

9 Noise and Vibration

9.1 INTRODUCTION

9.1.1 This chapter considers the effect of the Proposed Development on the local noise and vibration sensitive environment and assesses the suitability of the Site's existing noise environment for the Proposed Development. It considers the potential effects of site preparation, earthworks and construction and operational phases of the Proposed Development. Where appropriate, mitigation measures have been recommended such that any identified negative effects can be prevented or reduced. Residual effects following the implementation of mitigation measures have also been presented.

9.1.2 This chapter (and its associated figures and appendices) is not intended to be read as a stand alone assessment and reference should be made to the Front End of this **ES (Chapters 1– 5)**, as well as **Chapter 16 - Cumulative Effects**.

9.1.3 This chapter is necessarily technical in nature so to assist the reader, a glossary of terminology relating to noise and vibration is provided within **Appendix 9.1**.

9.1.4 The associated Figures are **Figures 9.1, 9.2, 9.3 and 9.4**.

9.2 LEGISLATION, POLICY AND GUIDANCE

Legislative Framework

9.2.1 For a development of this nature, there is no specific all-encompassing legislation relating to the standards associated with noise emission / noise effect. Noise legislation, where it does exist, tends to be either EC-derived and focussed on specific items of noise-emitting plant or on more general nuisance, such as that addressed by the provisions of the Environmental Protection Act 1990.

9.2.2 In lieu of any specific legislation, assessing the effect of such a development during the construction and operational phases must draw on information from a variety of sources. This assessment, therefore, makes reference to a number of British Standards, official planning guidance notes and national and local guidance on noise.

Planning Policy

9.2.3 Planning policy at the national, county and local level is discussed in **Chapter 5 - Planning Policy Context**. Those policies relevant to Noise and Vibration are discussed briefly below.

Noise Policy Statement for England (NPSE)

9.2.4 The Noise Policy Statement for England (**Ref 9.1**) was published in March 2010. The NPSE is the overarching statement of noise policy for England and applies to all forms of noise other than occupational noise, setting out the long term vision of Government noise policy which is to:

“Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.”

9.2.5 That vision is supported by the following aims:

“Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

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

9.2.6 The Explanatory Note to the NPSE has introduced three concepts to the assessment of noise in this country:

NOEL – No Observed Effect Level

This is the level below which no effect can be detected and below which there is no detectable effect on health and quality of life due to noise.

LOAEL – Lowest Observable Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

9.2.7 None of these three levels are defined numerically and for the SOAEL the NPSE makes it clear that the noise level is likely to vary depending upon the noise source, the receptor and the time of day/day of the week, etc. The need for more research to investigate what may represent an SOAEL for noise is acknowledged in the NPSE and the NPSE asserts that not stating specific SOAEL levels provides policy flexibility in the period until there is further evidence and guidance.

9.2.8 The NPSE concludes by explaining in a little more detail how the LOAEL and SOAEL relate to the three aims listed in paragraph 8.2.5 above. It starts with the aim of avoiding significant adverse effects on health and quality of life, then addresses the situation where the noise impact falls between the LOAEL and the SOAEL when “*all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development.*” The final aim envisages pro-active management of noise to improve health and quality of life, again taking into account the guiding principles of sustainable development.

National Planning Policy Framework (NPPF)

9.2.9 Published in March 2012, this document (**Ref 9.2**) sets out the Government’s planning policies for England and supersedes a number of previous Planning Policy Guidance Notes and Planning Policy Statements (amongst other documents), including Planning Policy Guidance Note 24: *Planning and noise*. At present no alternative detailed guidance has been proposed. In contrast to PPG 24, reference to noise is scant within the new NPPF. However it does make the following reference to noise in the section entitled *Conserving and enhancing the natural environment*:

“The planning system should contribute to and enhance the natural and local environment by... [a number of points including]...preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability”.

9.2.10 The NPPF also references noise in paragraph 123:

“123. Planning policies and decisions should aim to:

- *avoid noise from giving rise to significant adverse impacts²⁷ on health and quality of life as a result of new development;*
- *mitigate and reduce to a minimum other adverse impacts²⁷ on health and quality of life arising from noise from new development, including through the use of conditions;*
- *recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established,²⁸ and*
- *identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.”*

9.2.11 The reference numbers 27 and 28 point respectively to the Explanatory Note to the NPSE and the provisions of the Environmental Protection Act 1990 and other relevant law.

9.2.12 The Government is undertaking a review of technical guidance but currently there is none for noise other than in respect of minerals policy as given in the document Technical Guidance to the National Planning Policy Framework published to accompany the NPPF.

Planning Policy Guidance Note 24: 1994: Planning and Noise

9.2.13 Whilst Planning Policy Guidance Note (PPG) 24: Planning and Noise (**Ref 9.3**) has been superseded by the NPPF, in absence of any detailed noise assessment methodologies being contained within the new NPPF, and to provide further context, reference has been made to PPG 24, which is summarised below.

9.2.14 Published in September 1994, this document provided Government guidance to local authorities in England on the use of their planning powers to minimise the adverse impact of noise. Specifically, it:

- Outlined the considerations to be taken into account when determining planning applications for both noise-sensitive developments and for those activities which will generate noise;
- Set out Noise Exposure Categories (NECs) for residential development, encouraged their use and recommended appropriate levels for exposure to different sources of noise; and
- Advised on the use of planning conditions to minimise the effect of noise.

9.2.15 The four NEC bands set out in PPG24 were designed to assist local planning authorities in evaluating applications for residential development in noisy areas. **Table 9.1** summarises the planning guidance for each NEC band. **Table 9.2** sets out the noise levels relating to each NEC band for road traffic and mixed noise sources, as is relevant in this case.

Table 9.1: Planning Advice for each Noise Exposure Category

NEC	Planning Advice
A	Noise need not be considered as a determining factor in granting planning permission, although noise at the high end of the category should not be regarded as a desirable level.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

Table 9.2: Road Traffic and Mixed Source Noise Levels Corresponding to the NECs for New Dwellings

NEC	Road Traffic and Mixed Sources Noise, dB	
	Day 07:00-23:00, $L_{Aeq,16hour}$	Night 23:00-07:00, $L_{Aeq,8hour}$
A	<55	<45
B	55-63	45-57
C	63-72	57-66
D	>72	>66

9.2.16 In addition to the above, PPG24 also stated that during the night, (23:00-07:00 hours):

“Sites where individual noise events regularly exceed 82dB L_{Amax} (slow) several times in any hour should be treated as being in NEC C, regardless of the L_{Aeq} (8 hour) (except where the L_{Aeq} (8 hour) already puts the site into NEC D).”

9.2.17 Where the advice within PPG24 was that conditions should be imposed to ensure a commensurate level of protection against noise, reference was made to other standards that establish suitable internal noise levels, such as BS8233: 1987: *Sound Insulation and Noise Reduction for Buildings - Code of Practice* (updated in 1999).

9.2.18 The requirements of BS8233: 1999 are summarised below along with other relevant guidance and standards.

Local Planning Policy

9.2.19 Local planning policies applicable are contained within the recently (September 2011) adopted Barnsley Local Development Framework Core Strategy (**Ref 9.4**). The policies contained within this document that specifically relate to noise and vibration supersede those policies contained within the earlier Barnsley Unitary Development Plan.

9.2.20 Policy CSP40 of the Local Development Framework Core Strategy states that:

'Development will be expected to demonstrate that it is not likely to result, directly or indirectly, in an increase in air, surface water and groundwater, noise, smell, dust, vibration, light or other pollution which would unacceptably affect or cause a nuisance to the natural and built environment or to people ... Developers will be expected to minimise the effects of any possible pollution and provide mitigation measures where appropriate.'

Guidance

BS4142 1997: Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas

9.2.21 BS4142 (**Ref 9.5**) is intended to be used to assess whether noise from factories, industrial premises or fixed installations and sources of an industrial nature is likely to give rise to complaints from people residing in nearby dwellings.

9.2.22 The procedure contained in BS4142 for assessing the likelihood of complaint is to compare the measured or predicted noise level from the source in question, the '*specific noise*' level, immediately outside the dwelling with the '*background noise*' level. Where the noise contains a '*distinguishable discrete continuous note*' (whine, hiss, screech, hum etc.) or if there are distinct impulses in the noise (bangs, clicks, clatters or thumps), or if the noise is irregular enough to attract attention then a correction of +5 dB is added to the specific noise level to obtain the '*rating noise*' level.

9.2.23 The likelihood of noise provoking complaints is assessed by subtracting the background noise level from the rating noise level. BS4142 states:

'A difference of around 10dB or higher indicates that complaints are likely. A difference of around 5 dB is of marginal significance. A difference of -10dB is a positive indication that complaints are unlikely'.

9.2.24 For the daytime, this assessment is carried out over a one hour period, and over a five minute period at night. Day or night are not defined in the Standard but it states that night should cover the times when the general adult population are preparing for sleep or are actually sleeping. For the purposes of this assessment it is assumed that the day and night periods reflect those stated in PPG24, i.e. day is 07:00 to 23:00 hours and night 23:00 to 07:00 hours.

9.2.25 BS4142 advises that the measurement time interval for background noise measurements should be '*sufficient to obtain a representative value of the background level*'.

BS8233: 1999: Sound Insulation and Noise Reduction for Buildings - Code of Practice

9.2.26 BS8233: 1999 (**Ref 9.6**) provides recommendations for the control of noise in and around buildings. It suggests appropriate criteria and limits for different situations, which are primarily intended to guide the design of new buildings, or refurbished buildings undergoing a change of use, rather than to assess the effect of changes in the external noise climate.

9.2.27 The standard suggests suitable internal noise levels within different types of buildings, including residential dwellings. It suggests that an internal noise level of 30dB $L_{Aeq,T}$ within bedrooms is a '*good*' standard, whilst 35dB $L_{Aeq,T}$ is a '*reasonable*' standard. For living areas in the daytime, the standard recommends 30dB $L_{Aeq,T}$ as a '*good*' standard and 40dB $L_{Aeq,T}$ as being a '*reasonable*' standard. BS8233 also states that individual noise events should not normally exceed 45dB L_{AFmax} in bedrooms at night.

9.2.28 With regards to external noise levels, BS8233 states:

'it is desirable that the steady state noise level does not exceed 50dB $L_{Aeq,T}$ and 55dB $L_{Aeq,T}$ should be regarded as the upper limit'.

9.2.29 BS8233 also provides guidance on acceptable levels of noise for development types other than residential. For executive offices and meeting rooms a range of 35dB to 40dB $L_{Aeq,T}$ is recommended and for cellular offices a design range of 40dB to 50dB $L_{Aeq,T}$ is presented. For reasonable listening conditions within a public building a range

of 30 to 40dB $L_{Aeq,T}$ is recommended. For reasonable conditions for study and work requiring concentration the Standard advises a range of 35 to 50dB $L_{Aeq,T}$ and for reasonable speech or telephone communications a design range of 45 to 55dB $L_{Aeq,T}$ is recommended.

World Health Organisation (WHO): 1999: Guidelines for Community Noise

9.2.30 This is a wide ranging document (**Ref 9.7**) describing the effects of community noise. It provides information about the effects of noise that may occur at certain levels of exposure. For dwellings, the critical effects of noise are taken to be sleep disturbance, annoyance and speech interference.

9.2.31 Indoor guideline values are provided for bedrooms with the aim of protecting against sleep disturbance, a guideline value of 30dB L_{Aeq} for continuous noise and 45dB L_{Amax} for single sound events is recommended. To enable casual conversation during the daytime an internal guideline noise level of 35dB L_{Aeq} is provided.

9.2.32 With respect to external noise levels it is stated that:

'To protect the majority of people from being seriously annoyed during the daytime, it is recommended that the sound pressure level on balconies, terraces, and outdoor living areas should not exceed 55dB L_{Aeq} for a steady continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor noise level should not exceed 50dB L_{Aeq} '.

9.2.33 The 'good' and 'reasonable' internal noise level criteria stated in BS8233 are concordant with the WHO guidelines, as is the L_{AFmax} night-time noise criterion. Therefore, the recommendation for night-time L_{AFmax} noise levels presented in the WHO guidelines has been adopted for this assessment.

