REPORT N^{O} 70023367-404

OLD HALL STREET, LIVERPOOL

NOISE AND VIBRATION IMPACT ASSESSMENT

NOVEMBER 2016

WSP | PARSONS BRINCKERHOFF

OLD HALL STREET, LIVERPOOL

NOISE AND VIBRATION IMPACT ASSESSMENT

122 OLD HALL STREET LIMITED

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1 INTRODUCTION

1.1.1 WSP | Parsons Brinckerhoff have been appointed by 122 Old Hall Street Ltd to undertake a noise and vibration assessment to support the planning application for a proposed residential development for a site at Old Hall Street, Liverpool.

1.1.2 This report describes the noise and vibration monitoring, assessment and appropriate mitigation measures required in order achieve applicable internal noise level criteria and applicable vibration criteria in order to provide an appropriate level of protection to future residents within the proposed development, in addition to controlling noise emissions from the proposed development in order to protect existing noise sensitive receivers, as agreed with the local authority.

1.1.3 The report is necessarily technical in nature and so, to assist the reader, a glossary of terms is included in **Appendix A**.

2 SITE DESCRIPTION

2.1 EXISTING SITE

2.1.1 The site is located to the eastern side of Back Leeds Street in Liverpool and is currently occupied by a car park. Leeds Street (A5053) bounds the north of site with Great Howard Street (A5052) linking with Leeds Street at the north west of the site. There are existing office buildings immediately to the south of the site and the Radisson Blu Hotel approximately 30m to the south west of the site boundary.

2.1.2 The wider area of the site consists predominantly of office buildings to the south, in addition the Pall Mall NCP car park is situated to the east. To the north of the site on the opposite side of Leeds Street is an existing car dealership and the Merseyrail line which runs underground approximately 100m north of the site boundary. To the west of the site and Great Howard Street are some business units which house various commercial businesses on Gibraltar Row.

Figure 2-1. Aerial photograph of existing site and surroundings

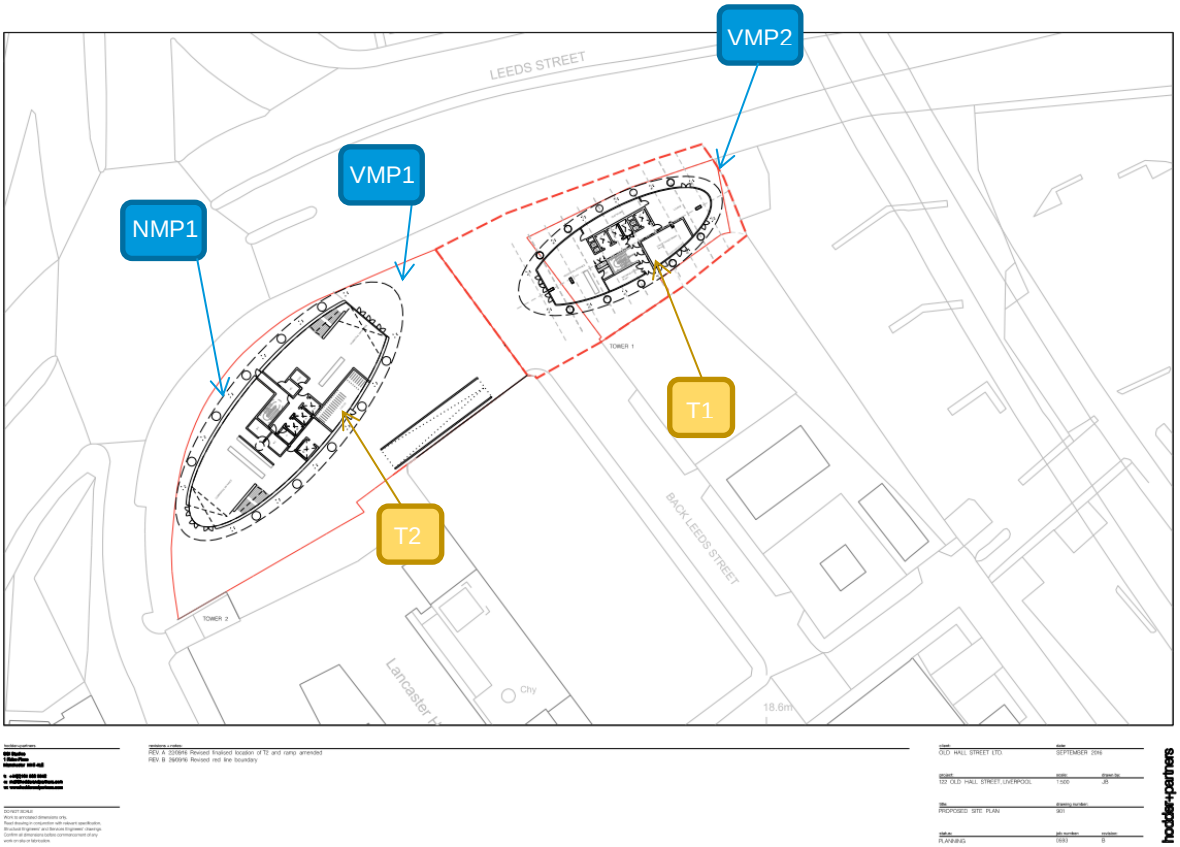
2.2 DEVELOPMENT PROPOSALS

2.2.1 The development assessed within this report is part of a wider proposed scheme which consists of two separate residential towers within the site named Tower 1 (T1) and Tower 2 (T2). T1 is proposed at the area of the site currently occupied by the car park accessed off Back Leeds Street. T2 is currently proposed to be situated in the location of the existing datacentre. The location of T1 and T2 in relation to the site and surroundings can be seen in Figure 2-2.

