

$L_{AN,T}$	Statistical percentile sound levels	$L_{AN,T}$ is the sound level, usually A-weighted, which is exceeded for N% of the measurement period, T. The most commonly used values are $L_{A10,T}$ used for the measurement and assessment of traffic sound, and $L_{A90,T}$, commonly used as a measure of background sound. $L_{A1,T}$ and $L_{A99,T}$ are also occasionally used to give an indication of the highest and lowest sound levels occurring during the measurement time interval.
	Background sound	Ambient sound which remains at a given site when occasional and transient bursts of higher level ambient sound levels have subsided to typically low levels; it is the sound normally present for most of the time at a given site. It is usually described by the L_{A90} value.
$L_{A90,T}$	Background sound level	Defined in BS 4142 as the value of the A-weighted residual sound at the assessment position that is exceeded for 90 % of a given time interval, T, (i.e. $L_{A90,T)}$ measured using time weighting, F, and quoted to the nearest whole number of decibels. (Also see under residual sound). Background sound itself often varies with time and so the $L_{A90,T}$ is almost universally used as the best measure of the 'more or less always present' sound level which underlies short term variations from other sources of sound.
	Specific Sound Source	The sound source under consideration when assessing the likelihood of adverse impact using BS4142:2014.
	Specific Sound Level	The value of $L_{Aeq,T}$ at the assessment position produced by the specific sound source, ref. BS4142:2014.
$L_{ar,Tr}$	Rating Level	The specific sound level, corrected to account for any characteristic features of the sound, by adding a rating penalty for any tonal, impulsive or irregular qualities, ref. BS4142:2014.
T_r	Reference time interval	Specified interval over which the specific sound level is determined, ref. BS4142:2014.
	Residual Sound	Ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound, ref. BS4142:2014.
$L_r = L_{Aeq,T}$	Residual Sound Level	Equivalent continuous A-weighted sound pressure level of the residual sound at the assessment location over a given time interval, T, ref. BS4142:2014.