9.2.34 With respect to the night-time L_{AFmax} noise levels, the WHO guidelines quote the findings from research conducted by Vallet & Vernet (**Ref 9.8**) which states:

'For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45dB L_{AFmax} more than 10-15 times per night'.

9.2.35 On this basis, for the purpose of assessing night-time L_{AFmax} noise events, it is common practice to base the assessment on the 10th highest L_{AFmax} noise event occurring in a typical night-time (23:00 – 07:00) period.

The Design Manual for Roads and Bridges (DMRB): Volume 11: Environmental Assessment

9.2.36 Published by the Department of Transport in 1993 (and last amended 2011), this document (**Ref 9.9**) sets out procedures for undertaking the environmental assessment of new road schemes, including the assessment of noise effects from road traffic. In particular, it describes a method for assessing the severity of a noise effect, in terms of the number of people who will be bothered from any noise increase due to a new road scheme. In undertaking a DMRB assessment, the calculation of traffic noise levels uses the methodology contained within the Calculation of Road Traffic Noise (CRTN) (**Ref 9.10**) document as described below.

9.2.37 Although the DMRB strictly applies to new road schemes, the principles of the approach contained within the document can also be applied to the assessment of noise from road traffic in general. The Proposed Development has the potential to affect road traffic noise levels along existing roads, hence the need for this assessment.

9.2.38 The DMRB assessment suggests that the magnitude of noise changes from a project should be classified into levels of effect. An example classification of magnitude of effects for traffic noise is provided within the document and has been replicated within **Table 9.3**.

Table 9.3: Classification of Magnitude of Noise Effect

Noise Change, dB $L_{A10,18hr}$	Magnitude of Effect
0	No Change
0.1 – 0.9	Negligible
1 – 2.9	Minor
3 – 4.9	Moderate
5+	Major

9.2.39 The DMRB goes on to state that the scale provided in **Table 9.3** may not be applicable to all situations or projects, in that other factors such as time of day, and the spectral content of the noise can also influence the magnitude of effect.

9.2.40 It is considered that the descriptions specified in **Table 9.3** provide a good indication of the likely significance of changes in noise levels in this case. Therefore, these have been used to supplement the assessment of potential effects.

Calculation of Road Traffic Noise (CRTN) 1988

9.2.41 Published by the then Department of Transport and the Welsh Office in 1988 (**Ref 9.10**), this document sets out standard procedures for calculating noise levels from road traffic. The calculation methods use a number of input variables, including traffic flow volume, average vehicle speed, percentage of heavy goods vehicles, type of road surface, site geometry and the presence of noise barriers or acoustically absorbent ground. CRTN predicts the $L_{A10,18\text{hour}}$ or $L_{A10,1\text{hour}}$ noise level for any receptor point at a given distance from the road.

BS5228: Noise and Vibration Control on Construction and Open Sites - Part 1: Noise: 2009

9.2.42 This Standard (**Ref 9.11**) sets out techniques to predict and assess the likely noise effects from construction works, based on detailed information on the type and number of plant being used, their location, and the length of time they are in operation.

9.2.43 The noise prediction method is used to establish likely noise levels in terms of the $L_{Aeq,T}$ over the core working day.

9.2.44 This Standard also documents a database of information, comprising previously measured sound power levels for a variety of different construction plant undertaking various common activities.

9.2.45 Example criteria are presented for the assessment of the significance of noise effects. Such criteria are concerned with fixed noise limits and ambient noise level changes. With respect to fixed noise limits BS5228 discusses those included within Advisory Leaflet 72: 1976: Noise Control on Building Sites (**Ref 9.12**). These limits are presented according to the nature of the surrounding environment, for a 12-hour working day. The presented limits are:

- 70dB(A) in rural, suburban and urban areas away from main road traffic and industrial noise; and
- 75dB(A) in urban areas near main roads and heavy industrial areas.

9.2.46 The standard goes on to provide methods for determining the significance of construction noise levels considering the change in the ambient noise level brought about by the construction work. Two example assessment methods are presented, these are the ABC method as summarised within **Table 9.4** and the 5dB(A) change described in paragraph 9.2.37.

Table 9.4: Example Threshold of Significant Effect at Dwellings – ABC Method

Assessment Category and threshold value period	Threshold value, in decibels (dB)		
	Category A ^{A)}	Category B ^{B)}	Category C ^{C)}
Night-time (23:00 – 07:00)	45	50	55
Evenings and weekends ^{D)}	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
NOTE 1: A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level. NOTE 2: If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity NOTE 3: Applied to residential receptors only			

- A) Category A: threshold values to use when ambient levels (when rounded to the nearest 5 dB) are less than these values.
 B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.
 C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values.
 D) 19.00-23.00 weekdays, 13.00-23.00 Saturdays and 07.00-23.00 Sundays

9.2.47 With respect to the 5dB(A) change method, the guidance states:

'Noise levels generated by construction activities are deemed to be significant if the total noise (pre-construction ambient plus construction noise) exceeds the pre-construction ambient noise level by 5dB or more, subject to lower cut-off values of 65dB, 55dB and 45dB $L_{Aeq, Period}$, from construction noise alone, for the daytime, evening and night-time periods, respectively; and a duration of one month or more, unless works of a shorter duration are likely to result in significant impact'.

BS5228: Noise and Vibration Control on Construction and Open Sites - Part 2: Vibration: 2009

9.2.48 This standard (Ref 9.13) provides recommendations for basic methods of vibration control relating to construction and open sites. The legislative background to vibration control is described and guidance is provided concerning methods of measuring vibration and assessing its effects on the environment.

9.2.49 Guidance criteria are suggested for the assessment of the significance of vibration effects; such criteria are provided in terms of Peak Particle Velocities (PPV) and are concerned with both human and structural responses to vibration. Those applicable to human perception and disturbance are presented within **Table 9.5** below.

Table 9.5: Guidance on Effects of Vibration Levels

Vibration Level (PPV)	Effect
0.14 mm s^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm s^{-1}	Vibration might be just perceptible in residential environments.
1.0 mm s^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm s^{-1}	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

9.2.50 The standard goes on to present guidance criteria applicable to the vibration response limits of buildings in terms of the component PPV, these are presented within **Table 9.6** below.

Table 9.6: Transient Vibration Guide Values for Cosmetic Damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	50 mm/s at 4Hz and above
Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
NOTE 1: Values referred to are at the base of the building.		
NOTE 2: At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded.		

9.2.51 It should be noted that the values presented within **Table 9.6** are applicable to cosmetic damage only. It is stated within BS5228-2 that minor damage is possible at vibration magnitudes which are greater than twice those given in the table.

9.3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

Scope of the Assessment and Consultations

9.3.1 Following initial consultation by telephone, a proposed scope of assessment was prepared and issued to Barnsley Council (Ms Lucy Allen) in June 2011. The scope of assessment was agreed and takes into account the requirements of Barnsley Council regarding acceptable noise levels from fixed plant. The agreed scope of work identified that the assessment should include:

- A baseline noise survey, to include the measurement of existing noise levels during the key daytime, evening and night-time periods at nearby noise sensitive receptors;
- An assessment of the potential noise impacts during construction, to be undertaken using the methods set out in BS5228: 2009 Part 1 and with an absolute noise criterion of 70 or 75dB $L_{Aeq,12hour}$;
- An assessment of the potential vibration impacts during construction, to be undertaken using the methods set out in BS5228: 2009 Part 2 and the assessment criteria detailed therein;
- An assessment of the potential noise impacts associated with development generated road traffic, to be conducted using the methods set out in The Calculation of Road Traffic Noise (CRTN) and the Design Manual for Roads and Bridges (DMRB);
- An assessment of noise from the proposed car parks. Calculations are to be undertaken based on measured noise levels from other, existing, car parks and the noise levels are to be assessed against the relative increase in $L_{Aeq,T}$ noise levels over a 1 hour period during the daytime and night time. In addition, any night-time noise from car parking activity would be assessed against the L_{Amax} noise criteria set out in BS8233: 1999;
- An assessment of noise from items of fixed plant, to be assessed against the guidance contained within BS4142: 1997. In accordance with the guidance from Barnsley Council, it has been agreed that any external fixed plant should be designed so as to achieve a rating level of 5dB below the existing background L_{A90} noise level. Given that the detailed design and selection of specific plant items will not have been completed at the planning stage, design noise limits will be set, based on the guidance from Barnsley Council, to ensure that the agreed criteria are not exceeded;
- An assessment of noise from service yard activities, to include the delivery of goods by heavy goods vehicles. This assessment is to follow the guidance contained within BS4142: 1997 and BS8233: 1999 and is to include an assessment of potential impacts associated with night-time deliveries;
- An assessment of noise from the proposed petrol filling station (and associated car-wash). This assessment is to be based on measured noise levels from similar facilities. The potential noise impacts are to be assessed against the guidance set out in BS4142 and BS8233, to include an assessment of potential night-time L_{Amax} noise levels as well as daytime and night-time L_{Aeq} noise levels; and
- An assessment of suitable mitigation measures that may be required to ensure that any identified potential noise or vibration impacts can be controlled to acceptable levels.

9.3.2 This chapter was originally drafted under the previous planning policy regime and the approach to the assessments was agreed with Barnsley Council in advance of this change in national policy. On publication of the new NPPF, the chapter and the assessments herein have been checked to ensure that the original assessments remain in compliance with current policy.

9.3.3 There is currently no relevant technical guidance published to accompany the NPPF, and the NPSE acknowledges the need for more research to investigate what may represent an SOAEL for noise. This effectively provides policy flexibility in the period until there is further evidence and guidance.

9.3.4 Therefore, in this interim period, an emphasis should be placed on existing British Standards and guidance, which has been the case in the assessments within this chapter and it is therefore considered that the strategy behind the assessment approach is in compliance with the both the previous planning policy and the new NPPF.

Extent of the Study Area

9.3.5 For the purposes of this assessment, the following noise and vibration sensitive receptors have been considered, and are assumed to be representative of other neighbouring receptors that could experience an impact as a result of the construction and operation of the development.

Table 9.7: Noise & Vibration Sensitive Receptors

Receptor	Receptor Type	Noise Sensitivity	Distance to Closest Development Site Boundary
13 Twibell Street (representative of 7 to 23 Twibell Street)	Residential	High	16m approx
25 Twibell Street (representative of 25 to 29 Twibell Street)	Residential	High	16m approx
39 Twibell Street (representative of 31 to 39 Twibell Street and 1 Eaming View)	Residential	High	18m approx
19 and 21 Burton Road (representative of 19 to 33 Burton Road)	Residential	High	60m approx
47 and 49 Burton Road (representative of 35 to 49 Burton Road 51 to 59 Burton Road)	Residential	High	64m approx
Various locations alongside the wider road network that could be affected by altered traffic flows	Various	High	Various

Method of Baseline Data Collection

Noise Survey

9.3.6 An environmental noise survey has been undertaken to determine the baseline noise climate currently affecting those noise sensitive receptors in the vicinity of the site. The noise measurement locations were selected to be representative of those noise sensitive locations identified in **Table 9.7** above.

9.3.7 Baseline noise levels were measured continuously over the period 12.30 hours on Thursday 23 June to 10.30 hours on Friday 24 June 2011. The survey therefore covered the daytime, evening and night-time periods.

9.3.8 Details of the Type 1 sound level monitoring equipment employed during the survey are presented within **Table 9.8**. All sound level meters had been calibrated to traceable standards within the preceding two years.

Table 9.8: Noise Measurement Equipment

Equipment	Make and Model	Serial Number	Calibration Expiry Date
Sound level meter	01dB Stell SIP 95	10566	20 November 2011
Preamplifier	01dB Stell PRE 12 N	990762	
Microphone	Microtech Gefell GmbH MK250	103416	
Field Calibrator	01dB Stell Cal 21	51031216	16 June 2012
Sound level meter	01dB Stell Solo Master	10330	6 May 2013
Preamplifier	01dB Stell PRE 21 S	10423	
Microphone	Microtech Gefell GmbH MCE 212	39620	
Field Calibrator	01dB Stell Cal 21	11332	6 May 2013

9.3.9 Weather conditions present throughout the survey periods were conducive to obtaining accurate and reliable measurements.