2.2.2 It is understood that all proposals for T2 will be assessed under a separate planning application, therefore this report considers the assessment for T1 only.

2.2.3 The proposals for T1 consist of a 27 storey residential tower comprising of a reception area with mezzanine level at ground floor, one level for transfer (cycle parking) and 26 levels of residential development of which there are a mix of 168 studio, one-bed, two-bed and three-bed apartments proposed.

Figure 2-2. Proposed site layout



3 CRITERIA

3.1 CONSULTATION WITH LIVERPOOL CITY COUNCIL

3.1.1 Prior to carrying out the assessment, the potential noise impacts on the proposed development and general principles of the assessment methodology were agreed with Dr Ian Rushforth of Liverpool City Council (LCC).

3.1.2 LCC agreed that an assessment carried out in line with BS 8233:2014 would be appropriate to assess the noise levels impacting on the proposed development in order to protect future residents. It was also agreed that an assessment in line with BS 4142:2014 would be required in order to protect existing nearby sensitive receivers, namely the Radisson Blu hotel on Old Hall Street from fixed plant noise emissions associated with the development.

3.1.3 Due to the Merseyrail line running underground approximately 60m from the development boundary, it was agreed with LCC that a vibration assessment in line with BS 6472-1:2008 would be undertaken.

3.1.4 In addition, LCC have a certain minimum standard of acoustic insulation in order to 'future-proof' such developments in the growing and lively city centre environment in accordance with the 'City Centre Noise Policy' document. The following criteria applies to this development:

> *"All residential conversion schemes, or new build residential developments, within the area of the City designated for the purposes of these requirements, shall be acoustically insulated prior to any occupation of the dwellings in accordance with details to be submitted and approved. Sound mitigation must take the form of a package of acoustic treatment to the windows of all habitable rooms in accordance with the specifications contained in the Noise Insulation Regulations, 1975, or double glazing (to the specification 10mm-12mm-6mm), and the provision of a scheme of acoustically attenuated mechanical ventilation to remove the need to open windows for rapid ventilation, which complies with the performance requirements of the Noise Insulation Regulations, 1975."*

3.1.5 The above paragraph sets out a minimum glazing specification for new development within the City area of Liverpool, which this development falls within, of 10mm glazing, 12mm air gap, 6mm glazing. In addition to the minimum glazing specification, rapid ventilation should be provided by a mechanical ventilation scheme to remove the need to open windows. A mechanical ventilation scheme should be designed such that internal noise levels are not exceeded within each apartment.

3.2 BRITISH STANDARD 4142: 2014 METHODS FOR RATING AND ASSESSING INDUSTRIAL AND COMMERCIAL SOUND (BS 4142)

3.2.1 The assessment procedure contained within BS 4142 is initially to determine the 'Rating Level' ($L_{Ar,Tr}$) that is (or would be) generated by the source under assessment, externally, at a noise sensitive receptor. Where this source does not include any acoustic features, such as tonality, impulsivity or intermittency etc., then the Rating Level ($L_{Ar,Tr}$) equals the specific sound level (LS), which is the sound pressure level produced by the source using the $L_{Aeq,T}$ noise index. Where the source under assessment does include acoustic characteristics, then a series of corrections are added to the specific sound level in the determination of the Rating Level. The degree of correction applied in the determination of the rating level depends upon the results of either subjective or objective appraisals.

3.2.2 The background noise level at the assessment location, measured using the $L_{A90,T}$ noise index, is then subtracted from the rating level. The result provides an indication of the magnitude of impact, where the greater the difference, the greater the magnitude of impact

3.2.3 The following scale is presented:

- A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.
- 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.

3.2.4 It can be seen form the above that the magnitude of impact is also dependent upon the context in which the sound arises. Factors that are considered with respect to context include: the absolute level of sound, and the character and level of the residual sound (the in absence of the source under assessment) compared to the character and level of the specific sound.

3.2.5 With regards to absolute level, amongst other points, it is stated that "*where background sound levels and rating levels are low, absolute levels might be as, or more relevant than the margin by which the rating level exceeds the background. This is especially true at night*".

3.3 BRITISH STANDARD 8233:2014: GUIDANCE ON SOUND INSULATION AND NOISE REDUCTION FOR BUILDINGS

3.3.1 This standard provides guidance for the control of noise within buildings. The guidance provided within the document is applicable to the design of new buildings, or refurbished buildings undergoing a change of use.

3.3.2 The guidance provided includes appropriate internal and external noise level criteria which are applicable to dwellings for steady external noise sources. It is stated that it is desirable that the internal ambient noise level does not exceed the following criteria set out in Table 1 below:

Table 1: Summary of internal ambient noise levels to be achieved in habitable rooms when assessed in accordance with BS 8233

ACTIVITY	LOCATION	PERIOD	
		07:00 to 23:00 Hours, i.e. Daytime	23:00 to 07:00 Hours, i.e. Night-time
Resting	Living Room	35 dB $L_{Aeq, 16\ Hour}$	-
Dining	Dining Room/area	40 dB $L_{Aeq, 16\ Hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq, 16\ Hour}$	30 dB $L_{Aeq, 8\ Hour}$

3.4 BS 6472:2008 GUIDE TO EVALUATION OF HUMAN EXPOSURE TO VIBRATION IN BUILDINGS: PART 1: VIBRATION SOURCES OTHER THAN BLASTING

3.4.1 BS 6472 contains guidance for the measurement and prediction of human response to vibration in buildings, caused by either by internal or external sources, expressed in terms of the probability of adverse comment from occupants residing within a development. This specifically relates to vibration over the frequency range 0.5 Hz to 80 Hz and gives guidance on the classification of vibration, i.e. continuous, intermittent and impulsive vibration.

3.4.2 The probability of adverse comment expected from occupants exposed to vibration within a building is determined by the 'vibration dose value' that the occupant would experience over a 16-hour daytime period or 8-hour night-time period.

3.4.3 The probability of complaints based on the predicted vibration dose value set out in BS 6472-1 is presented below:

Table 2 – Vibration Dose Value Ranges Which Might Result in Various Probabilities of Adverse Comment Within Residential Buildings

PLACE AND TIME	LOW PROBABILITY OF ADVERSE COMMENT $ms^{-1.75}$ (1)	ADVERSE COMMENT POSSIBLE $ms^{-1.75}$	ADVERSE COMMENT PROBABLE $ms^{-1.75}$ (2)
Residential buildings 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

(1) Below these ranges adverse comment is not expected
(2) Above these ranges adverse comment is very likely

3.4.4 For a vibration dose value of less than 0.2 $ms^{-1.75}$ during a 16 hour day and less than 0.1 $ms^{-1.75}$ during an 8 hour night-time period, adverse comment is not expected.

4 BASELINE NOISE AND VIBRATION SURVEY

4.1 OVERVIEW

4.1.1 A baseline noise and vibration survey has been conducted on the site in order to inform the assessment.

4.1.2 The baseline noise survey consisted of short-term fully attended measurements adjacent to the northern site boundary overlooking the junction of Leeds Street and Great Howard Street. Noise measurements were carried out between 23:30 and 00:00 on the 29th September 2016 and 08:00 and 09:00 on the 04th October 2016.

4.1.3 The baseline vibration survey was carried out in order to measure the impact of Merseyrail line induced vibration at the site. The survey was fully attended and took place between 09:30 and 11:00 on 04th October 2016.

4.2 MONITORING EQUIPMENT

4.2.1 The baseline noise and vibration surveys were carried out using the following Type 1 specification Sound Level Meters and vibration measurement equipment:

Table 3 – Noise and Vibration Measurement Equipment

INTERNAL EQUIPMENT REFERENCE	MEASUREMENT REFERENCE	EQUIPMENT DESCRIPTION	MANUFACTURER & TYPE NO.	SERIAL NO.
Solo 16	NMP1 (23:30-00:00)	Sound Level Meter	01dB-METRAVIB Solo Master	65704
		Pre-amplifier	01dB-Stell PRE 21 S	16925
		Microphone	Microtech Gefell GmbH MCE212	153382
		Calibrator	01dB-Metravib Cal 21	34134167
Solo 18	NMP1 (08:00-09:00)	Sound Level Meter	01dB-METRAVIB Solo Master	65804
		Pre-amplifier	01dB-Stell PRE 21 S	16471
		Microphone	Microtech Gefell GmbH MCE212	175391
		Calibrator	01dB-Metravib Cal 21	35113823
BM3-B	VMP1 & VMP2 (09:30 – 11:00)	Digital Seismograph	Instantel Blastmate III – 714A0801	BA11871
		Vibration Transducer	Instantel Triaxial Geophone 714A9701	BG10988

4.2.2 The measurement systems had been calibrated to traceable standards within the preceding two years and the calibrators within the preceding 12 months. The measurement systems were calibrated at the start and end of the measurement periods and no significant drifts in calibration occurred.

4.3 MONITORING LOCATIONS

4.3.1 It was identified that the dominant noise source at the site was road traffic noise from Leeds Street and Great Howard Street. A single noise measurement location was therefore selected such that the noise levels arising on the site from these sources could be determined. In addition, in order to monitor the impact of vibration on the site as a result of train passes on the Merseyrail line, a single short term vibration monitoring location was chosen. These locations are described as follows:

- Noise Measurement Position 1 (NMP1): This position was situated at the Northern site boundary overlooking the junction of Leeds Street and Great Howard Street. The microphone was mounted on a tripod approximately 1.5m above ground level. This measurement position was located 6m from the nearside kerb edge of Leeds Street and is considered to be representative of noise levels at the northern façade of the proposed building.
- Vibration Measurement Position 1 (VMP1): This was located to the east of the existing datacentre at the site, located approximately 60m from the underground Merseyrail line.
- Vibration Measurement Position 2 (VMP2): This was located at the eastern most elevation of the proposed T1 building to the eastern site boundary approximately 20m from the underground Merseyrail line.

4.3.2 The location of the measurement positions are shown in Figures 2-1 and 2-2.

4.3.3 All noise and vibration monitoring was fully attended and short term.

4.3.4 Noise measurements undertaken at NMP1 were likely to have been subject to reflections from existing buildings both on site and in the vicinity of the site, as it is not possible to accurately account for these reflections, measured noise levels have been treated as free-field in order to present a worst case.

4.3.5 VMP1 and VMP2 were adopted at the current proposed closest point of the T2 and T1 buildings to the Merseyrail line, respectively.