9.3.10 The measurement positions (MPs) used during the noise survey are presented within **Figure 9.1** and are described as follows:

- MP1: A free-field location on the southern side of Twibell Street, to the south of the development. This location was chosen to be representative of those noise sensitive residential receptors on Twibell Street; and
- MP2: A free-field location to the rear of the residential properties on the southern side of Burton Road, to the north of the development site. This location was chosen to be representative of those noise sensitive residential receptors on Burton Road.

Assessment Methodology

Construction Noise

9.3.11 For on-site construction, following the advice provided within BS5228-1:2009 and given the urban nature of the Site, it is considered appropriate that the construction noise assessment should be undertaken against the fixed noise limit of 75dB $L_{Aeq,T}$ (façade) applicable to the core working day. Demolition/construction noise levels are considered to have a medium magnitude of effect and result in a moderate to major effect where this adopted criterion is likely to be exceeded. Where noise levels are likely to fall below this criterion, the magnitude of effect is considered to be low resulting in a minor to moderate noise effect being registered.

Construction Vibration

9.3.12 The assessment of ground-borne vibration associated with typical on-site demolition/construction activities has been undertaken drawing upon the guidance presented within BS5228-2:2009. Predictions have been conducted in order to determine the likely levels of vibration produced by typical construction activities at varying distances from the activity in question. Such predictions have been performed based upon the collection of historic data presented within BS5228-2:2009 and employing the empirical prediction methods also detailed within that Standard.

9.3.13 The significance of vibration effects has been assessed drawing upon the guidance criteria presented within BS5228-2:2009, in this regard the following criteria have been adopted:

Table 9.9: Magnitude of Effect Applicable to Construction Vibration – Applicable to Human Perception

Vibration Level	Effect	Magnitude of effect
$<0.3 \text{ mms}^{-1}$	Unlikely to be perceptible in residential environments	Negligible
$0.3 > 1.0 \text{ mms}^{-1}$	Onset of perceptibility in residential environments.	Low
$1.0 > 10.0 \text{ mms}^{-1}$	Onset of complaints in residential environments	Medium
$>10.0 \text{ mms}^{-1}$	Vibration is likely to be intolerable for any more than a very brief exposure to this level.	High

9.3.14 **Table 9.9** has been generated based upon the guidance on effects of vibration levels applicable to human perception as presented within BS5228-2:2009, the corresponding vibration ranges and associated significance ratings adopted for the purpose of this assessment have also been included within the **Table 9.9**.

9.3.15 Human perception is more sensitive than the point at where cosmetic damage occurs (above 15mm/s) and structural damage (above 30mm/s). Therefore, mitigating the effect on human perception will also ensure building damage is not incurred.

Noise from Proposed Mechanical and Electrical Plant Items

9.3.16 It is anticipated that there will be mechanical and electrical plant items associated with the new development, which is likely to include cooling and refrigeration plant associated with the proposed foodstore. These plant items will have the potential to generate noise. However, at this stage, details of the proposed type, number and location of any such plant or the detailed nature of any such operations are not available.

9.3.17 Therefore, it is appropriate to specify suitable mechanical and electrical plant item noise limits in accordance with the criteria specified by Barnsley Council. Barnsley Council specifies that the noise rating level of any plant item shall not exceed a level 5dB below the existing background noise level.

Noise from Service Yard Activities, Petrol Filling Station and Car Wash

9.3.18 The development is likely to include two service yard areas; one for the proposed foodstore and, potentially, a smaller service yard associated with the proposed Retail Unit 3. It has been agreed with Barnsley Council that the potential noise effect from service yard activities will be assessed against the criteria presented within BS4142: 1997 and the internal noise criteria presented within BS 8233:1999. The same guidance will also be consulted in the assessment of noise from the proposed petrol filling station and associated car wash.

Development Generated Road Traffic Noise on Existing Receptors

9.3.19 The assessment of noise effects due to changes in road traffic noise has been undertaken drawing upon the suggested classification of effect provided within the DMRB, 2011. The DMRB classification of effects has been adapted to produce a set of significance criteria applicable to residential properties ranging from negligible to high as presented within **Table 9.10** below.

Table 9.10: Effect Scale for Comparison of Future Noise against Existing Noise

Change in Noise Level dB(A)	Magnitude of Effect
0	None
0 – 0.9	Negligible
1 – 2.9	Low
3 – 4.9	Medium
5+	High

Significance Criteria

9.3.20 The assessments of potential effects as a result of the Proposed Development have taken into account both the site preparation and construction and operational phases. The significance level attributed to each effect has been assessed based on the magnitude of change due to the Proposed Development, and the sensitivity of the affected receptor/receiving environment to change, as well as a number of other factors that are outlined in more detail in **Chapter 2 - Approach to the EIA**. Magnitude of change and the sensitivity of the affected receptor/receiving environment are both assessed on a scale of high, medium, low and negligible (as shown in **Chapter 2 - Approach to the EIA**).

Effect Significance

9.3.21 The following terms have been used to define the significance of the effects identified:

- **Major effect:** where the Proposed Development could be expected to have a very significant effect (either positive or negative) on the existing noise and vibration climate;
- **Moderate effect:** where the Proposed Development could be expected to have a noticeable effect (either positive or negative) on the existing noise and vibration climate;
- **Minor effect:** where the Proposed Development could be expected to result in a small, barely noticeable effect (either positive or negative) on the existing noise and vibration climate; and
- **Negligible:** where no discernible effect is expected as a result of the Proposed Development on the existing noise and vibration climate.

9.3.22 The significance of each effect assessed has been determined through consideration of the magnitude of the effect together with the sensitivity of the receptor under consideration. This has been undertaken in accordance with the significance matrix presented within **Table 9.11**.

Table 9.11: Matrix for Determining the Significance of Effects

		SENSITIVITY OF RECEPTOR/RECEIVING ENVIRONMENT TO EFFECT			
		High	Medium	Low	Negligible
Magnitude of Effect	High	Major	Moderate to Major	Minor to Moderate	Negligible
	Medium	Moderate to Major	Moderate	Minor	Negligible
	Low	Minor to Moderate	Minor	Negligible to Minor	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

9.4 BASELINE CONDITIONS

9.4.1 During attendance on Site to undertake the noise survey, it was noted that the local noise climate was dominated by noise from road traffic. However, at measurement position (MP) 1 there was some significant noise from the Hayes timber yard on Twibell Street between the hours of 8.00 am and 5.00 pm. At MP2, it was noticed that there was some noise from the construction works associated with the new Burton Road Bypass during the hours of approximately 8.00 am and 4.00 pm.

9.4.2 A summary of the measured noise levels recorded during the baseline noise survey is presented within **Table 9.12**. The full tabulated results are presented within **Appendix 9.2**.

Table 9.12: Summary of Measured Baseline Noise Levels

Measurement Position (Figure 8.1)	Time Period		Measured Sound Pressure Level (dB)			
			L _{Aeq,T}	L _{A90,T}	L _{A10,T}	L _{AFmax}
MP1	16 hour day	07:00 – 23:00	62.1	51.5	61.1	91.6
	Lowest 1 hour day	07:00 – 23:00	52.4	43.5	50.3	73.1
	8 hour night	23:00 – 07:00	51.6	40.3	48.8	81.9
	Lowest 1 hour night	23:00 – 07:00	40.4	36.6	42.3	54.8
	Lowest 5 minute night	23:00 – 07:00	37.5	33.5	40.4	46.5
MP2	16 hour day	07:00 – 23:00	51.6	46.4	53.4	72.2
	Lowest 1 hour day	07:00 – 23:00	47.4	41.7	49.5	62.2
	8 hour night	23:00 – 07:00	45.7	38.5	46.4	73.4
	Lowest 1 hour night	23:00 – 07:00	39.4	34.7	41.4	56.6
	Lowest 5 minute night	23:00 – 07:00	37.5	35.2	41.0	48.2
Notes: 1. All noise levels are free-field. 2. The lowest 1 hour daytime and 1 hour night time levels for the various indices did not necessarily occur during the same time period. 3. At MP1 the lowest 1 hour daytime noise levels occurred during the hours 21.00 to 22.00 or 22.00 to 23.00 hours. The lowest 1 hour night-time noise levels occurred during the hours 01.00 to 02.00 or 03.00 to 04.00. 4. At MP2 the lowest 1 hour daytime noise levels occurred during the hours 17.00 to 18.00 or 22.00 to 23.00 hours. The lowest 1 hour night-time noise levels occurred during the hours 03.00 to 04.00 or 04.00 to 05.00 hours. 5. The lowest daytime 1 hour noise levels detailed above were recorded during the periods when there was no influence from the temporary noise sources identified in paragraph 8.4.1 above. 6. The lowest recorded 5 minute night-time noise levels are taken to be those recorded during the 5 minute period between 03.00 and 03.05 hours. At both MP1 and MP2, the lowest recorded L _{A90,5minute} noise levels occurred during this period.						

Future Baseline

9.4.3 At the time of undertaking the baseline noise survey it was noted that the local noise climate appeared to be dominated by road traffic noise. It is also noted that the construction of the Burton Road Bypass is currently underway and that this bypass, as well as introducing a new road, could potentially result in higher traffic flows and higher average traffic speeds along other existing roads in the vicinity of the bypass. It is therefore anticipated that the existing baseline conditions could change in the near future, with a small increase in traffic noise levels particularly in the vicinity of the Burton Road Bypass.

9.5 ASSESSMENT OF EFFECTS, MITIGATION AND RESIDUAL EFFECTS

Site Preparation and Construction Phase (including Demolition)

Construction Noise Levels at Nearby Noise-Sensitive Receptors

9.5.1 It is inevitable with any major development that there will be some disturbance caused to those nearby during the site preparation and construction activities. However, disruption due to such activities is localised and is temporary in nature.

9.5.2 Although there are techniques available to predict the likely effect of noise from site clearance, earthworks and construction activities, such as those contained within BS5228 Part 1, they are necessarily based on detailed information of the type and number of plant being used, their location and the length of time they are in operation.

9.5.3 Such specific details are not available at this stage. However, an estimation of the likely noise effects from this phase have been made for a representative number of noise-sensitive receptors in close proximity to the Site boundary. These predictions have been undertaken based upon assumed construction methodologies and estimated numbers of plant and equipment. Such assumptions have been made based on experience gained from sites of similar scale and nature.

9.5.4 The predictions have followed the methodology contained within BS5228 Part 1 and are in terms of the $L_{Aeq,T}$ over the core working day. The predictions consider both an 'average' case scenario and a 'worst' case scenario, which take the form of the following:

- Average case scenario: Construction plant operating close to the approximate centre of the main construction areas; and
- Worst case scenario: The noisiest plant items operating at the closest part of the construction areas to each relevant noise sensitive receptor, with the remainder of the plant operating towards the centre of the main construction areas.

9.5.5 For the purpose of these noise predictions, the proposed works have been split down into the following sub-phases:

- Phase 1: Demolition of existing structures and site clearance;
- Phase 2: Earthworks / excavation and foundation piling;
- Phase 3: Main construction works associated with the erection of the building superstructure(s);
- Phase 4: Cladding, glazing, roofing, trade works and fitout; and
- Phase 5: Soft landscaping and infrastructure.

9.5.6 **Table 9.13** sets out the typical plant type, number and assumed utilisation (percentage 'on-time') used in the prediction of noise levels during the key construction phases.