4.4 OBSERVATION OF THE ON SITE NOISE ENVIRONMENT

4.4.1 During the survey, the general noise environment at the site was identified as being dominated by road traffic noise from Leeds Street and Great Howard Street. HGV movements and ambulance siren pass bys were noted during daytime and a single pass during the night-time noise measurements. It was noted that due to the traffic lighted junction between Leeds Street and Great Howard, traffic was not constantly free-flowing and was frequently queueing adjacent to the site. Infrequent car passes were noted on Back Leeds Street gaining access to the adjacent car park and frequent pedestrians and cyclists were also noted to pass.

4.5 NOISE MEASUREMENT RESULTS

4.5.1 Table 4 provides a summary of the ambient ($L_{Aeq,T}$), background ($L_{A90,T}$) and maximum (L_{AFmax}) noise levels measured during the baseline noise survey.

4.5.2 Noise measurements were undertaken such that the worst case 'rush-hour' traffic was captured during the daytime. The highest measured L_{AFmax}, night time noise level was identified to be a police siren pass by at approximately 23:40 which would not typically be expected to be regularly occurring throughout the night-time period and has been discounted from the analysis, therefore the second maximum noise level event identified as a car pass by has been taken as the L_{AFmax} during the measurement period.

4.5.3 The background noise levels have been determined by taking measured background noise levels ($L_{A90,T}$) at the time around which people are most susceptible to disturbance when sleeping (i.e. the beginning of the night-time period) for the night time period. A graphical representation of the measured daytime and night time noise levels are presented in Appendix B.

Table 4 – Summary of the measurement Results

Measurement Position	Measurement Period	$L_{Aeq,T}$, dB	$L_{A90,T}$, dB	Highest $L_{AFmax,T}$, dB[1]
NMP1	Daytime (08:00 – 09:00)	72	59 $L_{A90,60MIN}$	-
	Night-time (23:30 – 00:00)	63	49 $L_{A90,15MIN}$	81

[1] *L_{AFmax} noise level taken as the highest L_{AFmax} measured during the night-time survey period, excluding periods removed from analysis*

4.6 VIBRATION MEASUREMENT RESULTS

4.6.1 For the vibration measurements undertaken at VMP1, the tri-axial geophone was level mounted on a baseplate placed on solid concrete within the site. For the vibration measurements undertaken at VMP2, the tri-axial geophone was level mounted using ground spikes dug into the ground within the site. For both sets of measurements, sandbags were placed on top of the geophone in order to ensure sufficient coupling with the ground.

4.6.2 A total of 12 vibration measurements of individual rail movements were conducted across the two measurement positions. Vibration measurement data at VMP1 fall consistently below the noise floor of the vibration measurement equipment and therefore vibration is considered to not cause issue to human comfort at this location as Vibration Dose Values (VDV) would be very low. Measured vibration levels at VMP2 have been reported below.

4.6.3 The average Vibration Dose Value (VDV) from the rail measurements at VMP2 is presented in Table 5.

Table 5 – Measured vibration levels (mm/s$^{1.75}$) and calculated VDV summation(m/s$^{1.75}$) at VMP2

MEASUREMENT NUMBER	Measured VDV(mm/s$^{1.75}$)		
	TRANSVERSAL	VERTICAL	LONGITUDINAL
1	0.354	2.97	0.391
2	0.352	3.35	0.433
3	0.393	4.90	0.403
4	0.408	5.03	0.479
5	0.377	3.89	0.491
6	0.305	2.51	0.320
Total VDV sum[1]	0.0064 m/s$^{1.75}$		

[1] *VDVs have been calculated using the dominant vertical direction measured results, in line with BS 6472-1: 2008*

5 ASSESSMENT

5.1 ENVIRONMENTAL NOISE INGRESS INTO THE DEVELOPMENT

5.1.1 During the daytime (07:00-23:00) 16 hour period, the 55 dB $L_{Aeq,16hour}$ design target for external living areas has not been considered for the purpose of this assessment as there are no external living areas, e.g. balconies or gardens, proposed within this development. As such, only internal noise criteria will be considered.

5.1.2 Compliance with the internal noise level criteria will of course depend upon the sound insulation that is afforded by the means of building fabric of the proposed towers. In particular, the glazing and ventilation units which are commonly the acoustic weak link in the façade construction.

5.1.3 The calculation method provided in BS 8233:2014 has been used to determine the sound insulation performance of the external façade construction. The 'more rigorous' calculation method has been considered to inform the assessment.

5.1.4 Due to the shortened measurement procedure the L_{AFmax} criteria has been assessed using the maximum event noise level during the measurement period in order to present a robust case.

5.1.5 Measured noise levels have been distance corrected in order to predict the noise levels at the façade of the first floor of residential apartments (height of 27.1m). The road source has been taken to be 3.5m from the nearside carriage edge in line with The Department of Transports' technical memorandum "*Calculation of Road Traffic Noise*" 1988 (CRTN).

5.1.6 Table Table 6 provides recommended minimum façade sound insulation performances of the external facades based upon the results of the environmental noise measurements conducted at NMP1 which are considered to be representative of the noise levels expected at the façades of the proposed development.

Table 6 – Minimum Sound Insulation Performance for Bedrooms

	DAYTIME $L_{Aeq,16HOUR}$, dB	**NIGHT-TIME $L_{Aeq,8HOUR}$, dB**	**NIGHT-TIME TYPICAL L_{AFMAX}, dB**
Predicted free field noise level	67	57	76
Criteria	35	30	45
Recommended minimum sound reduction index $R_w + C_{tr}$, dB	35	31	35
Resultant recommended minimum sound reduction index $R_w + C_{tr}$, dB		**35**	

Indicative internal room dimensions have been used to predict the 10log(S/A) correction to determine the required minimum sound reduction index for the external façade.
Calculations have been based on the worst case affected rooms as part of the development, i.e. shallowest depth with largest external façade area.
A reverberation time of 0.5 seconds has been assumed within each room.

5.1.7 The noise levels presented in Table 6 present the worst case noise levels expected on the northern facade of the development. It is anticipated that the required minimum façade sound insulation performances will vary across the development and will be dependent upon the room dimensions, the proposed façade construction and area of glazing, the ventilation strategy as well as orientation and distances from the key identified site noise sources. The purpose of this noise impact assessment for planning is to demonstrate that appropriate internal ambient noise levels can be achieved within the development through the use of appropriate noise mitigation measures. The actual requirements for apartments throughout the development for each proposed can be developed as part of the detailed design review.

5.1.8 Based on initial calculations the glazing specification will be driven by LCC's minimum specification for glazing as described in Section 2 for living areas at approximately level 10 and above, however this can be investigated further during detailed design.

5.1.9 Recommendations for the minimum sound insulation performance of the external glazing is provided in Section 6.1.

5.2 NOISE EMISSION FROM PROPOSED DEVELOPMENT

5.2.1 Noise generated by externally mounted building services equipment associated with the development should be controlled such that it does not create an adverse noise level impact on nearby noise sensitive premises.

5.2.2 The nearest noise sensitive receptor is the Radisson Blu Hotel to the south west on Old Hall Street.

5.2.3 In accordance with the assumptions made in Section 2, the Rating Level generated from plant associated with the development should be controlled such that it does not exceed the existing background noise level during the daytime and night-time periods.

5.2.4 Based upon the background noise levels measured, and assumed requirements of the Local Authority, Table 7 provides the maximum permissible rating level limits for noise form fixed plant associated with development, when determined outside the existing nearby noise sensitive premises identified as being Radisson Blu Hotel on Old Hall Street, to the south west of the proposed development site.

5.2.5 Due to the distance of the hotel to the proposed T1 building (approximately 100m) and the periods in which occupancy is expected (i.e. typically not inhabited during the day), applicable noise rating levels have been based on the night-time background noise level. Table 7 below shows the applicable Rating Level to be achieved at the Radisson Blu Hotel during the day and night time.

Table 7 – Maximum Permissible Cumulative Rating Level Limits at Nearby Noise Sensitive Premises (free field)

NOISE-SENSITIVE PREMISES	ASSESSMENT PERIOD	MAXIMUM PERMISSIBLE RATING LEVEL AT THE NEARBY NOISE-SENSITIVE PREMISES (FREE FIELD), $L_{AR,TR}$. dB
Radisson Blu Hotel	Daytime (07:00 – 23:00)	49
	Night-time (23:00 – 07:00)	49

5.2.6 In accordance with BS 4142, it is appropriate to consider whether the noise level impact contains an acoustic character i.e. whether the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.) or the noise contains distinct impulses (bangs, clicks, clatters, or thumps) or the noise is irregular enough to attract attention. Such characteristics must be taken into consideration, with appropriate corrections added before comparison with the above noise level limits. Such corrections must be determined in accordance with the procedure outlined in BS 4142:2014.

5.3 MERSEYRAIL INDUCED VIBRATION IMPACT

5.3.1 The potential daytime and night-time vibration impact generated by rail movements along the Merseyrail line at the proposed development site has been determined based upon the average of the measured VDVs generated by rail pass-bys.

5.3.2 WSP | PB have determined the number of anticipated tram movements along the Merseyrail line based on publically available train frequency figures provided by Merseyrail on their website http://www.merseyrail.org/. It has been determined that up to 357 trains currently pass the site during the daytime (07:00-23:00) weekday period, with 33 trains passing the site during night-time (23:00-07:00) weekday period.

5.3.3 Average VDV generated by a train pass-by has been used to determine the resultant daytime and night-time Vibration Dose Values at the measurement position.

Table 8 – Resultant Predicted Vibration Dose Values at Vibration Monitoring Position 2

MEASUREMENT POSITION	ASSESSMENT PERIOD	AVERAGE VDV GENERATED BY TRAIN PASS-BY, $VDV_{b,Tr}$ ($ms^{-1.75}$)	ANTICIPATED NUMBER OF TRAIN MOVEMENTS	PREDICTED VIBRATION DOSE VALUE VDV_{day} ($ms^{-1.75}$)	LIKELIHOOD OF COMPLAINT IN ACCORDANCE WITH BS 6472
VMP1	Daytime (07:00 to 23:00)	0.0064	357	0.019	Less than 'Low probability of adverse comment'
	Night-time (23:00 to 07:00)		33	0.010	Less than 'Low probability of adverse comment'

5.3.4 Based upon the results of the vibration measurements, the likelihood of complaint of against train induced vibration at the location of the proposed development is expected to be less than "low" in accordance with BS 6472:2008-1.

5.3.5 It should be noted that the above assessment has been based on measured vibration levels at ground level at the site. Due to the rail line being located underground, there is the possibility that once the building foundations have been laid, the building could experience an increased level of vibration compared to that observed at ground level. The potential impact of this will depend upon a number of factors including the ground types and piling conditions etc. and is outside the scope of this planning report. Given that the levels of vibration observed at ground level are significantly lower than the threshold for "low probability of adverse comment" it is not expected that effect would alter the findings of the assessment but this still remains a risk. Should the client wish to quantify this level of impact, further specialist vibration advice should be sought during the development design.