Table 9.13: Assumed Construction Plant Details

Works Phase	Plant Type	Sound Power Level (L_{WA}) dB	No. of Plant	Assumed Percentage 'on' Time
Phase 1 – Demolition and Site Clearance	Tracked excavator	96	2	60 (each)
	Excavator-mounted breaker	119	2	20 (each)
	Dump truck	109	2	60 (each)
	Tracked crane	95	1	50
	Compressor/generator	93	2	20 (each)
	Stihl saw / angle grinder	108	1	10
Phase 2 – Excavation and Piling	Tracked excavator	96	2	60 (each)
	Dump truck	109	2	50 (each)
	Auger piling rig	107	2	60 (each)
	Tracked support crane	95	2	60 (each)
	Delivery wagon	105	1	20
	Concrete wagon	104	1	20
	Concrete pump	106	1	20
	Small site dumper or forks	104	1	50

Works Phase	Plant Type	Sound Power Level (L _{WA}) dB	No. of Plant	Assumed Percentage 'on' Time
Phase 3 – Building Works	Tracked Excavator	96	1	60
	Small site dumper or forks	104	1	40
	Concrete wagon	104	2	40 (each)
	Concrete pump	106	1	60
	Poker vibrators x 5	102	1	50
	Tracked support crane	95	2	50 (each)
	Formworks (banging and hammering)	108	1	10
	Formworks (hand tools / drills / wrenches)	100	1	10
	Delivery wagon	105	2	10 (each)
	Forklift	104	1	20
	Compressor/generator	93	2	20 (each)
	Tower crane	104	1	10
Phase 4 – Cladding / Glazing / Trades / Fitout	Tracked excavator	96	1	50
	Small site dumper	104	1	50
	Delivery wagon	105	2	50 (each)
	Forklift	104	1	70
	Tracked or mobile (wheeled) crane	95	1	40
	Hand tools (drills / wrenches)	100	2	10 (each)
	Tower crane	104	1	10
Phase 5 – Soft landscaping and Infrastructure	Tracked excavator	96	1	50
	Small site dumper	104	1	50
	Delivery wagon	105	1	50
	Hand tools (drills / wrenches)	100	2	10 (each)
Note: Assumed sound power levels taken from the database presented in BS5228-1: 2007 or from WSP's database of measured construction noise levels.				

9.5.7 Predictions have been carried out to determine noise levels likely to be generated by each of the above phases. For the purpose of these predictions, it is assumed that the intervening ground between the construction noise sources and the receivers will be acoustically hard such that there will be no additional attenuation of sound due to ground absorption, and that no acoustic barriers such as local buildings will be present. No attenuation due to atmospheric absorption is assumed. A +3dB facade correction is assumed. The predicted noise levels assume neutral meteorological conditions.

9.5.8 The noise predictions have been undertaken for those noise sensitive receptors identified in **Table 9.7** and shown on **Figure 9.1**.

9.5.9 **Table 9.14** sets out the range of predicted unmitigated construction noise levels, for each phase. The range extends from the average to the worst case situation as described above. Predicted noise levels above 75dB L_{Aeq,12hour}

are indicated in bold type. A75 dB assessment criterion has been adopted in accordance with guidance contained in BS5228 for urban areas.

Table 9.14: Predicted Unmitigated Average and Worst Case Construction Noise Levels – Façade $L_{Aeq,12hr}$

Noise Sensitive Receptor	Works Phase (average case / worst case)				
	1 Demolition and site clearance	2 Excavation and piling	3 Building works	4 Cladding, glazing, trades and fitout	5 Soft landscaping and infrastructure
13 Twibell Street	62.9 / 73.4	63.4 / 71.9	60.3 / 68.8	59.1 / 67.5	55.9 / 64.4
25 Twibell Street	65.1 / 78.8	65.1 / 76.1	62.0 / 73.1	60.8 / 71.7	57.6 / 68.6
39 Twibell Street	63.2 / 74.4	63.6 / 72.5	60.5 / 69.5	59.3 / 68.3	56.1 / 65.1
19/21 Burton Road	58.1 / 66.8	59.4 / 66.5	56.4 / 63.5	55.2 / 62.1	52.0 / 59.0
47/49 Burton Road	59.6 / 64.7	60.7 / 64.8	57.7 / 61.8	56.4 / 60.5	53.3 / 57.4
Note: All noise levels are $L_{Aeq,12hr}$ facade. Those predicted noise levels that exceed the adopted 75dB criterion are presented in bold text.					

9.5.10 A review of **Table 9.14** identifies that all of the calculated unmitigated average construction noise levels are below the $75dB_{L_{Aeq,T}}$ noise criterion adopted for this assessment. There are two instances where the worst case unmitigated construction noise levels are predicted to give rise to noise levels which are in excess of the adopted assessment criteria, however these would be temporary and local in nature and similar in magnitude to, for example, those generated during major temporary road works.

9.5.11 It should be noted that these predictions are worst case in that it is assumed that any mitigation measures, or screening afforded by site hoardings have not been implemented. Furthermore it should be noted that it is unlikely that operations are to be conducted at those parts of the Site closest to the each of the identified receptors for significant periods of time. For the majority of the site preparation and construction phase it is expected that activities will be conducted at greater distances such that the adopted criterion are likely to be met.

9.5.12 It has been considered prudent to compare the predicted construction noise levels with the existing ambient noise levels at noise measurement position MP1 as this is representative of the receptors at and in the vicinity of 25 Twibell Street, which is expected to experience a significant noise impact as a result of the temporary construction works. The existing daytime ambient (L_{Aeq}) noise level measured at MP1, when including for a faced correction and rounded up to the nearest 5dB, is 65dB L_{Aeq} . Accordingly, a comparison of this level with the criteria presented in **Table 9.4** indicates that a more appropriate, but also more stringent, criterion to use would be 70dB (Category B). **Table 9.14** indicates that the average construction noise level during the early stages of the site clearance and construction works is 65.1dB $L_{Aeq,12hr}$ and the worst case noise level is 78.8dB $L_{Aeq,12hr}$. The criteria detailed in **Table 9.4** indicate that the worst case predicted noise levels are considered to be '*significant*'.

9.5.13 Given that the sensitivity of the closest noise sensitive receptors to the Site is considered to be high and the magnitude of effect when construction operations are undertaken for the majority of the time at locations towards the centre of the site/away from the Site boundaries are expected to be low, there is likely to be a direct, temporary, short-term effect on such receptors of **minor to moderate negative** significance prior to the implementation of mitigation measures. Where for limited durations, activities are conducted towards the Site perimeter closest to residential receptors in the vicinity of 25 Twibell Street, the magnitude of effect is considered to be medium. Therefore, there is likely to be a direct, temporary, short-term effect on such receptors of **moderate to major negative** significance prior to the implementation of mitigation measures.

Mitigation

9.5.14 Generic safeguards exist to minimise the effects of construction noise, these include:

- The various EC Directives and UK Statutory Instruments that limit noise emissions of a variety of construction plant;
- Guidance set out in BS5228: Part 1: 2009, which covers noise control on construction sites; and

- The powers that exist for local authorities under Sections 60 and 61 of the Control of Pollution Act 1974 to control noise from construction sites.

9.5.15 The adoption of Best Practicable Means, as defined in Section 72 of the Control of Pollution Act 1974 is usually the most effective means of controlling noise from construction sites. Such measures, where appropriate, may include the following:

- Any compressors brought on to the Site to be silenced or sound reduced models fitted with acoustic enclosures;
- All pneumatic tools to be fitted with silencers or mufflers;
- Care to be taken when erecting or striking scaffolds to avoid impact noise from banging steel. All operatives undertaking such activities to be instructed on the importance of handling the scaffolds to reduce noise to a minimum;
- The majority of deliveries to be programmed to arrive during normal working hours only. Care to be taken when unloading vehicles to minimise noise. Delivery vehicles to be routed so as to minimise disturbance to local residents. Delivery vehicles to be prohibited from waiting within or in the vicinity of the Site with their engines running;
- All plant items to be properly maintained and operated according to manufacturers' recommendations in such a manner as to avoid causing excessive noise;
- All plant to be sited so that the effect of noise at nearby noise-sensitive properties is minimised;
- Local hoarding, screens or barriers to be erected as necessary to shield particularly noisy activities; and
- Problems concerning noise from site preparation, earthworks and construction activities can often be avoided by taking a considerate and neighbourly approach to relations with the local residents. Where possible, works should only take place during given periods (e.g. during normal construction hours) and not at night.

9.5.16 It is recommended that the above measures be included in any Construction Environmental Management Plan (CEMP) that may be issued to and agreed with the contractor(s) conducting the works.

9.5.17 Experience from other sites has shown that by implementing the above measures, typical noise levels from construction works can be reduced by up to 5dB(A).

Residual Effects

9.5.18 The implementation of the above mitigation measures will serve to minimise any disturbance caused to nearby receptors as a result of the site preparation and construction activity. Given that the sensitivity of the closest receptors to the Site is considered to be high and the magnitude of effect is considered to be low, there is likely to be a direct, temporary, short-term effect on such receptors of **minor to moderate negative** significance following the implementation of mitigation measures.

Vibration Levels at Nearby Vibration-Sensitive Receptors

9.5.19 Ground-borne vibration calculations have been performed for typical construction activities / machinery based on the empirical prediction procedures and historical measurement data presented within BS5228-2:2009 and WSP Acoustics' own database of measured vibration levels from demolition and construction works.

9.5.20 The main sources of groundborne vibration are likely to be:

- The use of percussive breakers during demolition of existing buildings on the site and also, possibly, the removal of hardstandings and other hard material during the excavation for the proposed basement level car parking;
- Impulsive vibration from demolition rubble or masonry striking the floor/ ground during the demolition of existing buildings;
- The use of tracked excavators;
- Piling works associated with the construction of foundations for the new buildings For the purpose of this assessment it is assumed that bored piling methods would be employed. The vibration sources associated with bored piling activities will include the use of pile augers whilst boring and the dollying and insertion of pile casings.

9.5.21 In order to estimate the levels of vibration that are likely to be generated by the works, predictions have been undertaken using a combination of the methods set out in BS5228-2 or, where no specific prediction method is set out in the Standard, using vibration measurement data obtained from similar construction activities at other sites.

9.5.22 In the case of percussive breakers used for the demolition of existing buildings and the breaking-out of hard materials, there is no recognised prediction method set out in BS5228-2 or any other standard. Instead, use is made of measurement data obtained by WSP Acoustics from another site during the breaking-out of rock and hard sandstone using an excavator mounted percussive breaker, as measured at various distances from the source.

9.5.23 In the case of falling rubble from the demolition works, again there is no specified method in BS5228-2. However, there is a prediction method for dynamic compaction which is essentially based on the same physical process, but with larger weights and drop heights. Assuming that 100kg of rubble or masonry falls from a height of 2m (e.g. during the demolition of existing structures) then this will release a potential energy of 1962 Joules. If this is used as an equivalent energy in combination with the BS5228-2 method for dynamic compaction, then an estimated vibration level can be calculated for any given distance. It is noted, however, that the BS5228-2 method has not been validated for the energies involved.

9.5.24 In the case of tracked excavators, there is no recognised prediction method set out in BS5228-2 or any other standard. Instead, use is made of measurement data obtained by WSP Acoustics from another site, as measured at various distances from the source.

9.5.25 In the case of bored piling works associated with the construction of foundations for the new buildings, use is made of the prediction methods for vibratory piling (for the vibrating-in of pile casings) and the historical measurement data (for augering and the dollying / vibrating-in of casings) presented in BS5228-2.

9.5.26 In all cases, the vibration predictions have considered the potential amplification and attenuation of vibration as it propagates through the ground, into the foundations of the building and then through the building to the internal floors where the vibration would be experienced by the inhabitants of the building.

9.5.27 The predictions are based on the closest distance that the relevant items of plant are likely to be operating from each noise sensitive location. The predictions are not specific to particular work stages and represent the worst case vibration levels that are likely to occur during any stage of the works. All predictions are in terms of the peak particle velocity vibration, in units of mm/s.

9.5.28 The predicted vibration levels are presented in the following tables. Also shown in the tables is an assessment of the predicted vibration levels by comparison against the magnitude of effect criteria set out in **Table 9.9**.