6 MITIGATION

6.1 INTERNAL NOISE LEVELS

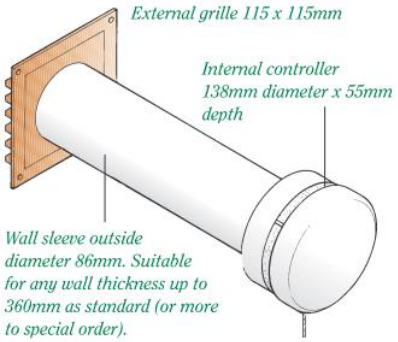
6.1.1 At this stage the required ventilation strategy has not been confirmed, therefore based upon the results of environmental noise survey, Table 9 presents the recommended minimum sound insulation performance for glazing should a full supply and extract duct ventilation system be employed. Should such a system be employed, specification of acoustic attenuators will be required for the system in order to ensure internal noise level criteria is met.

Table 9 – Recommended minimum sound insulation performance for the each façade element

	RECOMMENDED MINIMUM SOUND INSULATION PERFORMANCE FOR THE FAÇADE ELEMENT	POSSIBLE GLAZING / VENTILATION CONFIGURATION
Glazing (natural and mechanical ventilation strategies)	35 dB $R_w + C_{tr}$	Saftigard 8mm/6mm/8mm with 0.4mm laminate
Notes	*Windows are expected to be the weakest elements of the façade construction. It is assumed for the purposes of calculation that up to 100% of the façade to each apartment will be glazed in order to be robust. This should be reviewed and confirmed during the detailed design stage.*	

6.1.2 Should trickle ventilators be required, Table 10 provides the recommended minimum sound insulation performance requirements for glazing and façade mounted trickle ventilators. It should be noted that in order to achieve the below ventilator performance, through wall ventilators would likely be required.

Table 10 - Recommended minimum sound insulation performance for the each façade element

	RECOMMENDED MINIMUM SOUND INSULATION PERFORMANCE FOR THE FAÇADE ELEMENT	POSSIBLE GLAZING / VENTILATION CONFIGURATION
Glazing (natural and mechanical ventilation strategies)	40 dB $R_w + C_{tr}$	SG Phonip 9mm/20mm/11mm
Façade mounted passive Ventilation (if required)	37 dB $D_{ne} + C_{tr}$	Passivent Fresh 80dB(300m wall)
Notes	*Windows and ventilators re expected to be the weakest elements of the façade construction. It is assumed for the purposes of calculation that up to 100% of the façade to each apartment will be glazed in order to be robust. This should be reviewed and confirmed during the detailed design stage.* *An example of the recommended above ventilator is shown below.*  	

6.1.3 The façade mounted ventilation performances above assume that only one vent would be required per room. If more than one vent is required the above ventilation performances for each vent will need to be increased by the margin indicated in Table 11.

Table 11 – Required Improvement to Ventilator Performance

NUMBER OF VENTS, PER ROOM	1	2	3	4
Required improvement to ventilator performance, dB	+0	+3	+5	+6

6.1.4 It is understood from product data that the façade mounted trickle ventilators available that are capable of meeting the required sound insulation performance and capable of providing the minimum background ventilation rates. However, this will need to be reviewed and agreed with the Building Services Engineer as the design develops.

6.1.5 If open windows are used as a method to control overheating in apartment by occupants, the internal noise levels will be exceeded, therefore it is recommended that overheating is controlled by an alternative means of ventilation.

6.2 NOISE EGRESS FROM EXTERNALLY MOUNTED BUILDING SERVICES

At this stage, details of the proposed externally mounted building services equipment are not yet known. However, given the 35 metre distance between the proposed development and the Radisson Blu Hotel, it is anticipated that the maximum permissible noise level limits provided in Table 7 could be achieved through the appropriate selection of building services equipment fitted with appropriately specified of attenuation / silencer packages or enclosures where necessary. As such, it is anticipated that the potential noise impact from the proposed building services equipment could be suitably controlled.

6.3 VIBRATION IMPACT

6.3.1 Based upon the vibration assessment, no further vibration mitigation is recommended at this stage.

7 CONCLUSIONS

7.1.1 WSP | Parsons Brinckerhoff have been commissioned by 122 Old Hall Street Ltd to provide a noise and vibration assessment for the proposed residential development at a site located at Old Hall Street, Liverpool. The development is proposed to consist of a single 27 storey building comprised of residential apartments, ground floor reception area and cycle storage area.

7.1.2 In order to inform the assessment, an environmental noise and vibration survey has been conducted on the site to determine the existing environmental noise and vibration climate at the location of the proposed development. This took place from between 23:30 and 00:00 on the 29th September 2016 and 08:00 and 11:00 on 04th October 2016.

7.1.3 The results of the environmental noise and vibration measurements have been used to:

- Review of the required minimum façade sound insulation performance to proposed apartments. Recommendations have been provided for external glazing and ventilation openings (if applicable).
- Determination of appropriate plant noise level limits for all externally mounted building services equipment associated with the development.
- Review of the potential vibration level impact from passing trains on the Sandhill – Moorfields Merseyrail Line. The assessment has confirmed that no further mitigation measures would be required to mitigate the existing levels of vibration.