Table 9.15: Predicted Vibration from Bored Piling (augering)

Receptor Location	Peak Particle Velocity (mm/s)	Magnitude of Effect
13 Twibell Street	<0.03	Negligible
25 Twibell Street	<0.03	Negligible
39 Twibell Street	<0.03	Negligible
19/21 Burton Road	<0.03	Negligible
47/49 Burton Road	<0.03	Negligible

Table 9.16: Predicted Vibration from Bored Piling (casing vibrator)

Receptor Location	Peak Particle Velocity (mm/s)	Magnitude of Effect
13 Twibell Street	<0.6	Low
25 Twibell Street	<0.9	Low
39 Twibell Street	<0.4	Low
19/21 Burton Road	<0.2	Negligible
47/49 Burton Road	<0.2	Negligible

Table 9.17: Predicted Vibration from Falling Demolition Rubble

Receptor Location	Peak Particle Velocity (mm/s)	Magnitude of Effect
13 Twibell Street	<0.05	Negligible
25 Twibell Street	<0.07	Negligible
39 Twibell Street	<0.04	Negligible
19/21 Burton Road	<0.02	Negligible
47/49 Burton Road	<0.02	Negligible

Table 9.18: Predicted Vibration from Excavation and Tracked Machinery

Receptor Location	Peak Particle Velocity (mm/s)	Magnitude of Effect
13 Twibell Street	<0.03	Negligible
25 Twibell Street	<0.03	Negligible
39 Twibell Street	<0.03	Negligible
19/21 Burton Road	<0.03	Negligible
47/49 Burton Road	<0.03	Negligible

Table 9.19: Predicted Vibration from Breaking-Out Works

Receptor Location	Peak Particle Velocity (mm/s)	Magnitude of Effect
13 Twibell Street	0.13	Negligible
25 Twibell Street	0.13	Negligible
39 Twibell Street	0.13	Negligible
19/21 Burton Road	0.03	Negligible
47/49 Burton Road	0.03	Negligible

9.5.29 It should be noted that the assessment of magnitude of vibration effect, as detailed in the tables above, is based on the criteria for human response to vibration. In all cases, and for all phases of the construction works, the predicted vibration levels are substantially below those that could have a significant effect on the fabric of even the most sensitive buildings or other structures.

9.5.30 The overall magnitude of effect, based on the worst-case predicted levels of vibration during any stage of the construction works, as experienced at each sensitive receptor, is detailed in **Table 9.20**.

Table 9.20: Overall Magnitude of Vibration Effect during Construction Works

Receptor Location	Overall Magnitude of Effect
13 Twibell Street	Low
25 Twibell Street	Low
39 Twibell Street	Low
19/21 Burton Road	Negligible
47/49 Burton Road	Negligible

9.5.31 Taking into account the sensitivity of the nearby receptors and the temporary nature of the construction works, the overall vibration impact during construction is considered to be of **minor to moderate, negative** significance.

9.5.32 It should be noted that this is very much a worse case assessment based on the minimum possible distances at which construction activities could reasonably take place from existing vibration sensitive receptors. In reality, for the large majority of the site preparation and construction phase, it is expected that activities will take place at greater distances from such properties thus leading to lesser significance of effects.

9.5.33 It should also be noted that the above assessment has been undertaken based on vibration levels associated with a small range of ground-borne vibration generative construction activities. It is possible that activities other than those presented may take place; similarly some of those presented may not be applicable to the activities specific to the Proposed Development. The conclusions drawn from this assessment should therefore be used for indicative purposes only.

Mitigation

9.5.34 The only activity that has been considered in the above assessment that has been found to give rise to significant levels of groundborne vibration is the insertion of pile casings (via the use of a casing vibrator). Wherever possible, the piling method should avoid the use of temporary casings or, where they are necessary, the casings should not be vibrated-in but should instead be inserted by a "screw-in" method. Where ground conditions allow, the depth of any pile casings should be kept to a minimum. Given that the insertion of pile casings is of relatively short duration, such activities should be programmed for the least sensitive times of the day.

9.5.35 It is possible to employ other measures in order to reduce the potential effects resulting from construction generated vibration, such measures may include;

- Where possible, using an excavator with blade attachment for the removal of hardstandings and other hard material rather than a percussive breaker;
- Where large areas of hardstanding need to be removed, consideration should be given to removing those sections closest to the sensitive receptors first, in order to provide the earliest possible structural break in the transmission path through the solid surface materials (e.g. concrete);
- During the demolition of buildings, care should be taken to lower materials to the ground and not to let demolition rubble fall through any appreciable height. Care should also be taken when loading any demolition rubble into trucks for removal. The objective is to place the material into the truck and not let any material fall;
- Piling rig operators should not adopt the common practice of simply reversing the auger back and forward to remove spoil, because of the potential noise this can cause. This is a matter of instruction and supervision by the contractor and site management. Alternative measures to reduce such noise include using water on the auger which creates more mud but ensures that piled ground slips off the auger, or spinning the auger quickly enough to spin off the spoil (this sounds more like a washing machine than the reversing which bangs metal on metal with a resulting crashing noise and potential vibration); and
- Where piling is to take place, probing for obstructions and the removal of any significant obstructions prior to the works;

9.5.36 It is expected that mitigation measures and operational considerations such as these would be incorporated within the demolition and construction methodologies in order that the effects of ground-borne construction vibration can be controlled wherever practically possible.

Residual Effects

9.5.37 It is expected that ground-borne construction vibration levels can be controlled to ensure the magnitude of change is not greater than low. The sensitivity of the nearby residential receptors is considered to be high, therefore, it is expected that, for worst case activities such as the insertion of pile casings there is likely to be a direct, temporary, short-term, local effect on the closest vibration sensitive receptor of **minor to moderate negative** significance following the implementation of mitigation measures.

9.5.38 Following confirmation of the precise construction programme it is recommended that a further assessment be undertaken based on the detailed designs.

Operational Phase

Noise from Development Generated Road Traffic

9.5.39 Upon completion of the Proposed Development, it is possible that local road traffic noise levels may change as a result of development generated traffic. Therefore, it is appropriate to consider the magnitude of any associated changes that might arise.

9.5.40 The results of the traffic assessment prepared by Curtins have been used as the basis for determining the change in road traffic noise levels that would result from development generated traffic.

9.5.41 Road traffic noise calculations have been carried out in accordance with CRTN, being undertaken for a notional receptor location 10m from the edge of the carriageway of each road considered, and 1.5m above ground level. A notional receptor has been used because the change in traffic noise level adjacent to any given road will be the same at all distances where noise from that route is dominant. Traffic noise calculations have been undertaken to establish the change in the weekday and Saturday daytime $L_{A10,18hr}$ noise level and the night-time (23.00 to 07.00) $L_{A10,8hr}$ noise level.

9.5.42 Calculations have been undertaken for the baseline year (2011) and the year of opening (2016) both with and without the proposed development. Road traffic speeds have been applied based on the speed limits applicable to each link.

9.5.43 The traffic data supplied has included for other committed developments for both the opening year, including the Burton Road Bypass.

9.5.44 The predicted changes in road traffic noise are shown in **Tables 9.21 to 9.23**. These tables show the difference between the 2011 baseline situation and the assumed year of opening (2016) both with and without the Proposed Development.

Table 9.21: Predicted Changes in Road Traffic Noise Levels (18 hour Weekday)

Link	Road section	Predicted Free-field Noise Level dB $L_{A10, 18hr}$			Change in Noise Levels (B-A) / (C-A)
		2011 baseline (A)	2016 without development (B)	2016 with development (C)	
1	Wakefield Road North	70.8	70.9	71.8	0.1 / 1.0
2	Carlton Road	66.3	66.4	66.4	0.1 / 0.1
3	Smithies Lane	66.7	66.8	66.8	0.1 / 0.1
4	Wakefield Road South	70.7	70.9	71.8	0.2 / 1.1
5	Burton Road	low flow	low flow	low flow	
6	Old Mill Lane North	73.6	73.8	74.5	0.2 / 0.9
7	Twibell Street	59.5	59.7	low flow	0.2 /

Link	Road section	Predicted Free-field Noise Level dB L _{A10} , 18hr			Change in Noise Levels (B-A) / (C-A)
		2011 baseline (A)	2016 without development (B)	2016 with development (C)	
8	Dryden Road	63.8	63.9	63.9	0.1 / 0.1
9	Harborough Hill Rd (south of gyratory)	72.4	72.5	71.4	0.1 / -1.0
10	Meadow Street	low flow	low flow	low flow	
11	Old Mill Lane South	72.0	72.1	72.4	0.1 / 0.4
12	Canal Way	68.1	68.2	67.0	0.1 / -1.1
13	Sheffield Road South	74.0	74.2	74.2	0.2 / 0.2
14	West Way	73.4	73.5	73.3	0.1 / -0.1
15	Sheffield Road North	66.4	66.6	66.5	0.2 / 0.1
16	Burton Rd Bypass (west of site access)	69.4	69.6	72.3	0.2 / 2.9
17	Burton Rd Bypass (east of site access)	69.2	69.4	69.9	0.2 / 0.7
18	Burton Rd (east of bypass)	69.4	69.6	70.0	0.2 / 0.6
Note: 'low flow' indicates that it has not been possible to undertake these calculations as the traffic flows are below the range of validity of the CRTN prediction model.					

Table 9.22: Predicted Changes in Road Traffic Noise Levels (18 hour Saturday)

Link	Road section	Predicted Free-field Noise Level dB L _{A10} , 18hr			Change in Noise Levels (B-A) / (C-A)
		2011 baseline (A)	2016 without development (B)	2016 with development (C)	
1	Wakefield Road North	69.8	69.9	70.9	0.1 / 1.1
2	Carlton Road	65.1	65.2	65.1	0.1 / 0
3	Smithies Lane	64.8	64.9	64.9	0.1 / 0.1
4	Wakefield Road South	70.1	70.2	71.1	0.1 / 1.0
5	Burton Road	low flow	low flow	low flow	
6	Old Mill Lane North	72.7	72.8	73.6	0.1 / 0.9
7	Twibell Street	61.5	61.6	low flow	0.1 /
8	Dryden Road	65.5	65.6	65.6	0.1 / 0.1
9	Harborough Hill Rd (south of gyratory)	71.4	71.6	72.1	0.2 / 0.7
10	Meadow Street	low flow	low flow	low flow	
11	Old Mill Lane South	71.1	71.2	71.6	0.1 / 0.5
12	Canal Way	68.3	68.4	67.3	0.1 / -1.0
13	Sheffield Road South	73.2	73.3	73.3	0.1 / 0.1
14	West Way	72.4	72.5	72.3	0.1 / -0.1
15	Sheffield Road North	67.2	67.3	67.3	0.1 / 0.1
16	Burton Rd Bypass (west of site access)	68.8	68.9	71.6	0.1 / 2.8
17	Burton Rd Bypass (east of site access)	68.5	68.6	69.1	0.1 / 0.6

Link	Road section	Predicted Free-field Noise Level dB L _{A10} , 18hr			Change in Noise Levels (B-A) / (C-A)
		2011 baseline (A)	2016 without development (B)	2016 with development (C)	
18	Burton Rd (east of bypass)	68.7	68.8	69.3	0.1 / 0.6
Note: 'low flow' indicates that it has not been possible to undertake these calculations as the traffic flows are below the range of validity of the CRTN prediction model.					

Table 9.23: Predicted Changes in Road Traffic Noise Levels (8 hour Night-time)

Link	Road section	Predicted Free-field Noise Level dB L _{A10} , 8hr			Change in Noise Levels (B-A) / (C-A)
		2011 baseline (A)	2016 without development (B)	2016 with development (C)	
1	Wakefield Road North	64.6	64.8	65.7	0.2 / 1.1
2	Carlton Road	59.2	59.4	59.3	0.2 / 0.1
3	Smithies Lane	59.8	59.9	59.9	0.1 / 0.1
4	Wakefield Road South	64.6	64.8	65.7	0.2 / 1.1
5	Burton Road	low flow	low flow	low flow	
6	Old Mill Lane North	67.5	67.7	68.4	0.2 / 0.9
7	Twibell Street	low flow	low flow	low flow	
8	Dryden Road	55.9	56.1	56.0	0.2 / 0.1
9	Harborough Hill Rd (south of gyratory)	66.3	66.4	67.0	0.1 / 0.7
10	Meadow Street	low flow	low flow	low flow	
11	Old Mill Lane South	65.9	66.0	66.3	0.1 / 0.4
12	Canal Way	62.0	62.1	60.6	0.1 / -1.4
13	Sheffield Road South	67.9	68.1	68.1	0.2 / 0.2
14	West Way	67.3	67.4	67.2	0.1 / -0.1
15	Sheffield Road North	59.2	59.5	59.4	0.3 / 0.2
16	Burton Rd Bypass (west of site access)	63.5	63.5	66.2	0 / 2.7
17	Burton Rd Bypass (east of site access)	63.2	63.3	63.8	0.1 / 0.6
18	Burton Rd (east of bypass)	63.2	63.3	63.8	0.1 / 0.6
Note: 'low flow' indicates that it has not been possible to undertake these calculations as the traffic flows are below the range of validity of the CRTN prediction model.					

9.5.45 It can be seen from **Tables 9.21 to 9.23** that the greatest predicted road traffic noise level increase is +2.9dB on the Burton Road Bypass (west of the proposed site access). Of this increase, 0.2dB is a result of natural traffic growth and other committed developments and 2.7dB is due to development generated traffic. For all other road links, there is no change in noise level, as a result of development generated traffic only, of more than 1dB.

9.5.46 Comparing this increase in road traffic noise level as a result of the Proposed Development with the guidance contained in the DMRB (**Table 9.3**), it can be shown that this noise effect is categorised as minor. It is considered that the sensitivity of the existing noise sensitive receptors is high and the magnitude of effect on existing noise sensitive receptors is low. Therefore there is likely to be a direct permanent long term effect on existing noise sensitive receptors of **minor** to **moderate negative** significance.

Mitigation

9.5.47 As minor to moderate noise effects have been identified, noise mitigation measures are considered unwarranted.

Residual Effects

9.5.48 It can be concluded that the sensitivity of residential receptors located adjacent to local road traffic routes is considered to be high and that the magnitude of effect on existing noise sensitive receptors is predicted to be low. Therefore, there is likely to be a direct, permanent, long-term effect on such receptors of **minor** to **moderate negative** significance.

Noise from Car Parking

9.5.49 At large distances from the car parking areas, noise from parking and manoeuvring vehicles will not be generally distinguishable from road traffic on the wider road network. The majority of the car parking for the main foodstore will be beneath the building, which will serve to reduce noise levels. However, there will inevitably be some partially open aspects to the car park to allow for ventilation. There will also be some surface level parking associated with both the foodstore and the proposed Retail Unit 3. It is therefore appropriate to consider the potential noise effects from car parking at those sensitive receptors closest to the development, on Twibell Street and Burton Road.

9.5.50 Source noise data for vehicle movements has been obtained from direct measurements undertaken at other car parks, including a supermarket car park of similar size to that proposed for this development. Free-field activity noise levels were obtained for various vehicle movements, including noise from doors slamming, starting engines, reversing out of parking bays and pulling away. The results of these measurements are shown in **Table 9.24**.

Table 9.24 Reference Vehicular Noise Levels

Activity	Typical Duration (seconds)	Typical $L_{Aeq,T}$ Noise Level @ 10m (dB)	Typical $L_{AFmax,T}$ Noise Level @ 10m (dB)
Car manoeuvre into space	10	60	65
Car door slam	1 (per door)	65	72
Supermarket trolley being pushed	10	67	68
Car starting engine	3	60	66
Car manoeuvre out of space	10	60	65
Car pulling away	3	62	64

9.5.51 In order to predict noise levels from the car park activity, certain assumptions have been made, based on observations made at other car parks. Predictions are made for worst case scenarios in order that the noise impact will not be underestimated.

9.5.52 For the sake of predicting noise levels, it is assumed that having entered the car park, 50% of the vehicles will drive straight into a car parking space with the remainder driving around the car park to find a vacant space. As a worst case, a 100% occupancy rate is assumed; that is, there will be a movement into and out of every parking space during the course of a 1-hour period. A typical 'night-time' case has also been considered, based on a 25% occupancy rate.

9.5.53 Using these assumptions and standard acoustic prediction methodologies, noise levels from the car park have been predicted for those noise sensitive receptors on Twibell Street and Burton Road. The predictions are in terms of the $L_{Aeq,1hour}$ and L_{AFmax} noise levels. The results of these predictions are shown in **Tables 9.25 and 9.26**.

Table 9.25: Predicted Noise Levels from Car Parking – Worst Case (100% Occupancy)

Receptor Location	Predicted $L_{Aeq,1hour}$ Noise Level, free-field dB	Predicted L_{AFmax} Noise Level, free-field dB
13 Twibell Street	33.2	41.0
25 Twibell Street	33.0	38.7
39 Twibell Street	32.1	38.7
19/21 Burton Road	30.9	37.2
47/49 Burton Road	30.1	35.7

Table 9.26: Predicted Noise Levels from Car Parking – Night-time Case (25% Occupancy)

Receptor Location	Predicted $L_{Aeq,1hour}$ Noise Level, free-field dB	Predicted L_{AFmax} Noise Level, free-field dB
13 Twibell Street	27.2	41.0
25 Twibell Street	27.0	38.7
39 Twibell Street	26.1	38.7
19/21 Burton Road	24.9	37.2
47/49 Burton Road	24.1	35.7

9.5.54 A comparison of the above predicted noise levels against the existing levels recorded during the baseline noise survey reveals that, for all receptor locations, the L_{Aeq} noise levels from the car parking activity are more than 13dB lower than existing ambient L_{Aeq} noise levels. This applied during both the daytime and night-time. The noise from car parking activity will therefore not lead to an increase in ambient noise levels.

9.5.55 The predicted L_{Aeq} noise levels are also more than 6dB lower than the lowest recorded baseline L_{A90} noise levels. The predicted L_{Amax} noise levels are similarly much lower than those recorded during the baseline noise survey.

9.5.56 On this basis, the assessment finds that there will be no significant noise increases and no significant noise effects.

Noise from Petrol Filling Station and Car Wash

9.5.57 In order to inform the assessment of noise from the proposed petrol filling station and associated car wash, use has been made of noise measurement data obtained from activities undertaken at other similar sites. A summary of this data is presented in **Table 9.27**.

Table 9.27: Source Noise Level Data for Typical Fuel Station and Car Wash Activities

Noise source	Typical duration (s)	Measured L_{Aeq} at 10m distance (dB)	Measured L_{Amax} at 10m distance (dB)
Car pull up	3	60	65
Car door slam	1	65	72
Car starting engine	3	60	66
Car pull away	3	62	64
Automated car wash	300	67	78
'Blow dry' after car wash	150	65	72

9.5.58 In order to determine the potential noise impact of these activities at the nearest sensitive receptors, this data has been used, in conjunction with standard acoustic propagation models, to calculate the $L_{Aeq,T}$ noise level at the closest (most exposed) noise sensitive receptors. During the daytime, the assessment has considered the likely worst case $L_{Aeq,1hour}$ noise levels, whilst for the night-time the $L_{Aeq,5minute}$ noise level is considered. This is in accordance with the methodology set out in BS4142: 1997.

9.5.59 For the purpose of undertaking these calculations, the following assumptions have been made:

- The petrol filling station is to have 12 fuel pumps. There is to be one automated car wash;
- The duration of each fuel-filling event is taken to be 5 minutes. This includes the time for each vehicle to arrive, charge their fuel tank, pay for the fuel and then leave;
- The duration of each car wash event is taken to be 10 minutes. This includes the time for each vehicle to arrive and then pass through the wash and dry cycles before departing;
- For the petrol filling station it is assumed, as a worst case, that there will be 100% occupancy during the daytime; i.e. that all 12 fuel pumps / filling spaces are continuously occupied. Similarly, it is assumed as a worst case that, during the daytime, the car wash will be in continuous operation;
- For the night-time, the occupancy rate for the petrol filling station is assumed to be 25%; i.e. that, at any one time, a maximum of 4 of the 12 fuel pumps / filling spaces will be in operation. For the car wash, it is assumed that for the 5 minute noise assessment period the car wash will be in operation;
- The effective source height of these activities is taken to be 1.0m above local ground level for the petrol filling station and 3m above local ground level for the car wash;
- The receptor heights are taken to be 4.5m above local ground level for the two storey houses on Twibell Street and 6.5m for the 2.5 / 3 storey houses on the southern side of Burton Road;
- As a worst case assumption, it is assumed that there will be no sound attenuation due to boundary fencing. However, other obstacles to the passage of sound such as the proposed food store have been considered;
- Distance attenuation is calculated according to the geometric divergence from a point source;
- The intervening ground between the noise sources and the receptors is acoustically 'hard' such that there is no attenuation of sound due to ground effects;
- No atmospheric attenuation is assumed; and
- Meteorological conditions are neutral; i.e. conditions that do not influence the propagation of sound.

9.5.60 The predicted noise levels from the petrol filling station and car wash activities are set out in **Table 9.28**.

Table 9.28: Predicted Noise Levels from Petrol Filling Station and Car Wash Activities

Receptor location	Predicted $L_{Aeq,1hour}$ daytime noise level, free-field dB	Predicted $L_{Aeq,5minute}$ night-time noise level, free-field dB	Predicted $L_{AFmax,5minute}$ night-time noise level, free-field dB
13 Twibell Street	24.7	23.5	36.7
25 Twibell Street	24.6	23.4	36.6
39 Twibell Street	24.1	22.9	36.1
19/21 Burton Road	27.8	26.7	39.9
47/49 Burton Road	27.1	25.9	39.1

9.5.61 BS4142 states that a 5dB acoustic feature correction should be applied to the specific noise level if the noise source in question:

- Contains a distinguishable, continuous or discrete note; or
- Contains distinct impulses (i.e. bangs, clicks, clatters or thumps).

9.5.62 At least some of the noise sources associated with the petrol filling station and car wash activities are likely to exhibit such characteristics. It is therefore appropriate, for an assessment in accordance with BS4142, to apply the 5dB acoustic feature correction to the predicted L_{Aeq} noise levels to obtain the BS4142 rating level.

9.5.63 **Tables 9.29 and 9.30** present an assessment of the predicted noise levels against the guidance contained within BS4142.

Table 9.29: BS4142 Assessment for Petrol Filling Station and Car Wash Activities: Dwellings at Twibell Street

	Noise Level, free-field dB(A)	
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)
Worst Case Predicted $L_{Aeq,T}$ Noise Level from PFS and Car Wash	24.7	23.5
Character Correction	+5	+5
Rating Noise Level	29.7	28.5
$L_{A90,T}$ Background Noise Level	43.5	33.5
Rating Level – Background Level	-13.8	-5.0
BS4142 Assessment	Complaints Unlikely	Of less than marginal significance

Note: Background noise levels measured at Measurement Position MP1.

Table 9.30: BS4142 Assessment for Petrol Filling Station and Car Wash Activities: Dwellings on Burton Road

	Noise Level, free-field dB(A)	
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)
Worst Case Predicted $L_{Aeq,T}$ Noise Level from PFS and Car Wash	27.8	26.7
Character Correction	+5	+5
Rating Noise Level	32.8	31.7
$L_{A90,T}$ Background Noise Level	38.7	35.2
Rating Level – Background Level	-5.9	-3.5
BS4142 Assessment	Of less than marginal significance	Of less than marginal significance

Note: Background noise levels measured at Measurement Position MP2.

9.5.64 The BS4142 assessment detailed in the above tables identifies that, without any form of mitigation, the noise impact as described by BS4142 would be '*of less than marginal significance*'. However, it should be noted that BS4142 considers that '*rating noise levels below about 35dB are considered to be low*'. The rating noise levels for the petrol filling station and car wash are all significantly below 35dB. The assessment according to BS4142, as recognised in the Standard, may therefore be considered to be overly pessimistic.

9.5.65 Furthermore, a comparison of the above predicted noise levels against the existing levels recorded during the baseline noise survey reveals that, for all receptor locations, the L_{Aeq} noise levels from the petrol filling station and car wash activities are more than 10dB lower than existing ambient L_{Aeq} noise levels. This applies during both the daytime and night-time. Similarly, the predicted L_{Amax} noise levels are much lower than those recorded during the baseline noise survey. The noise from petrol filling station and car wash activities will therefore not lead to a significant increase in ambient noise levels.