7.1.4 This report demonstrates that through the use of appropriate mitigation, the potential noise and vibration impact on future occupants of the proposed development as well as the potential impact to existing off site noise sensitive receptors can be shown to meet appropriate criteria. However, it is likely that internal noise levels will be exceeded should the use of open windows be relied upon to control overheating in proposed apartments, this will need to be controlled by other means and is expected to be addressed by an overheating assessment.

Appendix A

GLOSSARY OF ACOUSTIC TERMINOLOGY

APPENDIX A-1

GLOSSARY OF ACOUSTIC TERMINOLOGY

NOISE

Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq}, L_{A90} etc, according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

SOUND LEVELS	LOCATION
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 4 0dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of pain

ACOUSTIC TERMINOLOGY

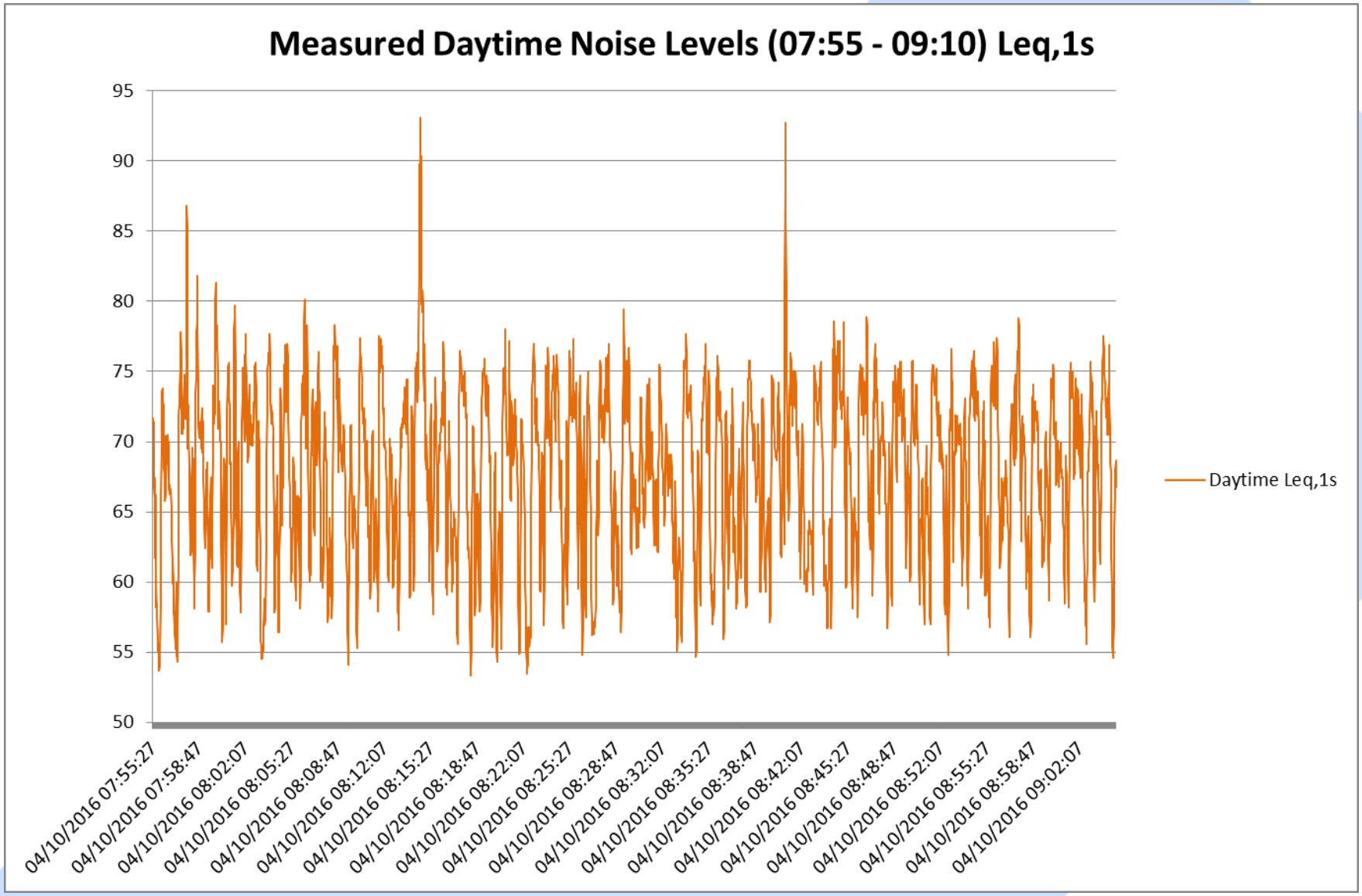
TERMINOLOGY	MEANING
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$Pa).
dB(A)	A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' - weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
$L_{Aeq,T}$	L_{Aeq} is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.
L_{Amax}	L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{10} and L_{90}	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time. Hence L_{10} is the level exceeded for 10% of the time, and the L_{90} is the level exceeded for 90% of the time.
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other reflective surfaces. Generally as measured outside and away from buildings.
Façade Level	A sound field determined at a distance of 1m in front of a large sound reflecting object such as a building façade.

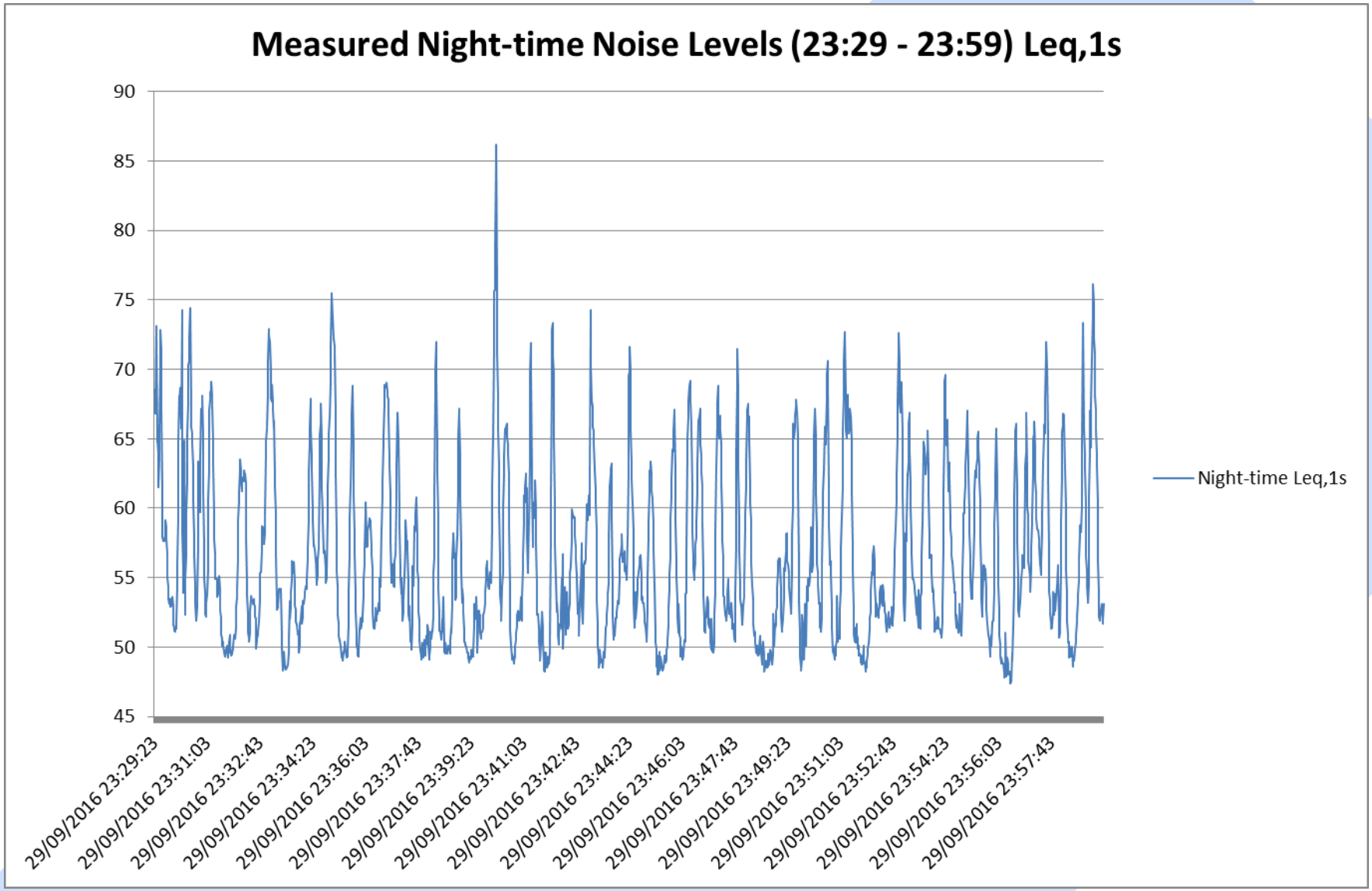
Appendix B

SUMMARY OF MEASURED NOISE LEVELS

APPENDIX B-1

GRAPHICAL REPRESENTATION OF MEASURED NOISE LEVELS


Measured Daytime Noise Levels (07:55 - 09:10) Leq,1s
95
90
85
80
75
70
65
60
55
50
04/10/2016 07:55:27
04/10/2016 07:58:47
04/10/2016 08:02:07
04/10/2016 08:05:27
04/10/2016 08:08:47
04/10/2016 08:12:07
04/10/2016 08:15:27
04/10/2016 08:18:47
04/10/2016 08:22:07
04/10/2016 08:25:27
04/10/2016 08:28:47
04/10/2016 08:32:07
04/10/2016 08:35:27
04/10/2016 08:38:47
04/10/2016 08:42:07
04/10/2016 08:45:27
04/10/2016 08:48:47
04/10/2016 08:52:07
04/10/2016 08:55:27
04/10/2016 08:58:47
04/10/2016 09:02:07
Daytime Leq,1s


Measured Night-time Noise Levels (23:29 - 23:59) Leq,1s
90
85
80
75
70
65
60
55
50
45
29/09/2016 23:29:23
29/09/2016 23:31:03
29/09/2016 23:32:43
29/09/2016 23:34:23
29/09/2016 23:36:03
29/09/2016 23:37:43
29/09/2016 23:39:23
29/09/2016 23:41:03
29/09/2016 23:42:43
29/09/2016 23:44:23
29/09/2016 23:46:03
29/09/2016 23:47:43
29/09/2016 23:49:23
29/09/2016 23:51:03
29/09/2016 23:52:43
29/09/2016 23:54:23
29/09/2016 23:56:03
29/09/2016 23:57:43
Night-time Leq,1s

Appendix C

LIMITATIONS TO THIS REPORT

APPENDIX C-1

LIMITATIONS TO THIS REPORT