9.5.66 On this basis, the assessment finds that any noise impacts associated with the petrol filling station and car wash activities will be of low magnitude.

Mitigation

9.5.67 Although the assessment detailed above has found that the noise impacts associated with the petrol filling station and car wash activities will be low in magnitude, it is still appropriate to consider the available means to mitigate the effects of noise.

9.5.68 The potential mitigation measures are to:

- Curtail the operation of the car wash at night. The car wash activities present the most significant source of noise from the petrol filling station and car wash area; and / or
- Provide an acoustic barrier to screen noise emissions from the car wash activities. Such a barrier would need to be positioned on each side of the car wash and parallel to the service road into and out of the car wash, as identified in **Figure 9.2**.

9.5.69 If the operation of the car wash were to be curtailed at night, the predicted noise levels and BS4142 assessment would be as follows:

Table 9.31: BS4142 Assessment for Petrol Filling Station and Daytime Only Car Wash Activities: Twibell Street

	Noise Level, free-field dB(A)	
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})
Worst Case Predicted L _{Aeq,T} Noise Level from PFS and Car Wash	24.7	5.9
Character Correction	+5	+5
Rating Noise Level	29.7	10.9
L _{A90,T} Background Noise Level	43.5	33.5
Rating Level – Background Level	-13.8	-22.6
BS4142 Assessment	Complaints Unlikely	Complaints Unlikely

Note: Background noise levels measured at Measurement Position MP1.

Table 9.32: BS4142 Assessment for Petrol Filling Station and Daytime Only Car Wash Activities: Burton Road

	Noise Level, free-field dB(A)	
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})
Worst Case Predicted L _{Aeq,T} Noise Level from PFS and Car Wash	27.8	6.8
Character Correction	+5	+5
Rating Noise Level	32.8	11.8
L _{A90,T} Background Noise Level	38.7	35.2
Rating Level – Background Level	-5.9	-23.4
BS4142 Assessment	Of less than marginal significance	Complaints Unlikely

Note: Background noise levels measured at Measurement Position MP2.

9.5.70 If noise barriers as described in paragraph 9.5.69 above and shown in Figure 9.2 were to be implemented, the predicted noise levels and BS4142 assessment would be as follows:

Table 9.33: BS4142 Assessment for Petrol Filling Station and Car Wash with Noise Barrier: Twibell Street

	Noise Level, free-field dB(A)	
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})
Worst Case Predicted L _{Aeq,T} Noise Level from PFS and Car Wash	14.7	13.5
Character Correction	+5	+5
Rating Noise Level	19.7	18.5
L _{A90,T} Background Noise Level	43.5	33.5
Rating Level – Background Level	-23.8	-15.0
BS4142 Assessment	Complaints Unlikely	Complaints Unlikely

Note: Background noise levels measured at Measurement Position MP1.

Table 9.34: BS4142 Assessment for Petrol Filling Station and Car Wash with Noise Barrier: Burton Road

	Noise Level, free-field dB(A)	
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)
Worst Case Predicted $L_{Aeq,T}$ Noise Level from PFS and Car Wash	17.8	16.7
Character Correction	+5	+5
Rating Noise Level	22.8	21.7
$L_{A90,T}$ Background Noise Level	38.7	35.2
Rating Level – Background Level	-15.9	-13.5
BS4142 Assessment	Complaints Unlikely	Complaints Unlikely

Note: Background noise levels measured at Measurement Position MP2.

9.5.71 If either of the mitigation measures detailed above were to be implemented, the potential noise impacts associated with the petrol filling station and car wash would be reduced significantly, to the point where it can be considered that the magnitude of noise effect would be **negligible**.

Residual Effects

9.5.72 The sensitivity of the residential dwellings on Twibell Street and Burton Road is considered to be high. The magnitude of effect is considered to be negligible. Therefore, the overall significance of effect from the petrol filling station and car wash activities is considered to represent a **negligible** impact.

Noise from Service Yard Activities

9.5.73 In order to inform the assessment of noise from the service yard areas, use has been made of noise measurement data obtained from service yard activities undertaken at a number of large foodstores. A summary of this data is presented in **Table 9.35**.

Table 9.35: Source Noise Level Data for Typical Service Yard Activities

Noise source	Typical duration (s)	Measured L_{Aeq} at 10m distance (dB) free-field	Measured L_{Amax} at 10m distance (dB) free-field
HGV (refrigerated) pulls into yard	11	68	72
HGV turns to reverse into docking bay	37	75	80
HGV reverses into docking bay	32	68	72
Unloading trolley cages (per trolley)	60 (per trolley)	60	72
HGV departs	16	75	80
LGV (refrigerated) pulls into yard	22	64	72
LGV departs	22	64	72

9.5.74 In order to determine the potential noise impact of these activities at the nearest sensitive receptors, this data has been used, in conjunction with standard acoustic propagation models, to calculate the $L_{Aeq,T}$ noise level at the closest (most exposed) noise sensitive receptors. The closest sensitive receptors are 39 Twibell Street and 47/49 Burton Road. During the daytime, the assessment has considered the likely worst case $L_{Aeq,1hour}$ noise levels, whilst for the night-time the $L_{Aeq,5minute}$ noise level is considered. This is in accordance with the methodology set out in BS 4142: 1997.

9.5.75 For the purpose of undertaking these calculations, the following assumptions have been made:

- There are to be two service yard areas. The largest of these is associated with the proposed food store and will also include a provision for the 'dot com' (home delivery) activities as well as for the foodstore itself. The other, smaller, service yard is associated with the proposed Retail Unit 3;
- For the large service yard area (foodstore and 'dot com'), the worst case activities occurring in any one hour daytime period is taken to be the arrival, unloading and departure of two HGVs and two LGVs. During the night-time, the worst case activity during any 5 minute period is assumed to be the arrival or departure of two HGVs (but, due to the small time period, not the arrival and departure of the same vehicles);
- For the smaller service yard area (to the rear of Retail Unit 3), the worst case activities during any one hour daytime period is taken to be the arrival, unloading and departure of one HGV. For the night-time, the worst case activity during any 5 minute period is taken to be the arrival or departure (but not both) of one HGV;
- The effective source height of these activities is taken to be 2.0m above local ground level;
- The receptor heights are taken to be 4.5m above local ground level for the two storey houses on Twibell Street and 6.5m for the 2.5 / 3 storey houses on the southern side of Burton Road;
- As a worst case assumption, it is assumed that there will be no sound attenuation due to boundary fencing or other obstacles;
- Distance attenuation is calculated according to the geometric divergence from a point source;
- The intervening ground between the noise sources and the receptors is acoustically 'hard' such that there is no attenuation of sound due to ground effects;
- No atmospheric attenuation is assumed; and
- Meteorological conditions are neutral; i.e. conditions that do not influence the propagation of sound.

9.5.76 The predicted noise levels from service yard activities are set out in **Table 9.36**.

Table 9.36: Predicted Noise Levels from Service Yard Activities

Receptor location	Predicted $L_{Aeq,1hour}$ daytime noise level, free-field dB	Predicted $L_{Aeq,5minute}$ night-time noise level, free-field dB	Predicted $L_{AFmax,5minute}$ night-time noise level, free-field dB
39 Twibell Street	53.7	57.2	69.1
47/49 Burton Road	45.2	50.1	63.3

9.5.77 BS4142 states that a 5dB acoustic feature correction should be applied to the specific noise level if the noise source in question:

- Contains a distinguishable, continuous or discrete note; or
- Contains distinct impulses (i.e. bangs, clicks, clatters or thumps).

9.5.78 At least some of the noise sources associated with the service yard activities are likely to exhibit such characteristics. It is therefore appropriate, for an assessment in accordance with BS4142, to apply the 5dB acoustic feature correction to the predicted L_{Aeq} noise levels to obtain the BS4142 rating level.

9.5.79 **Tables 9.37 and 9.38** present an assessment of the predicted noise levels against the guidance contained within BS4142.

Table 9.37: BS4142 Assessment for Service Yard Activities: 37 Twibell Street

	Noise Level, free-field dB(A)	
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)
Predicted $L_{Aeq,T}$ Noise Level from Service Yard	53.7	57.2
Character Correction	+5	+5
Rating Noise Level	58.7	62.2
$L_{A90,T}$ Background Noise Level	43.5	33.5
Rating Level – Background Level	+15.2	+28.7
BS4142 Assessment	Complaints Likely	Complaints Likely

Note: Background noise levels measured at Measurement Position MP1.

Table 9.38: BS4142 Assessment for Service Yard Activities: 47/49 Burton Road

	Noise Level, free-field dB(A)	
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)
Predicted $L_{Aeq,T}$ Noise Level from Service Yard	45.2	50.1
Character Correction	+5	+5
Rating Noise Level	50.2	55.1
$L_{A90,T}$ Background Noise Level	38.7	35.2
Rating Level – Background Level	+11.5	+19.9
BS4142 Assessment	Complaints Likely	Complaints Likely

Note: Background noise levels measured at Measurement Position MP2.

Mitigation

9.5.80 The BS4142 assessment detailed in the above tables identifies that, without any form of mitigation, there are likely to be major adverse impacts associated with noise from the service yard activities. It is therefore necessary to consider the available mitigation measures to reduce this noise impact.

9.5.81 In accordance with the scope of assessment detailed in Paragraph 8.3.1, the proposed mitigation measures should aim to ensure that the internal noise levels at the nearby noise sensitive receptors meet with the criteria set out in BS8233: 1999. This standard states that a 'good' criterion for indoor L_{Aeq} noise levels during the daytime and at night is 30dB $L_{Aeq,T}$. For the night-time period, the standard also recommends that noise levels within bedrooms should not exceed 45dB $L_{AFmax,T}$. These criteria relate to indoor noise levels, and it is usual practice to assume that these criteria should be met in situations where windows are open to allow for natural ventilation. The equivalent external noise criteria, assuming an open window, are 45dB $L_{Aeq,T}$ during the daytime and at night and 60dB $L_{AFmax,T}$ during the night-time period (applicable to bedrooms).

9.5.82 **Tables 9.39 and 9.40** identify the noise attenuation required from mitigation measures to ensure that the criteria detailed within BS8233 are met.

Table 9.39: Required Attenuation of Service Yard Noise : 37 Twibell Street

	Noise Level, free-field dB(A)		
	Daytime ($L_{Aeq,1hour}$)	Night ($L_{Aeq,5minutes}$)	Night (L_{AFmax})
Predicted $L_{Aeq,T}$ Noise Level from Service Yard (external)	53.7	57.2	69.1
Design Target (based on BS 8233 – external)	45.0	45.0	60.0
Attenuation Required	8.7	12.2	9.1

Table 9.40: Required Attenuation of Service Yard Noise : 47/49 Burton Road

	Noise Level, free-field dB(A)		
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})	Night (L _{AFmax})
Predicted L _{Aeq,T} Noise Level from Service Yard (external)	45.2	50.1	63.3
Design Target (based on BS 8233 – external)	45.0	45.0	60.0
Attenuation Required	0.2	5.1	3.3

9.5.83 It can be seen from the tables presented above that in order to provide sufficient mitigation to protect the properties on Twibell Street, a reduction in noise levels of at least 12.2dB(A) must be achieved. For the properties on Burton Road, a reduction of at least 5.1dB(A) must be achieved.

9.5.84 The most appropriate and effective means of achieving such a noise reduction is through the provision of noise barriers at the boundary of the service yard areas. Calculations have therefore been undertaken to determine the height and extent of noise barriers required to achieve the desired attenuation. These calculations have been undertaken using the method described by Makeawa (Ref 9.12), which is the industry standard noise barrier calculation method.

9.5.85 These calculations have revealed that, in order to ensure that noise from service yard activities meets with the internal design limits contained within BS8233 (with windows open), the service yard areas would need to be provided with a boundary fence or noise barrier that meets with the following specifications:

- For the main service yard area (foodstore and 'dot com'), a barrier with a minimum height of 6.0m above ground level, to extend along the southern edge of the service yard area and in line with the build-line of the southern facade of the foodstore, as shown in **Figure 9.3**; and
- For the smaller service yard area at the proposed Retail Unit 3, a barrier with a minimum height of 3.0m above ground level, to be constructed along the northern site boundary of the service yard area, as shown in **Figure 9.4**.

9.5.86 The predicted noise levels with such barriers in place are as follows:

Table 9.41: Predicted Noise Levels from Service Yard – With Noise Barrier: 37 Twibell Street

	Noise Level, free-field dB(A)		
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})	Night (L _{AFmax})
Predicted L _{Aeq,T} Noise Level from Service Yard (external)	41.4	44.9	56.8
Design Target (based on BS 8233 – external)	45.0	45.0	60.0

Table 9.42: Predicted Noise Levels from Service Yard – With Noise Barrier: 47/49 Burton Road

	Noise Level, free-field dB(A)		
	Daytime (L _{Aeq,1hour})	Night (L _{Aeq,5minutes})	Night (L _{AFmax})
Predicted L _{Aeq,T} Noise Level from Service Yard (external)	39.2	44.1	57.3
Design Target (based on BS 8233 – external)	45.0	45.0	60.0

Residual Effects

9.5.87 It should be noted that, although with these noise barriers in place the design targets specified within BS8233 will be met, noise levels from the service yard area are still predicted to exceed the existing background noise levels. Although the BS8233 targets are met, there will still, therefore, remain a noise impact.

9.5.88 The sensitivity of the residential dwellings on Twibell Street and Burton Road is considered to be high. The magnitude of the residual effect is considered to be low. Therefore, as the design target can be met with suitable mitigation the overall significance of effect from the service yard noise is considered to represent a **minor adverse** impact.

Noise from Fixed Mechanical and Electrical Plant

9.5.89 The Proposed Development is likely to require a number of electrical and mechanical plant items, such as cooling and refrigeration plant associated with the foodstore, ventilation and heating plant associated with the proposed Retail Unit 3 and possibly other plant such as standby generators.

9.5.90 At this stage of the Proposed Development, precise details relating to the type, number and location of any such plant or the nature of any such operations are not available. In the absence of detailed information it is appropriate to specify suitable noise control limits to which any plant/operations should conform. These limits should include any corrections for acoustic characteristics.

9.5.91 BS4142 states that a rating noise level of +5dB above background is of marginal significance when assessing the likelihood of complaints. However, if such a criterion was applied to individual items of plant it is likely that background 'creep' would result. Consequently, it is appropriate that cumulatively all external plant to be incorporated in the proposals and operating at worst case duty, should be specified to meet an excess of rating over background level of -5dB at the closest noise-sensitive receptors during both the daytime and night-time periods. This approach to setting mechanical and electrical plant noise level limits accords with the criteria specified by Barnsley Council.

9.5.92 The closest existing noise sensitive receptors, at which background noise measurements have been undertaken, are:

- At the front of the residential dwellings on Twibell Street – background noise measurements undertaken at MP1 are considered representative of the noise climate here; and
- At the rear of the residential dwellings on the southern side of Burton Road – background noise measurements undertaken at MP2 are considered representative of the noise climate here.

9.5.93 BS4142 advises that the measurement time interval for background noise measurements should be 'sufficient to obtain a representative value of the background level'. For the purpose of this assessment, the lowest 1 hour daytime and lowest 1 hour and 5 minute night-time values have been considered.

9.5.94 Following on from the above, where existing background noise levels are already very low BS4142 states:

'For the purposes of this standard, background noise levels below 30 dB and rating levels below about 35 dB are considered to be very low'.

9.5.95 Consequently, it is considered appropriate that where the rating level limit based on measured background $L_{A90,T}$ noise level is below 35 dB a plant level limit of 35 dB $L_{A,T,r}$ should be adopted.

9.5.96 On the basis of the above, the combined noise level from all plant associated with the Site should be designed to meet the noise limits presented in **Table 9.43**.

Table 9.43: Proposed Plant Noise Limits

Receptor (Location)	Time period	Lowest $L_{A90,T}$	Measurement Location	Rating Noise Level Limit $L_{A,T,r}$
Dwellings on Twibell Street	Daytime	43.5	1	38.5
	Night-time	33.5		35.0
Dwellings on Burton Road	Daytime	41.7	2	36.7
	Night-time	34.7		35.0

9.5.97 The above rating noise level limits apply at 3.5m from the façade of any residential property (free-field).

9.5.98 The sensitivity of the existing noise sensitive receptors as outlined in **Table 9.43** is considered to be high. Provided that the above plant noise limits are complied with, it is considered that the magnitude of change is predicted to be negligible. Therefore, there is likely to be a **negligible** effect on existing and proposed noise sensitive receptors prior to the implementation of mitigation measures.

Mitigation

9.5.99 The assessment of commercial plant / equipment noise effects has been limited in view of the absence of detailed uses and equipment specifications. Therefore, this assessment has proposed noise limits in accordance with BS4142: 1997 and plant noise emission limit criteria specified by Barnsley Council.

9.5.100 It is anticipated that at this stage of the Proposed Development, the specification and location of any plant is sufficiently flexible to ensure suitably quiet plant can be procured, and / or mitigation options can be investigated, to ensure compliance with the proposed noise limits.

9.5.101 It is anticipated that the proposed noise limits could be incorporated into the planning conditions with respect to fixed plant items associated with the Proposed Development.

9.5.102 Once the detailed nature of such future uses are confirmed, noise from any related operations can be considered and an appropriate noise mitigation scheme devised and incorporated into the layout of the Proposed Development to ensure that the above limits can be met. It is anticipated that this may require consideration to the selection of appropriate plant.

9.5.103 It should be noted that a noise emission limits specified within **Table 9.43** would be applicable to the total noise from the simultaneous operation of all external plant serving the Proposed Development. This would include any CHP plant, if such a facility is to be included in the Proposed Development. As such, noise emissions from individual items of plant would need to be lower than the given limit, although the exact limit for each individual item of plant would be dependent upon its type, noise characteristics, location etc. This issue is best addressed during the detailed design stage.

Residual Effects

9.5.104 The proposed noise limits are based on the situation being better than that described in BS4142 as of 'marginal significance'. The sensitivity of both existing and proposed noise sensitive receptors as outlined in **Table 9.43** is considered to be high. Provided that the above plant noise limits are complied with, it is considered that the magnitude of change is predicted to be negligible. Therefore, there is likely to be a **negligible** effect on existing and proposed noise sensitive receptors, following the implementation of mitigation measures.

Monitoring and Follow Up

Site Preparation and Construction

9.5.105 It is recommended that a Construction Noise Management Plan, possibly as part of a wider Construction Environmental Management Plan, be put in place to control, as far as is reasonably practicable, any potential noise and vibration impacts from the construction works. Any adopted plan should take into account the requirements of the Control of Pollution Act 1974, Part 3, relating to noise and vibration, and the control measures set out in Parts 1 and 2 of BS5228.

Operation

9.5.106 The detailed design of the development should consider the various noise mitigation and control measures that have been presented in this assessment. Where necessary, some further assessment may be required. This should include:

- Confirmation of the required height and extent of the proposed noise barriers at the service yard areas, when final details of the activities, and timing of activities, within the service yard areas have been confirmed;
- Confirmation of the required height and extent of any noise barriers that may be required to screen noise emissions from the car wash activities, particularly if such activities are to occur at night; and
- Detailed specification of noise emission limits from fixed mechanical and electrical plant, once the schedule of operating plant is confirmed.

Limitations and Assumptions

9.5.107 As the Proposed Development is currently at outline stage, sufficiently detailed information on construction techniques and equipment is not available. Consequently it has not been possible to accurately determine the noise

effects from the site preparation and construction activities. The potential effects associated with these activities has therefore been assessed in a generic manner.

9.5.108 Similarly, a number of assumptions have had to be made in order to estimate the extent of activities within the service yard areas and the consequent noise emissions that would result from such activities. This also applies to the assessment of noise from the petrol filling station and electrical and mechanical plant.

9.5.109 However, it is considered that both for the construction and operational phases of the development, appropriate worst case or relatively worst case assumptions have been made.

Table 9.44: Summary of Effects Table for Noise & Vibration

Description of Likely Significant Effects	Significance of Effects					Summary of Mitigation / Enhancement Measures / Development Design	Significance of Residual Effects					Relevant Policy	Relevant Legislation
	(Major, Moderate, Minor, Negligible)	Positive / Negative	(P/T)	(D/I)	ST/MT/LT)		(Major, Moderate, Minor, Negligible)	Positive / Negative	(P/T)	(D/I)	ST/MT/LT)		
Site Preparation and Construction Phase (including Demolition)													
Increase in noise due to construction works	Moderate to Major	Negative	T	D	ST	■ Adoption of Best Available Techniques. ■ CEMP.	Minor to Moderate	Negative	T	D	ST	N/A	The Control of Pollution Act. 1974 BS5228: Part 1: 2009.
Perceptible levels of vibration from construction works at nearby vibration sensitive receptors.	Minor to Moderate	Negative	T	D	ST	■ Adoption of Best Available Techniques, with emphasis on piling. ■ CEMP.	Minor to Moderate	Negative	T	D	ST	N/A	The Control of Pollution Act. 1974 BS5228: Part 2: 2009.
Operational Phase													
Increase in noise from development generated road traffic	Minor to Moderate	Negative	P	D	LT	■ None proposed or feasible	Minor to Moderate	Negative	P	D	LT	N/A	N/A
Increase in noise from car parking	Negligible	N/A	N/A	N/A	N/A	■ None proposed	Negligible	N/A	N/A	N/A	N/A	N/A	N/A
Increase in noise from Petrol Filling Station and associated car wash	Negligible to Minor to Moderate	Negative	P	D	LT	■ Noise barrier at car wash area; and/or ■ Curtail operation of car wash at night	Negligible	N/A	N/A	N/A	N/A	N/A	BS4142: 1997. BS8233: 1999
Increase in noise from service yard activities	Major	Negative	P	D	LT	■ Provision of noise barriers	Minor	Negative	P	D	LT	N/A	BS4142: 1997. BS8233: 1999
Noise generated by mechanical and electrical plant	Negligible	N/A	N/A	N/A	N/A	■ Specification and selection of plant to meet noise limits based on BS4142: 1997	Negligible	N/A	N/A	N/A	N/A	N/A	BS4142: 1997.

Key to table:

P/T = Permanent or Temporary, D/I = Direct or Indirect, ST/MT/LT = Short Term, Medium Term or Long Term

N/A = Not Applicable

9.6 REFERENCES

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- Ref 9.2 The Department for Environment, Food and Rural Affairs, Noise Policy Statement For England, March 2010.
- Ref 9.3 The Department of the Environment and the Welsh Office, Planning Policy Guidance Noise 24: 1994: Planning and Noise.
- Ref 9.4 Barnsley Metropolitan Borough Council, Local Development Framework Core Strategy, adopted September 2011 (www.barnsley.gov.uk/core-strategy-adopted-sept-2011)
- Ref 9.5 The British Standards Institute, BS4142 1997: Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas
- Ref 9.6 The British Standards Institute, BS8233: 1999: Sound Insulation and Noise Reduction for Buildings – Code of Practice.
- Ref 9.7 The World Health Organisation: 1999: Guidelines for Community Noise.
- Ref 9.8 Vallet M and Vernet I: 1991: Night Aircraft Noise Index and Sleep Research Results. Proc Inter-Noise 91, Vol 1, pp207-210, USA
- Ref 9.9 Department of Transport in 1993 (last amended 2011), The Design Manual for Roads and Bridges (DMRB): Volume 11: Environmental Assessment.
- Ref 9.10 The Department of Transport and the Welsh Office: 1988: Calculation of Road Traffic Noise.
- Ref 9.11 The British Standards Institute, BS5228: 2009 Noise and Vibration Control on Construction and Open Sites – Part 1: Noise.
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- Ref 9.13 The British Standards Institute, BS5228: 2009 Noise and Vibration Control on Construction and Open Sites – Part 2: Vibration.
- Ref 9.14 Maekawa Z, Noise Reduction by Screens, Applied Acoustics 1, 1968.